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Standard Guide for Specifying Water Vapor Transmission Material Properties of Water-Resistive Barriers and Air Barriers[1]

This standard is issued under the fixed designation E3127; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This document provides guidelines for specifying water vapor transmission (WVT) properties for above-grade water-resistive barriers and air barriers (WRB/AB), typically installed between building structural components and cladding that compose the exterior side of building envelopes in North America.

1.2 This guide applies to all types of water-resistive barrier and air barrier products, including multifunctional products, regardless of the manufacturing process, type of material, or installation technique.

1.3 This guide provides general provisions for specifying and reporting the water vapor transmission properties of WRB/AB determined by standardized test methods, in accordance with in-service conditions these products typically experience within building envelopes.

1.4 It is beyond the scope of this guide to optimize the water vapor transmission characteristics of WRB/AB for specific conditions of use. The specific conditions of use should account for variations in indoor and outdoor climates, cladding type, moisture storage capacity of cladding materials, thermal insulating measures for wall and roof assemblies, air movement, and vapor diffusion control strategies.

1.5 This guide does not address proper installation and integration of WRB/AB with other wall and roof components.

1.6 The values stated in inch-pound units are to be regarded separately as standard. Within the text, the SI units shown in parentheses are provided for information only. The values stated in each system are not exact equivalents; therefore, each system shall be used independently. Combining values from two systems may result in non-conformance with the standard. However, derived results can be converted between systems using appropriate conversion factors (see Table 1).

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C168 Terminology Relating to Thermal Insulation
C578 Specification for Rigid, Cellular Polystyrene Thermal Insulation
C1289 Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board
D226/D226M Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
D779 Test Method for Determining the Water Vapor Resistance of Sheet Materials in Contact with Liquid Water by the Dry Indicator Method
D1079 Terminology Relating to Roofing and Waterproofing
D1653 Test Methods for Water Vapor Transmission of Organic Coating Films
D3833/D3833M Test Method for Water Vapor Transmission of Pressure-Sensitive Tapes
E96/E96M Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials
E398 Test Method for Water Vapor Transmission Rate of Sheet Materials Using Dynamic Relative Humidity Measurement
E631 Terminology of Building Constructions
E2556/E2556M Specification for Vapor Permeable Flexible Sheet Water-Resistive Barriers Intended for Mechanical Attachment

[1] This guide is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.41 on Air Leakage and Ventilation Performance.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

TABLE 1 Units and Conversion Factors[A, B]

Multiply	By	To Obtain (for the same test condition)
	WVT[C]	
g/h·m^2	1.43	grains/h·ft^2
grains/h·ft^2	0.697	g/h·m^2
	Permeance	
g/Pa·s·m^2	1.75×10^7	1 Perm (Inch-pound)
1 Perm[D] (Inch-pound)	5.72×10^{-8}	g/Pa·s·m^2
	Permeability	
g/Pa·s·m	6.88×10^8	1 Perm-inch
1 Perm-inch	1.45×10^{-9}	g/Pa·s·m

[A] These units are used in the construction trade. Other units may be used in other standards.
[B] All conversions of mm Hg to Pa are made at a temperature of 0 °C.
[C] WVT = water vapor transmission.
[D] 1 Perm = 1 US Perm = 1 grains/h·ft^2·in. Hg.

E3054/E3054M Guide for Characterization and Use of Hygrothermal Models for Moisture Control Design in Building Envelopes
F1249 Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor

2.2 *ANSI/ASHRAE Standard:*[3]
ANSI/ASHRAE 160 Criteria for Moisture-Control Design Analysis in Buildings (ANSI Approved)

2.3 *Other Informative References:*
ICC-ES Acceptance Criteria AC38 Water-resistive Barriers[4]
ICC-ES Acceptance Criteria AC71 Foam Plastic Sheathing Panels Used as Water-resistive Barriers[4]
ICC-ES Acceptance Criteria AC212 Water-resistive Coatings Used as Water-resistive Barriers over Exterior Sheathing[4]
ICC-ES Acceptance Criteria AC310 Water-resistive Membranes Factory-bonded to Wood-based Structural Sheathing, Used as Water-resistive Barriers[4]
IBC[5] ICC International Building Code[5]
IRC[5] ICC International Residential Code[5]

