INTRODUCTION TO ASTM E96

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OFFICIAL TITLE OF LATEST E96 REVISION

"Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials"

- **Latest revisions approved December 2021**
- **"Methods" (plural) in title refer to Desiccant and Water Methods**
- **The word "Gravimetric" was added to differentiate from other types of methods for determining MVTR such as ASTM F1249, which employs an automated analyzer**

BACKGROUND

- Originally became a standard in 1953
- Revised many times over the years; continues to evolve through revision
- Under the jurisdiction of ASTM Committee C16 on Thermal Insulation, Subcommittee C16.33 on Insulation Finishes and Moisture
- An ASTM Task Group in the C16.33 Subcommittee is responsible for maintaining the standard
- Used outside the insulation industry, primarily for other building materials and for packaging

PURPOSE OF TEST

- Determine the Water Vapor Transmission Rate (WVTR) of *any* material; not just insulation and vapor retarders
- From WVTR, Water Vapor Permeance (WVP) is calculated for the test conditions used
- From WVP, (Water Vapor) Permeability is calculated for homogeneous materials such as insulation

➢ Note: *Water vapor permeance* is the technically correct term; *permeance* is the commonly used term

➢ Note: For simplification, this presentation uses only I-P units. Apologies to the metric crowd

ASTM DEFINITIONS

- Water Vapor Transmission Rate (WVTR):

the steady water vapor flow in unit time through unit area of a body, normal to specific parallel surfaces, under specific conditions of temperature and humidity at each surface

- Water Vapor Permeance (WVP):

the time rate of water vapor transmission through unit area of flat material or construction induced by unit vapor pressure difference between two specific surfaces, under specified temperature and humidity conditions

- Water Vapor Permeability:

the time rate of water vapor transmission through unit area of flat material <u>of unit thickness</u> induced by unit vapor pressure difference between two specific surfaces, under specified temperature and humidity conditions

DISCUSSION: WVTR IN I-P UNITS

(Water Vapor Transmission Rate)

- WVTR = grains/hr/ft^2
- That is: The number of grains (or fraction thereof) of moisture passing through a 1square foot area of material in 1 hour
- WVTR is the slope of the rate of moisture gain or loss of the specimen in test. It is used to calculate permeance using the partial vapor pressure differential created by the test conditions and is not commonly used as a stand-alone value in our industry.
- For reference, one grain = 0.065 gram or 0.0023 ounce

DISCUSSION: PERMEANCE I-P UNITS

- Perm = (1grain/hr/ft^2)/inHg
- That is: One grain of moisture passing through a 1square foot area of a material or structure in 1 hour, as induced by 1 inch of Mercury partial vapor pressure differential
- Permeance (WVP) is a measurement of performance; it can be determined for any material or multiple-component structure, such as ASJ, FSK, and other facings, as well as for insulation, alone or in combination with facing.

DISCUSSION: PERMEABILITY I-P UNITS

- Perm-inch = ((1grain/hr/ft^2)/inHg)-inch
- That is: One grain of moisture passing through a 1 square foot area of 1 inch thick homogeneous material in 1 hour, as induced by 1 inch of Mercury partial vapor pressure differential
- Permeability is a measurement of a material property; it can be calculated only for homogenous materials such as insulation with no facing or coating. It is an inappropriate term for use with facings.

TEST METHOD BASICS

- Test is conducted in a controlled environment in a room or chamber
- Both sides of the specimen are at the same temperature
- The relative humidity is different on either side of the specimen, creating a partial vapor pressure differential between the sides
- This differential causes a vapor drive through the specimen
- There are two types of tests: Desiccant Method ("Dry Cup") and Water Method ("Wet Cup")

TEST METHOD BASICS

- In the desiccant method, the higher partial vapor pressure in the test environment forces the moisture in the air through the specimen into the dish reservoir.

➢ The moisture is absorbed by the desiccant and the dish assembly gains weight.

- In the water method, the saturation (100% RH) vapor pressure in the dish reservoir forces the moisture in the air layer through the specimen into the test environment.

➢ The migration of moisture from the reservoir causes the dish assembly to lose weight.

