**Designation: C755 – 20**

# Standard Practice for
# Selection of Water Vapor Retarders for Thermal Insulation[1]

This standard is issued under the fixed designation C755; 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 practice outlines factors to be considered, describes design principles and procedures for water vapor retarder selection, and defines water vapor transmission values appropriate for established criteria. It is intended for the guidance of design engineers in preparing vapor retarder application specifications for control of water vapor flow through thermal insulation. It covers commercial and residential building construction and industrial applications in the service temperature range from −40 to +150°F (−40 to +66°C). Emphasis is placed on the control of moisture penetration by choice of the most suitable components of the system.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 *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.*

1.4 *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

C647 Guide to Properties and Tests of Mastics and Coating Finishes for Thermal Insulation

C921 Practice for Determining the Properties of Jacketing Materials for Thermal Insulation

C1136 Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation

E96/E96M Test Methods for Water Vapor Transmission of Materials

## 3. Terminology

3.1 For definitions of terms used in this practice, refer to Terminology C168.

## 4. Significance and Use

4.1 Experience has shown that uncontrolled water entry into thermal insulation is the most serious factor causing impaired performance. Several ways exist by which water enters into an insulation system, the primary ones being diffusion of water vapor, air leakage carrying water vapor, and leakage of surface water. Application specifications for insulation systems that operate below ambient dew-point temperatures necessarily include an adequate vapor retarder system. A vapor retarder system is separate and distinct from the insulation, or is provided by the insulation itself when it is has adequate vapor resistant properties and all joints are sealed against water vapor intrusion, in which case a separate vapor retarder system is not necessary. For selection of adequate retarder systems to control vapor diffusion, it is necessary to establish acceptable practices and standards.

4.2 *Vapor Retarder Function*—The primary function of a vapor retarder is to control movement of diffusing water vapor into or through a permeable insulation system. The vapor retarder system in some cases is designed to prevent entry of surface water. When properly functioning as a vapor retarder, it will also serve as a barrier to air leakage.

4.3 *Vapor Retarder Performance*—Design choice of retarders will be affected by thickness of retarder materials, substrate to which applied, the number of joints, available length and width of sheet materials, useful life of the system, and inspection procedures. Each of these factors will have an effect on the retarder system performance and each must be considered and evaluated by the designer.

4.3.1 Although this practice properly places major emphasis on selecting the best vapor retarders, it must be recognized that

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[1] This practice is under the jurisdiction of ASTM Committee C16 on Thermal Insulation and is the direct responsibility of Subcommittee C16.33 on Insulation Finishes and Moisture.

Current edition approved March 1, 2020. Published March 2020. Originally approved in 1973. Last previous edition approved in 2019 as C755 – 19b. DOI: 10.1520/C0755-20.

[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.