3. Terminology

3.1 *Definitions*—For possible variation in definitions of terms used in this guide, refer to corresponding Terminology section in Terminologies C168, D1079, and E631.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *air barrier (AB), n*—a material or assembly installed as a system in a building envelope and designed to resist uncontrolled air movement into or through the opaque wall or roof assembly. An air barrier can be specified as a control layer on the inside, outside, or middle sections of exterior wall and roof assemblies, or as an entire assembly.

3.2.1.1 *Discussion*—A given material may serve multiple functions within a wall or roof assembly if it meets the requirements for each function. For example, it is possible to specify and install a single product that functions both as a water-resistive and air barrier on the exterior side of the assembly. Some products can also provide additional structural support and thermal insulating capability.

3.2.2 *air leakage, n—in buildings*, the passage of uncontrolled air through cracks or openings in the building envelope or its components, such as ducts, because of air pressure or temperature difference.

3.2.3 *building envelope, n*—a boundary that encloses and separates conditioned space from the outdoor environment or other environments with different conditions (for example, semi-conditioned spaces, cold storage spaces, manufacturing or industrial processing environments).

3.2.3.1 *Discussion*—A building's interior is typically the enclosed conditioned space that, in general, does not include vented attics, unconditioned basements, vented crawl spaces, or attached spaces (for example, unconditioned garages or other utility spaces that are connected to the main structure but are not conditioned). In commercial buildings, these interior environments may include designated spaces for storage, manufacturing, or industrial processing.

3.2.4 *responsive water vapor transmission properties, n*—water vapor transmission properties that vary as a function of temperature and relative humidity.

3.2.4.1 *Discussion*—The water vapor permeance (WVP) of many WRB/AB materials increases with increasing temperature and relative humidity, often in a nonlinear fashion.

3.2.5 *water vapor diffusion, n*—the process by which water vapor moves through a vapor permeable material by molecular diffusion due to a difference (gradient) in water vapor pressure across the material.

3.2.6 *water-resistive barrier (WRB), n*—a protective material installed on the exterior surface or behind the exterior building covering (for example, wall cladding or roof covering) that is intended to resist further intrusion of liquid water that has penetrated the exterior covering and prevent it from reaching interior components of the building envelope.

3.2.6.1 *Discussion*—Wall and roof assemblies designed to function as a drainage system include two layers of resistance against rainwater penetration; the exterior covering provides the initial resistance to rainwater penetration, and the WRB provides the ultimate resistance against any water that bypasses the exterior covering or drains down from upper levels.

3.2.7 *water vapor permeability, n*—a material property that represents the time rate of water vapor transmission by diffusion through unit area of a flat material of unit thickness induced by a unit vapor pressure difference between two specific surfaces, under specified temperature and relative humidity conditions.

3.2.8 *water vapor permeance, n*—a material layer property that represents the time rate of water vapor transmission by diffusion through unit area of a flat material or assembly

[3] Available from American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), 1791 Tullie Circle, NE, Atlanta, GA 30329, http://www.ashrae.org.
[4] Available from ICC Evaluation Service (a registered trademark) (ICC-ES), 3060 Saturn Street, Suite 100, Brea, Ca 92821, https://icc-es.org.
[5] Available from and a registered trademark of International Code Council (ICC), 500 New Jersey Ave., NW, 6th Floor, Washington, DC 20001, http://www.iccsafe.org.

induced by a unit vapor pressure difference between two specific surfaces, under specified temperature and humidity conditions.

3.2.8.1 *Discussion*—Permeance is an extrinsic material property for the specific thickness of the material. Permeability is an intrinsic material property that must be divided by the thickness to determine the permeance of the material. Water vapor permeance has been traditionally reported in "perms," and material classes are established based on this perm rating for sheet- and fluid-applied materials.

