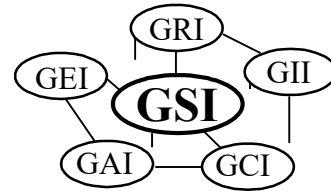


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## **GRI - GM17 Standard Specification\***

Standard Specification for

“Test Methods, Test Properties and Testing Frequency for  
Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes”<sup>SM</sup>

This specification was developed by the Geosynthetic Research Institute (GRI), with the cooperation of the member organizations for general use by the public. It is completely optional in this regard and can be superseded by other existing or new specifications on the subject matter in whole or in part. Neither GRI, the Geosynthetic Institute, nor any of its related institutes, warrant or indemnifies any materials produced according to this specification either at this time or in the future.

### 1. Scope

- 1.1 This specification covers linear low density polyethylene (LLDPE) geomembranes with a formulated sheet density of 0.939 g/ml, or lower, in the thickness range of 0.50 mm (20 mils) to 3.0 mm (120 mils). Both smooth and textured geomembrane surfaces are included.
- 1.2 This specification sets forth a set of minimum, maximum, or range of physical, mechanical and endurance properties that must be met, or exceeded by the geomembrane being manufactured.
- 1.3 In the context of quality systems and management, this specification represents manufacturing quality control (MQC).

Note 1: Manufacturing quality control represents those actions taken by a manufacturer to ensure that the product represents the stated objective and properties set forth in this specification.

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\*This GRI standard specification is developed by the Geosynthetic Research Institute through consultation and review by the member organizations. This specification will be reviewed at least every 2-years, or on an as-required basis. In this regard it is subject to change at any time. The most recent revision date is the effective version and it is kept current on the Institute’s Website <<geosynthetic-institute.org>>.

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- 14 This standard specification is intended to ensure good uniform quality LLDPE geomembranes for use in general applications.

Note 2: Additional tests, or more restrictive values for the tests indicated, may be necessary under conditions of a particular application. In this situation, interactions with the manufacturers are required.

Note 3: For information on installation techniques, users of this standard are referred to the geosynthetics literature, which is abundant on the subject.

## 2. Referenced Documents

### 21 ASTM Standards

- D 792 Specific Gravity (Relative Density) and Density of Plastics by Displacement
- D 1004 Test Method for Initial Tear Resistance of Plastics Film and Sheeting
- D 1238 Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
- D 1505 Test Method for Density of Plastics by the Density-Gradient Technique
- D 1603 Test Method for Carbon Black in Olefin Plastics
- D 4218 Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
- D 4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
- D 5199 Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
- D 5323 Practice for Determination of 2% Secant Modulus for Polyethylene Geomembranes
- D 5596 Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
- D 5617 Test Method for Multi-Axial Tension Test for Geosynthetics
- D 5721 Practice for Air-Oven Aging of Polyolefin Geomembranes
- D 5885 Test method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry
- D 5994 Test Method for Measuring the Core Thickness of Textured Geomembranes
- D 6370 Standard Test Method for Rubber-Compositional Analysis by Thermogravimetry (TGA)
- D 6693 Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
- D 7238 Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent Condensation Device
- D 7466 Test Method for Measuring the Asperity Height of Textured Geomembranes

D 8117 Standard Test Method for Oxidative Induction Time of Polyolefin  
Geosynthetics by Differential Scanning Calorimetry

- 22 U. S. Environmental Protection Agency Technical Guidance Document "Quality Control Assurance and Quality Control for Waste Containment Facilities," EPA/600/R-93/182, September 1993, 305 pgs.

3. Definitions

Manufacturing Quality Control (MQC) - A planned system of inspections that is used to directly monitor and control the manufacture of a material which is factory originated. MQC is normally performed by the manufacturer of geosynthetic materials and is necessary to ensure minimum (or maximum) specified values in the manufactured product. MQC refers to measures taken by the manufacturer to determine compliance with the requirements for materials and workmanship as stated in certification documents and contract specifications.

ref. EPA/600/R-93/182

Manufacturing Quality Assurance (MQA) - A planned system of activities that provides assurance that the materials were constructed as specified in the certification documents and contract specifications. MQA includes manufacturing facility inspections, verifications, audits and evaluation of the raw materials (resins and additives) and geosynthetic products to assess the quality of the manufactured materials. MQA refers to measures taken by the MQA organization to determine if the manufacturer is in compliance with the product certification and contract specifications for the project.

ref. EPA/600/R-93/182

Linear Low Density Polyethylene (LLDPE), n – A ethylene/ $\alpha$ -olefin copolymer having a linear molecular structure. The comonomers used to produce the resin can include 1-butene, 1-hexene, 1-octene or 4-methyl-1-pentene. LLDPE resins have a natural density in the range of 0.915 to 0.926 g/ml (ref. Pate, T. J. Chapter 29 in Handbook of Plastic Materials and Technology, I.I. Rubin Ed., Wiley, 1990).

