



Designation: D7613 – 17 (Reapproved 2023)

# Standard Specification for Flexible Polypropylene Reinforced (fPP-R) and Nonreinforced (fPP) Geomembranes<sup>1</sup>

This standard is issued under the fixed designation D7613; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This specification covers flexible polypropylene reinforced (fPP-R) and nonreinforced (fPP) geomembranes made from flexible polypropylene as the principal polymer prepared by the polymerization of propylene with or without other alpha olefin monomers.

1.2 The tests and property limits used to characterize the sheet are values intended to ensure minimum quality. In-place system design criteria, such as field-seaming strength and material compatibility, among others, are factors that should be considered but are beyond the scope of this specification.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

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:*<sup>2</sup>

**D573 Test Method for Rubber—Deterioration in an Air Oven**

**D751 Test Methods for Coated Fabrics**

**D883 Terminology Relating to Plastics**

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.06 on Geosynthetic Specifications.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the specification's Document Summary page on the ASTM website.

- D1004 Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheet**
- D1204 Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheet or Film at Elevated Temperature**
- D2136 Test Method for Coated Fabrics—Low-Temperature Bend Test**
- D4439 Terminology for Geosynthetics**
- D4833/D4833M Test Method for Index Puncture Resistance of Geomembranes and Related Products**
- D5199 Test Method for Measuring the Nominal Thickness of Geosynthetics**
- D5538 Practice for Thermoplastic Elastomers—Terminology and Abbreviations**
- D5884/D5884M Test Method for Determining Tearing Strength of Internally Reinforced Geomembranes**
- D6636 Test Method for Determination of Ply Adhesion Strength of Reinforced Geomembranes**
- D6693/D6693M Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes**
- D7004/D7004M Test Method for Grab Tensile Properties of Reinforced Geomembranes**
- G151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources**
- G154 Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Materials**
- G155 Practice for Operating Xenon Arc Lamp Apparatus for Exposure of Materials**

## 3. Terminology

3.1 *Definitions*—For definitions of terms used in this specification, refer to Terminologies D883 and D4439 and Practice D5538.

## 4. Materials and Manufacture

4.1 The sheet shall be capable of being heat welded, fused, or adhesively bonded to itself for making watertight field splices and repairs.

4.2 Geomembrane can be nonreinforced or reinforced with fabric or scrim.

## 5. Chemical Composition

5.1 The geomembrane shall be formulated from virgin flexible polypropylene in amounts greater than 85 % by weight of the total polymer content. The remaining 15 % shall be comprised of compatible polymers or pigments (or both), stabilizers, and colorants that are suitably compounded to satisfy the physical requirements in the specification (see Practice **D5538** for definitions).

NOTE 1—The compound shall not contain postconsumer (PCR) components containing bitumen or any other ingredients that could interfere with the long-term stability of the geomembrane. No more than 10 % rework resin is allowed for the production of the membrane and shall be fully compatible with the parent material.

## 6. Properties

6.1 Each sheet specimen shall meet or exceed the property requirements prescribed in **Table 1** (fPP-R) or **Table 2** (fPP).

6.2 The tolerance for time conditions (aging, weathering, and so forth) is  $\pm 15$  min or  $\pm 1$  % of the period, whichever is greater, unless otherwise specified.

6.3 The tolerance for temperature conditions (aging and so forth) is  $\pm 2$  °C of the specified temperature, unless otherwise specified.

## 7. Dimensions, Mass, and Permissible Variations

7.1 The width and length of the sheet shall be agreed upon between the purchaser and the supplier.

7.2 The tolerance for both width and length shall be +3 %, -1 %.

7.3 The thickness tolerance shall be +15 %, -10 % of thickness agreed upon by the purchaser and supplier, but in no case shall the thickness be less than the minimum in **Table 1** or **Table 2**.

## 8. Workmanship, Finish, and Appearance

8.1 The sheet, including factory seams, if present, shall be watertight and free of pinholes, particles of foreign matter, protruding fibers or reinforcement, undispersed raw material,

nicks and cuts, voids, thin areas, delaminations, or other manufacturing defects that might adversely affect serviceability.

## 9. Test Methods

9.1 *Dimensions*—Test Methods **D751** for reinforced and nonreinforced, after permitting the sheet to relax at 23 °C for 1 h.

9.2 *Thickness*—Test Method **D5199** for reinforced and nonreinforced.

9.3 *Thickness of Coating Over Scrim (Reinforcing Fabric)*—Optical method described in **Annex A1** for reinforced.