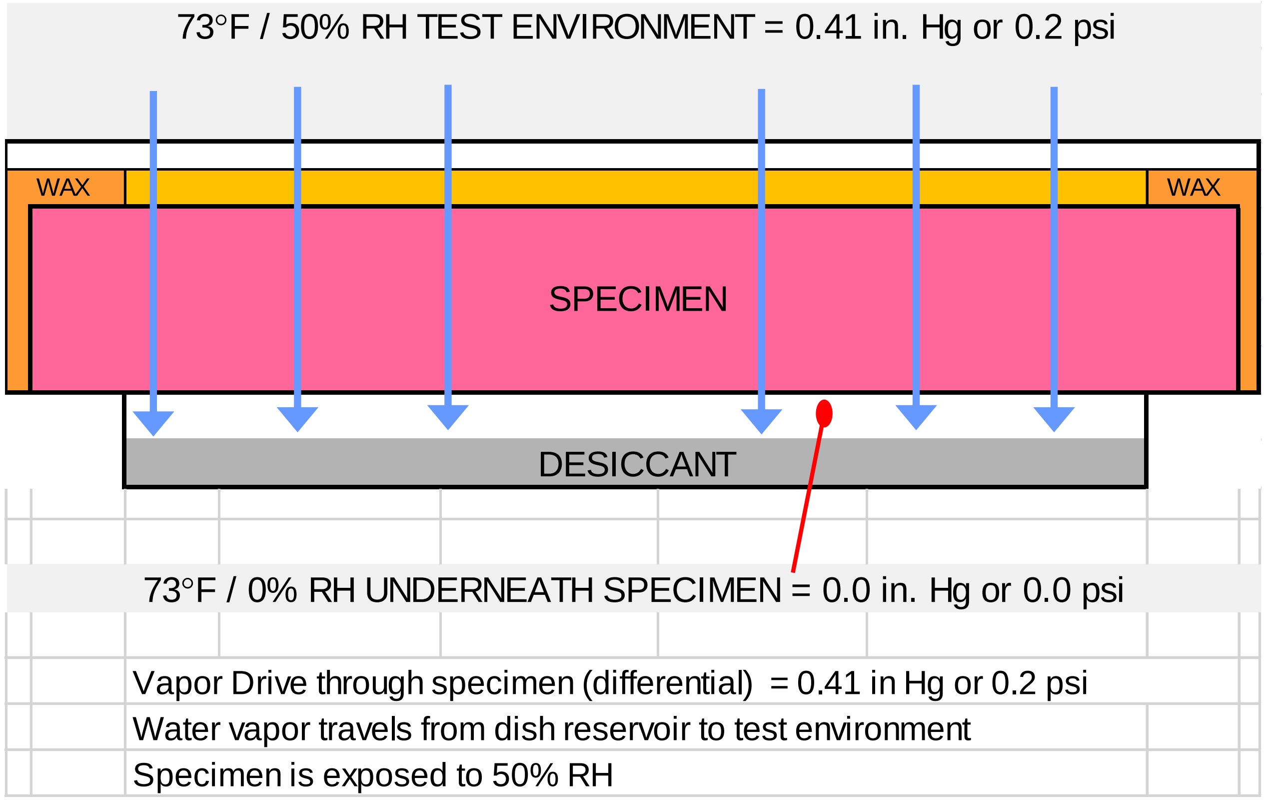
CALCULATING PARTIAL VAPOR PRESSURES

Example–Procedure A:

73°F/50% RH ambient 73°F/0% RH under specimen

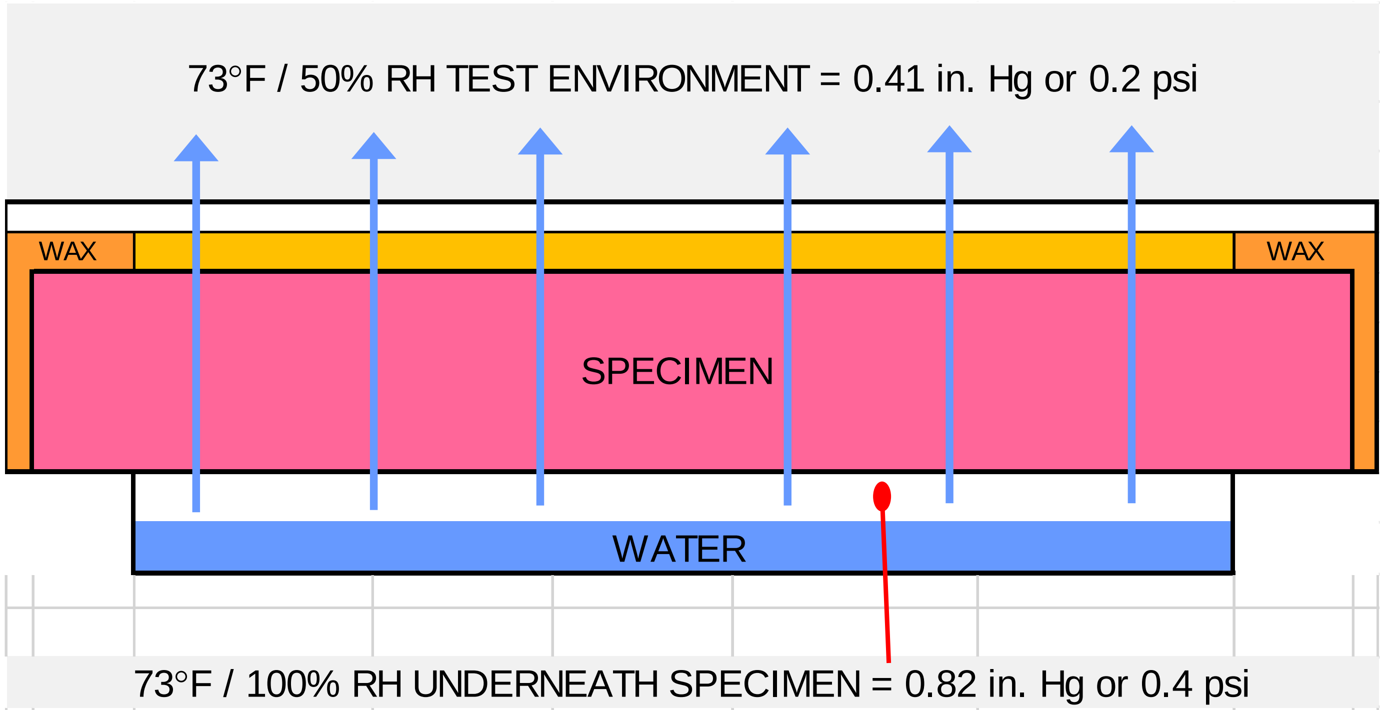
- Saturation vapor pressure @ 73°F = 0.82 in Hg
- 0.82 in. X 0.50 = 0.41 in. Hg ambient partial vapor pressure
- 0.82 in. X 0.00 = 0.00 in. Hg partial vapor pressure under specimen
- 0.41 in. – 0.00 in. = 0.41 in. Hg pvp differential

DESICCANT METHOD VAPOR PATH



Partial vapor pressures indicated

WATER METHOD VAPOR PATH



Vapor Drive through specimen (differential) = 0.41 in Hg or 0.2 psi

Water vapor travels from dish reservoir to test environment

Specimen is exposed to 100% RH

Partial vapor pressures indicated, except in reservoir which is at saturation vapor pressure due to 100%RH

TEST METHOD BASICS

- Specimen is cut to fit dish or pan; various sizes and shapes can be used.
- Tested with service-exposed side to higher humidity side.
- Seal is made around edge of specimen with wax mixture or other impervious material.
- Specimens are placed in environmental chamber or controlled room with tightly controlled temperature and relative humidity.
- Specimens are weighed periodically, with time noted, to determine rate of moisture gain or loss.
- The total time of test depends on the MVTR of the material; the lower the rate of moisture transmission, the longer the test runs and vice versa, in order to obtain valid data.

DRY CUP TEST DISH WITH DESICCANT

LEDGE FOR
WAX SEAL

WET CUP TEST DISH WITH WATER IN RESERVOIR

LEDGE FOR WAX SEAL

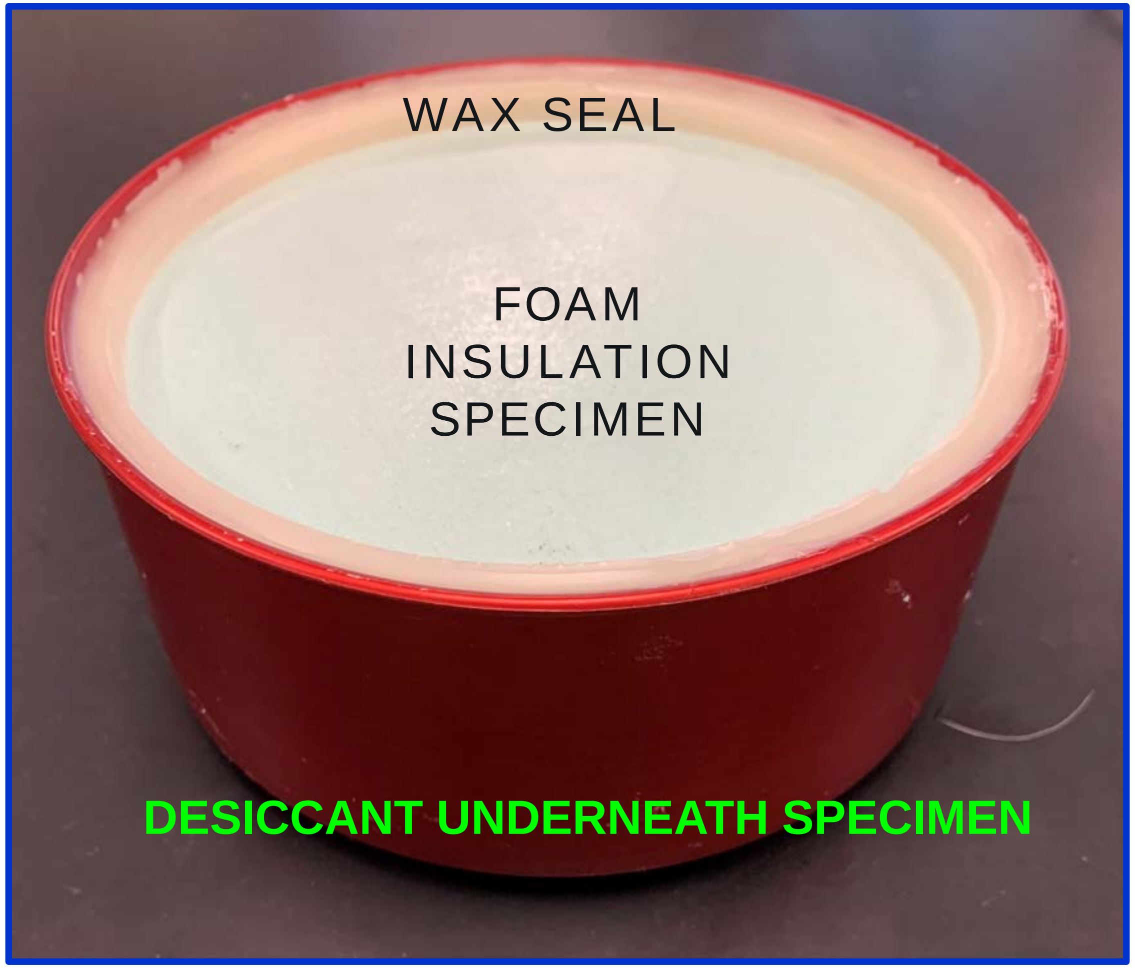
PREPARING SPECIMEN

PREPARING SPECIMEN

WAX APPLICATOR

DRY CUP TEST DISH WITH FSK FACING SPECIMEN

DRY CUP TEST WITH 2 INCH THICK FOAM



TESTING IN ENVIRONMENTAL CHAMBER

TEST METHOD BASICS

- Test dish assemblies are weighed periodically, the interval generally determined by how quickly the assembly is expected to gain or lose weight.
- A minimum number of data points obtained during the time when the rate of weight gain is stable, or in "steady state," is required for a valid test.
- The rate of weight change over time provides the WVTR, from which water vapor permeance and permeability can be calculated.

TESTING NOTES

- “Procedure A,” the desiccant method conducted at 73°F and 50% RH, is the most commonly used method in the insulation industry.
- “Procedure B,” the water method conducted at the same conditions imparts the same vapor driving pressure, while also exposing the specimen to high humidity.
- E96 allows for testing at any conditions that the user chooses.
- Any report of results must call out the type of test (dry or wet cup) and test conditions.
- Results of tests performed at a given set of conditions are *not* to be used to extrapolate results at other conditions. This is because the structural characteristics of a material may change at different conditions and impact the water vapor transmission properties.

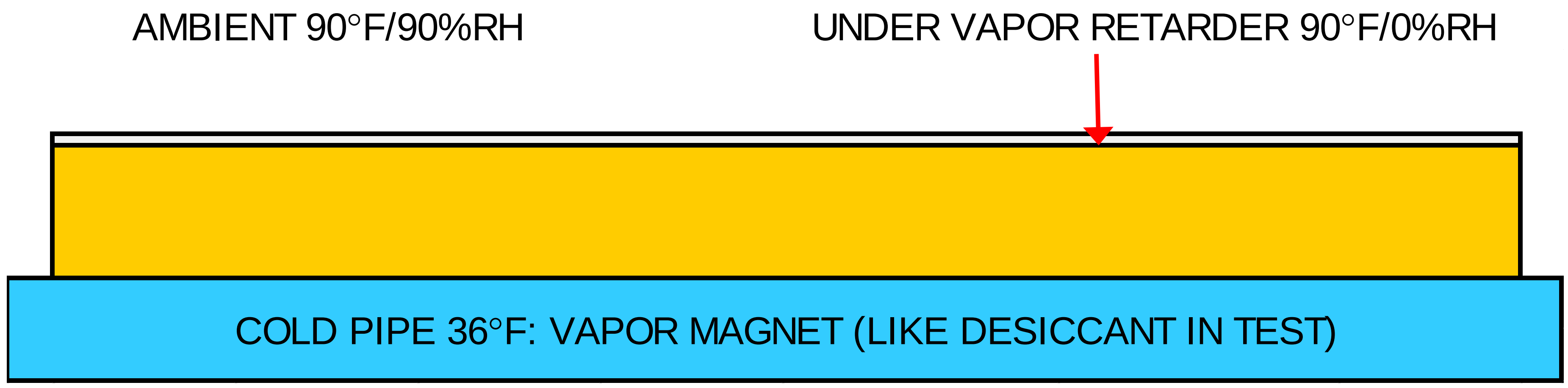
TESTING NOTES

- Desiccant method tests at high temperature and RH, while iso-thermal, can be used to duplicate the partial vapor pressures and vapor pressure differentials that would be encountered in the most severe below-ambient mechanical insulation applications.
- In the "real world," while the temperature on either side of a sheet vapor retarder is the same, the source of cold on the opposite side of the insulation effectively acts as the desiccant, pulling the moisture out of the air/insulation under the vapor retarder and thereby reducing the relative humidity on the inside of the vapor retarder.

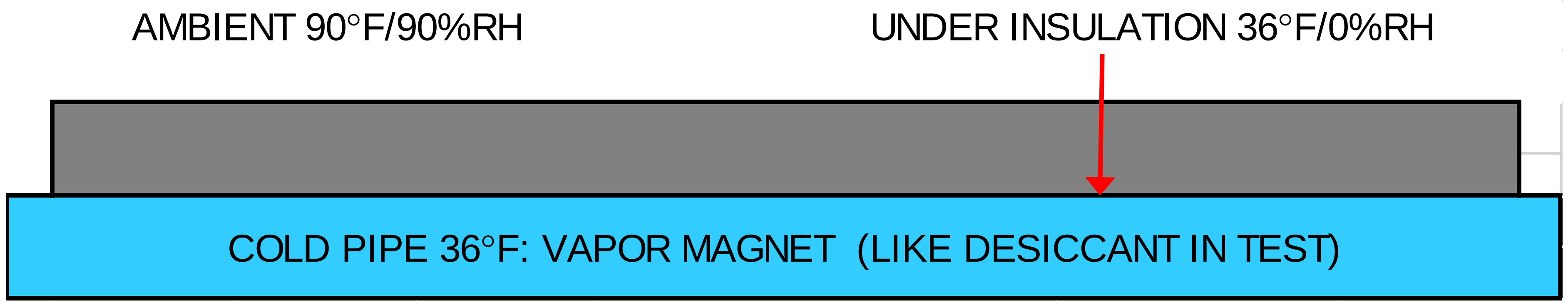
TESTING NOTES

- In the case of a low permeability foam insulation with no separate vapor retarder, the temperature on one side of the insulation will be lower than the other side, and the source of cold pulls the moisture out of the insulation, creating the RH difference as above.

POROUS INSULATION WITH SHEET VAPOR RETARDER



FOAM INSULATION WITHOUT SEPARATE VAPOR RETARDER



TEST CONDITIONS EMPLOYED IN INDUSTRY

✓Procedure A; Desiccant Method (Dry Cup) @ 73°F / 50%RH

Most common test, published data & spec requirement

Vapor drive: 0.41 in. Hg (0.20 psi)

✓Procedure B; Water Method (Wet Cup) @ 73°F / 50%RH

Exposes specimen to 100%RH with same partial vapor pressure differential as Procedure A

Vapor drive: 0.41 in. Hg (0.20 psi)

TEST CONDITIONS EMPLOYED IN INDUSTRY

✓Desiccant Method @ 90°F / 90% RH

To be used in ASHRAE research project testing vapor retarder *systems*

Vapor Drive: **1.28 in. Hg** (0.63 psi)

✓Procedure E; Desiccant Method @ 100°F / 90% RH

In use by some to test vapor retarders for cryogenic applications

Vapor Drive: 1.74 in. Hg (0.85 psi)

EXAMPLE OF LARGE AREA VAPOR INFILTRATION

- 100 square feet of faced insulation under procedure A conditions
- Assume constant 73°F, 50% RH on one side
- After 1 year with a 1 perm vapor retarder, theoretically 15.1 gallons of water in vapor form is allowed through.
- After 1 year with a 0.02 perm vapor retarder, theoretically 2.4 pints of water in vapor form is allowed through.

THANKS FOR YOUR ATTENTION!

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