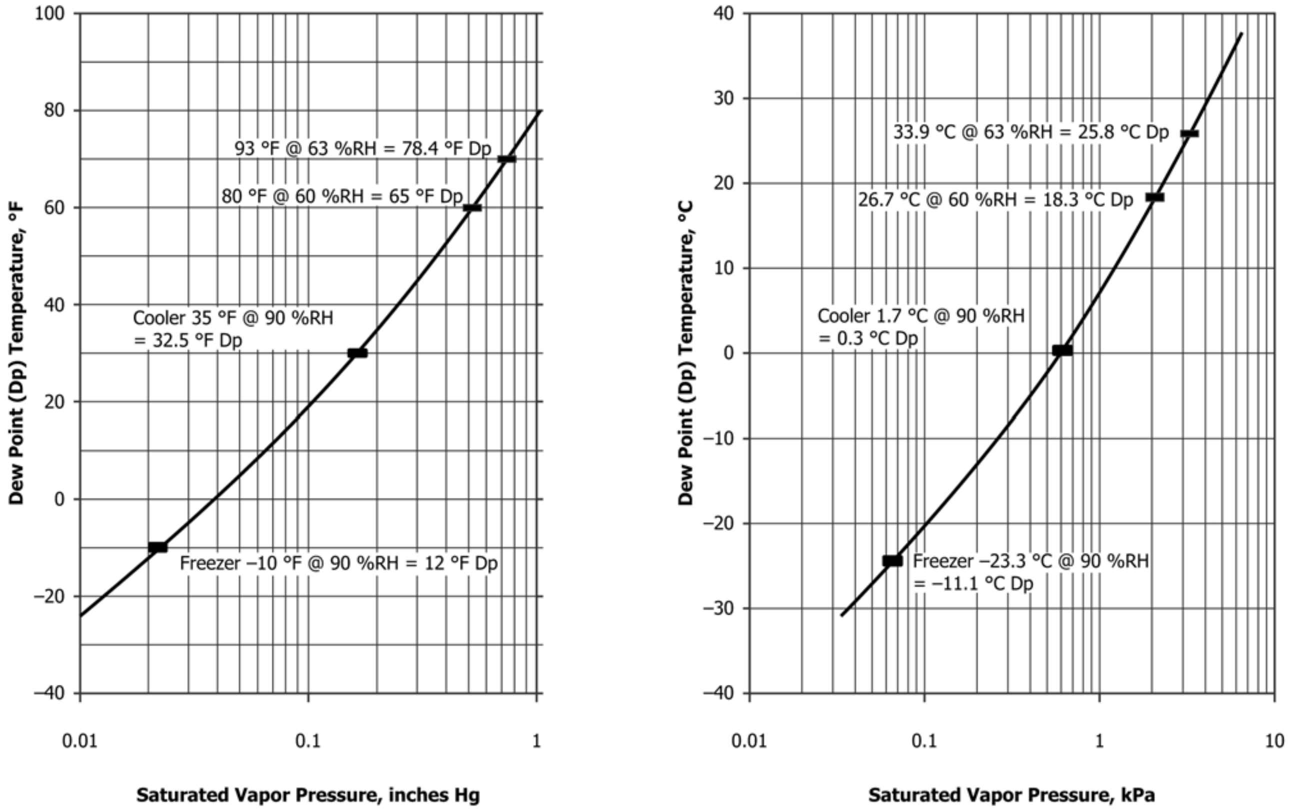

**FIG. 1 Dew Point (Dp) Relation to Water Vapor Pressure**

faulty installation is likely to impair vapor retarder performance. The effectiveness of installation or application techniques in obtaining design water vapor permeance (WVP) performance must be considered in the selection of retarder materials.

4.3.2 It is impractical to specify an “as installed” permeance value because, due to the nature of field application, attainment of system permeance equivalent to the vapor retarder materials themselves is assumed not possible. The best approach is to specify an appropriate vapor retarder and insure that proper installation and sealing procedures are followed.

## 5. Factors to Be Considered in Choosing Water Vapor Retarders

5.1 *Water Vapor Pressure Difference* is the difference in the pressure exerted on each side of an insulation system or insulated structure that is due to the temperature and moisture content of the air on each side of the insulated system or structure. This pressure difference determines the direction and magnitude of the driving force for the diffusion of the water vapor through the insulated system or structure. In general, for a given permeable structure, the greater the water vapor pressure difference, the greater the rate of diffusion. One is able to calculate water vapor pressure differences for specific conditions by numerical methods or from psychrometric tables showing thermodynamic properties of water at saturation.

5.1.1 Fig. 1 shows the variation of dew-point temperature with water vapor pressure.

5.1.2 Fig. 2 illustrates the magnitude of water vapor pressure differences for four ambient air conditions and cold-side operating temperatures between +40 and −40°F (+4.4 and −40°C).

5.1.3 At a stated temperature the water vapor pressure is proportional to relative humidity but at a stated relative humidity the vapor pressure is not proportional to temperature.

5.1.4 Outdoor design conditions vary greatly depending upon geographic location and season with the potential to have a substantial impact on system design requirements. It is therefore necessary to calculate the actual conditions rather than rely on estimates. As an example, consider the cold-storage application shown in Table 1. The water vapor pressure difference for the facility located in Biloxi, MS is 0.98 in. Hg (3.25 kPa) as compared to a 0.001 in. Hg (3 Pa) pressure difference if the facility was located in International Falls, MN. In the United States the design dew point temperature seldom exceeds 75°F (24°C) (**1**).[3]

5.1.5 The expected vapor pressure difference is a very important factor that must be based on realistic design data (not estimated) to determine vapor retarder requirements.

5.2 *Service Conditions*—The direction and magnitude of water vapor flow are established by the range of ambient atmospheric and design service conditions. These conditions

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

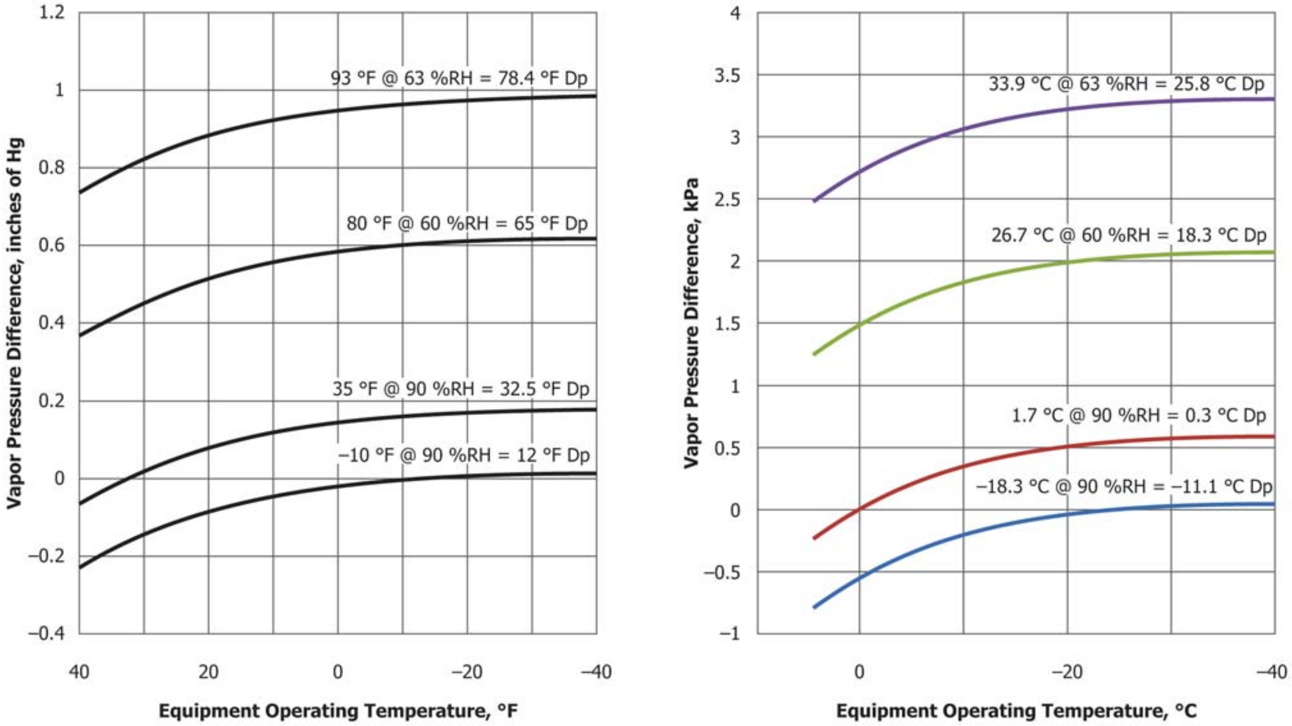

**FIG. 2 Magnitude of Water Vapor Pressure Difference for Selected Conditions (Derived from Fig. 1)**

**TABLE 1 Cold Storage Example**

| Location<br>Season | Biloxi, MS<br>Summer | International Falls, MN<br>Winter |
|---|---|---|
| *Outside Design Conditions* | | |
| Temperature , °F (°C) | 93 (34) | -35 (-37) |
| Relative Humidity, % | 63 | 67 |
| Dew Point Temperature, °F (°C) | 78.4 (26) | -42 (-41) |
| Water Vapor Pressure in. Hg (kPa) | .9795 (3.32) | .003 (0.01) |
| *Inside Design Conditions* | | |
| Temperature, °F (°C) | -10 | -10 |
| Relative Humidity, % | 90 | 90 |
| Water Vapor Pressure in. Hg (kPa) | .02 | .02 |
| *System Design Conditions* | | |
| Water Vapor Pressure Difference in. Hg (kPa) | 0.9795 | 0.001 (0.067) |
| Direction of Diffusion | From outside | From inside |

normally will cause vapor flow to be variable in magnitude, and either unidirectional or reversible.

5.2.1 Unidirectional flow exists where the water vapor pressure is constantly higher on one side of the system. With buildings operated for cold storage or frozen food storage, the summer outdoor air conditions will usually determine vapor retarder requirements, with retarder placement on the outdoor (warmer) side of the insulation. In heating only buildings for human occupancy, the winter outdoor air conditions would require retarder placement on the indoor (warmer) side of the insulation. In cooling only buildings for human occupancy (that is, tropic and subtropic locations), the summer outside air conditions would require retarder placement on the outdoor (warmer) side.

5.2.2 It is possible that reversible flow will occur where the higher vapor pressure alternates between sides of the system, changing because of seasonal variations, for example. It is possible that the inside temperature and vapor pressure of a refrigerated structure will be below the outside temperature and vapor pressure at times, and above them at other times. Cooler rooms with operating temperatures in the range from 35 to 45°F (2 to 7°C) at 90 % relative humidity and located in northern latitudes will experience an outward vapor flow in winter and an inward flow in summer. This reversing vapor flow requires special design consideration.

5.3 *Properties of Insulating Materials with Respect to Moisture*—Insulating materials permeable to water vapor will allow moisture to diffuse through at a rate defined by its permeance and exposure. The rate of movement is inversely proportional to the vapor flow resistance in the vapor path. Insulation having low permeance and vapor-tight joints will act as a vapor retarder to varying degrees, depending on type of insulation and sealing materials.

5.3.1 When condensed water vapor becomes entrained in the insulation, the insulation's thermal properties will be affected to varying degrees where wetted. The overall effect is less impactful when the condensation does not become trapped in the insulation itself, or is dissipated from the system in some manner. Liquid water resulting from condensation has a thermal conductivity some fifteen times greater than that of a typical low-temperature insulation. Ice conductivity is nearly four times that of water. Condensation reduces the thermal effectiveness of the insulation in the zone where it occurs, but when the zone is thin and perpendicular to the heat flow path, the reduction is not extreme. Water or ice in insulation joints