



## 2018 Standard Specification for Polypropylene Geomembranes

### 1. Scope

- 1.1 This specification covers reinforced (fPP-R) and unreinforced (fPP) flexible polypropylene 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 geomembrane shall be formulated from virgin flexible polypropylene, in amounts greater than 85%, by weight of the total polymer content. Virgin flexible polypropylene can include up to 10% reworked material from a processor's own production of the same geomembrane product that has been reground or pelletized after having been previously processed by molding, extrusion, etc. 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.
- 1.3 The compound shall not contain postconsumer (PCR) components or any other ingredients that could interfere with the long-term stability of the geomembrane.
- 1.4 This specification applies to any color of flexible polypropylene geomembrane, i.e., unreinforced and reinforced.
- 1.5 The tests and property limits used to characterize the index properties of the geomembranes in this standard are values intended to ensure minimum quality. In-place system design criteria, such as slope stability, wrinkles, interface strengths, elevated temperature performance, field-seam strength and material compatibility, among others, are factors that should be considered.
- 1.6 The values stated in SI units are to be regarded as standard. Imperial equivalents are provided for reference.
- 1.7 *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 Test Methods:

- 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
- D5721 Practice for Air-Oven Aging of Polyolefin Geomembranes
- D5884 Test Method for Determining Tongue 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 in sheet and at junction
- D7238 Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus
- D7613 Standard Specification for Flexible Polypropylene Reinforced (fPP-R) and Nonreinforced (fPP) Geomembranes
- G151 Standard Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources
- G154 Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials
- G155 Standard Practice for Operating Xenon Arc Light Apparatus for Exposure on Non-Metallic Materials

## 3. Terminology

- 3.1 *Definitions* – For definitions of terms used in this specification, refer to Terminologies D883 and D4439.
- 3.2 *Elongation at scrim break, min* – the elongation corresponding to the breaking load, that is, the maximum load.
- 3.3 *Factory prepared, ply adhesion strength* – D6636 measure the adhesion strength between reinforced geomembrane plies and utilizes the test to determine the force per unit width (adhesion strength) necessary to peel an individual ply from a laminated geomembrane material at an angle of 180 degrees.
- 3.4 *Linear dimensional stability/change* – D1204 is applicable to nonrigid thermoplastic sheeting or film made by the calendar or extrusion process. The test gives an indication of the degree of internal strains introduced during processing by -manufacturing.
- 3.5 *Low-temperature bend* – D2136 evaluates the ability of coated fabrics to withstand a prescribed bend at a given low temperature.
- 3.6 *Minimum Average* –the lowest acceptable average value for a given property for a conformance roll test.
- 3.7 *Nominal* – representative value of a measurable property determined under a set of conditions, by which a product may be described.
- 3.8 *Puncture resistance* – the inherent resisting mechanism of the test specimen to the failure by a

penetrating or puncturing object.

- 3.9 *Reinforced geomembrane* — a geomembrane internally reinforced with a scrim or textile.
- 3.10 *Scrim* – a lightweight textile made from woven or knitted yarns used to reinforce geomembrane.
- 3.11 *Thickness over scrim at yarn junction* – thickness of film overlying the reinforcing scrim where the yarns cross using Annex 1 in ASTM D7613.
- 3.12 *Tongue Tear strength* –sometimes referred to as trouser tear taking two legs and pulling them in different directions; the peak strength to tear the geomembrane.
- 3.13 *Yarn* – a generic term for a continuous strand of textile fibers, filaments or material in a form suitable for knitting, weaving or otherwise intertwining to form a textile fabric.

#### **4. Roll Appearance and Roll Quality**

- 4.1 *Appearance* – uniform color, texture, and appearance per side, e.g., matte v. glossy finish per side.
- 4.2 *Roll Quality* – free of defects or holes, no telescoping, consistent widths, no exposed scrim along the edges, particles of foreign matter, protruding fibers or reinforcement, undispersed raw material, nicks, voids, thin areas, delaminations, or other manufacturing defects that might adversely affect liquid.
- 4.3 The sheet shall be capable of being heat welded, fused, or adhesively bonded to itself for making watertight field splices and repairs.
- 4.4 Geomembrane can be reinforced with fabric or scrim or unreinforced.

