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Water Vapor Permeance

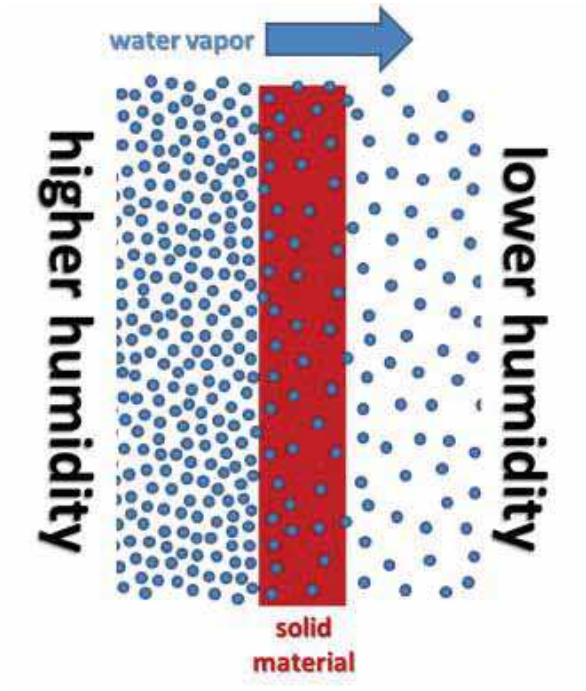
The Basics – Vapor Permeability of Building Products

This document addresses the basic concepts of vapor diffusion and the ASTM E 96 test methods for measuring water vapor permeance.

Vapor permeability is the transmission of water vapor directly through solid material. This property can be important when specifying wall assembly components such as membranes and insulation. For example, a material with very low permeability may be desirable for protecting moisture-sensitive materials from an adjacent moist environment. Or, a highly permeable material may be desired to allow underlying materials to dry, should they become wet.

Moisture always flows from wet to dry, or from high vapor pressure to low vapor pressure. In everyday life, we observe this simply as "wet things drying out". The mechanism of vapor diffusion through solid material or "drying out" is shown in Figure 1.

Figure 1: Vapor Diffusion through Solid Material



For water vapor to travel through solid material, there must be a difference in humidity on one side of the material versus the other and the material must have some degree of permeability to moisture vapor. Water vapor diffusion through solid material is typically a very slow process. The rate of water vapor diffusion through the material is governed primarily by two factors: 1) the vapor pressure difference and 2) the material's inherent permeability to water vapor (permeance). The rate of water diffusion is proportional to the vapor pressure difference and the material's inherent water vapor permeance.

Test Method for Measuring a Material's Water Vapor Permeance

In the construction business, the universally accepted method of measuring water vapor diffusion through solid materials is ASTM E 96 "Standard Test Methods for Water Vapor Transmission of Materials". The test method works by sealing a membrane or board sample to a metal cup. The cup is then placed in a controlled environment. Over time, the cup is weighed on a very sensitive scale to determine change in mass. The change in mass is attributed to water vapor diffusing either into or out of the cup. ASTM E 96 contains two different methods for conducting the testing. These are the Desiccant Method, shown in Figure 2 and the Water Method shown in Figure 3.

Figure 2: ASTM E 96 A "Desiccant Method"

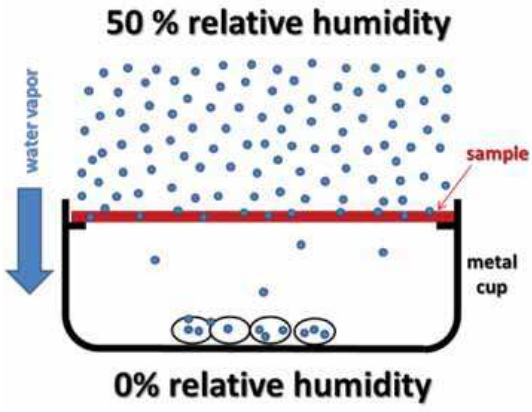


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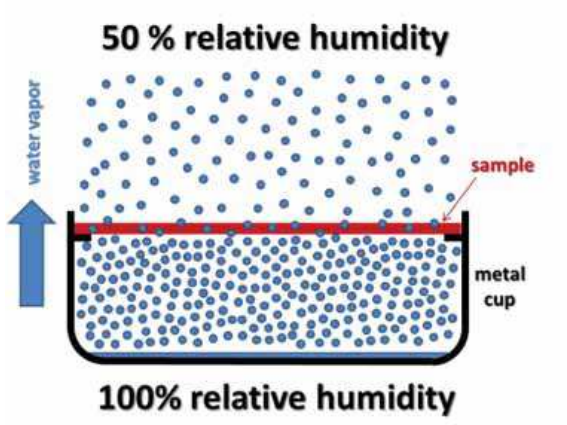
Figure 3: ASTM E 96 B "Water Method"



As stated previously, water vapor transmission will not occur unless there is vapor pressure difference across the specimen. ASTM E 96 Method A or Method B maintains a steady vapor pressure difference by creating a stable environment within the metal cup, and placing the metal cup in a controlled temperature/humidity chamber. The chamber is typically held at 23.0°C/ 50% RH.

With the desiccant method, the inside of the cup is dry and contains pellets of $CaCl_2$ desiccant. Sealing the sample to the rim of the cup, the environment inside the cup is effectively 0% relative humidity. With the water method, the inside of the cup is wet, filled with enough water to cover the bottom of the cup. With the sample sealed to the rim of the cup, the environment inside the cup is saturated, effectively 100% relative humidity.

Either method A or method B maintains a steady 50% relative humidity difference. The duration of the test depends on a number of factors stated in the test method. Once the test is completed, water vapor transmission is calculated using the test data as follows:

$$WVT = \frac{\text{Mass change [grains]}}{\text{Time of test [h]} * \text{sample area [ft}^2\text{]}}$$

Water vapor permeance is then calculated based on the vapor pressure difference created by the controlled test conditions. The following formula is used:

$$\text{Permeance} = \frac{WVT}{S * (R_1 - R_2)}$$

S = vapor pressure of water at test temperature and 100% humidity. R_1 is the relative humidity of the wetter environment (test chamber or cup) and R_2 is the relative humidity of the drier environment (test chamber or cup).

Although ASTM E 96 method A and method B impart the same vapor pressure difference across the specimen, test results derived from either method are not interchangeable. As method B exposes the material to a wetter environment, permeance results using method B are typically higher than those from method A. That is because many materials physically change and effectively become more permeable when wet. A material's tendency to become more permeable when wet may be advantageous or undesirable depending on the assembly and the scenario.

References

ASTM E 96/96M-05 "Standard Test Methods for Water Vapor Transmission of Materials", 2010 Annual Book of ASTM Standards Volume 4.06 © ASTM International 100 Barr Harbor Drive West Conshoken, PA 19428

Elementary Principles of Chemical Processes, Second Edition by Richard M. Felder & Ronald W. Rousseau © 1986 by John Wiley & Sons, Inc.

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