Formulation - The mixture of a unique combination of ingredients identified by type, properties and quantity. For linear low density polyethylene geomembranes, a formulation is defined as the exact percentages and types of resin(s), additives and carbon black.

Nominal - Representative value of a measurable property determined under a set of conditions, by which a product may be described. Abbreviated as nom. in Tables 1 and 2.

4. Material Classification and Formulation

- 4.1 This specification covers linear low density polyethylene geomembranes with a formulated sheet density of 0.939 g/ml, or lower. Density can be measured by ASTM D1505 or ASTM D792. If the latter, Method B is recommended.

- 42 The polyethylene resin from which the geomembrane is made will generally be in the density range of 0.926 g/ml or lower, and have a melt index value per ASTM D1238 of less than or equal to 1.0 g/10 min. This refers to the natural, i.e., nonformulated, resin.
- 43 The resin shall be virgin material with no more than 10% rework. If rework is used, it must be of the same formulation (or other approved formulation) as the parent material.
- 44 No post consumer resin (PCR) of any type shall be added to the formulation.

5. Physical, Mechanical and Chemical Property Requirements

- 5.1 The geomembrane shall conform to the test property requirements prescribed in Tables 1 and 2. Table 1 is for smooth LLDPE geomembranes and Table 2 is for single and double sided textured LLDPE geomembranes. Each of the tables are given in English and SI (metric) units. The conversion from English to SI (metric) is “soft”. It is to be understood that the tables refer to the latest revision of the referenced test methods and practices.

Note 4: The tensile strength properties in this specification were originally based on ASTM D 638 which uses a laboratory testing temperature of  $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ . Since ASTM Committee D35 on Geosynthetics adopted ASTM D 6693 (in place of D 638), this GRI Specification followed accordingly. The difference is that D 6693 uses a testing temperature of  $21^{\circ}\text{C} \pm 2^{\circ}\text{C}$ . The numeric values of strength and elongation were not changed in this specification. If a dispute arises in this regard, the original temperature of  $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$  should be utilized for testing purposes.

Note 5: There are several tests sometimes included in other LLDPE geomembrane specifications which are omitted from this standard because they are outdated, irrelevant or generate information that is not necessary to evaluate on a routine MQC basis. The following tests have been purposely omitted:

- Volatile Loss
- Dimensional Stability
- Coeff. of Linear Expansion
- Resistance to Soil Burial
- Low Temperature Impact
- ESCR Test (D 1693 and D 5397)
- Wide Width Tensile
- Water Vapor Transmission
- Solvent Vapor Transmission
- Water Absorption
- Ozone Resistance
- Hydrostatic Resistance
- Tensile Impact
- Small Scale Burst
- Various Toxicity Tests
- Field Seam Strength

Note 6: There are several tests which are included in this standard (that are not customarily required in other LLDPE geomembrane specifications) because they are relevant and important in the context of current manufacturing processes. The following tests have been purposely added:

- Oxidative Induction Time
- Oven Aging
- Ultraviolet Resistance
- Asperity Height of Textured Sheet

Note 7: There are other tests in this standard, focused on a particular property, which are updated to current standards. The following are in this category:

- Thickness of Textured Sheet
- Tensile Properties, incl. 2% Secant Modulus
- Puncture Resistance
- Axi-Symmetric Break Resistance Strain
- Carbon Black Dispersion (In the viewing and subsequent quantitative interpretation of ASTM D 5596 only near spherical agglomerates shall be included in the assessment).

Note 8: The minimum average value of asperity height does not represent an expected value of interface shear strength. Shear strength associated with geomembranes is both site-specific and product-specific and should be determined by direct shear testing using ASTM D5321/ASTM D6243 as prescribed. This testing should be included in the particular site's CQA conformance testing protocol for the geosynthetic materials involved, or formally waived by the Design Engineer, with concurrence from the Owner prior to the deployment of the geosynthetic materials.

Note 9: When textured geomembrane with a weld edge is manufactured, the weld edge of the textured geomembrane should meet specification for thickness of the geomembrane per Tables 1a and 1b.

52 The values listed in the tables of this specification are to be interpreted according to the designated test method. In this respect they are neither minimum average roll values (MARV) nor maximum average roll values (MaxARV).

53 The various properties of the LLDPE geomembrane shall be tested at the minimum frequencies shown in Tables 1 and 2. If the specific manufacturer's quality control guide is more stringent, it must be followed in like manner.

Note 10: This specification is focused on manufacturing quality control (MQC). Conformance testing and manufacturing quality assurance (MQA) testing are at the discretion of the purchaser and/or quality assurance engineer, respectively. Communication and interaction with the manufacturer is strongly suggested.

## 6. Workmanship and Appearance

- 61 Smooth geomembrane shall have good appearance qualities. It shall be free from such defects that would affect the specified properties and hydraulic integrity of the geomembrane.
- 62 Textured geomembrane shall generally have uniform texturing appearance. It shall be free from such defects that would affect the specified properties and hydraulic integrity of the geomembrane.
- 63 General manufacturing procedures shall be performed in accordance with the manufacturer's internal quality control guide and/or documents.

## 7. MQC Sampling

- 71 Sampling shall be in accordance with the specific test methods listed in Tables 1 and 2. If no sampling protocol is stipulated in the particular test method, then test specimens shall be taken evenly spaced across the entire roll width.
- 72 The number of tests shall be in accordance with the appropriate test methods listed in Tables 1 and 2.
- 73 The average of the test results should be calculated per the particular standard cited and compared to the minimum value listed in these tables, hence the values listed are the minimum average values and are designated as "min. ave."

## 8. MQC Retest and Rejection

- 81 If the results of any test do not conform to the requirements of this specification, retesting to determine conformance or rejection should be done in accordance with the manufacturing protocol as set forth in the manufacturer's quality manual.

## 9. Packaging and Marketing

- 91 The geomembrane shall be rolled onto a substantial core or core segments and held firm by dedicated straps/slings, or other suitable means. The rolls must be adequate for safe transportation to the point of delivery, unless otherwise specified in the contract or order.
- 92 Marking of the geomembrane rolls shall be done in accordance with the manufacturer's accepted procedure as set forth in their quality manual.

10. Certification

- 10.1 Upon request of the purchaser in the contract or order, a manufacturer's certification that the material was manufactured and tested in accordance with this specification, together with a report of the test results, shall be furnished at the time of shipment.

**Table 1(a) – Linear Low Density Polyethylene (LLDPE) Geomembrane  
(SMOOTH)**

Properties	Test Method	Test Value								Testing Frequency (minimum)	
		20 mils	30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils		
Thickness - (min. ave.) - mils • lowest individual of 10 values - %	D5199	nom. -10	nom. -10	nom. -10	nom. -10	nom. -10	nom. -10	nom. -10	nom. -10	nom. -10	per roll
Formulated Density (max.) - g/cc	D 1505/D 792	0.939	0.939	0.939	0.939	0.939	0.939	0.939	0.939	0.939	200,00 lb
Tensile Properties (1) (min. ave.) • break strength - lb/in. • break elongation - %	D 6693 Type IV	76 800	114 800	152 800	190 800	228 800	304 800	380 800	456 800	800	20,000 lb
2% Modulus (max.) - psi	D 5323	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	per formulation
Tear Resistance (min. ave.) - lb	D 1004	11	16	22	27	33	44	55	66		45,000 lb
Puncture Resistance (min. ave.) - lb	D 4833	28	42	56	70	84	112	140	168		45,000 lb
Axi-Symmetric Break Resistance Strain (min.) - %	D 5617	30	30	30	30	30	30	30	30	30	per formulation
Carbon Black Content (range) - %	D 4218 (2)	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	45,000 lb
Carbon Black Dispersion	D 5596	note (3)	note (3)	note (3)	note (3)	note (3)	note (3)	note (3)	note (3)	note (3)	45,000 lb
Oxidative Induction Time (OIT) (min. ave.) (4) (a) Standard OIT - min. — or — (b) High Pressure OIT - min.	D 8117 D 5885	100 400	100 400	100 400	100 400	100 400	100 400	100 400	100 400	100 400	200,000 lb
Oven Aging at 85°C (5) (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 8117 D 5885	35 60	35 60	35 60	35 60	35 60	35 60	35 60	35 60	35 60	per formulation
UV Resistance (6) (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs (8)	D 7238 D 8117 D 5885	N. R. (7) 35	N.R. (7) 35	N.R. (7) 35	N.R. (7) 35	N.R. (7) 35	N.R. (7) 35	N.R. (7) 35	N.R. (7) 35	N.R. (7) 35	per formulation

