Vapor Barriers

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The function of a vapor barrier is to retard the migration of water vapor. Where it is located in an assembly and its permeability is a function of climate, the characteristics of the materials that comprise the assembly and the interior conditions. Vapor barriers are not typically intended to retard the migration of air. That is the function of air barriers.

Confusion on the issue of vapor barriers and air barriers is common. The confusion arises because air often holds a great deal of moisture in the vapor form. When this air moves from location to location due to an air pressure difference, the vapor moves with it. This is a type of migration of water vapor. In the strictest sense air barriers are also vapor barriers when they control the transport of moisture-laden air.

Terminology

Part of the problem is that we struggle with names and terms. We have vapor retarders, we have vapor barriers, we have vapor permeable we have vapor impermeable, etc. What do these terms mean? It depends on whom you ask and whether they are selling something or arguing with a building official. In an attempt to clear up some of the confusion the following definitions are proposed:

Vapor Retarder*: The element that is designed and installed in an assembly to retard the movement of water by vapor diffusion.

* taken somewhat from ASHRAE Fundamentals 2001, Chapter 23.

The unit of measurement typically used in characterizing the water vapor permeance of materials is the "perm". It is further proposed here that there should be several classes of vapor retarders (this is nothing new – it is an extension and modification of the Canadian General Standards Board approach that specifies Type I and Type II vapor retarders – the numbers here are a little different however):

Class I	Vapor Retarder:	0.1 perm or less
Class II	Vapor Retarder:	1.0 perm or less and greater than 0.1 perm
Class III	Vapor Retarder:	10 perm or less and greater than 1.0 perm

Test Procedure for vapor retarders: ASTM E-96 Test Method A (the desiccant method or dry cup method)

Finally, a vapor barrier is defined as:

Vapor Barrier:	A Class I vapor retarder.

The current International Building Code (and its derivative codes) defines a vapor retarder as 1.0 perm or less (using the same test procedure). In other words the current code definition of a vapor retarder is equivalent to the definition of a Class II Vapor Retarder proposed by the author.

Continuing in the spirit of finally defining terms that are tossed around in the enclosure business. It is also proposed that materials be separated into four general classes based on their permeance (again nothing new, this is an extension of the discussion in ASHRAE Journal, February 02 – Moisture Control for Buildings):

Vapor impermeable:	0.1 perm or less
Vapor semi-impermeable:	1.0 perm or less and greater than 0.1 perm
Vapor semi-permeable:	10 perms or less and greater than 1.0 perm
Vapor permeable:	greater than 10 perms

Recommendations for Building Enclosures

The following building assembly recommendations are climatically based (see SIDE BAR 1) and are sensitive to cladding type (brick or stone veneer, stucco) and structure (concrete block, steel or wood frame, precast concrete).

Building assembly recommendations should be based on the following principles:

- Avoidance of using vapor barriers where vapor retarders will provide satisfactory performance. Avoidance of using vapor retarders where vapor permeable materials will provide satisfactory performance. Thereby encouraging drying mechanisms over wetting prevention mechanisms.

- Avoidance of the installation of vapor barriers on both sides of assemblies – i.e. "double vapor barriers" in order to facilitate assembly drying in at least one direction.

- Avoidance of the installation of vapor barriers such as polyethylene vapor barriers, foil faced batt insulation and reflective radiant barrier foil insulation on the interior of air-conditioned assemblies – a practice that has been linked with moldy buildings (Lstiburek, 2002).

- Avoidance of the installation of vinyl wall coverings on the inside of air-conditioned assemblies – a practice that has been linked with moldy buildings (Lstiburek, 1993).

More Definitions – Taking On The Air Barrier

The following is an extension of the definitions proposed in ASHRAE Journal, February 02 – Moisture Control For Buildings.

Air barrier systems are systems of materials used to control airflow in building enclosures. They typically completely enclose the air within a building. The physical properties, which distinguish air barriers from other materials, are the ability to resist airflow and air pressure.

Air barrier systems are intended to resist the air pressure differences that act on them. Rigid materials such as gypsum board, exterior sheathing materials like plywood or OSB, and supported flexible barriers (rigid materials on both sides of the barriers) are typically effective air barrier systems if joints and seams are sealed and if they are supported by rigid materials. Their rigidity aids in their ability to resist air pressures, which act on them.

Continuity of air barrier systems at holes, openings and penetrations of building enclosures is a key performance indicator of an effective air barrier.

Often, rubber or bitumen-based membranes are adhered to masonry or sheathing materials to create an air barrier system. These rubber or bitumen-based membranes are also impermeable and are therefore also vapor barriers.

Many, but not all, air barriers are vapor barriers and many, but not all, vapor barriers are air barriers.