3.2.9 *water vapor transmission rate (WVTR), n*—the steady water vapor flow by diffusion in unit time through unit area of a material, normal to specific parallel surface, under specific temperature and relative humidity conditions on each surface.

3.2.9.1 *Discussion*—Water vapor transmission rate is sometimes reported as the amount of water vapor flow over a 24 h time interval, for example, g/24 h·m^2 or grains/24 h·ft^2. It is required that the units are reported with the numerical value when stating the WVTR or water vapor permeance of a material.

3.2.9.2 *Discussion*—Although some technical documents report WVTR values as a measure of water vapor permeance of building materials instead of traditionally reported "perm" rating, the WVTR is not a complete performance measure of water vapor transmission. If water vapor pressure differentials across tested specimens are not reported, estimation of water vapor transmission properties cannot be accomplished without making assumptions about the water vapor pressures on each side of tested specimens.

3.3 *Symbols:*

q_v = mass flux rate of vapor flow, grains/h·ft^2, (kg/s·m^2)
μ_p = water vapor permeability, grains/h·ft·in. Hg, (kg/Pa·s·m)
M = water vapor permeance, grains/h·ft^2·in. Hg, (kg/Pa·s·m^2)
P_v = water vapor pressure, in. Hg (Pa)
$P_{v,sat}$ = saturation water vapor pressure, in. Hg, (Pa)
$WVTR$ = water vapor transmission rate, grains/h·ft^2, (g/h·m^2)

4. Significance and Use

4.1 As the building industry shifts towards performance-based design, specification of material properties consistent with anticipated in-service conditions becomes paramount to the design process. When specifying water vapor transmission properties, it is important to identify water vapor transmission properties for WRB/AB products that are measured under test conditions relevant to anticipated in-service conditions. This guide provides a performance-based framework for characterizing the water vapor transmission properties of WRB/AB.

4.2 When specifying WRB/AB, water vapor permeance is an important attribute to consider for proper moisture management and functioning of wall and roof assemblies in service. In North America, water vapor transmission properties of water-resistive and air barrier materials are traditionally tested in accordance with Test Methods E96/E96M. This guide adopts the ASTM E96/E96M test methods as a primary source of information for water vapor transmission properties of WRB/AB unless otherwise instructed by the design professional.

4.3 Most standard test methods rely on a limited set of steady-state testing conditions for evaluating the water vapor transmission properties of materials. Test conditions used to measure and report water vapor transmission values of WRB/AB should represent the in-service conditions of the tested material as closely as possible (that is, should cover the range of temperature and relative humidity conditions the products will experience when installed in wall and roof assemblies). The water vapor permeance of many WRB/AB materials can vary by more than an order of magnitude when tested for ranges of temperatures and relative humidity expected in service. For this reason, WVT properties over the full range of environmental conditions that the material will most likely experience in service should be used or evaluated when specifying a material or assembly design for a specific project.

5. Classification

5.1 This guide addresses selection and reporting of water vapor transmission properties for WRB/AB in accordance with their in-service conditions regardless of the manufacturing process and physical characteristics of the products.

5.2 The International Building Code (IBC) and International Residential Code (IRC) adopt the following vapor retarder classes for materials as defined using the Desiccant Method ("Procedure A") of Test Methods E96/E96M:

(1) Class I: 0.1 perm or less,
(2) Class II: 0.1 < perm ≤ 1.0 perm, and
(3) Class III: 1.0 < perm ≤ 10 perm.

The vapor retarder classes listed above have been primarily developed for classification of vapor retarders installed typically on the interior side of frame walls to better characterize potential of vapor retarders to control the magnitude of water vapor diffusion from inside to outside in winter time. The vapor retarder classes in 5.2 may not be sufficient to provide complete metrics needed to characterize the performance of WRB/AB.

