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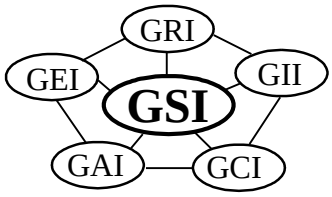

Revision 4: December 18, 2012
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GRI Test Method GM25*

Standard Specification for

"Test Methods, Test Properties and Testing Frequency for Reinforced Linear Low Density Polyethylene (LLDPE-R) Geomembranes"

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 It is completely optional in this regard and can be superseded by other existing or new specifications on the subject matter in whole or in part.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 reinforced linear low density polyethylene (LLDPE-R) geomembranes with a formulated sheet density of 0.939 g/ml, or lower, in three thickness categories arbitrarily listed as severe, moderate and standard. These categories reflect both varying thicknesses and mechanical property strength values.

Note 1: By "reinforced" is meant that fabric scrim providing enhanced mechanical properties is "sandwiched" between plys or layers of LLDPE sheet, thus the final products are composite materials.

Note 2: The three categories are meant to reflect handling, subgrade conditions, backfilling type and placement (if any), trafficking, equipment and maintenance. That said, they are admittedly qualitative in nature.

*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.

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 3: 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 uniform quality LLDPE-R geomembranes for use in general applications.

Note 4: Additional tests, or more restrictive values for the tests indicated, may be necessary under conditions of a particular application. In this situation, interactions between the purchaser/specifier and the manufacturer are required.

Note 5: For information on installation techniques, users of this standard are referred to the geosynthetics literature, which is abundant on the subject. Manufacturer's literature may also indicate product-specific considerations.

2. Referenced Documents

2.1 ASTM Standards

D 792 Specific Gravity (Relative Density) and Density of Plastics by Displacement
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 3895 Test Method for Oxidative Induction Time of Polyolefins by Thermal Analysis
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 5261 Test Method for Measuring Mass per Unit Area of Geotextiles
D 5721 Practice for Air-Oven Aging of Polyolefin Geomembranes
D 5884 Test Method for Determining Tearing Strength of Internally Reinforced Geomembranes
D 5885 Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry
D 6636 Test Method for Determination of Ply Adhesion Strength of Reinforced Geomembranes

D 7004 Test Method for Grab Tensile Properties of Reinforced Geomembranes
D 7238 Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus

2.2 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/α-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).

Note 6: The use of low density polyethylene (LDPE) is specifically excluded from use as the resin to which this specification is addressed. By virtue of its different polymerization method it results in numerous branches which are not desired in the material. The identification of LDPE (versus the desired LLDPE) can be made by use of differential scanning colorimetry (DSC) melting point testing.

Formulation, n – 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, additives and carbon black.

Minimum Average (min. ave.), n – The minimum value of a set of average readings. For example, thickness is measured in several locations across a roll width to get an "average" value. When reporting on a number of rolls, as in a shipment for a particular project, the "minimum average" roll value defines "min. ave.".

4. Material Classification and Formulation

4.1 This specification covers linear low density polyethylene geomembrane plys 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.

4.2 The polyethylene resin from which the geomembrane is made will generally be in the density range of 0.926 g/ml or lower. This refers to the natural, i.e., nonformulated, resin.

4.3 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.

4.4 No post consumer resin (PCR) of any type shall be added to the formulation.

4.5 For reinforced linear low density polyethylene (LLDPE-R) geomembranes, a fabric reinforcement (also called "scrim") shall be present so as to give the desired specification values to be presented in the next section.

Note 7: Fabric scrim is available in many patterns and configurations. The yarns are usually made from high tenacity polyester resin. Reinforced geomembranes are sometimes referred to as "supported" geomembranes.

5. Physical, Mechanical and Endurance Property Requirements

5.1 The geomembrane shall conform to the test property requirements prescribed in Tables 1 and 2. Table 1 is for LLDPE-R geomembranes in U.S. (English) Units and Table 2 is for LLDPE-R geomembranes in SI (metric) units. The conversion from U.S. (English) to SI (metric) is "soft". It is also to be understood that the tables refer to the latest revision of the referenced test methods and practices.