9.4 *Breaking Strength*—Test Method **D7004/D7004M** for reinforced.

9.5 *Tensile Strength*—Test Method **D6693/D6693M** for nonreinforced.

9.6 *Elongation at Break*—Test Method **D7004/D7004M** for reinforced.

9.7 *Ultimate Elongation %*—Test Method **D6693/D6693M** for nonreinforced.

9.8 *Tearing Strength*—Test Method **D5884/D5884M** for reinforced.

9.9 *Tear Resistance*—Test Method **D1004** for nonreinforced.

9.10 *Low-Temperature Bend*—Test Method **D2136** at -40 °C for reinforced and nonreinforced.

9.11 *Heat Aging*—Test Method **D573** for reinforced and nonreinforced.

9.11.1 Age sheet specimens for 670 h at 116 °C.

9.11.2 After exposure, remove the sheet specimens from the oven.

9.11.3 Specimens are then cut from the aged sheet for testing of breaking or tensile strength, elongation at break or ultimate elongation, and tearing strength or resistance.

9.11.4 Specimens are then wrapped around a 75 mm diameter mandrel.

**TABLE 1 Property Requirements for Flexible Polypropylene Reinforced (fPP-R)**

Property Requirements	Method	Nominal Thickness, mm (in.)			
		0.76 (0.030)	0.91 (0.036)	1.14 (0.045)	1.52 (0.060)
Thickness, minimum average, mm (in.)	<b>D5199</b>	0.68 (0.027)	0.82 (0.032)	1.03 (0.040)	1.35 (0.054)
Thickness over scrim, minimum, mm (in.)	<b>Annex A1</b>	0.20 (0.008)	0.25 (0.010)	0.33 (0.013)	0.46 (0.018)
Breaking strength, minimum, N (lbf)	<b>D7004/D7004M</b>	750 (170)	890 (200)	1100 (250)	1100 (250)
Elongation at break, minimum, %	<b>D7004/D7004M</b>	15	15	15	15
Tearing strength, minimum N (lbf)	<b>D5884/D5884M</b>	220 (50)	244 (55)	310 (70)	310 (70)
Low-temperature bend, °C (°F)	<b>D2136</b>	-40 (-40)	-40 (-40)	-40 (-40)	-40 (-40)
Properties after heat aging & weathering	<b>D573, G151, G154, G155</b>				
Retention of breaking strength, minimum, %		85	85	85	85
Retention of elongation at break, minimum, %		85	85	85	85
Retention of tearing strength, minimum, %		60	60	60	60
Visual inspection, no cracks or crazing (10×)		Pass	Pass	Pass	Pass
Linear dimensional change, maximum change, %	<b>D1204</b>	1.0	1.0	1.0	1.0
Puncture resistance, minimum, N (lbf)	<b>D4833/D4833M</b>	220 (50)	330 (75)	378 (85)	400 (90)
Factory prepared, ply adhesion strength, minimum, N/m (lbf/in.)	<b>D6636</b>	2630 (15)	2630 (15)	2630 (15)	2630 (15)

**TABLE 2 Property Requirements for Flexible Polypropylene Nonreinforced (fPP)**

Property Requirements	Method	Nominal Thickness, mm (in.)		
		0.76 (0.030)	1.02 (0.040)	1.52 (0.060)
Thickness, minimum average, mm (in.)	D5199	0.68 (0.027)	0.90 (0.035)	1.35 (0.054)
Tensile strength, minimum, kN/m (lbf/in.)	D6693/D6693M	10.5 (60)	10.5 (60)	17 (96)
Ultimate elongation, minimum, %	D6693/D6693M	700	600	600
Tear resistance, minimum, N (lbf)	D1004	44 (10)	44 (10)	80 (18)
Low-temperature bend, °C (°F)	D2136	−40 (−40)	−40 (−40)	−40 (−40)
Properties after heat aging & weathering	D573, G151, G154, G155			
Retention of tensile strength, minimum, %		85	85	85
Retention of ultimate elongation, minimum, %		85	85	85
Retention of tear resistance, minimum, %		60	60	60
Visual inspection, no cracks or crazing (10×)		Pass	Pass	Pass
Linear dimensional change, maximum change, %	D1204	3	3	3
Puncture resistance, minimum, N (lbf)	D4833/D4833M	110 (25)	110 (25)	180 (40)

9.11.5 The specimens shall then be inspected for cracks or crazing at 10× magnification and be tested for breaking or tensile strength, elongation at break or ultimate elongation, and tearing strength or resistance, for reinforced or nonreinforced materials, respectively.

