Incorporating Fully-Adhered Membrane Air Barriers into Wall Assemblies within Climate Zones 5 & 6

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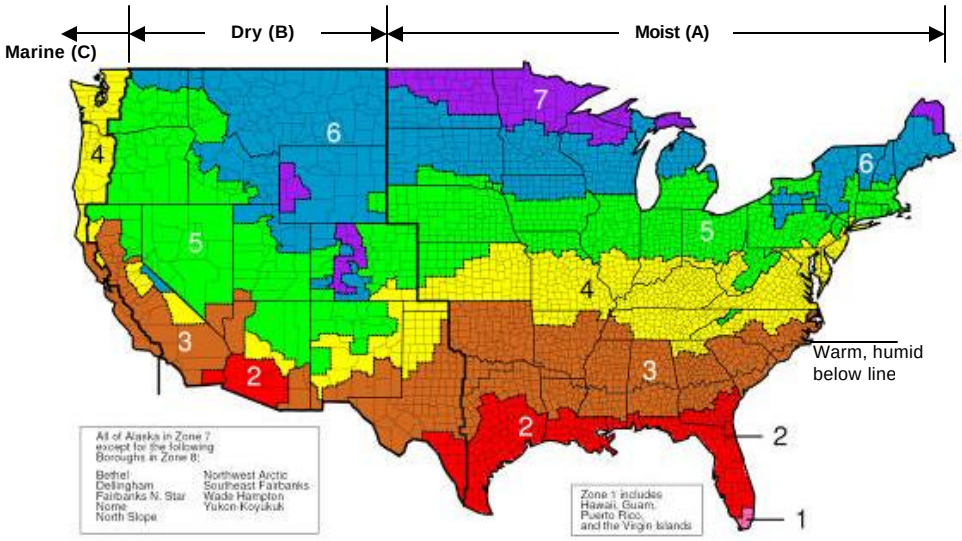
Introduction:

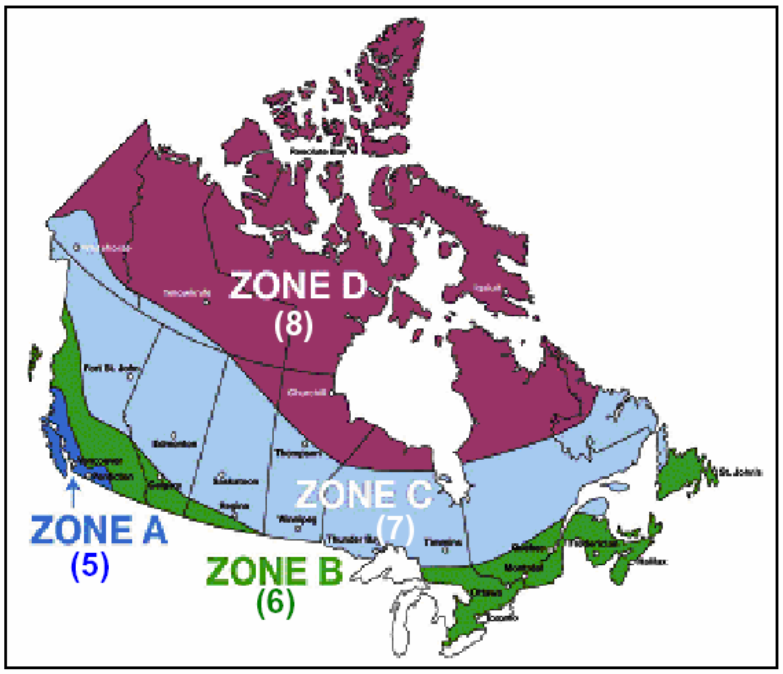
This paper disseminates general, best-practice recommendations for use of fully-adhered membrane air barriers within United States Department of Energy (USDOE) Climate Zones 5 and 6. Climate Zone 5 is indicated in green and Climate Zone 6 is indicated in blue on the climate zone map, which is shown in Figure 1. Zone 5 Moist (5A), Zone 5 Dry (5B), Zone 6 Moist (6A) and zone 6 Dry (6B) are covered in this paper.

Figure 1:
USDOE Climate Zone Map



Canadian Zones A and B are also covered by the recommendations in this paper. Canadian Zone A is indicated in blue while Canadian Zone B is indicated in green. The Canadian Climate Zone map is shown in Figure 2.

Figure 2:
Canadian Climate Zone Map



WUFI 4.1 heat & moisture analysis software and field/market experience form the basis of the recommendations. The WUFI software is useful for assessing moisture management of a wall system when it is exposed to a given climate. However, this software cannot model air leakage. Numerous academic and case studies show that uncontrolled building envelope air leakage is detrimental to energy efficiency, durability and indoor conditions. The wall systems discussed in this paper have been shown to manage moisture effectively within climate zones 5 & 6 according to WUFI 4.1 while also incorporating an effective air barrier. Recommendations in this paper should be considered a good starting point for membrane air barrier product selection. These recommendations are not a substitute for project building envelope design, which should be performed by experts based on the specific needs, applications and conditions.

Air Barriers in Building Envelope Construction:
It has been shown that the use of air barriers enables tremendous energy savings as well as prevention of moisture problems. Many materials can function as air barriers. Fully-adhered membranes are a proven means of achieving air tightness. These membranes are either self-adhering sheet membranes or fluid-applied at 0.040 inch (40 mil) thickness or more by spray, roller or trowel. They are typically installed on the exterior side of the wall and covered with a drained and vented cladding system.

Using this approach to provide an air barrier has a number of advantages. First is the ability to provide continuity. Because of the location within the wall assembly, the membrane products can be installed over transitions, around openings/penetrations, over joints/junctions, connected to the roof and foundation air barriers. The membrane is also self-sealing around penetrating fasteners from subsequent construction. The second advantage is the durability of these membranes. They are flexible, rubber-like and integrally-bonded to a sound substrate. They are water proof and

installed to shed and discharge to the exterior any intruding moisture. Finally, they are built into the wall assembly so they are protected from exposure to the elements and temperature extremes.

Vapor Barrier or Vapor Permeable?

Table 1 shows vapor permeability classification of membrane for use in wall assemblies according to the International Energy Conservation Code (IECC) and the American Society of Heating Refrigerating and Air Conditioning Engineers (ASHRAE) 90.1.

Table 1:
Classification of Membrane used in Wall Assemblies

IECC version 2006	**IECC 2007 Supplement**	**ASHRAE 90.1 Version 2004 and Version 2007**
Vapor Barrier =1 perm	Type I Vapor Retarder =0.1 perm	Vapor Barrier =1 perm
	Type II Vapor Retarder >0.1 perm, =1 perm	
Vapor Permeable =5 perms Basis: AC-38, Acceptance Criteria for water resistive barriers applied over sheathing	Type III Vapor Retarder >1 perm, =10 perms	No threshold value for vapor permeable material

Language in all of these established standards indicates that a material exhibiting water vapor permeance of 1 perm or less is a vapor barrier. There is no clear agreement on what constitutes a vapor permeable product. Commercially available membrane air barriers fitting the recommendations of this paper typically have a perm rating of 5 to 15 perms where they are marketed as “vapor permeable”.

Membrane air barriers for wall systems may also be vapor barriers, in which case they are called “air/vapor barriers” or they can be vapor permeable, in which case they are called “vapor-permeable air barriers”. Building walls with either of these types of membranes has its advantages and limitations. The wall system design must be considered for proper incorporation of these materials into the assembly.

Code Requirements for Insulation and Vapor Barriers:

Like any wall system, those incorporating membrane air barriers must be code compliant. Insulation and vapor barrier code requirements factor into the wall system designs endorsed by this paper. A summary of code requirements for insulation and vapor barriers is listed in Tables 2, 3 and 4 below.

Table 2:
Zone 5 Commercial Construction Insulation Requirements for Wall Assemblies

	2006 International Energy Conservation Code (IECC)*		ASHRAE 90.1 Version 2004		ASHRAE 90.1 Version 2007	
Wall Type	Residential	Non-Residential	Residential	Non-Residential	Residential	Non-Residential
Mass	R-13	R-7.6 ci	R-11.4 ci	R-7.6 ci	R-13.3 ci	R-11.4 ci
Steel Stud	R-13 + 9 R-19 + 8 R-25 + 7	R-13 + R-3.8 ci	R-13 + R-7.5 ci	R-13 + R-3.8 ci	R-13 + R-7.5 ci	R-13 + R-7.5 ci
Wood Stud	R-19 or R-13 + R-5 ci	R-13	R-13	R-13	R-13 + R-7.5 ci	R-13 + R-3.8 ci

* Also includes Zone 4C (Marine)
ci = continuous insulation

Table 3:
Zone 6 Commercial Construction Insulation Requirements for Wall Assemblies

	2006 International Energy Conservation Code (IECC)		ASHRAE 90.1 Version 2004		ASHRAE 90.1 Version 2007	
Wall Type	Residential	Non-Residential	Residential	Non-Residential	Residential	Non-Residential
Mass	R-15	R-9.5 ci	R-11.4 ci	R-9.5 ci	R-15.2 ci	R-13.3 ci
Steel Stud	R-13 + 9 R-19 + 8 R-25 + 7	R-13 + R-3.8 ci	R-13 + R-7.5 ci	R-13 + R-3.8 ci	R-13 + R-7.5 ci	R-13 + R-7.5 ci
Wood Stud	R-19 or R-13 + R-5 ci	R-13	R-13 + R-3.8 ci	R-13	R-13 + R-7.5 ci	R-13 + R-7.5 ci

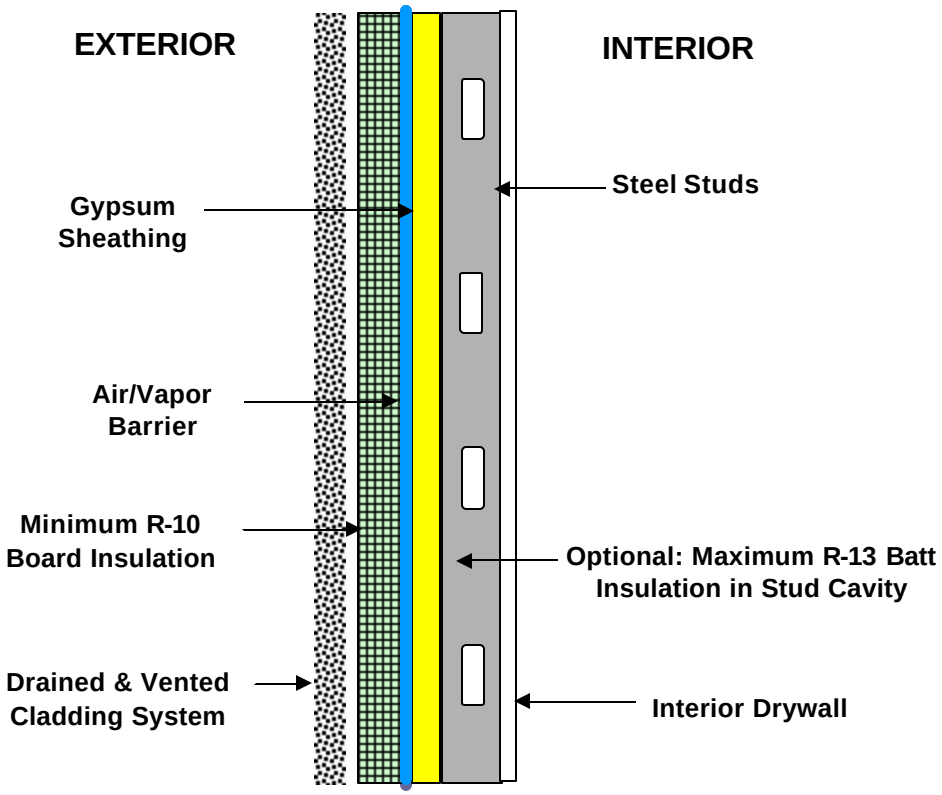
ci = continuous insulation

Table 4:
Zone 5 & 6 Commercial Construction Vapor Barrier Requirements for Wall Assemblies

IECC version 2006	IECC 2007 Supplement	ASHRAE 90.1 Version 2004, 2007
Vapor barrier having 1 perm or less required	Class I or Class II vapor retarder required	Vapor barrier having 1 perm or less required

Incorporating Air/Vapor Barriers into Wall Systems:
When using an air/vapor barrier membrane, it is important to keep the materials on the interior side of the membrane warm enough so that condensation of moisture from the interior air does not occur. Zones 5 & 6 have a very cold winter period, so it is important to place all or most of the insulation outside of the air/vapor barrier membrane. It is also important that the wall be able to dry to the interior, since moisture cannot dry through air/vapor barrier membrane. Therefore, a vapor barrier on the interior side of the wall, such as 6 mil polyethylene, must NEVER be installed in wall systems incorporating an air & vapor barrier on the exterior. The best practice for incorporating an air/vapor barrier into a steel stud wall system within Zones 5 & 6 is shown in Figure 3.

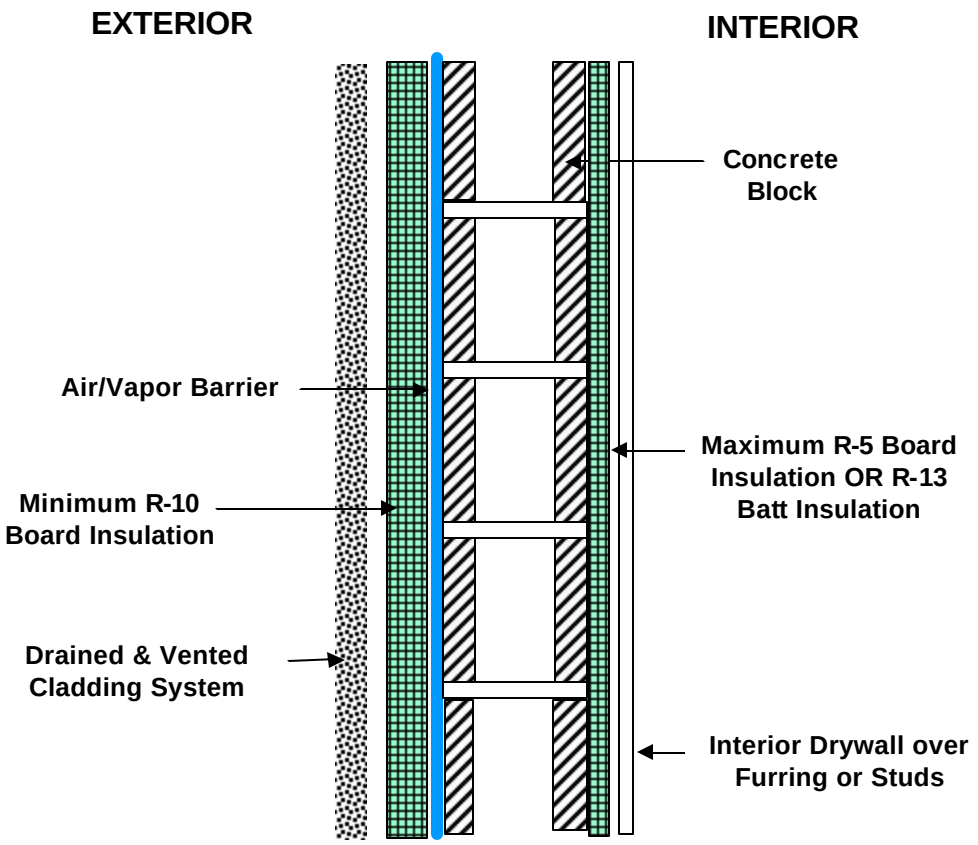
Figure 3:
Steel Stud Wall System with Air/Vapor Barrier for Zones 5 & 6



Steel stud walls require continuous insulation in Zones 5 & 6, which is fulfilled by the board insulation shown in the wall system in Figure 3. It is recommended to secure minimum R-10 board insulation outside of the air/vapor barrier membrane and place maximum R-13 un-faced batt insulation in the stud cavity.

A mass wall system incorporating an air/vapor barrier is shown in Figure 4. Mass wall systems in this Zones 5 & 6 often require continuous insulation by code. The wall system shown in figure 4 fulfills this requirement with minimum R-10 board insulation installed over the air/vapor barrier. The air/vapor barrier also provides the important function of waterproofing the concrete block.

Figure 4:
Mass Wall System with Air/Vapor Barrier for Zones 5 & 6



These are the key features and benefits of the wall systems shown in Figures 3 and 4:

1) ***Improved Energy Efficiency:*** The air/vapor barrier membrane provides up to 37% annual HVAC energy savings by stopping envelope air leakage. The air/vapor barrier membrane also keeps batt insulation drier by stopping moisture deposition into the stud cavity from air leaks and by stopping bulk water intrusion from the exterior.

2) ***Higher Insulating Value:*** These wall systems have an enhanced R-value through the use of continuous insulation. Continuous insulation provides an R-value in the wall assembly close to the insulation's nominal R-value. Insulation is tightly secured to the wall with fasteners or adhesive with joints filled with sealant. R-10 board insulation installed in this manner actually gives a higher effective R-value than R-19 batt insulation installed between steel studs. According to ASHRAE 90.1, batt insulation loses slightly more than half of it's nominal R-value when bridged by steel studs in typical wall construction. Also note that many types of board insulation are virtually unaffected by exposure to moisture, while batt insulation will lose much or nearly all of its R-value when wet.

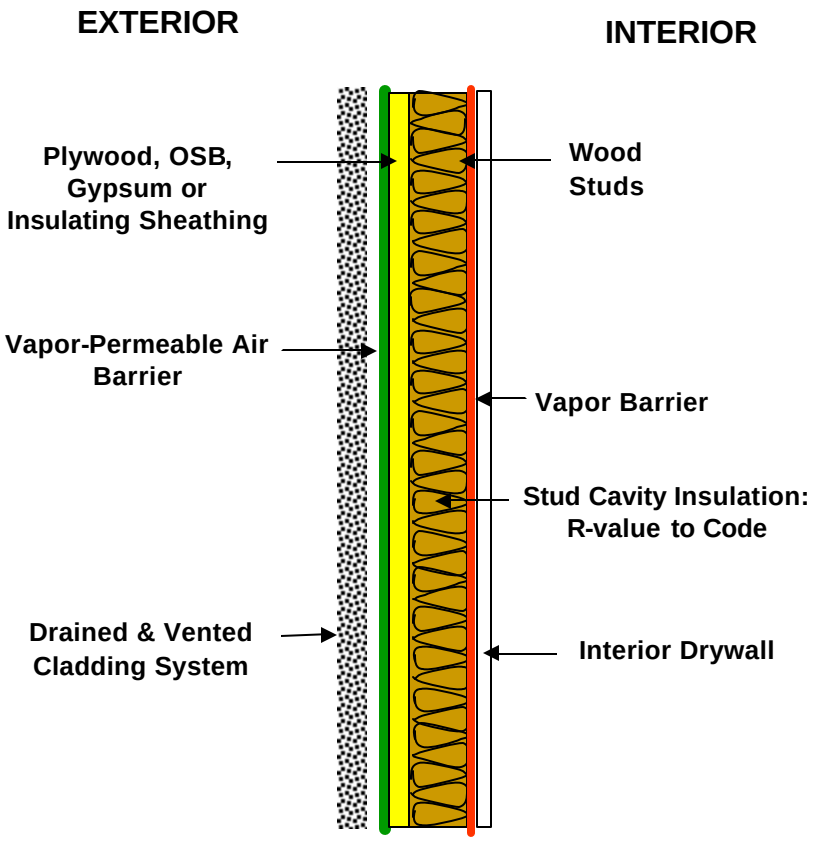
3) ***Improved Indoor Air Quality and Comfort:*** The air/vapor barrier provides complete separation of inside from outside. Moisture sensitive materials are kept dry, which prevents mold. The air tight envelope construction enables better function of the HVAC systems.

4) ***Improved Durability:*** These wall systems are designed to prevent condensation in moisture sensitive layers by actually moving the dew point outside of the air/vapor barrier membrane year-round. The air/vapor barrier membrane protects the underlying construction from intruding moisture and vapor drive and stops all air leaks. The exterior cladding is drained and vented, able to function as a pressure-equalized rain screen because of the plane of air tightness created by the fully-adhered membrane. The combination of exterior insulation and air/vapor barrier membrane assures that moisture sensitive materials stay dry year-round, so the wall can achieve its maximum service life.

Incorporating Vapor-Permeable Air Barriers into Wall Systems:
Vapor-permeable membranes are required for use in stud wall systems having all of the insulation in the stud cavity and in mass wall systems where all of the insulation is on the interior side. Where the air barrier membrane is applied on the exterior side of the wall, wall systems with the aforementioned placement of insulation have a dew point inside of the membrane for much of the year. Therefore, a vapor-permeable membrane is required to prevent moisture build-up by allowing drying through it. In zones 5 & 6, a vapor retarder (barrier) must be installed on the interior of the insulation to prevent condensation of moisture from the inside heated environment during winter.

Sheathing-over-wood-stud walls are commonly built with batt insulation placed between studs and no exterior insulation. Although the benefit of continuous insulation is universal, it is not always a code requirement for this type of wall in Zones 5 & 6. A sheathing-over-stud wall system of this type is shown in Figure 5.

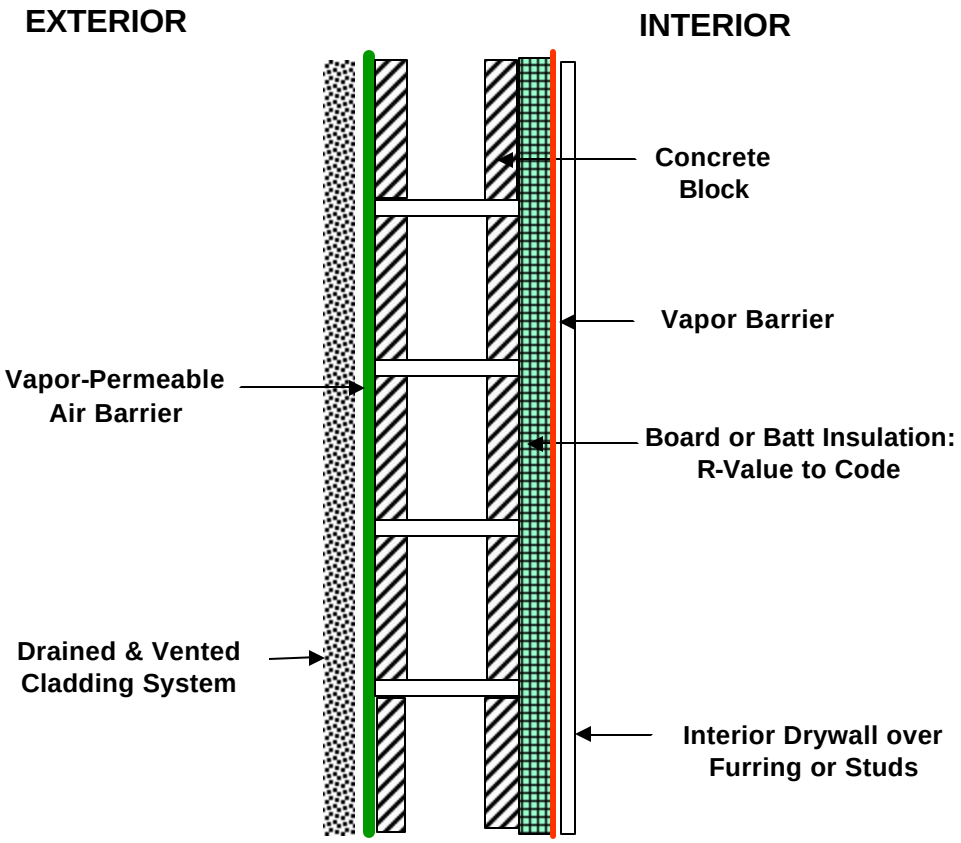
Figure 5:
Sheathing over Stud Wall System with Vapor-Permeable Air Barrier



This wall system has a fully-adhered, vapor-permeable membrane installed over the sheathing. A 6 mil polyethylene vapor barrier is installed on the interior side of the studs.

The wall system shown in Figure 6 has a fully-adhered, vapor-permeable membrane installed on the exterior side of the concrete block. The insulation in this wall system, which may or may not be continuous depending on code and design, is located on the interior side of the block wall. A 6 mil polyethylene vapor barrier is installed on the interior side of the insulation.

Figure 6:
Mass Wall System with Vapor-Permeable Air Barrier



These are the key features and benefits of the wall systems shown in Figures 5 and 6:

1) ***Improved Energy Efficiency:*** The air barrier membrane provides up to 37% annual HVAC energy savings by stopping envelope air leakage. It also keeps the insulation drier by stopping moisture deposition into the stud cavity from air leaks and by stopping bulk water intrusion from the exterior.

2) ***Improved Indoor Air Quality and Comfort:*** The air barrier membrane protects the underlying construction from intruding moisture and stops all air leaks. Moisture sensitive materials are kept dry, which prevents mold. The air tight envelope construction enables better function of the HVAC systems.

3) ***Improved Durability:*** These wall systems are designed to allow incidental moisture to dry to the exterior though the vapor permeable membrane. The interior vapor retarder is critical for stopping the high vapor drive from the heated interior during the cold winter in these zones. The air barrier membrane removes a lot of potential problems by keeping out bulk moisture from the exterior and by stopping air leaks. The exterior cladding is drained and vented, able to function as a pressure-equalized rain screen because of the plane of air tightness created by the fully-adhered membrane. These wall systems effectively manage moisture, so that moisture sensitive materials are not damaged by excessive wetting.

Conclusion:
Selection of Vapor-Permeable versus Vapor Barrier Membrane air Barriers in Zones 5 & 6

Use table 5 as a guideline for selection of either type of air barrier membrane in these climate Zones.

Table 5:

Scenario	Air/Vapor Barrier	Vapor-Permeable Air Barrier
Exterior insulation required or specified	X	
No exterior insulation required or specified		X
Renovation project, existing wall has an interior vapor barrier		X