#### **5. Test Methods and Frequency for Flexible Reinforced Polypropylene Geomembranes (Table 1)**

- 5.1 *Dimensions*—Test Methods D751, after permitting the sheet to relax at 23°C for 1 h.
- 5.2 *Thickness*—Test Method D5199
- 5.3 *Thickness of Coating Over Scrim (Reinforcing Fabric)*—Optical method described in Annex A1 of ASTM D7613
- 5.4 *Breaking Strength*—Test Method D7004
- 5.5 *Elongation at Break*—Test Method D7004
- 5.6 *Tongue Tear Strength*—Test Method D751 and D5884
- 5.7 *Low-Temperature Bend*—Test Method D2136 at -40°C
- 5.8 *Linear Dimensional Stability*—Test Method D1204
- 5.9 *Puncture Resistance*—Test Method D4833
- 5.10 *Factory Prepared Ply Adhesion Strength*—Test Method D6636
- 5.11 *Standard Practice for Air-Oven Aging of Polyolefin Geomembranes*—Test Method D5721
- 5.12 *Standard Practice for UV Exposure Aging of Polyolefin Geomembranes*—Test Methods D7238, G151, G154, G155

#### **6. Test Methods and Frequency for Flexible Unreinforced Polypropylene Geomembranes (Table 2)**

- 6.1 *Dimensions*—Test Methods D751, after permitting the sheet to relax at 23°C for 1 h.
- 6.2 *Thickness*—Test Method D5199
- 6.3 *Tensile Strength*—Test Method D6693
- 6.4 *Elongation at Break*—Test Method D6693

- 6.5 *Ultimate Elongation %*—Test Method D6693
- 6.6 *Graves Tears*—Test Method D1004
- 6.8 *Low-Temperature Bend*—Test Method D2136 at -40°C
- 6.9 *Linear Dimensional Stability*—Test Method D1204
- 6.10 *Puncture Resistance*—Test Method D4833
- 6.11 *Standard Practice for UV Exposure Aging of Polyolefin Geomembranes*—Test Methods D7238, G151, G154, G155
- 6.12 *Standard Practice for Air-Oven Aging of Polyolefin Geomembranes*—Test Method D5721

## **7. Material Properties**

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

## **8. Dimensions, Mass, and Permissible Variations**

- 8.1 The width and length of the sheet shall be agreed upon between the purchaser and the supplier.
- 8.2 The tolerance for both width and length of the sheet specimen shall be +3%, -1%.
- 8.3 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.

## **9. Quality Assurance and Quality Control**

- 9.1 The sheet, including any factory seams, shall be watertight and free of pinholes, particles of foreign matter, protruding fibers or reinforcement, undispersed raw material, nicks, cuts, voids, thin areas, delaminations, or any other manufacturing defects that may adversely affect serviceability.
- 9.2 Inspection of the material shall be agreed upon by all involved parties.
- 9.3 Failure to conform to any one of the requirements prescribed in this specification shall constitute grounds for rejection. A written rejection shall be reported to the material supplier in a prompt fashion. The material supplier shall have the right to re-inspect the rejected shipment and resubmit the lot after removal of those packages not conforming to the specified requirements.
- 9.4 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.

## **10. Packaging and Storage**

10.1 Please see **FGI-3-2012 - Guideline for Packaging, Handling, Storage, and Deployment of Fabricated Geomembrane Panels**, which was also converted to ASTM D7865-13 - Standard Guide for Identification, Packaging, Handling, Storage and Deployment of Fabricated Geomembrane Panels

## **11. Keywords**

11.1 flexible polypropylene; geomembrane; geosynthetic; landfill; pond liner; reservoir; thermoplastic olefin; thermoplastic polyolefin (TPO); water containment membrane fabricated, reinforced, unreinforced, seamed, scrim

