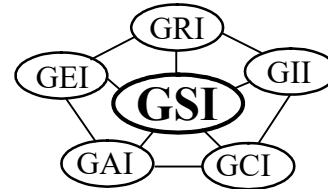


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GRI – GM39 Standard Specification

Standard Specification for

“Test Methods, Test Properties and Testing Frequency for
High Performance-High Density Polyethylene (HP-HDPE)”

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 It is completely optional in this regard and can be superseded by other existing or new specifications on the subject matter in whole or in part.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 high performance high density polyethylene (HP-HDPE) geomembranes with a formulated sheet density of 0.940 g/ml, or higher, in the thickness range of 1.5 mm (60 mils) to 3.0 mm (120 mils).
- 1.2 This specification sets forth a set of minimum, physical, mechanical and chemical properties that must be met, or exceeded by the geomembrane being manufactured. In a few cases a range is specified.
- 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.

- 1.4 This standard specification is intended to ensure good quality and performance of HP-HDPE geomembranes in general applications, but is possibly not adequate for the complete specification in a specific situation. Additional tests, or more restrictive values for test 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 792 Specific Gravity (Relative Density) and Density of Plastics by Displacement
- D 1004 Test Method for Initial Tear Resistance of Plastics Film and Sheet
- 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 3895 Test Method for Oxidative Induction Time of Polyolefins by Thermal Analysis
- D 4218 Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
- D4703 Standard Practice for Compression Molding Thermoplastic Materials into Test Specimens, Plaques, or Sheets
- 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
- D5322 Standard Practice for the laboratory Immersion Procedures for Evaluating the Chemical Resistance of Geosynthetics to Liquids
- D 5397 Procedure to Perform a Single Point Notched Constant Tensile Load – (SP-NCTL) Test: Appendix
- D 5596 Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin 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 UV Condensation Apparatus
- D 7466 Test Method for Measuring the Asperity Height of Textured Geomembranes
- D 8117 Test Method for Oxidative Induction Time of Polyolefins by Differential Scanning Calorimetry at Standard Pressure

2.2 CEN Standards

- EN 17096 Geosynthetics – Test method for the determination of the strain Hardening modulus of PE-HD geosynthetic barriers

2.3 TRI Standards

- TRI-GMDP Procedure for making thin films

2.4 Other References

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

Formulation - The mixture of a unique combination of ingredients identified by type, properties and quantity. For HD-HDPE 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 Table 1.

4. Material Classification and Formulation

4.1 This specification covers bimodal high performance high density polyethylene geomembranes with a formulated sheet density of 0.940 g/ml, or higher. Density can be measured by ASTM D1505 or ASTM D792. If the latter, Method B is recommended.

4.2 The polyethylene resin from which the geomembrane is made will generally be in the density range of 0.932 g/ml or higher, and have a melt index value per ASTM D1238 of less than or equal to 1.0 g/10 min.

4.3 The resin shall be manufactured with virgin material having **no** post-consumer recycled material, rework or regrind of any kind.

5.0 Physical, Mechanical and Chemical Property Requirements

- 5.1 The geomembrane shall conform to the test property requirements prescribed in Table 1.
- 5.2 The values listed in table 1 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).
- 5.3 The properties of the HP-HDPE geomembrane shall be tested at the minimum frequencies shown in Table 1. If the specific manufacturer's quality control guide is more stringent and is certified accordingly, it must be followed in like manner.
- 5.4 TRI-GMDP protocol for accelerated oxidation resistance testing used for all samples included the following steps.
 - Manufacturing of a 10-mil thin sample from the as-manufactured sample in accordance with ASTM D4703.
 - 48-hour leaching procedure in deionized, deaired water at 80°C.
 - Oven (ASTM D5721), QUVA (ASTM D7238) or Chlorine (ASTM D5322) aging.
 - Standard OIT and high pressure OIT testing before and after various intervals of exposure.

