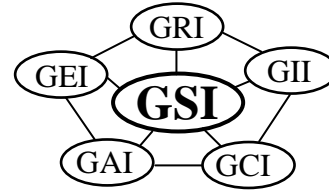


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Revision 3: April 21, 2008
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Revision schedule on pg. 11

GRI Test Method GM21*

Standard Specification for

“Test Methods, Properties, and Frequencies for Ethylene Propylene Diene Terpolymer (EPDM) Nonreinforced and Scrim Reinforced Geomembranes”

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1. Scope

- 1.1 This specification addresses ethylene propylene diene terpolymer (EPDM) geomembranes in nonreinforced and scrim reinforced forms, in thicknesses of 1.14 mm (45 mil) and 1.52 mm (60 mil).
- 1.2 This specification sets forth a set of minimum physical, mechanical and durability 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 (see definitions).

- 1.4 This standard specification is intended to ensure good quality and performance of EPDM geomembranes in general applications, but is possibly not adequate for the complete specification in a specific or unique situation. Additional tests, or more

* This GRI standard 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.

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restrictive values for the tests indicated, may be necessary under conditions of a particular application.

Note 2: For information on installation techniques, users of this standard are referred to the geosynthetics literature, which is abundant on the subject.

2. Referenced Documents

2.1 ASTM Standards

- D 412 Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension
- D 751 Test Methods for Coated Fabrics (thickness), (mass/unit area), (tongue tear), (grab), (hydrostatic resistance) and/or (bonded seam strength)
- D 1004 Test Method for Initial Tear Resistance of Plastics Film and Sheeting
- D 2137 Test Method for Rubber Property - Brittleness Point of Flexible Polymers and Coated Fabrics
- 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 5617 Test Method for Multi-Axial Tension of Geosynthetics
- D 5721 Practice for Air-Oven Aging of Polyolefin Geomembranes
- D 5884 Test Method for Determining Tearing Strength of Internally Reinforced Geomembranes
- G 26 Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials

2.2 GRI Standards

- GM 11 Accelerated Weathering of Geomembranes using a Fluorescent UVA-Condensation Exposure Device
- GM 16 Observation of Surface Cracking of Geomembranes

- ### 2.3 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. Also available in updated form as "Waste Containment Facilities: Guidance for CQA and CQC of Liner and Cover Systems," D. E. Daniel and R. M. Koerner, ASCE Press, 2007.

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

Formulation, n - The mixture of a unique combination of ingredients identified by type, properties and quantity. For ethylene propylene diene terpolymer (EPDM) geomembranes, a formulation refers to the exact percentages of resin, additives, and carbon black. It does not necessarily refer to individual suppliers of each ingredient. The individual suppliers must meet the manufacturer's internal quality control specification.

4. Material Classification and Formulation

4.1 This specification covers ethylene propylene diene terpolymer (EPDM) geomembranes.

4.2 This specification covers two-types of EPDM geomembranes: nonreinforced (smooth surface) geomembranes and scrim reinforced (undulating surface) geomembranes. Both types are available in two thicknesses; 1.14 mm (45 mil) and 1.52 mm (60 mil).

4.3 In the manufacturing and curing of EPDM no rework is permitted, once the EPDM membrane is cured in the autoclave it is impossible to add other cured product. When the product is cured it is then subjected to a visual inspection for surface defects including cracking and crazing. Should defects be subsequently found then that particular piece of geomembrane is written off as scrap.

5. Physical, Mechanical and Durability Property Requirements

5.1 The finished geomembrane shall conform to the test property requirements prescribed in either Tables 1 or 2. Table 1 is for nonreinforced EPDM geomembranes and Table 2 is for scrim reinforced EPDM geomembranes. Each of the tables are given in English and SI (metric) units. The conversion from English to SI (metric) units is "soft".

Note 3: There are several tests sometime included in other EPDM 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:

- Dimensional Stability
- Resistance to Soil Burial
- Water Absorption
- Durometer A Hardness
- Ozone Resistance

Note 4: There are several tests which are included in this standard that are not customarily required in other EPDM specifications because they are relevant and important in the context of current manufacturing processes. The following tests have been purposely added:

- Multiaxial Tension
- Ultraviolet Resistance (Xenon Arc)
- Ultraviolet Resistance (UV Fluorescent)

Note 5: 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
- Tensile Properties
- Tear Resistance
- Puncture Resistance
- Heat (Oven) Aging
- UV Fluorescent Light Exposure

Note 6: There is a GRI test currently included in this standard. This is necessary since the topic is not adequately covered by current ASTM or ISO standards. They are the following:

- Observation of Surface Cracking

5.2 The properties of the EPDM geomembrane shall be tested at the minimum frequency shown in Tables 1 or 2. If the specific manufacturer's quality control guide is more stringent and is certified accordingly, it must be followed in like manner.