- (1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
  - Break elongation is calculated using a gage length of 2.0 in. at 2.0 in./min.
- (2) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.
- (3) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
  - 9 in Categories 1 or 2 and 1 in Category 3
- (4) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
- (5) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
- (6) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
- (7) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
- (8) UV resistance is based on percent retained value regardless of the original HP-OIT value.



**Table 1(b) – Linear Low Density Polyethylene (LLDPE) Geomembrane  
(SMOOTH)**

Properties	Test Method	Test Value								Testing Frequency (minimum) per roll	
		0.50 mm	0.75 mm	1.00 mm	1.25 mm	1.50 mm	2.00 mm	2.50 mm	3.00 mm		
Thickness - (min. ave.) - mm • lowest individual of 10 values - %	D5199	nom. -10	nom. -10	nom. -10	nom. -10	nom. -10	nom. -10	nom. -10	nom. -10	nom. -10	per roll
Formulated Density (max.) - g/cc	D 1505/D 792	0.939	0.939	0.939	0.939	0.939	0.939	0.939	0.939	0.939	90,000 kg
Tensile Properties (1) (min. ave.) • break strength - N/mm • break elongation - %	D 6693 Type IV	13 800	20 800	27 800	33 800	40 800	53 800	66 800	80 800	80 800	9,000 kg
2% Modulus (max.) - MPa	D 5323	414	414	414	414	414	414	414	414	414	per formulation
Tear Resistance (min. ave.) - N	D 1004	50	70	100	120	150	200	250	300	300	20,000 kg
Puncture Resistance (min. ave.) - N	D 4833	120	190	250	310	370	500	620	750	750	20,000 kg
Axi-Symmetric Break Resistance Strain - % (min.)	D 5617	30	30	30	30	30	30	30	30	30	per formulation
Carbon Black Content (range) - %	D 4218 (3)	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	20,000 kg
Carbon Black Dispersion	D 5596	note (3)	note (3)	note (3)	note (3)	note (3)	note (3)	note (3)	note (3)	note (3)	20,000 kg
Oxidative Induction Time (OIT) (min. ave.) (4) (c) Standard OIT - min. — or — (d) High Pressure OIT - min.	D 8117 D 5885	100 400	100 400	100 400	100 400	100 400	100 400	100 400	100 400	100 400	90,000 kg
Oven Aging at 85°C (5) (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 8117 D 5885	35 60	35 60	35 60	35 60	35 60	35 60	35 60	35 60	35 60	per formulation
UV Resistance (6) (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs (8)	D 7238 D 8117 D 5885	N. R. (7) 35	N.R. (7) 35	N.R. (7) 35	N.R. (7) 35	N.R. (7) 35	N.R. (7) 35	N.R. (7) 35	N.R. (7) 35	N.R. (7) 35	per formulation

- (1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
  - Break elongation is calculated using a gage length of 50 mm at 50mm/min.
- (2) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.
- (3) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
  - 9 in Categories 1 or 2 and 1 in Category 3
- (4) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
- (5) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
- (6) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
- (7) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
- (8) UV resistance is based on percent retained value regardless of the original HP-OIT value.

**Table 2(a) – Linear Low Density Polyethylene (LLDPE) Geomembrane  
(TEXTURED)**

Properties	Test Method	Test Value								Testing Frequency (minimum)
		20 mils	30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils	
Thickness (min. ave.) - mils • lowest individual for 8 out of 10 values - % • lowest individual for any of the 10 values - %	D 5994	nom. -5% -10 -15	nom. -5% -10 -15	nom. -5% -10 -15	nom. -5% -10 -15	nom. -5% -10 -15	nom. -5% -10 -15	nom. -5% -10 -15	nom. -5% -10 -15	per roll
Thickness for weld edges (if applicable) (min. individual specimen (1))	D5199 Modified	nom -10%	nom -10%	nom -10%	nom -10%	nom -10%	nom -10%	nom -10%	nom -10%	Per roll
Asperity Height (min. ave.) - mils	D 7466	16	16	16	16	16	16	16	16	Every 2 <sup>nd</sup> roll (2)
Formulated Density (max.) - g/cc	D 1505/D 792	0.939	0.939	0.939	0.939	0.939	0.939	0.939	0.939	200,000 lb
Tensile Properties (3) (min. ave.) • break strength - lb/in. • break elongation - %	D 6693 Type IV	30 250	45 250	60 250	75 250	90 250	120 250	150 250	180 250	20,000 lb
2% Modulus – (max.) psi	D 5323	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	per formulation
Tear Resistance (min. ave.) - lb	D 1004	11	16	22	27	33	44	55	66	45,000 lb
Puncture Resistance (min. ave.) - lb	D 4833	22	33	44	55	66	88	110	132	45,000 lb
Axi-Symmetric Break Resistance Strain (min.) - %	D 5617	30	30	30	30	30	30	30	30	per formulation
Carbon Black Content - %	D 4218 (4)	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	45,000 lb
Carbon Black Dispersion	D 5596	note (5)	note (5)	note (5)	note (5)	note (5)	note (5)	note (5)	note (5)	45,000 lb
Oxidative Induction Time (OIT) (min. ave.) (6) (e) Standard OIT - min. — or — (f) High Pressure OIT - min.	D 8117 D 5885	100 400	100 400	100 400	100 400	100 400	100 400	100 400	100 400	200,000 lb
Oven Aging at 85°C (7) (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 8117 D 5885	35 60	35 60	35 60	35 60	35 60	35 60	35 60	35 60	per formulation
UV Resistance (8) (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs (10)	D 7238 D 8117 D 5885	N. R. (8) 35	N.R. (9) 35	N.R. (9) 35	N.R. (9) 35	N.R. (9) 35	N.R. (9) 35	N.R. (9) 35	N.R. (9) 35	per formulation

- (1) For textured geomembrane with a smooth weld edge, one specimen should be taken from each edge within 6” or 150mm of the edge of the geomembrane sheet. These individual specimen values should be reported separately from the textured geomembrane sheet thickness
- (2) Alternate the measurement side for double sided textured sheet
- (3) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
  - Break elongation is calculated using a gage length of 2.0 in. at 2.0 in./min.
- (4) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D4218 (muffle furnace) can be established.
- (5) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
  - 9 in Categories 1 or 2 and 1 in Category 3
- (6) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
- (7) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
- (8) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
- (9) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
- (10) UV resistance is based on percent retained value regardless of the original HP-OIT value.

**Table 2(b) – Linear Low Density Polyethylene (LLDPE) Geomembrane  
(TEXTURED)**

Properties	Test Method	Test Value								Testing Frequency (minimum)
		0.50 mm	0.75 mm	1.00 mm	1.25 mm	1.50 mm	2.00 mm	2.50 mm	3.00 mm	
Thickness (min. ave.) - mm • lowest individual for 8 out of 10 values • lowest individual for any of the 10 values	D 5994	nom. -5% -10 -15	nom. -5% -10 -15	nom. -5% -10 -15	nom. -5% -10 -15	nom. (5%) -10 -15	nom. -5% -10 -15	nom. -5% -10 -15	nom. -5% -10 -15	per roll
Thickness for weld edges (if applicable) (min. individual specimen (1))	D5199 Modified	nom -10%	nom -10%	nom -10%	nom -10%	nom -10%	nom -10%	nom -10%	nom -10%	Per roll
Asperity Height mm (min. ave.)	D 7466	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	Every 2 <sup>nd</sup> roll (2)
Formulated Density (max.) - g/cc	D 1505/D 792	0.939	0.939	0.939	0.939	0.939	0.939	0.939	0.939	90,000 kg
Tensile Properties (3) (min. ave.) • break strength - N/mm • break elongation - %	D 6693 Type IV	5 250	9 250	11 250	13 250	16 250	21 250	26 250	31 250	9,000 kg
2% Modulus (max.) - MPa	D 5323	414	414	414	414	414	414	414	414	per formulation
Tear Resistance (min. ave.) - N	D 1004	50	70	100	120	150	200	250	300	20,000 kg
Puncture Resistance – (min. ave.) - N	D 4833	100	150	200	250	300	400	500	600	20,000 kg
Axi-Symmetric Break Resistance Strain (min.) - %	D 5617	30	30	30	30	30	30	30	30	per formulation
Carbon Black Content (range) - %	D 4218 (4)	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	20,000 kg
Carbon Black Dispersion	D 5596	note (5)	note (5)	note (5)	note (5)	note (5)	note (5)	note (5)	note (5)	20,000 kg
Oxidative Induction Time (OIT) (min. ave.) (6) (g) Standard OIT - min. — or — (h) High Pressure OIT - min.	D 8117	100	100	100	100	100	100	100	100	90,000 kg
Oven Aging at 85°C (7) (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 8117 D 5885	35 35 60	35 35 60	35 35 60	35 35 60	35 35 60	35 35 60	35 35 60	35 35 60	per formulation
UV Resistance (8) (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs (10)	D 7238 D 8117 D 5885	N. R. (9) N. R. (9) 35	N. R. (9) N. R. (9) 35	N. R. (9) N. R. (9) 35	N. R. (9) N. R. (9) 35	N. R. (9) N. R. (9) 35	N. R. (9) N. R. (9) 35	N. R. (9) N. R. (9) 35	N. R. (9) N. R. (9) 35	per formulation

- (1) For textured geomembrane with a smooth weld edge, one specimen should be taken from each edge within 6” or 150mm of the edge of the geomembrane sheet. These individual specimen values should be reported separately from the textured geomembrane sheet thickness
- (2) Alternate the measurement side for double sided textured sheet
- (3) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
  - Break elongation is calculated using a gage length of 50 mm at 50 mm/min.
- (4) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D4218 (muffle furnace) can be established.
- (5) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
  - 9 in Categories 1 or 2 and 1 in Category 3
- (6) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
- (7) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
- (8) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
- (9) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
- (10) UV resistance is based on percent retained value regardless of the original HP-OIT value.

## **Adoption and Revision Schedule for GRI Test Method GM17**

- “Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes”
- Adopted: April 3, 2000
- Revision 1: June 28, 2000: added a new Section 5.2 that the numeric tables values are neither MARV nor MaxARV. They are to be interpreted per the designated test method. Also, corrected typographical error of textured sheet thickness test method designation from D5199 to D5994.
- Revision 2: December 13, 2000: added one Category 3 is allowed for carbon black dispersion. Also, unified terminology to “strength” and “elongation”.
- Revision 3: June 23, 2003: Adopted ASTM D 6693, in place of ASTM D 638, for tensile strength testing. Also, added Note 4.
- Revision 4: February 20, 2006: Added Note 9 on Asperity Height clarification with respect to shear strength.
- Revision 5: Removed recommended warranty from specification.
- Revision 6: June 1, 2009: Replaced GRI-GM12 test method for asperity height of textured geomembranes with ASTM D 7466.
- Revision 7: April 11, 2011: Added alternative carbon black test methods.
- Revision 8: October 3, 2011: Expanded types of comonomers in the definition of LLDPE.
- Revision 9: December 14, 2012: Replaced GRI-GM12 with the equivalent ASTM D 7238.
- Revision 10: November 14, 2014: Increased asperity height of textured sheet from 10 to 16 mils (0.25 to 0.40 mm).
- Revision 11: April 13, 2015: Unit conversion error was corrected for 0.75 mm (30 mil) thickness for the property of 2% modulus. The test value was changed from 370 N/mm to 315 N/mm in the SI (Metric) units tables to agree with the English units tables.
- Revision 12: November 4, 2015: Removed Footnote (1) on asperity height from tables.
- Revision 13: September 9, 2019: Editorial update to harmonize tables.
- Revision 14: March 17, 2021: Updated Standard OIT Test from ASTM D3895 to D8117.
- Revision 15: July 17, 2023: Changed units for ASTM D5323 2% Secant Modulus from N/m (lb/in) to MPa (psi) and added Note 9 about weld edge thickness.

Revision 16: October 4, 2024: Characterization of textured geomembrane with a smooth edge was clarified for thickness measurements in Tables 2a and 2b.