6. Workmanship and Appearance

- 6.1 The geomembrane shall have good appearance qualities. It shall be free from such defects that would affect the specified properties of the geomembrane.
- 6.2 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 Table 1. 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 shall be in accordance with the appropriate test methods listed in Table.
- 7.3 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

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 manual.

9. Packaging and Marketing

9.1 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.

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.

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SI (METRIC) UNITS

Table 1 – High Performance (HP) High Density Polyethylene (HDPE) Geomembrane -Smooth (1), (2) & (3)

Properties	Test Method	Test Value				Testing Frequency (minimum)
		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	per roll
Formulated Density (min. ave.) - g/cc	D 1505/D 792	0.940	0.940	0.940	0.940	90,000 kg
Tensile Properties (4) (min. ave.) • yield strength - kN/m • break strength - kN/m • yield elongation - % • break elongation - %	D 6693 Type IV	22 40 12 500	29 53 12 500	37 67 12 500	44 80 12 500	9,000 kg
Tear Resistance (min. ave.) - N	D 1004	187	249	311	374	20,000 kg
Puncture Resistance (min. ave.) - N	D 4833	480	640	800	960	20,000 kg
Stress Crack Resistance (5) - hr.	D 5397 (App.)	1000	1000	1000	1000	per each formulation
Strain Hardening performance (6) - MPa	EN17096	47	47	47	47	90,000 kg
Carbon Black Content (range) – (7) %	D 4218	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	9,000 kg
Carbon Black Dispersion – (8) Category	D 5596	1 or 2	1 or 2	1 or 2	1 or 2	20,000 kg
Oxidative Induction Time (OIT) (min. ave.) (a) Standard OIT - min. — and — (b) High Pressure OIT - min.	(TRI-GMDP): D 8117 D 5885	100 400	100 400	100 400	100 400	90,000 kg
Oven Aging at 85°C (9) (a) Standard OIT (min. ave.) - % retained after 350 hours — or — (b) High Pressure OIT (min. ave.) - % retained after 350 hours	(TRI-GMDP): D 5721 D 8117 D 5885	55 80	55 80	55 80	55 80	per each formulation
UV Resistance (10) High Pressure OIT (min. ave.) - % retained after 350 hrs (11)	(TRI-GMDP): D 7238 D 5885	50	50	50	50	per each formulation
Chlorine Aging at 10 PPM 50°C (9) (c) Standard OIT (min. ave.) - % retained after 350 hours — or — High Pressure OIT (min. ave.) - % retained after 350 hours	(TRI-GMDP): D 5322 D 8117 D 5885	55 80	55 80	55 80	55 80	per each formulation

- (1) No post-consumer recycled materials are permitted.
- (2) No internal recycled materials are permitted (i.e. reground edge trim).
- (3) Edges should be marked for welding and protected from exposure prior to welding.
- (4) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
 - Yield elongation is calculated using a gage length of 33 mm
 - Break elongation is calculated using a gage length of 51 mm
- (5) The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.
- (6) EN17096 strain hardening modulus (SHM) testing may be performed to verify resistance to stress cracking when correlation to ASTM D5397 has been documented in the following way. 20 samples of a given formulation and representing different lots of production must be tested using both procedures. All measured ASTM D5397 values must be greater than 1500 hours and the average values of the corresponding measured SHM measurements must be established as the required minimum SHM value to assure a 1000-hour stress crack resistance. The correlation of SHM measurements to ASTM D5397 measurements shall be established on each individual formulation and should be re-established on an annual basis.
- (7) 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.
- (8) Carbon black dispersion (only near spherical agglomerates) for
10 different views.
- (9) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
- (10) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
- (11) UV resistance is based on percent retained value regardless of the original HP-OIT value.

**Adoption and Revision Schedule
for
HDPE Specification per GRI-GM39**

“Test Methods, Test Properties, Testing Frequency for
High Performance High Density Polyethylene (HP-HDPE) Geomembranes”

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Revision 1: