



Standard Guide for the Selection of Test Methods for Flexible Polypropylene (fPP) Geomembranes¹

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1. Scope

1.1 This guide provides recommendations for the selection of appropriate test methods for flexible polypropylene sheet used in geomembrane applications to provide consistency in data reporting.

1.2 This guide includes test methods for three types of flexible polypropylene geomembranes including smooth non-reinforced sheet, textured nonreinforced sheet, and scrim-reinforced sheet.

1.3 This guide is intended to aid all personnel involved in the selection, manufacture, installation, or evaluation of flexible polypropylene geomembrane sheet.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

- D 412 Test Method for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers—Tension²
- D 413 Test Methods for Rubber Property—Adhesion to Flexible Substrate²
- D 471 Test Method for Rubber Property—Effect of Liquids²
- D 573 Test Method for Rubber—Deterioration in an Air Oven²
- D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing³
- D 638 Test Method for Tensile Properties of Plastics³
- D 696 Test Method for Coefficient of Linear Thermal Expansion of Plastics³
- D 746 Test Method for Brittleness Temperature of Plastics and Elastomers by Impact³
- D 751 Test Methods for Coated Fabrics⁴
- D 790 Test Methods for Flexural Properties of Unreinforced

and Reinforced Plastics and Electrical Insulating Materials³

- D 792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement³
- D 882 Test Methods for Tensile Properties of Thin Plastic Sheeting³
- D 1004 Test Method for Initial Tear Resistance of Plastic Film and Sheeting³
- D 1149 Test Method for Rubber Deterioration—Surface Ozone Cracking in a Chamber²
- D 1204 Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature³
- D 1238 Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer³
- D 1505 Test Method for Density of Plastics by the Density-Gradient Technique³
- D 1603 Test Method for Carbon Black in Olefin Plastics³
- D 2136 Test Method for Coated Fabrics—Low-Temperature Bend Test²
- D 2137 Test Method for Rubber Property—Brittleness Point of Flexible Polymers and Coated Fabrics²
- D 3389 Test Method for Coated Fabrics Abrasion Resistance (Rotary Platform, Double-Head Abrader)⁴
- D 3417 Test Method for Heats of Fusion and Crystallization of Polymers by Thermal Analysis⁵
- D 4218 Test Method for Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique⁵
- D 4364 Practice for Performing Accelerated Outdoor Weathering of Plastics Using Concentrated Natural Sunlight⁶
- D 4437 Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes
- D 4439 Terminology for Geotextiles⁷
- D 4545 Practice for Determining the Integrity of Factory Seams Used in Joining Manufactured Flexible Sheet Geomembranes⁷
- D 4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products⁷

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² *Annual Book of ASTM Standards*, Vol 09.01.

³ *Annual Book of ASTM Standards*, Vol 08.01.

⁴ *Annual Book of ASTM Standards*, Vol 09.02.

⁵ *Annual Book of ASTM Standards*, Vol 08.02.

⁶ *Annual Book of ASTM Standards*, Vol 08.03.

⁷ *Annual Book of ASTM Standards*, Vol 04.09.

- D 5199 Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes⁷
- D 5321 Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic Friction by the Direct Shear Method⁷
- D 5323 Practice for Determination of 2 % Secant Modulus for Polyethylene Geomembranes⁷
- D 5397 Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test⁷
- D 5514 Test Method for Large Scale Hydrostatic Puncture Testing of Geosynthetics⁷
- D 5617 Test Method for Multi-Axial Tension Test for Geosynthetics⁷
- D 5721 Practice for Air-Oven Aging Polyolefin Geomembranes⁷
- D 5747 Practice for Tests to Evaluate the Chemical Resistance of Geomembranes to Liquids⁷
- D 5884 Test Method for Determining Tearing Strength of Internally Reinforced Geomembranes⁷
- D 5994 Test Method for Measuring the Core Thickness of Textured Geomembrane⁷
- E 96 Test Methods for Water Vapor Transmission of Materials⁸
- F 1249 Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor⁹
- G 26 Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials¹⁰
- G 151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices That Use Laboratory Light Sources¹⁰

- G 154 Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials¹⁰
- G 155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Nonmetallic Materials¹⁰
- 2.2 *Federal Test Method Standards:*
FTMS 101C–2031 Puncture Resistance¹¹

3. Terminology

3.1 *Definitions*—For definitions of geosynthetics terms used in this guide, refer to Terminology D 4439.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *flexible polypropylene, n*—a material having a 2 % secant modulus of less than 300 MPa (40 000 psi) as determined by Practice D 5323 produced by polymerization of propylene with or without other alpha olefin monomers.

4. Significance and Use

4.1 To evaluate flexible polypropylene properly, tests must be performed according to specific test methods and procedures. Failure to follow this guide can result in data not representative of the material's characteristics and performance.