Note 7: 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 organization, respectively (see Section 3 on Definition).

6. Workmanship and Appearance

- 6.1 Nonreinforced EPDM geomembrane shall have smooth uniform and consistent appearance qualities. It shall be free from defects including cracking and crazing that would affect the specified properties of the geomembrane.
- 6.2 Scrim reinforced EPDM geomembrane shall generally have a uniformly undulating surface appearance. It shall be free from cross-over yarns and defects including cracking and crazing that would affect the specified properties of the geomembrane.
- 6.3 General manufacturing procedures shall be performed in accordance with the manufacturer's internal quality control guide and/or documents.

7. MQC Sampling

- 7.1 Sampling shall be in accordance with the specific test methods listed in Tables 1 or 2 for the respective type of EPDM geomembrane. If no sampling protocol is stipulated in the particular test method, then test specimens shall be taken evenly spaced across the entire roll width.
- 7.2 The number of tests conducted shall be in accordance with the appropriate test methods listed in Tables 1 or 2.
- 7.3 The average of the test results should be calculated per the particular standard cited and compared to the minimum (or maximum) value listed in these tables, hence the values listed are generally the minimum average values and are designated as "min. ave."

8. MQC Retest and Rejection

- 8.1 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 control guide and/or documents.

9. Packaging and Storage

- 9.1 The finished geomembrane shall be folded in the machine direction in accordance with the roll width, and then rolled onto a stable core for handling storage and shipment. The manufacturer's identification label should be clearly visible on the core and in a manner consistent with established policy of the manufacturer.
- 9.2 Handling of the rolls of geomembrane shall be by forklift stinger, or by dedicated slings consistent with the weight of the rolls in a manner that does not result in physical damage to the geomembrane or core.
- 9.3 The rolls of geomembrane shall be stored at the manufacturer's facility in a neat and orderly fashion until shipment to the field site.

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) – Ethylene Propylene Diene Terpolymer (EPDM) – Nonreinforced

Property	Test Method	Test Value		Testing Frequency (minimum)
Thickness, mm (min. ave.) • lowest individual of 10 values	D 5199	1.14 -10%	1.52 -10%	20,000 kg
Tensile Properties ⁽¹⁾ • break strength, kN/m ² (min.) • break elongation, % (min.)	D 412	8300 500	8300 500	20,000 kg
Tear Resistance, N (min.)	D 1004	53	66	25,000 kg
Puncture Resistance, N (min.)	D 4833	133	178	25,000 kg
Multiaxial Tension • break elongation, % (min.)	D5617	100	100	per formulation ⁽²⁾
Brittleness Temperature, deg C (max.)	D2136	-45	-45	per formulation ⁽²⁾
Oven Aging at 100°C for 170 hours • % retained on tensile break strength • % retained on tensile break elongation • surface cracking at 7X magnification	D 5721 D 882 D 882 GM 16	90 75	90 75 no cracks	per formulation ⁽²⁾
UV Resistance (a) Xenon Arc for 2000 hours at 80°C • % retained on tensile break strength • % retained on tensile break elongation • surface cracking at 7X magnification -or- (b) UVA-Fluorescent after 7500 hours total testing time ⁽³⁾ • % retained on tensile break strength • % retained on tensile break elongation • surface cracking at 7X magnification	G 26 D 882 D 882 GM 16 D 7238 D 882 D 882 GM16	90 75	90 75 no cracks	per formulation ⁽²⁾

(1) machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens in each direction

(2) at least once per year or whenever formulation changes

(3) condition of the test should be 20 hours UV cycle at 75°C followed by 4 hours condensation at 60°C.

Table 1(b) – Ethylene Propylene Diene Terpolymer (EPDM) – Nonreinforced

Property	Test Method	Test Value		Testing Frequency (minimum)
Thickness, mil (min. ave.) • lowest individual of 10 values	D 5199	45 -10%	60 -10%	40,000 lb
Tensile Properties ⁽¹⁾ • break strength, lb/in. ² (min.) • break elongation, % (min.)	D 412	1200 500	1200 500	40,000 lb
Tear Resistance, lb (min.)	D 1004	12	15	50,000 lb
Puncture Resistance, lb (min.)	D 4833	30	40	50,000 lb
Multiaxial Tension • break elongation, % (min.)	D5617	100	100	per formulation ⁽²⁾
Brittleness Temperature, deg F (max.)	D2136	-49	-49	per formulation ⁽²⁾
Oven Aging at 100°C for 170 hours • % retained on tensile break strength • % retained on tensile break elongation • surface cracking at 7X magnification	D 5721 D 882 D 882 GM 16	90 75	90 75	per formulation ⁽²⁾ no cracks
UV Resistance (b) Xenon Arc for 2000 hours at 80°C • % retained on tensile break strength • % retained on tensile break elongation • surface cracking at 7X magnification -or- (b) UVA-Fluorescent after 7500 hours total testing time ⁽³⁾ • % retained on tensile break strength • % retained on tensile break elongation • surface cracking at 7X magnification	G 26 D 882 D 882 GM 16 D 7238 D 882 D 882 GM16	90 75	90 75	per formulation ⁽²⁾ no cracks

- (1) machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens in each direction
- (2) at least once per year or whenever formulation changes
- (3) condition of the test should be 20 hours UV cycle at 75°C followed by 4 hours condensation at 60°C.