5.2.1 For proper characterization of water vapor retarding properties for WRB/AB in service, selected test methods and test conditions should reproduce the full range of temperatures and relative humidity encountered in service. It is strongly recommended that technical data sheets for WRB/AB report water vapor transmission properties for at least three mean relative humidity levels:

(1) 25 % (matches the Desiccant Method or Procedure "A" test conditions in accordance with Test Methods E96/E96M),
(2) 75 % (matches the Water Method or Procedure "B" test conditions in accordance with Test Methods E96/E96M), and
(3) 95 % (evaluates performance in "wet" conditions and assesses potential for drying after incidental water intrusion events).

5.2.1.1 The reported values for each recommended average relative humidity level should be assessed at three different temperatures covering the most typical range of temperatures expected in service: 40 °F, 73.4 °F, and 90 °F.

5.2.1.2 It is recommended that test results be presented in graphical form by using a water vapor permeance performance chart as shown in Fig. 1, which provides a summary of test data for three different products "A," "B," and "C" represented by green, blue, and red boxes, respectively. Numeric labels next to the green boxes indicate mean relative humidity for each tested temperature, and width of the boxes corresponds to tested permeance values to be reported. For clarity, relative humidity labels were omitted for products "B" and "C." It is possible that certain WRB/AB products demonstrate a wider range of water vapor permeance values at different humidity and temperature conditions than others.

5.2.2 The Desiccant Method ("Procedure A") of ASTM E96/E96M test methods is conducted at a single environmental condition, 73 °F (23 °C) and average relative humidity (RH) of 25 % and may be used as a baseline to characterize vapor retarding properties for WRB/AB.

5.2.3 In addition to the Desiccant Method ("Procedure A"), Test Methods E96/E96M specifies five other standard test conditions and permits the use of additional temperature and RH conditions with the requirement that test conditions shall be stated in the test report.

6. Test Methods and Practices

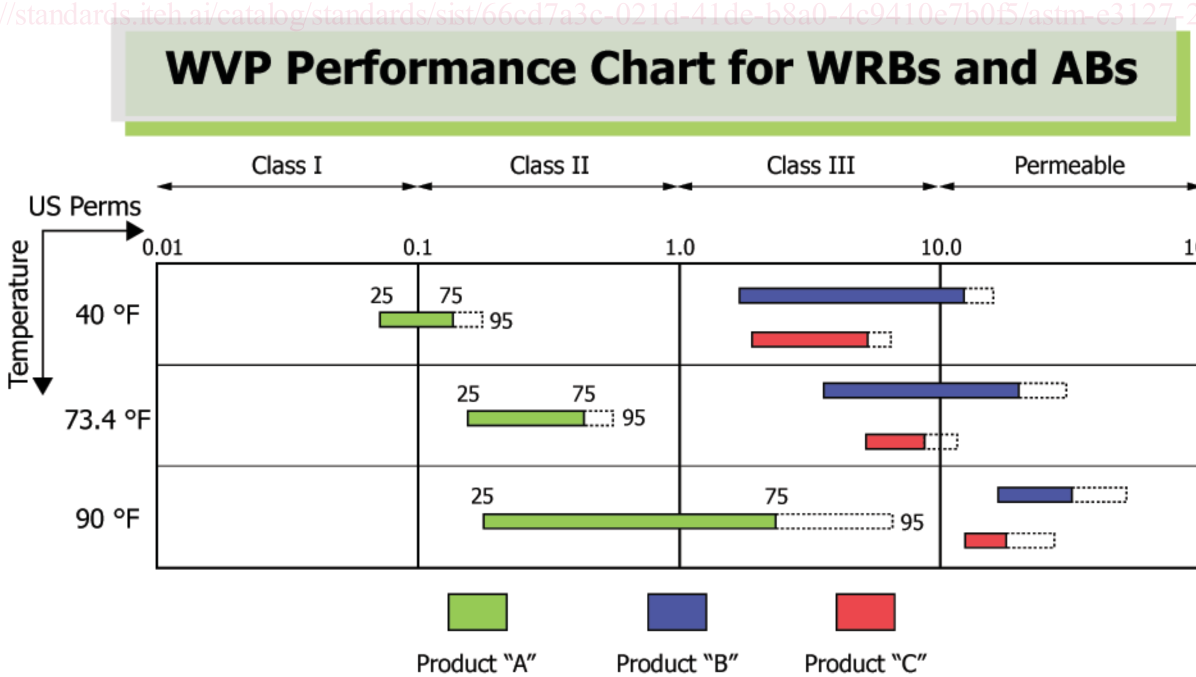
6.1 Regardless of the test method used for evaluation of water vapor transmission properties of WRB/AB, it is highly recommended that selected test conditions represent the anticipated range of in-service conditions.

6.2 ASTM E96/E96M is recommended as a primary test method for determining the WVT properties of both WRB/AB, unless the nature of the tested material, test method conditions, or the range and dynamics of in-service conditions suggest an alternative test method would be more appropriate.

6.3 Test Methods E96/E96M provide a limited number of recommended standard test conditions (temperature and relative humidity). The test chamber conditions for the two most widely reported test methods, Desiccant Method ("Procedure A") and Water Method ("Procedure B"), are 73.4 °F (23 °C) and 50 % ± 2 % relative humidity. The test dishes are filled either with dried desiccant to maintain 0 % relative humidity ("Procedure A"), or with distilled water ("Procedure B") to maintain 100 % relative humidity on one side of the tested material. These standard conditions, however, provide only limited information and may not reflect the actual conditions that tested barrier materials may experience in service.

6.4 It is strongly recommended that, at a minimum, manufacturers of WRB/AB materials report the results for at least the two most common test methods used in industry; that is, to test the material to both the ASTM E96/E96M Desiccant Method ("Procedure A") and Water Method ("Procedure B") to facilitate better the specification of water vapor transmission properties based on project-specific conditions.

6.5 Test Methods E96/E96M is a simple, straightforward, and relatively inexpensive testing protocol commonly used in the industry to evaluate water vapor transmission properties of building materials. Variations in test results typically occur due to inhomogeneity of tested material, fluctuations in environmental conditions, a lack of detailed specifications for shape and size of test dishes, absence of detailed instructions for sealing methods, reliance on operator skill to adequately seal the test specimen, and difficulties in test specimen preparation for certain categories of WRB/AB products. Typically, these test methods provide reliable and repeatable values for water vapor transmission properties of building materials by means



NOTE 1—Perm ratings on top of the chart expressed in US perms on logarithmic scale.

FIG. 1 Proposed WVP Performance Chart for WRB/AB

of simple apparatus; however, interlaboratory studies conducted on several materials revealed that percent coefficient of variation could be up to 20 % for some materials as reported in Precision and Bias section of the ASTM E96/E96M test standard.

6.6 Test reports should follow the Test Methods E96/E96M reporting requirements and include the test procedure or method, or both, along with test temperature and relative humidity in the test chamber. If non-standard test conditions are selected, report temperature and relative humidity on each side of the tested specimen. When testing multilayered and composite materials, report the specimen side that was exposed to the environment with higher water vapor pressure and higher relative humidity, keeping in mind that orientation may change with selected procedure (Desiccant Method versus Water Method).

6.7 Water vapor transmission properties obtained in accordance with alternative test methods such as ASTM E398, D1653, D3833/D3833M, or F1249 are also acceptable provided that reported water vapor transmission properties reflect in-service conditions of the tested materials or conditions similar to "Procedure A" and "Procedure B" of ASTM E96/E96M test methods. The test results generated using alternative test methods may not be equal to the test results produced using Test Methods E96/E96M testing protocol for the same testing conditions. It is the design professional's responsibility to interpret and use the alternative test data accordingly in the design process. Some alternative test methods for measuring water vapor transmission allow for material property testing under dynamic conditions. Test data generated under such conditions may be preferable when tested materials will be subjected to similar conditions in service.

6.7.1 The benefits of using alternative test methods over Test Methods E96/E96M may include speed and ease in specifying of variable test conditions. A limitation of some alternative test methods is the allowable specimen thickness that can be tested. As most alternative test methods are designed for sheet and membrane materials, they may not be suitable for testing thick WRB/AB products or composite materials.

6.8 Evaluation of interaction between barrier material and the exterior sheathing substrate and assessing the actual or effective permeability is critical for performance assessment of barrier products that require full adhesion to the substrate (for example, self-adhered membranes, fluid-applied, factory-laminated, or bonded products). Due to limitations imposed on specimen thickness, use of certain test methods for evaluation of interaction between barrier material and exterior sheathing substrate may not be appropriate.

6.9 In general, most standard test methods specify a limited set of conditions for evaluating the water vapor transmission characteristics of tested material, and selection of alternative test methods, along with evaluation of reported test results using alternative test methods, requires professional expertise and assessment.

7. In-Service Conditions and Water Vapor Permeance Reporting Requirements for Water-Resistive Barriers and Air Barriers

7.1 In-service conditions impact the performance of WRB/AB and should be carefully considered when selecting conditions for measuring, reporting, and specifying water vapor transmission properties of barrier products for project-specific in-service conditions. Factors governing the in-service conditions of WRB/AB as installed on the exterior side of building envelopes include, but are not limited to:

(1) local climate (for example, temperature, relative humidity, solar radiation, wind direction and wind speed, precipitation);

(2) exposure to liquid water in service (for example, cladding type and installation method, local site and building exposure conditions such as wall orientation in relation to predominant wind-driven rain direction, location relative to protective features such as overhangs and porches, and flashing practices employed for redirecting water);

(3) exposure to indirect and intermittent ultraviolet (UV) radiation from sunlight in open joint rainscreen applications;

(4) interior ambient conditions (temperature and relative humidity);

(5) location of barrier material within the wall and roof assembly;

(6) characteristics of other layers in the wall and roof assembly with regards to heat, air, and moisture transport (for example, water vapor transmission and air leakage properties, moisture absorption, moisture storage characteristics, and thermal insulating properties), as they all affect wetting and drying potential of a particular assembly; and

(7) properties of the substrate to which the barrier is applied, and interaction between barrier, substrate material, and flashing for proper installation (for example, chemical compatibility and use of adhesives, primers, and other means to adhere the barrier material to the substrate and flashing).

7.1.1 Most severe wind-driven rain conditions, magnitude of water vapor drive, and corresponding thermal gradients throughout the year in relation to moisture storage capacities and water vapor transmission properties of adjacent layers should be carefully considered in selecting and reporting water vapor transmission characteristics of WRB (**1**).[6] These factors can impact product in-service performance due to variation in water vapor transmission characteristics with change in relative humidity and temperature. Therefore, using test conditions that are consistent with the in-service environment of the barrier product is necessary when providing water vapor transmission data to support the specification process.

7.2 Some WRB/AB products rely on either mechanical attachment or physical bonding (for example, fluid-applied and self-adhered products) to the substrate for proper installation; others are manufactured with the WRB/AB laminated directly to the exterior sheathing. Physical interaction between the barrier material and the substrate can affect the water vapor transmission characteristics of multilayered composites. To

[6] The boldface numbers in parentheses refer to the list of references at the end of this standard.

achieve a minimum required bond strength to a particular substrate, some WRB/AB products specify the use of primers, which also may affect the water vapor transmission characteristics of the composite product. Therefore, in addition to evaluating the water vapor transmission characteristics of individual layers in a multilayered system, evaluation of the water vapor transmission properties of composite products that include substrate, surface treatments, and coatings or facers is recommended.

7.3 Water vapor permeability measured under test conditions representative of the in-service conditions should be used when choosing a material for a particular building application (**2**).

7.3.1 For WRB/AB materials with vapor transmission properties not significantly impacted by changes in temperature and relative humidity, specifying testing conditions and reporting water vapor transmission properties in accordance with in-service conditions is less relevant.

7.3.2 For WRB/AB materials with responsive water vapor transmission characteristics, that is, water vapor transmission properties that vary with temperature and relative humidity, it is essential to select and report the water vapor transmission values measured under conditions that are similar to expected in-service conditions. The specification and reporting documents for these products should acknowledge that variability can exist in water vapor transmission properties and take fluctuating in-service conditions into consideration. It is recommended to report test results in graphic form that reflect a range of varying hygrothermal conditions representative of in-service conditions (**3**), and reporting metrics as described in 5.2.1 should be used. Though the limited set of testing conditions does not fully represent actual conditions these materials may encounter in service, testing to these standard test conditions provides adequate performance metrics for comparison of water vapor transmission material properties of water-resistive and air barriers.

7.4 It is the design professional's responsibility to select and specify the water vapor permeability and water vapor permeance values for WRB/AB appropriate for the given application. Ideally, the WVT characteristics should be defined across the whole range of relative humidity and temperature values expected in service. Complete evaluation of water vapor transmission characteristics for WRB/AB can be time consuming, and current industry standards do not prescribe such comprehensive test condition requirements for these barrier products. The intent of the subsequent sections of this guide is to provide direction for the design professional to select, specify, and report water vapor transmission characteristics of WRB/AB with regards to anticipated service conditions, using the limited laboratory test information typically reported in manufacturers' technical literature and following guidelines established in 5.2.1.

7.5 Moisture management in wall and roof assemblies typically consists of controlling moisture accumulation and enhancing the drying potential of the assemblies. Moisture management represents a critical concern for architects and designers due to the negative impacts excess moisture can have on structural integrity of buildings (wood decay, corrosion, and freeze-thaw damage), mold growth, occupant health and comfort, and energy use. Properly designed wall and roof assemblies have WRB/AB selected with optimal material properties for the particular climate and indoor environments and are placed in appropriate location within the assembly. Temperature gradients across the assembly and insulation strategies (for example, use of exterior-applied insulation products having a wide range of water vapor transmission properties) can alter the significance or importance of the water vapor transmission characteristics of WRB/AB.

7.6 When continuous insulation on exterior was not required in codes, traditional wall assemblies in cold climates used a vapor permeable WRB coupled with interior vapor retarder and AB to control condensation and to prevent moisture accumulation in wall assemblies. Vapor permeable WRB allowed for faster dissipation of excessive moisture outwards and controlled moisture accumulation in building envelopes. In general, vapor permeable WRB/AB products enable faster drying when accidental water infiltration into the exterior wall or roof cavity occurs; however, assemblies with water absorptive claddings permit moisture to migrate through and accumulate within a wall or roof assembly. Provision of ventilation between cladding and WRB using exterior ambient air may mitigate this problem and reduce amount of moisture migration inwards in those circumstances. In assemblies where continuous rigid insulation is installed on the exterior, use of a barrier product with high water vapor permeability over the exterior sheathing becomes less important. Properly specified thickness of continuous insulation provides adequate resistance to condensation, and drying inwards is promoted by using more water vapor permeable (Class III) interior vapor retarders and interior finishes.

7.7 The water vapor transmission properties of WRB/AB measured at higher relative humidity as discussed in 5.2.1 provide a better description of performance of wall and roof assemblies in the following scenarios:

7.7.1 *Scenario 1–Accidental Wetting and Elevated Moisture Contents in Building Materials*—Water vapor diffusion is an important moisture transport mechanism for normal seasonal drying of building materials or immediate drying after accidental wetting events. Higher water vapor permeability allows for faster removal of excessive moisture absorbed and stored in building materials.

7.7.2 *Scenario 2–Assemblies with WRB/AB Located Directly beneath the Cladding or Roof Covering*—WRB/AB experience temperature and relative humidity conditions highly correlated and similar to the exterior environment when they are not separated from cladding or roof covering by exterior insulation.

7.7.3 *Scenario 3–Wall Assemblies with Absorptive Claddings and Inadequate Provisions for Drainage and Ventilation Drying*—These wall assemblies may exhibit significant thermally-driven moisture transport into the wall assembly after rain events, particularly when solar radiation acts upon the exterior surface of wet cladding. The water-resistive and air barrier products installed directly beneath wet absorptive claddings will be subjected to elevated relative humidity levels.

