Designation: D7613 – 17

Standard Specification for Flexible Polypropylene Reinforced (fPP-R) and Nonreinforced (fPP) Geomembranes[1]

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 (ε) 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 and health 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]

D573 Test Method for Rubber—Deterioration in an Air Oven

D751 Test Methods for Coated Fabrics

D883 Terminology Relating to Plastics

D1004 Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting

D1204 Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature

D2136 Test Method for Coated Fabrics—Low-Temperature Bend Test

D4439 Terminology for Geosynthetics

D4833 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 Test Method for Determining Tearing Strength of Internally Reinforced Geomembranes

D6636 Test Method for Determination of Ply Adhesion Strength of Reinforced Geomembranes

D6693 Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes

D7004 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 Nonmetallic Materials

G155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic 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.

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

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[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 specification's Document Summary page on the ASTM website.

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 ±15 min or ±1 % of the period, whichever is greater, unless otherwise specified.

6.3 The tolerance for temperature conditions (aging and so forth) is ±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 for reinforced.

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

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

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

9.8 *Tearing Strength*—Test Method D5884 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.

9.11.5 The specimens shall then be inspected for cracks or crazing at 10× magnification and be tested for breaking or

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.]	D5199	0.68 [0.027]	0.82 [0.032]	1.03 [0.040]	1.35 [0.054]
Thickness over scrim, minimum, mm [in.]	Annex A1	0.20 [0.008]	0.25 [0.010]	0.33 [0.013]	0.46 [0.018]
Breaking strength, minimum, N [lbf]	D7004	750 [170]	890 [200]	1100 [250]	1100 [250]
Elongation at break, minimum, %	D7004	15	15	15	15
Tearing strength, minimum N [lbf]	D5884	220 [50]	244 [55]	310 [70]	310 [70]
Low-temperature bend, °C [°F]	D2136	–40 [–40]	–40 [–40]	–40 [–40]	–40 [–40]
Properties after heat aging & weathering	D573, G151, G154, G155				
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, %	D1204	1.0	1.0	1.0	1.0
Puncture resistance, minimum, N [lbf]	D4833	220 [50]	330 [75]	378 [85]	400 [90]
Factory prepared, ply adhesion strength, minimum, N/m [lbf/in.]	D6636	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	10.5 [60]	10.5 [60]	17 [96]
Ultimate elongation, minimum, %	D6693	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	110 [25]	110 [25]	180 [40]

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 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^2·nm) at 340 nm. The maximum allowable operational fluctuation of the irradiance setting is ±0.02 W/(m^2·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^2·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^2·nm) at 340 nm. The maximum allowable operational fluctuation of the irradiance setting is ±0.02 W/(m^2·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^2·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 elongation, and tearing strength or resistance, for reinforced or nonreinforced materials, respectively.

9.15.8 A specimen is rated "pass" if no cracks, crazing and chalking are observed and it meets the minimum property requirements prescribed in Table 1 or Table 2 for heat aging and weathering.

10. Inspection

10.1 Inspection of the material shall be agreed upon between involved parties.

11. Rejection and Rehearing

11.1 Failure to conform to any one of the requirements prescribed in this specification shall constitute grounds for rejection. Rejection shall be reported to the supplier promptly and in writing. The seller shall have the right to reinspect the rejected shipment and resubmit the lot after removal of those packages not conforming to the specified requirements.

12. Certification

12.1 Test reports for the certified and index properties, if required by the specification, are to be provided with every order. These are typically referred to as material certifications.

13. Packaging and Package Marking

13.1 Each roll or panel shall be marked or labeled with the following:

13.1.1 Supplier's name and address,

13.1.2 Material or product description,

13.1.3 Size (length and width),

13.1.4 An individual alphanumeric designation to identify specifically this item from any other similar item (that is, serial number), and

13.1.5 Total weight.

13.2 *Rolled Material*—The material shall be rolled on a substantial core and packaged in a manner to ensure acceptance by common or other carriers for safe transportation to the point of delivery, unless otherwise specified in the contract or order.

13.3 *Folded Material*—The material shall be accordion folded onto a pallet and protected for shipment by common or other carriers for safe transportation to the point of delivery, unless otherwise specified in the contract or order.

13.4 Shipping containers shall be also be marked with the same information as rolls or panels whenever the tagged information on the rolls are covered by the packaging.

14. Keywords

14.1 flexible polypropylene; geomembrane; geosynthetic; landfill; pond liner; reservoir; thermoplastic olefin; thermoplastic polyolefin; TPO; water containment membrane

ANNEX

(Mandatory Information)

A1. OPTICAL METHOD FOR MEASUREMENT OF THICKNESS OF COATING OVER SCRIM (REINFORCING FABRIC) FOR REINFORCED GEOMEMBRANE

A1.1 *Scope*—This method measures the thickness of the coating over reinforcing fabric.

A1.2 Measurement Method

A1.2.1 *Principle*—The thickness of coating material over fiber, fabric, or scrim can be observed with a standard reflectance microscope. Measurement is made with a calibrated eyepiece.

A1.2.2 *Apparatus:*

A1.2.2.1 *Microscope,* 60× with reticle.

A1.2.2.2 *Light Source,* if light source on the microscope is not adequate, use a small high-intensity lamp.

A1.2.2.3 *Stage Micrometre,* 0.0254-mm divisions.

A1.2.3 *Calibration Procedure:*

A1.2.3.1 Place a standard reflectance stage micrometre in place of the specimen.

A1.2.3.2 Turn on the microscope light source.

A1.2.3.3 Position the reticle eyepiece and the micrometre such that the scales are superimposed. Focus the reticle by turning the eyepiece. Focus the specimen and reticle by turning the vertical adjustment knob.

A1.2.3.4 Locate a point at which both scales line up. Count the number of micrometre divisions away. Measure to the nearest 0.0125 mm. The calibration may be optimized by increasing the number of divisions measured.

A1.2.3.5 Repeat the calibration three times and average the results. A calibration example is given in A1.2.3.6.

A1.2.3.6 If four reticle divisions (RD) are found equal to 4.5 micrometre divisions (MD), then:

$$1(RD) = 4.5/4\ (MD)\ or\ 1\ (RD) = 1.125(MD) \qquad (A1.1)$$

A1.2.3.7 Since one micrometre division is also equal to 25.4 μm, therefore, 1(RD) = 28.6 μm or the calibration factor

A1.2.4 *Specimen Analysis:*

A1.2.4.1 Carefully center a sharp single-edge razor or equivalent over the fiber intersections along the *x–x* axis.

A1.2.4.2 Make a clean bias cut completely through the sheet.

A1.2.4.3 Remove the razor-cut section and mount in common putty with the cut surface facing upward.

A1.2.4.4 Observe the cut surface with the eyepiece reticle. Measure the thickness of the coating on either side of the thread intersection by counting the number of reticle divisions (to the nearest one-half division).

A1.2.4.5 Sample three areas of the coatings and average the results.

A1.3 Calculation and Report

A1.3.1 Multiply the number or reticle divisions representing the thickness of the coating by the calibration factor. Report the average results from the three areas of the coating to the nearest 12.7 μm.

A1.4 Precision and Bias

A1.4.1 *Precision*—Measurements are accurate to ±12.7 μm when the thickness is about 0.05 mm.

A1.4.2 *Bias*—Since there is no accepted reference material suitable for determining the bias for measuring coating thickness, no statement on bias is being made.