Table 2(a) – Ethylene Propylene Diene Terpolymer (EPDM) – Scrim Reinforced

Property	Test Method	Test Value		Testing Frequency (minimum)
Thickness, mm (min. ave.) • lowest individual of 10 values	D 5199	1.14 -10%	1.52 -10%	20,000 kg
Tensile Properties ⁽¹⁾ • break strength, N (min.)	D 751	850	1100	20,000 kg
Tear Resistance, N ⁽²⁾ (min.)	D 5884	580	750	25,000 kg
Puncture Resistance, N (min.)	D 4833	270	350	25,000 kg
Brittleness Temperature, deg C (max.)	D2136	-45	-45	per formulation ⁽³⁾
Oven Aging at 100°C for 170 hours • % retained on tensile break strength • surface cracking a 7X magnification	D 5721 D 751 GM 16	90	90 no cracks	per formulation ⁽³⁾
UV Resistance (a) Xenon Arc for 2000 hours at 80°C • % retained on tensile break strength • surface cracking at 7X magnification -or- (b) UVA-Fluorescent after 7500 hours total testing time ⁽⁴⁾ • % retained on tensile break strength • surface cracking at 7X magnification	G26 G 751 GM 16 D 7238 D 751 GM 16	90	90 no cracks 90 no cracks	per formulation ⁽³⁾

(1) machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens in each direction

(2) the strength refers to prior fiber pullout

(3) at least once per year or whenever formulation changes

(4) condition of the test should be 20 hours UV cycle at 75°C followed by 4 hours condensation at 60°C.

English Units

Table 2(b) – Ethylene Propylene Diene Terpolymer (EPDM) – Scrim Reinforced

Property	Test Method	Test Value	Testing Frequency (minimum)
Thickness, mil (min. ave.) • lowest individual of 10 values	D 5199	45 60 -10% -10%	40,000 lb
Tensile Properties ⁽¹⁾ • break strength, lb (min.)	D 751	190 250	40,000 lb
Tear Resistance, lb ⁽²⁾ (min.)	D 5884	130 170	50,000 lb
Puncture Resistance, lb (min.)	D 4833	60 80	50,000 lb
Brittleness Temperature, deg F (max.)	D2136	-49 -49	per formulation ⁽³⁾
Oven Aging at 100°C for 170 hours • % retained on tensile break strength • surface cracking a 7X magnification	D 5721 D 751 GM 16	90 90 no cracks	per formulation ⁽³⁾
UV Resistance (b) Xenon Arc for 2000 hours at 80°C • % retained on tensile break strength • surface cracking at 7X magnification -or- (b) UVA-Fluorescent after 7500 hours total testing time ⁽⁴⁾ • % retained on tensile break strength • surface cracking at 7X magnification	G26 G 792 GM 16 D 7238 D 792 GM 16	90 90 no cracks 90 90 no cracks	per formulation ⁽³⁾

(1) machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens in each direction

(2) the strength refers to prior fiber pullout

(3) at least once per year whenever formulation changes

(4) condition of the test should be 20 hours UV cycle at 75°C followed by 4 hours condensation at 60°C.

**Adoption and Revision Schedule
for
EPDM Specification per GRI-GM21**

“Test Methods, Properties, and Frequencies for Ethylene Propylene Diene Terpolymer (EPDM)
Nonreinforced and Scrim Reinforced Geomembranes”

Adopted: October 17, 2003

Revision 1: July 10, 2006 - Removed recommended warranty from specification

Revision 2: May 14, 2007 - Decreased puncture resistance of nonreinforced sheet: 45 mil from 35 to 30 lb and 60 mil from 45 to 40 lb (1.14 mm from 150 to 133 N and 1.52 mm from 190 to 178 N)

Revision 3: April 21, 2008 – (i) Changed tensile test of nonreinforced sheet to D 412 and increased strength properties by \simeq 10%. (ii) Increased tear resistance by \simeq 33%. (iii) Increased testing interval for tear and puncture. (iv) Eliminated specific gravity from required test tables. (v) Changed units of break strength of EPDM to stress values. (vi) Updated text in an editorial manner.