9.11.6 A specimen is rated “pass” if no cracks or crazing is observed using a 10× magnification and it meets the minimum property requirements prescribed in Table 1 or Table 2 for heat aging and weathering.

9.12 *Linear Dimensional Change*—Test Method D1204 for reinforced and nonreinforced. Age specimen for 6 h at 70 °C or 1 h at 100 °C.

9.13 *Puncture Resistance*—Test Method D4833/D4833M for reinforced and nonreinforced.

9.14 *Ply Adhesion Strength*—Test Method D6636 for reinforced.

9.15 *Weather Resistance*—Accelerated weathering tests shall be performed using exposures described in either 9.15.1 or 9.15.2. Refer to Practices G151, G154, and G155 for guidance regarding laboratory weathering. Choice of type of exposure shall be by mutual agreement among the interested parties. The two different types of exposure may produce different test results. Therefore, they cannot be used interchangeably without supporting data that demonstrates equivalency for the materials tested.

9.15.1 *Fluorescent UV/ Condensation Exposure*—Apparatus described in Practice G154 shall be operated in accordance with the following conditions:

9.15.1.1 *Bulb Type*—Fluorescent UVA-340 lamp.

9.15.1.2 *Irradiance*—Apparatus with irradiance control shall be set at 0.78 W/(m<sup>2</sup>·nm) at 340 nm. The maximum allowable operational fluctuation of the irradiance setting is ±0.02 W/(m<sup>2</sup>·nm).

9.15.1.3 *Cycle*—20 h UV at an uninsulated black panel temperature set point of 70 °C alternating with 4 h condensation at an uninsulated black panel set point of 60 °C. The maximum allowable operational fluctuation of the temperature settings is ±2.5 °C.

9.15.1.4 *Specimen Repositioning*—Refer to Practice G154, subsection 9.5.

9.15.1.5 *Radiant Exposure*—23 400 kJ/(m<sup>2</sup>·nm) at 340 nm. (The apparatus is to be run for a total exposure of 10 000 h.

This equates to 8336 h of UV at 70 °C and 1664 h of condensation at 60 °C.)

9.15.2 *Xenon-Arc Exposure*—Apparatus described in Practice G155 shall be operated in accordance with the following conditions:

9.15.2.1 *Filter Type*—Daylight.

9.15.2.2 *Irradiance*—0.70 W/(m<sup>2</sup>·nm) at 340 nm. The maximum allowable operational fluctuation of the irradiance setting is ±0.02 W/(m<sup>2</sup>·nm).

9.15.2.3 *Cycle*—690 min light, alternating with 30 min light plus water spray on the front surface.

9.15.2.4 *Uninsulated Black Panel Temperature*—80 °C. The maximum allowable operational fluctuation is ±2.5 °C.

9.15.2.5 *Relative Humidity*—50 %. The maximum allowable operational fluctuation is ±10 %.

9.15.2.6 *Spray Water*—Refer to Practice G155, subsection 6.6.1. Typical water temperature used for specimen spray is 21 ± 2.5 °C, but if ambient temperature is low and a holding tank is not used to store purified water, the water temperature can be below the typical range.

9.15.2.7 *Specimen Repositioning*—Refer to Practice G155, subsection 9.5.

9.15.2.8 *Radiant Exposure*—15 210 kJ/(m<sup>2</sup>·nm) at 340 nm. (The apparatus is to be run for a total exposure of 6036 h at a black body temperature of 80 °C.)

9.15.2.9 *Chamber Air (if Controlled)*—50 °C. The maximum allowable operational fluctuation is ±2 °C.

9.15.3 If the operational fluctuations are greater than the maximum allowable after the equipment has stabilized, discontinue the test and correct the cause of the problem before continuing.

9.15.4 Perform the weathering tests on the intact, as-fabricated sheet with the weathering side, if applicable, facing the lamp(s). Mount specimens for exposure under no strain.

9.15.5 After exposure, remove the sheet specimens from the chamber. Specimens are then cut from the aged sheet for testing of breaking or tensile strength, elongation at break or ultimate elongation, and tearing strength or resistance.

9.15.6 The specimens are then wrapped around a 75 mm mandrel.

9.15.7 The specimens shall then be inspected for cracks, crazing, and chalking at 10× magnification and be tested for breaking or tensile strength, elongation at break or ultimate