Air barrier:	The element in an assembly designed and constructed to control air leakage between a conditioned space and an unconditioned space.
Conditioned Space*:	The part of the building that is designed to be thermally conditioned for the comfort of occupants or for other occupancies or for other reasons.

Indoor Air*: Air in a conditioned space.

Outdoor Air*: Air outside the building. It can enter the conditioned space via the ventilation system, or by infiltration through holes in the pressure boundary or designed ventilation openings.

Air barriers typically define the location of the "pressure boundary" of the building enclosure. The pressure boundary is defined as the location where 50 percent or more of the air pressure drop across an assembly occurs.

Pressure Boundary*: Primary air enclosure boundary separating conditioned air and unconditioned air. For example, a volume that has more leakage to the outside than to the conditioned space would be considered outside the pressure boundary such as vented unconditioned attics and vented unconditioned crawlspaces.

Air Retarders: Materials or systems that reduce air flow or control airflow but do not resist 50 percent or more of the air pressure drop across an assembly.

Occupiable Space*: Any enclosed space inside the pressure boundary and intended for human activities, including but not limited to, all habitable spaces, toilets, closets, halls, storage and utility areas, and laundry areas.

Habitable Space*: Building space intended for continual human occupancy. Such space generally includes areas used for living, sleeping, dining, and cooking, but does not generally include bathrooms, toilets, hallways, storage areas, closets, or utility rooms.

* Taken from ASHRAE Standard 62.2

And Finally – Defining the Drainage Plane

Drainage planes are water repellant materials (building paper, house wrap, foam insulation, etc), which are located behind the cladding and are designed and constructed to drain water that passes through the cladding. They are interconnected with flashings, window and door openings, and other penetrations of the building enclosure to provide drainage of water to the exterior of the building. The materials that form the drainage plane overlap each other shingle fashion or are sealed so that water flow is down and out of the wall.

Proposed Building Code Requirements for Vapor Retarders

The proposed building code requirements are based on a combination of field experience and laboratory testing. The requirements were also evaluated using dynamic hygrothermal modeling. The modeling program used was WUFI (Kunzel, 1999). Under the modeling evaluation, the moisture content of building materials that comprise the building assemblies evaluated all remained below the equilibrium moisture content the materials as specified in ASHRAE 160 P. Interior air conditions and exterior air conditions as specified by ASHRAE 160 P were used.

The climate zones referenced are the U.S. Department of Energy climate zones as proposed for adoption in the 2006 International Residential Code (IRC) and International Energy Conservation Code (IECC). Their development is the subject of two ASHRAE papers (Briggs, Lucas & Taylor, 2003). An accompanying map defines the climate zones - see attached.

Note that vapor retarders are defined and classed using ASTM E-96 Test Method A (the desiccant method or dry cup method) consistent with the current code language. However, exterior sheathings are defined and classed using Test Method B (the "wet cup" method) in order to take advantage of the ability of some sheathings to "breathe" as they are exposed to high relative humidities.

1. Zone 1, Zone 2, Zone 3 and Zone 4 do not require any class of vapor retarder on the interior surface of insulation in insulated assemblies (this recommendation has already been accepted by the code committee at the code hearings in Nashville, September 2003 and Kansas City, May 2004).

2. Zone 5 requires a Class III (or lower) vapor retarder on the interior surface of insulation in insulated wall and floor assemblies where the permeance of the exterior sheathing is greater than 1.0 perm as tested by Test Method B (the "wet cup" method) of ASTM E-96).

3. Zone 6 and Zone 7 require a Class II (or lower) vapor retarder on the interior surface of insulation in insulated wall and floor assemblies where the permeance of the exterior sheathing is greater than 1.0 perm as tested by Test Method B (the "wet cup" method) of ASTM E-96).

4. Zone 5, Zone 6 and Zone 7 require a Class III (or lower) vapor retarder on the interior surface of insulation in insulated wall and floor assemblies where the permeance of the exterior sheathing is 1.0 perm or less as tested by Test Method B (the "wet cup" method) of ASTM E-96) and the interior surface of the exterior sheathing shall be maintained above the dew point temperature of the interior air.

Under this design approach assume steady state heat transfer, interior air at a temperature of 70 degrees F (21 degrees C), at a relative humidity specified in Table 1 and exterior air at a temperature that is equal to the average outdoor temperature for the location during the coldest three months of the year (e.g. December, January and February).

TABLE 1: DESIGN CONDITIONS FOR STEADY STATE DESIGN PROCEEDURE (not the actual service conditions for typical residential occupancy – but the design conditions for the simple steady state design procedure being used)

Zone 5	30 percent RH @ 70 degrees F	(Dew Point 37 degrees F)
Zone 6	25 percent RH @ 70 degrees F	(Dew Point 32 degrees F)
Zone 7	20 percent RH @ 70 degrees F	(Dew Point 28 degrees F)

5. Zone 5 requires a Class III (or lower) vapor retarder on the interior surface of insulation in insulated roof or attic assemblies.

6. Zone 6 and Zone 7 require a Class II (or lower) vapor retarder on the interior surface of insulation in insulated roof or attic assemblies.

7. Zone 5, Zone 6 and Zone 7 require a Class III (or lower) vapor retarder on the interior surface of insulation in internally insulated below grade masonry and concrete walls. Frame walls (i.e. “stem walls”) that are constructed on the top of concrete or masonry foundation walls are not considered below grade walls.

8. Concrete slab floors in ground contact are required to have a Class I vapor retarder below the slab in direct contact with the slab or rigid insulation having a thermal resistance of at least R-5 below the slab in direct contact with the slab.

9. Exceptions to the above requirements shall be allowed when assemblies are evaluated by dynamic hygrothermal modeling. The moisture content of building materials that comprise the building assembly shall remain below the equilibrium moisture content the materials as specified in ASHRAE 160 P under this evaluation approach. Interior air conditions and exterior air conditions as specified by ASHRAE 160 P shall be used.

TABLE 2: SUMMARY OF RECOMMENDATIONS FOR VAPOR RETARDERS ON THE INTERIOR OF WALL, ROOF OR ATTIC ASSEMBLIES

Wall Assembly Exterior Sheathing	Wall Assembly Exterior Sheathing	Roof/Attic Assembly	Internally Insulated Concrete Below Grade Walls
(Greater Or Equal 1 perm)	(Less Than 1 Perm)	(vented or unvented)	(not applicable to wood

				foundations)**
Zone				
1	not required	not required	not required	not required
2	not required	not required	not required	not required
3	not required	not required	not required	not required
4	not required	not required	not required	not required
5	Class III	Class III*	Class III	Class III
6	Class II	Class III*	Class II	Class III
7	Class II	Class III*	Class II	Class III

* Additionally, the interior surface of the exterior sheathing shall be maintained above the dew point temperature of the interior air.

** Wood foundations constructed in Zone 6 and Zone 7 that are internally insulated require a Class II vapor retarder on the interior surface of insulation. Externally insulated wood foundations do not require any class of vapor retarder.

What This Means From A Practical Perspective

Polyethylene is a Class I vapor retarder. A kraft faced fiberglass batt is a Class II vapor retarder. Latex painted gypsum board (one coat of latex paint) is a Class III vapor retarder.

Plywood sheathing and oriented strand board (OSB) have perm values of greater than 1 perm when using the wet cup test. Similarly for exterior gypsum sheathing or fiberboard sheathing.

Extruded polystyrene of 1 inch thick or thicker has a perm value of 1.0 perm or less. Film faced extruded polystyrenes of 1/2 inch thickness that have perforated facings have perm values of greater than 1 perm. Non-perforated foil and polypropylene faced rigid insulations have perm values of less than 1 perm.

Foil faced isocyanurate 1/2 thick (R 3.5) installed over a 2x4 frame wall meets requirement #4 in Chicago. Therefore, an unfaced batt with gypsum board painted with latex paint (Class III vapor retarder) is required on the interior of this assembly.

Foil faced isocyanurate 1 inch thick (R 7) installed over a 2x6 frame wall (R 19) meets requirement #4 in Minneapolis. Therefore, an unfaced batt with gypsum board painted with latex paint (Class III vapor retarder) is required on the interior of this assembly.

In Chicago where plywood or OSB exterior sheathing is used, an unfaced fiberglass batt can be installed within the wall cavity and gypsum board painted with latex paint (Class III vapor retarder) is required on the interior of this assembly. If this assembly is moved to Minneapolis, a Class II vapor retarder is required on the interior (a kraft paper faced fiberglass batt).

References

Briggs, R.S., Lucas, R.G., and Taylor, T.; Climate Classification for Building Energy Codes and Standards: Part 1 – Development Process, Technical & Symposium Papers, ASHRAE Winter Meeting, Chicago, IL, January, 2003.

Briggs, R.S., Lucas, R.G., and Taylor, T.; Climate Classification for Building Energy Codes and Standards: Part 2 – Zone Definitions, Maps and Comparisons, Technical & Symposium Papers, ASHRAE Winter Meeting, Chicago, IL, January, 2003.

Kunzel, H.M.; WUFI: PC Program for Calculating the Coupled Heat and Moisture Transfer in Building Components; Fraunhofer Institute for Building Physics, Holzkirchen, Germany, 1999.