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GRI GM42 Standard Specification

Standard Specification for

“Test Methods, Test Properties and Testing Frequency for
High Density Polyethylene (HDPE) Geomembrane used in Extreme Conditions”

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 It is completely optional in this regard and can be superseded by other existing or new specifications on the subject matter in whole or in part.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-density polyethylene (HDPE) geomembranes with a formulated sheet density of 0.945 g/ml, or higher, in the thickness range of 1.5 mm (60 mils) to 3.0 mm (120 mils). Both smooth and textured geomembranes are covered under this specification.
- 1.2 This specification sets forth a set of minimums, 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 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
- 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 GSI Standards

GRI - GM 40 Standard Procedure for Preparation of Film for Accelerated Oxidation Resistance Testing of Polyolefin Geomembranes

GRI - GM 41 Standard Procedure for Accelerated oxidation Resistance Testing of Polyolefin Geomembranes

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.

Extreme Conditions – Can endure exposure to intense solar radiation at high altitudes. Chemical resistance to a wide range of compounds, including strong acids and bases, reducing agents, oxidants, and solvents. The HDPE geomembrane made under this specification has shown satisfactory performance up to 180°F (82°C) and below -50°F (-46°C) for extended periods of time. Conditions where extended service lifetimes are necessary are in mining, hazardous waste landfills, and chemical processing applications.

4. Material Classification and Formulation

- 4.1 This specification covers high density polyethylene geomembranes with a formulated sheet density of 0.945 g/ml, or higher. Density can be measured by ASTM D1505 or ASTM D792.
- 4.2 The polyethylene resin from which the geomembrane is made should 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 no more than 2% rework. If rework is used, it must be the same formulation as the parent material. (i.e., edge trim only)
- 4.4 No post-consumer resin (PCR) of any type shall be added to the formulation. (ie., such as recycled or reclaimed polymer)

5.0 Physical, Mechanical and Chemical Property Requirements

- 5.1 The geomembrane shall conform to the test property requirements prescribed in Table 1 and Table 2.
- 5.2 The values listed in Table 1 and Table 2 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 HDPE geomembrane shall be tested at the minimum frequencies shown in Table 1 and Table 2. If the specific manufacturer's quality control guide is more stringent and is certified accordingly, it must be followed in like manner.
- 5.4 Base line OIT testing to be conducted after GRI-GM40 procedure.
- 5.5 Endurance testing (Oven Aging, UV Resistance and Chlorine Aging) to be conducted on samples after procedures GRI-GM40 (plaquing) and GRI-GM41 (annealing).

6. Workmanship and Appearance

- 6.1 The geomembrane shall have good appearance qualities. It shall be free from defects that would affect the specified properties of the geomembrane.
- 6.2 Textured geomembrane shall generally have uniform texturing appearance. It shall be free from agglomerated texturing material and defects 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 Table 1 and Table 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.
- 7.2 The number of tests shall be in accordance with the appropriate test methods listed in Table 1 and Table 2.
- 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.

SI (METRIC) UNITS

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

Properties	Test Method	Test Value				Testing Frequency (minimum)
		1.50 mm	2.00 mm	2.50 mm	3.00 mm	
Thickness - (min. ave.) - mm	D5199	nom.	nom.	nom.	nom.	per roll
Formulated Density (min. ave.) - g/cc	D 1505/D 792	0.945	0.945	0.945	0.945	90,000 kg
Tensile Properties (3) (min. ave.)	D 6693 Type IV	22	29	37	44	9,000 kg
• yield strength - kN/m		40	53	67	80	
• break strength - kN/m		12	12	12	12	
• yield elongation - %		500	500	500	500	
• break elongation - %						
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 (4) - hours With assumed yield stress at 20,700 kPa	D 5397 (App.)	1000	1000	1000	1000	semi-annual
Strain Hardening Modulus (5) (min. ave.)- MPa	EN17096	37	37	37	37	90,000 kg
Carbon Black Content (range) – (6) %	D 4218	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	9,000 kg
Carbon Black Dispersion – (7) Category	D 5596	1 or 2	1 or 2	1 or 2	1 or 2	20,000 kg
Oxidative Induction Time (OIT) (min. ave.) (8)	After GRI - GM40					
(a) Standard OIT - minutes — and —	D 8117	100	100	100	100	90,000 kg
(b) High Pressure OIT - minutes	D 5885	400	400	400	400	
Oven Aging at 85°C (9)	After GRI- GM40 & GM41					
(a) Standard OIT (min. ave.) - % retained after 350 hours — and —	D 5721 D 8117	55	55	55	55	per each formulation
(b) High Pressure OIT (min. ave.) - % retained after 350 hours	D 5885	80	80	80	80	
UV Resistance (9)	After GRI - GM40 & GM41					
High Pressure OIT (min. ave.) - % retained after 350 light hours	D 7238 D 5885	50	50	50	50	per each formulation
Chlorine Aging at 10 PPM 50°C (9)	After GRI - GM40 & GM41					
(a) Standard OIT (min. ave.) - % retained after 350 hours — and —	D 5322 D 8117	55	55	55	55	per each formulation
(b) High Pressure OIT (min. ave.) - % retained after 350 hours	D 5885	80	80	80	80	

- (1) No post-consumer recycled materials are permitted in the formulation of this geomembrane. Maximum 2% rework (i.e. edge trim) allowed back in formulation.
- (2) Edges should be marked for welding and protected from exposure prior to welding.
- (3) 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
- (4) The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.
- (5) 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.
- (6) 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.
- (7) Carbon black dispersion (only near spherical agglomerates) for 10 different views.
- (8) OIT Testing to be conducted on samples after GRI-GM40 procedure (plaquing).
- (9) All endurance exposures and subsequent testing to be conducted on samples after GRI-GM40 procedure (plaquing) and subsequent GRI-GM41 procedure (annealing).

Table 2 – High Density Polyethylene (HDPE) Geomembrane – Textured (1) & (2)

Properties	Test Method	Test Value				Testing Frequency (minimum)
		1.50 mm	2.00 mm	2.50 mm	3.00 mm	
Thickness for Textured Area of Sheet (min. ave.) - mm	D 5994	nom.	nom.	nom.	nom.	per roll
Thickness for weld edges (if applicable) (min. ave.) -mm (3)	D 5199 modified	nom.	nom.	nom.	nom.	per roll
Asperity Height mils (min. ave.) – mm (4)	D 7466	0.40	0.40	0.40	0.40	every 2 nd roll (2)
Formulated Density (min. ave.) - g/cc	D 1505/D792	0.945	0.945	0.945	0.945	90,000 kg
Tensile Properties (min. Ave.) (5) <ul style="list-style-type: none"> • yield strength - kN/m • break strength - kN/m • yield elongation - % • break elongation - % 	D 6693 Type IV	22 16 12 100	29 21 12 100	37 26 12 100	44 32 12 100	9,000 kg
Tear Resistance (min. ave.) - N	D 1004	187	249	311	374	20,000 kg
Puncture Resistance (min. ave.) - N	D 4833	400	534	667	800	20,000 kg
Stress Crack Resistance (6) - hours with assumed yield stress at 20,700 kPa	D 5397 (App.)	1000	1000	1000	1000	semi-annual
Strain Hardening Modulus (min. ave.) - MPa	EN 17096	37	37	37	37	90,000 kg
Carbon Black Content (range) - %	D 4218 (7)	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	9,000 kg
Carbon Black Dispersion (8)	D 5596	1 or 2	1 or 2	1 or 2	1 or 2	20,000 kg
Oxidative Induction Time (OIT) (min. ave.) (9) (a) Standard OIT - minutes — and — (b) High Pressure OIT - minutes	After GRI-GM40 D 8117 D 5885	 100 400	 100 400	 100 400	 100 400	 90,000 kg
Oven Aging at 85°C (10) (a) Standard OIT (min. ave.) -% retained after 350 hours — and — (b) High Pressure OIT (min. ave.) - % retained after 350 hours	After GRI-GM40 & GM41 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 light hours	After GRI-GM40 & GM41 D7238 D8117 D 5885	 50	 50	 50	 50	 per each formulation
Chlorine Aging at 10 PPM 50°C (10) (a) Standard OIT (min. ave.) - % retained after 350 hours — and — (b) High Pressure OIT (min. ave.) - % retained after 350 hours	After GRI - GM40 & GM41 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 in the foundation of this geomembrane. Maximum 2% rework (i.e. edge trim) allowed back in formulation.
- (2) Edges should be marked for welding and protected from exposure prior to welding.
- (3) For textured geomembrane with a smooth weld edge, one specimen should be taken from each edge within 150mm of the edge of the geomembrane sheet. These individual specimen values should be reported separately from the textured geomembrane sheet thickness
- (4) Alternate the measurement side for double sided textured sheet
- (5) 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 50 mm
- (6) The SP-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.
The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.
- (7) Other methods such as D1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D4218 (muffle furnace) can be established.
- (8) Carbon black dispersion (only near spherical agglomerates) for 10 different views.
- (9) OIT testing to be conducted on samples after GRI-GM40 procedure (plaquing)
- (10) All endurance exposures and subsequent testing to be conducted on samples after GRI-GM40 procedure (plaquing) and subsequent GRI-GM41 procedure (annealing).

**Adoption and Revision Schedule
for
Standard HDPE Specification per GRI-GM42**

“Test Methods, Test Properties, Testing Frequency for
High-Density Polyethylene (HDPE) Geomembranes used in Extreme Conditions”

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