5. Test Methods

5.1 Recommended test methods for flexible polypropylene sheet are listed in tables as follows:

5.1.1 *Table 1*—Flexible Polypropylene (fPP) Sheet Manufacturing Quality Control Tests;

5.1.2 *Table 2*—Optional Performance Tests for Flexible Polypropylene (fPP) Sheet; and,

5.1.3 *Table 3*—Tests for Field Prepared Seams of Flexible Polypropylene (fPP) Sheet.

6. Keywords

6.1 flexible polypropylene; geomembrane

⁸ *Annual Book of ASTM Standards*, Vol 04.06.

⁹ *Annual Book of ASTM Standards*, Vol 15.09.

¹⁰ *Annual Book of ASTM Standards*, Vol 14.02.

¹¹ Available from Standardization Documents Order Desk, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111–5094, Attn: NPODS.

TABLE 1 Flexible Polypropylene (fPP) Sheet Manufacturing Quality Control Tests

Sheet Type	Reinforced Sheet	Smooth Nonreinforced Sheet	Textured Sheet	Comments
General:				
Terminology	D 4439	D 4439	D 4439	
Conditioning	D 618	D 618	D 618	
Physical Properties:				
Thickness	D 5199	D 5199	D 5994	
Ultimate tensile strength and elongation	D 751 Procedure A	D 638 modified	D 638 modified	Type IV, no extensometer grip separation = 63.5 mm (2.50 in.), strain rate = 509 mm/min (20 in./min)
	D 412, Die C	D 412, Die C	D 412, Die C	
	D 882	D 882	D 882	D 882 for thickness < 1 mm (0.040 in.)
Tear resistance	D 751	D 1004	D 1004	
	D 5884			
Puncture resistance	D 751			
	D 4833	D 4833	D 4833	
	FTMS 101C–2031			
Ply Adhesion	D 413	—	—	

TABLE 2 Optional Performance Tests for Flexible Polypropylene (fPP) Sheet

Sheet Type	Reinforced Sheet	Smooth Nonreinforced Sheet	Texture, d Sheet	Comments
General:				
Terminology	D 4439	D 4439	D 4439	
Conditioning	D 618	D 618	D 618	
Physical Properties:				
Flow rates of thermoplastics		D 1238	D 1238	230°C, 2.16 kg
Carbon black content	D 1603	D 1603	D 1603	
	D 4218	D 4218	D 4218	
Low temperature bend	D 2136	D 2136	D 2136	
Thermal expansion	D 696	D 696	D 696	
Density	D 1505	D 1505	D 1505	
	D 792	D 792	D 792	
Water vapor transmission	E 96	E 96	E 96	
	F 1249	F 1249	F 1249	
Water absorption	D 471	D 471	D 471	
Mechanical Properties:				
2 % Secant modulus	D 5323	D 5323	D 5323	
Flexural modulus	D 790	D 790	D 790	
Hydrostatic resistance	D 5514	D 5514	D 5514	
	D 751A, Procedure 1			
Multi-axial tensile	D 5617	D 5617	D 5617	
Geosynthetic friction by direct shear	D 5321	D 5321	D 5321	
Thermal Properties:				
Dimensional stability	D 1204	D 1204	D 1204	100°C, 1 h
Melting temperature	D 3417	D 3417	D 3417	
Brittleness point	D 2137	D 2137	D 2137	
	D 746	D 746	D 746	
Endurance Properties:				
UV resistance	G 26	G 26	G 26	80°C, 0.35 W/m ²
	G 151	G 151	G 151	
	G 154	G 154	G 154	
	G 155	G 155	G 155	
	D 4364	D 4364	D 4364	
Ozone resistance	D 1149	D 1149	D 1149	
Stress crack resistance	D 5397	D 5397	D 5397	
Oven aging	D 573	D 573	D 573	85°C
	D 5721	D 5721	D 5721	
Abrasion resistance	D 3389	D 3389	D 3389	
Chemical resistance	D 471	D 471	D 471	
	D 5747	D 5747	D 5747	

TABLE 3 Tests for Field Prepared Seams of Flexible Polypropylene (fPP) Sheet

Seam Properties	Test Method	Comments
Peel strength (hot air, hot wedge, and extrusion welds)	D 4437 modified	strip width = 25.4 mm (1.00 in.) grip separation = 50.8 mm (2.00 in.) + seam strain rate = 508 mm/min (20 in./min) maximum test strain = 200 %
Shear strength (hot air, hot wedge, and extrusion welds)	D 4437 modified	strip width = 25.4 mm (1.00 in.) grip separation = 50.8 mm (2.00 in.) + seam strain rate = 508 mm/min (20 in./min) maximum test strain = 200 % for shear tests on reinforced sheet welds, use strip width = 101.6 mm (4.00 in.)
Factory seam integrity	D 4545	

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