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Vapor Barriers / Retarders

The information presented is not the results of studies conducted by Advanced Fiber Technology but rather the results of studies conducted by building scientists. The following summarize some of the numerous technical and scientific documents on this topic. AFT does not recommend the use of vapor barriers except in specific applications.

The goals are to: 1) keep water vapor out and 2) let water vapor out if it gets in. Achieving goal 2) also is beneficial when moisture in the form of a liquid gets into the wall cavity. Achieving the goals gets complicated because the best strategies to keep water vapor out also trap water vapor in. This can be a real problem if the assemblies get wet. It gets more complicated because of climate.

The overall strategy is to keep building assemblies from getting wet from the interior, from getting wet from the exterior, and allowing them to dry to either the interior or exterior should they get wet or start out wet as a result of the construction process.

In general, water vapor moves from the warm side of building assemblies to the cold side of building assemblies. Therefore we need to consider the differences between winter and summer. Basically highs want to move toward lows, i.e. high temperature moves toward low temperature, high moisture concentrations move toward low moisture concentrations, high pressure moves toward low pressures, etc.

Water vapor can move through materials as a result of vapor pressure differential or a temperature difference. The permeability of building materials affects this movement. Some materials change their permeability as a function of the relative humidity.

Materials can be separated in to four general classes based on the permeance. This is an extension and modification of the Canadian General Standards Board approach that specifies types or vapor retarders. The following is attributed to Joseph Lstiburek of Building Science Corporation.

Vapor Impermeable:	0.1 perm or less
Examples:	Rubber membranes
	Polyethylene film
	Glass
	Aluminum foil
	Sheet metal
	Foil-faced insulating sheathing
	Foil-faced non-insulating sheathing
Vapor Semi-Impermeable	1.0 perms or less and greater than 0.1 perm
Examples:	Oil-based paints
	Most vinyl wall coverings
	Unfaced extruded polystyrene greater than 1-inch thick

	Traditional hard-coat stucco applied over building paper and OSB sheathing.
Vapor Semi-permeable	10 perms or less and greater than 1.0 perms Plywood Bitumen impregnated kraft paper OSB Unfaced expanded polystyrene (EPS) Unfaced extruded polystyrene (XPS) 1-inch thick or less Fiber-faced isocyanurate Heavy asphalt impregnated building papers #30 pound Most latex based paints
Vapor Permeable	Greater than 10 perms Unpainted gypsum board and plaster Unfaced fiberglass insulation Cellulose insulation Synthetic stucco Some latex-based paints Lightweight asphalt impregnated building papers (#15 building paper) Asphalt impregnated fiberboard sheathing Housewraps

Mixed climates have a complicated situation. During the heating season, temperature and moisture vapor move from inside to outside. During the cooling season, the temperature and moisture vapor move from outside to inside. Hence it makes sense to have a wall system design that allows drying to both the interior and exterior to accommodate the changing seasons or a “flow-through” wall assembly. Placing a vapor impermeable material in a wall works against the concept of a “flow-through” wall assembly.

Vapor barriers are used to keep moisture from moving from one side to the other. If a wall cavity gets wet, the vapor barrier will restrict drying to the opposite side. If the vapor barrier is place on the warm side, the wall cavity can only dry to the outside. Vapor barriers are intended to prevent assemblies from getting wet. However their use also prevents them from drying.

A look at some real-life scenarios point toward the acceptability of the “flow-through” wall assembly concept. This is not a new concept but one that unknowingly has been used for millions of homes. During the 70’s energy crisis, significant efforts were made by the U.S. Department of Energy to insulate existing houses for lower income persons. These weatherization programs continue today. All that is typically done is install “vapor permeable” cellulose insulation without the use of “vapor impermeable” polyethylene film when retrofitting existing walls. This would not be acceptable under the current building code in certain climates however it was and continues to be common practice.

If the science behind the current building code was correct, then there should be millions of houses experiencing problems as a result of the government's weatherization program. In 1979 a field study in Portland, Oregon (4,792 degree days) concluded there is no risk of moisture damage in mild climates without a vapor barrier however it was not established whether it might be a problem in colder climates. Thus a second major field study was done in Spokane, Washington (6,835 degree days) by George Tsongas, Ph.D. P.E. Professor of Mechanical Engineering at Portland State University. The exterior walls of 103 homes were opened, 79 with retrofitted insulation and 24 uninsulated as a control group. "*This study strongly concludes that the addition of wall insulation without a vapor barrier does not cause moisture problems in existing homes in climates similar to that of Spokane.*" Bonneville Power Administration provided funding for this study.

