Designation: D5886 − 95 (Reapproved 2023)

Standard Guide for Selection of Test Methods to Determine Rate of Fluid Permeation Through Geomembranes for Specific Applications[1]

This standard is issued under the fixed designation D5886; 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 guide covers selecting one or more appropriate test methods to assess the permeability of all candidate geomembranes for a proposed specific application to various permeants. The widely different uses of geomembranes as barriers to the transport and migration of different gases, vapors, and liquids under different service conditions require determinations of permeability by test methods that relate to and simulate the service. Geomembranes are nonporous, homogeneous materials that are permeable in varying degrees to gases, vapors, and liquids on a molecular scale in a three-step process by: (*1*) dissolution in or absorption by the geomembrane on the upstream side, (*2*) diffusion through the geomembrane, and (*3*) desorption on the downstream side of the barrier.

1.2 The rate of transmission of a given chemical species, whether as a single permeant or in mixtures, is driven by its chemical potential or in practical terms by its concentration gradient across the geomembrane. Various methods to assess the permeability of geomembranes to single component permeants, such as individual gases, vapors, and liquids are referenced and briefly described.

1.3 Various test methods for the measurement of permeation and transmission through geomembranes of individual species in complex mixtures such as waste liquids are discussed.

1.4 *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.*

1.5 *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]

D471 Test Method for Rubber Property—Effect of Liquids

D814 Test Method for Rubber Property—Vapor Transmission of Volatile Liquids

D815 Test Method for Testing Coated Fabrics Hydrogen Permeance (Withdrawn 1987)[3]

D1434 Test Method for Determining Gas Permeability Characteristics of Plastic Film and Sheeting

D4439 Terminology for Geosynthetics

D4491/D4491M Test Methods for Water Permeability of Geotextiles by Permittivity

E96/E96M Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials

F372 Test Method for Water Vapor Transmission Rate of Flexible Barrier Materials Using an Infrared Detection Technique (Withdrawn 2009)[3]

F739 Test Method for Permeation of Liquids and Gases Through Protective Clothing Materials Under Conditions of Continuous Contact

3. Terminology

3.1 *Definitions:*

3.1.1 *downstream, n*—the space adjacent to the geomembrane through which the permeant is flowing.

3.1.2 *geomembrane, n*—an essentially impermeable geosynthetic composed of one or more synthetic sheets. (See Terminology D4439.)

3.1.2.1 *Discussion*—In geotechnical engineering, "essentially impermeable" means that no measurable liquid flows through a geosynthetic when tested in accordance with Test Methods D4491/D4491M.

[1] This guide is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.10 on Geomembranes.

Current edition approved May 1, 2023. Published May 2023. Originally approved in 1995. Last previous edition approved in 2018 as D5886 – 95 (2018). DOI: 10.1520/D5886-95R23.

[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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

3.1.3 *geosynthetic, n*—a planar product manufactured from polymeric material used with soil, rock, earth, or other geotechnical engineering-related material as an integral part of a man-made project, structure, or system. (See Terminology D4439.)

3.1.4 *permeability, n*—the rate of flow under a differential pressure, temperature, or concentration of a gas, liquid, or vapor through a material. (Modified from Test Methods D4491/D4491M.)

3.1.5 *permeant, n*—a chemical species, gas, liquid, or vapor that can pass through a substance.

4. Summary of Guide

4.1 The wide range of uses of geomembranes as barriers in many different environments to many different permeating species requires different test procedures to assess the effectiveness of a given membrane for a given application. The permeating species range from a single component to highly complex mixtures such as those found in waste liquids and leachates. In specialized applications, it may be important to measure transmission or migration of a species that would take place under specific conditions and environments including temperature, vapor pressure, and concentration gradients. Tests that would be applicable to the measurement of the permeability of a material to different permeants present in various applications are summarized in Table 1.

4.1.1 In the use of geomembranes in service as barriers to the transmission of fluids, it is essential to recognize the difference between geomembranes that are nonporous, homogeneous materials and other liner materials that are porous, such as soils and concretes. The transmission of permeating species through geomembranes without holes proceeds by absorption of the species in the geomembrane and diffusion through the geomembrane on a molecular basis. The driving force is chemical potential across the geomembrane. A liquid permeates porous materials in a condensed state that can carry the dissolved constituents, and the driving force for such permeation is hydraulic pressure. Due to the selective nature of geomembranes, the permeation of the dissolved constituents in liquids can vary greatly, that is, components of a mixture can permeate at different rates due to differences in solubility and diffusibility in a given geomembrane. With respect to the inorganic aqueous salt solution, the geomembranes are semipermeable, that is, the water can be transmitted through the geomembranes, but the ions are not transmitted. Thus, the water that is transmitted through a hole-free geomembrane does not carry dissolved inorganics. The direction of permeation of a component in the mixture is determined thermodynamically by its chemical potential difference or concentration gradient across the geomembrane. Thus, the water in the wastewater on the upstream side is at a lower potential than the less contaminated water on the downstream side and can permeate the geomembrane into the wastewater by osmosis.

4.1.2 Although inorganic salts do not permeate geomembranes, some organic species do. The rate of permeation through a geomembrane depends on the solubility of the organic in the geomembrane and the diffusibility of the organic in the geomembrane as driven by the chemical potential gradient. Principle factors that can affect the diffusion of an organic within a geomembrane include:

4.1.2.1 The solubility of the permeant in the geomembrane,

4.1.2.2 The microstructure of the polymer, for example, percent crystallinity,

4.1.2.3 Whether the condition at which diffusion is taking place is above or below the glass transition temperature of the polymer,

4.1.2.4 The other constituents in the geomembrane compound,

4.1.2.5 Variation in manufacturing processes,

4.1.2.6 The flexibility of the polymer chains,

4.1.2.7 The size and shape of the diffusing molecules,

TABLE 1 Applicable Test Method for Measuring Permeability of Geomembranes to Various Permeants

Fluid Being Contained	Example of Permeant	Example of Field Application	Applicable Test Method and Permeant Detector and Quantifier
Single-Component Fluids:			
Gas	H_2, O_2 N_2, CH_4 CO_2	Barriers, pipe, and hose liners	D815 D1434-V D1434-P
Water vapor	H_2O	Moisture vapor barriers, water reservoir covers	E96/E96M, D653
Liquid water	H_2O	Liners for reservoirs, dams, and canals	Soil-type permeameter with hydraulic pressure
Organic vapor	Organic species	Secondary containment for organic solvent and gasoline	D814, E96/E96M, F372
Organic liquid	Organic solvents species	Containers, tank liners secondary containment	D814, E96/E96M
Multicomponents Fluids:			
Gases	CO_2/CH_4	Barriers, separation of gases	F372, GC, GCMS
Aqueous solutions of inorganic, for example, brines, incinerator ash leachates, leach pad leachate	Ions, salts	Pond liners	Pouch, osmotic cell, ion analysis
Mixtures of organics, spills, hydrocarbon fuels	Organic species	Liners for tanks and secondary containment	E96/E96M with headspace, GC
Aqueous solutions of organics	Organic species, H_2O	Liners for ponds and waste disposal	Pouch, Multicompartment cell with analysis by GC on GCMS
Complex aqueous solutions of organics and inorganic species	H_2O, organic species, dissolved salts	Liners for waste disposal	Pouch, Multicompartment cell, osmotic cell, analysis by head-space GC