Considering that many materials tend to become more vapor permeable at higher relative humidity, this recommendation allows the design professional to control more accurately the inward moisture drive in wall assemblies with absorptive claddings.

7.8 Wall and roof assemblies located in arid climates (that is, average annual rainfall <20 in. and average monthly relative humidity of <50 % year-round, see Appendix X2) and with interior ambient conditions maintained at moderate relative humidity (30 % to 50 %) may be exempt from the recommendations of 7.7. Under these circumstances, the water vapor transmission properties tested at low relative humidity provide better assessment for performance of WRB/AB in service. Selection of low relative humidity test conditions is particularly valid when, in addition to residing in an arid climate, exposure of WRB/AB to rain is minimal within the assembly. Nevertheless, considering there is always a risk of accidental moisture intrusion into the wall and roof cavity, WVT properties measured at higher relative humidity as discussed in 5.2.1 might also be a useful source of information in assessing drying characteristics.

7.9 In assemblies with continuous foam plastic insulating sheathing or semi-rigid mineral fiber board insulation installed on the exterior, the water-resistive and air barrier products may be located either over the exterior insulation or between the exterior insulation and the exterior sheathing.

7.9.1 Foam plastic insulating sheathing board materials have good thermal insulating properties and are typically characterized either as Class II or Class III materials (per unit thickness). Certain facer materials such as aluminum can further reduce the overall water vapor permeance. When installed in thick layers on the exterior, substantial temperature and water vapor pressure gradients across foam plastic insulation can occur. Generally, in assemblies where barrier products are installed inboard of the exterior insulation layer without an intervening drainage space between the barrier and insulation, with an insulation layer of lower water vapor permeance rating than the barrier material, the water vapor transmission properties of the barrier materials are less important for proper functioning of the assembly.

7.9.2 Semi-rigid mineral fiber board insulation is considered a vapor permeable product. The water vapor permeability of these products reduces the water vapor pressure gradient and corresponding relative humidity gradients across this layer in service, regardless of substantial temperature gradients across this layer.

7.9.3 When WRB/AB are installed over exterior insulation, WVT properties measured at higher relative humidity as discussed in 5.2.1 provide more accurate representation of in-service conditions, regardless of the exterior insulation type used.

7.9.4 When installed between the exterior insulation and exterior sheathing, temperature, relative humidity, and water vapor pressure gradients through exterior insulation may vary significantly and reduce the impact of the exterior environment resulting in slightly different in-service conditions for WRB/AB. Specifying and reporting water vapor transmission properties for barrier products installed beneath the exterior insulation should account for the permeance characteristics of the exterior insulation layer.

7.10 Foam plastic insulating sheathing can function as a WRB/AB if all joints are either sealed or taped in accordance with the manufacturers' instructions to provide continuous water-resistive or air barrier system. Similarly, closed-cell spray polyurethane foam may also function as a barrier product when it is applied continuously and directly to the outboard surface of exterior sheathing in accordance with the manufacturers' instructions. Assessment of in-service performance, specification, and reporting of water vapor transmission properties should be based on estimated temperature, relative humidity, and water vapor pressure gradients across the insulating layer following the recommendations in 5.2.1. In most cases, foam plastic insulation products (both insulating sheathing and closed-cell spray polyurethane foam) tend to have water vapor transmission properties that are independent of relative humidity and moisture content.

7.11 Supplementary information such as field data measured in similar wall and roof assemblies located in similar climates, advanced hygrothermal simulation, or analytical model results can provide additional accuracy in estimating service conditions of water-resistive and air barriers. The supplementary information should include range of temperatures and relative humidity that barrier materials will most likely exhibit in service and verify that performance criteria with respect to water vapor transmission have been properly specified.

8. Keywords

8.1 air barrier (AB); building envelope; hygrothermal model; water-resistive barrier (WRB); water-resistive barrier and air barrier (WRB/AB); water vapor permeability; water vapor permeance (WVP); water vapor transmission (WVT)