A 2004 study released by building scientist Erkki Kokko of Finland, *"Hygroscopic Cellulose Fiber Insulated Structures"* found the use of permeable building materials resulted in improved indoor air quality. The absence of a vapor barrier, such as polyethylene film, allowed the wall to absorb and desorb relative humidity. This enables the interior relative humidity to remain more constant and comfortable to the occupants. They also found a 30% reduction in the carbon dioxide levels.

The U.S. Department of Energy's Building America Program is reengineering the American home for energy efficiency and affordability. The EEBA's Builder's Guide for Cold Climates states in Appendix III, *"Polyethylene on the inside of building assemblies in cold, mixed-humid, mixed-dry, hot-humid, and hot-dry climates is not generally a good idea." "A classic flow-through wall assembly should have a permeable interior surface and finish and permeable exterior sheathing and permeable building paper drainage plane."* This permits drying to both the interior and exterior.

In a December 2001 presentation in Proceedings of Thermal Performance of Building Envelopes VIII, Asst. Prof. John Straube stated *"In many practical situations, a low-permeance vapour barrier will not improve hygrothermal performance, and may in fact increase the likelihood of damaging condensation or trap moisture in the system. In some cases, a low-permeance vapour barrier may be called for, but in many practical high performance enclosures, none is needed, and eliminating them will actually improve performance by encouraging drying and avoiding solar-driven diffusion wetting. The preconceptions of many building codes, standards, and designers need to be modified to acknowledge the facts of low permeance vapour barriers.*

Joseph Lstiburek, Ph.D. P.E. in "Understanding Vapor Barriers" in the August 2004 ASHRAE journal proposes a vapor semi-permeable vapor retarder (i.e. latex paint) when the exterior sheathing material has a perm over 1.0 (vapor semi-permeable, i.e. plywood, OSB, fiberboard) for DOE climate zone, which includes Ohio.

Kraft faced fiberglass has commonly been accepted as a vapor retarder yet this material falls in the vapor semi-permeable category along with latex based paints due to a perm rating of 5 under a wet-cup test to determine permeability. However when cellulose insulation is installed, often a vapor impermeable polyethylene film is required.

Cellulose insulation combined with latex paint on the gypsum drywall provides the same “flow-through” characteristics as the commonly used fiberglass with kraft facing.

Based upon building science, the DOE proposed a code change that eliminates mandatory use of vapor retarders in most of the U.S., including every county in Ohio. It read, *“The building design shall not create conditions of accelerated deterioration from moisture condensation. Frame walls, floors, and ceilings not ventilated to allow moisture to escape shall be provided with an approved vapor retarder. The vapor retarder shall be installed on the warm-in-winter side of the thermal insulation. Exceptions: 1. In construction where moisture or its freezing will not damage the materials. 2. Frame walls, floors, and ceilings in jurisdictions in Zones 1 through 5. (Crawl space floor vapor retarders are not exempted.) 3. Where other approved means to avoid condensation are provided.”*

Unfortunately the following was approved and contained in the 2004 SUPPLEMENT to the INTERNATIONL RESIDENTIAL CODE (IRC) pertaining to moisture control and vapor retarders. No scientific basis was provided for dropping zone 5 from the exception.

SECTION R318.1 MOISTURE CONTROL

R3181. Moisture Control. *In all framed walls, floors and roof/ceilings comprising elements of the building thermal envelope, a vapor retarder shall be installed on the warm-in-winter side of the insulation.* ***Exceptions:***

1. *In construction where moisture or freezing will not damage the materials.*
2. *Where the framed cavity or space is ventilated to allow moisture to escape.*
3. *In counties identified as in climate zones 1 through 4 in Table N1101.2*

Southern portions of Indiana, Ohio, West Virginia, and Pennsylvania are included in zone 4 while the northern portions are included in zone 5. At least the building codes are finally recognizing building science on this topic.

<u>Conclusion:</u>
Vapor retarders are a complicated topic however a couple of key points need to be kept in mind. Wall cavities can get wet. If they can get wet, can the wall assembly allow them to dry? Vapor semi-permeable and vapor permeable materials provide the best combination for wall cavity assemblies to allow them to dry in both an exterior and interior direction depending upon the season of the year. Will polyethylene film cause a wall assembly to fail, probably not if moisture can be kept out of the wall cavity. The difficulty is keeping moisture out of wall cavities. Since this is a difficult challenge, why not use permeable building materials utilizing a “flow-through” wall assembly that give the wall assembly the best chance to dry after getting wet.

The above do no apply to special use enclosures such as spas, pool buildings, museums, hospitals, data processing centers or other engineered enclosures such as factory, storage or utility enclosures.