**TABLE 1: Required Properties of Reinforced Flexible Polypropylene (fPP-R) Geomembranes**

**fPP-R Geomembrane Thickness, mm (in)**

Property Requirements	*Test Method	0.76 [30 mil]	0.91 [36 mil]	1.14 [45 mil]	1.52 [60 mil]
The geomembrane shall be formulated from virgin flexible polypropylene, in amounts greater than 85%, by weight of the total polymer content. Virgin flexible polypropylene can include plastic from a processor's own production of the same geomembrane product that has been reground or pelletized after having been previously processed by molding, extrusion, etc. 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.					
Thickness, nominal ( $\pm 10\%$ ), mm [mil/in]	D5199	0.76 [30/0.030]	0.91 [36/0.036]	1.14 [45/0.045]	1.52 [60/0.060]
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 at junction, minimum average, mm [in]	Annex A1 of ASTM D7613	0.20 [0.008]	0.25 [0.010]	0.33 [0.013]	0.46 [0.018]
Tensile breaking strength, minimum average, N [lbf]	D7004	750 [170]	890 [200]	1,100 [250]	1,100 [250]
Elongation at scrim break, minimum average, %	D7004	22	22	22	22
**Tongue Tear strength, minimum average in each direction, 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]
*Linear dimensional stability/change under 1 hour @ 100°C [212 °F] or 6 hours @ 70°C [158 °F], maximum change, %	*D1204	1.0	1.0	1.0	1.0
Puncture resistance, minimum average, N [lbf]	D4833	220 [50]	330 [75]	378 [85]	400 [90]
Factory prepared, ply adhesion strength, Film Tear Bond (FTB) <u>OR</u> minimum average, N/m [lbf/in]	D6636	2,630 [15]	2,630 [15]	2,630 [15]	2,630 [15]
*Properties after 10,000 hours of UV	*G151, G154, G155				
Retention of breaking strength, minimum, % of unaged material		85	85	85	85
Retention of elongation at break, minimum, % of unaged material		85	85	85	85
Retention of tearing strength, minimum, % of unaged material		60	60	60	60
Visual inspection, no cracks or crazing (10x)		Pass	Pass	Pass	Pass
*Properties after 2160 hours of heat aging at 85°C	*D5721				
Retention of breaking strength, minimum, % of unaged material		85	85	85	85
Retention of elongation at break, minimum, % of unaged		85	85	85	85
Retention of tearing strength, minimum, % of unaged material		60	60	60	60
Visual inspection, no cracks or crazing (10x)		Pass	Pass	Pass	Pass

**NOTES:**

\* This test is performed once per formulation not a quality control test.

\*\* Values of tongue tear should be discarded if any of the conditions are in Section 9.3 of ASTM D5884, e.g., bunching reinforcing fibers (as bunching may cause erroneously high values).

**TABLE 2: Physical Properties of Unreinforced Flexible Polypropylene (fPP) Geomembranes**

**fPP Geomembrane Thickness, mm (mils)**

<b>Property Requirements</b>	<b>*Test Method</b>	<b>0.76 [30 mil]</b>	<b>1.02 [40 mil]</b>	<b>1.52 [60 mil]</b>
Thickness, nominal ( $\pm 10\%$ ), mm [mil/in]	D5199	0.76 [30/0.030]	1.02 [40/0.040]	1.52 [60/0.060]
Thickness, minimum average, mm [mil/in]	D5199	0.68 [27/0.027]	0.91 [36/0.036]	1.35 [54/0.054]
Tensile breaking strength, minimum average, N [lbf]	D6693	10.5 [60]	10.5 [60]	17.0 [96]
Elongation at break, minimum average, %	D6693	700	700	700
Graves Tear Resistance, minimum, N [lbf]	D1004	44 [10]	53 [12]	80 [18]
*Low-temperature bend, °C [°F]	*D2136	-40 [-40]	-40 [-40]	-40 [-40]
*Linear dimensional stability or change under 1 hour @ 100°C [212 °F] or 6 hours @ 70°C [158 °F], maximum change, %	*D1204	3.0	3.0	3.0
Puncture resistance, minimum average, N [lbf]	D4833	110 [25]	133 [30]	180 [40]
*Properties after 10,000 hours of UV aging	*G151, G154, G155			
Retention of tensile breaking strength, minimum, % of unaged		85	85	85
Retention of elongation at break, minimum, % of unaged material		85	85	85
Retention of tearing strength, minimum, % of unaged material		60	60	60
Visual inspection, no cracks or crazing (10x)		Pass	Pass	Pass
*Properties after 2160 hours of heat aging at 85°C	*D5721			
Retention of tensile breaking strength, minimum, % of unaged		85	85	85
Retention of elongation at break, minimum, % of unaged material		85	85	85
Retention of tearing strength, minimum, % of unaged material		60	60	60
Visual inspection, no cracks or crazing (10x)		Pass	Pass	Pass

**NOTES:**

\* This test is performed once per formulation not a quality control test.

\*\* Values of tongue tear should be discarded if any of the conditions are in Section 9.3 of ASTM D5884, e.g., bunching reinforcing fibers (as bunching may cause erroneously high values).

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## ANNEX A1

### A1. OPTICAL METHOD FOR MEASUREMENT OF THICKNESS OF COATING OVER SCRIM (REINFORCING FABRIC) FOR REINFORCED FLEXIBLE POLYPROPYLENE GEOMEMBRANES

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:

$$1(\text{RD}) = 4.5/4 (\text{MD}) \quad \text{or} \quad (\text{A1.1})$$

$$1(\text{RD}) = 1.125 (\text{MD}) \quad (\text{A1.2})$$

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.