Note 8: There are several tests sometimes included in other 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:

- Melt Index
- 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
- Seam Tests
- Water Vapor Transmission
- Solvent Vapor Transmission
- Water Absorption
- Ozone Resistance
- Hydrostatic Resistance
- Tensile Impact
- Multiaxial Burst
- Small Scale Burst
- Various Toxicity Tests

Note 9: There are several tests which are included in this standard (that are not customarily required in other geomembrane specifications) because they are relevant and important in the context of current manufacturing processes. The following endurance tests have been purposely added:

- Oxidative Induction Time
- Oven Aging
- Ultraviolet Resistance

5.2 The values listed in the tables of this specification are to be interpreted according to the designated test method. The physical and mechanical properties are all "min. ave." values. See the definition section for this interpretation. In this respect they are neither minimum average roll values (MARV) nor maximum average roll values (MaxARV).

5.3 The various properties of the LLDPE-R 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

6.1 Scrim reinforced LLDPE-R geomembrane shall generally have a uniform undulating appearance. It shall be essentially free from irregular yarns, yarns that are bunched together, yarns crossing over one another, and such defects that mechanically affect the specified properties of the geomembrane. Strictly cosmetic flaws that do not affect specified properties are generally acceptable.

6.2 For LLDPE-R geomembranes there shall be no exposed scrim except at the roll ends. A 0.375 ± 0.25 in. (10 ± 6 mm) edge encapsulation on each side is required.

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 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.

7.2 The number of tests shall be in accordance with the appropriate test methods listed in Tables 1 and 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.

9.2 Marking of the geomembrane rolls shall be done in accordance with the manufacturers 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.

U. S. (English) Units

Table 1 – Specification Values for Scrim Reinforced Linear Low Density Polyethylene (LLDPE-R) Geomembranes

Property and Units	ASTM Test Method	Category 1 – Severe	Category 2 – Moderate	Category 3 – Standard	Testing Frequency Minimum
Thickness	D5199				
Nominal (mils)	-	45	36	24	per roll
min. ave. (mils)	-	40	32	20	
Weight	D5261				
Nominal (lb/1000 ft^2)	-	210	168	112	per roll
min. ave. (lb/1000 ft^2)	-	189	151	101	
Grab Tensile	D7004				
Strength (lb), min. ave.	(each direction)	250	200	150	30,000 lb
Elongation (%), min. ave.	(each direction)	22	22	22	30,000 lb
Tongue Tear (lb), min. ave.	D5884 (each direction)	55	55	55	30,000 lb
Index Puncture (lb), min. ave.	D4833	85	75	65	30,000 lb
Ply Adhesion (lb), min. ave.[1]	D6636	20	20	20	30,000 lb
Oxidative Induction Time (OIT)[2]					
(a) Standard OIT	D3895	←	100	→	formulation
—or—					
(b) High Pressure OIT	D5885		400		
Oven Aging at 85°C[2]	D5721				
(a) Standard OIT - % retained after 90 days[3]	D3895	←	35	→	formulation
—or—					
(b) High Pressure OIT - % retained after 90 days[3]	D5885		60		
UV Resistance[4][5]	D7238				
(a) Standard OIT[6]	D3895	←	N/R[5]	→	formulation
—or—					
(b) High Pressure OIT - % retained after 1600 hours	D5885		35		

Notes:

(1) Alternatively, an acceptable ply adhesion is to have a film tearing bond occur within the sheet material.

(2) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant effectiveness in the geomembrane.

(3) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(4) UV resistance is based on percent retained value regardless of the original HP-OIT value.

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

(6) 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.

SI (Metric) Units

Table 2 – Specification Values for Scrim Reinforced Linear Low Density Polyethylene (LLDPE-R) Geomembranes

Property and Units	ASTM Test Method	Category 1 – Severe	Category 2 – Moderate	Category 3 – Standard	Testing Frequency Minimum
Thickness	D5199				
Nominal (mm)	-	1.14	0.91	0.61	per roll
min. ave. (mm)	-	1.02	0.81	0.51	
Weight	D5261				
Nominal (g/m^2)	-	10.0	8.0	5.4	per roll
min. ave. (g/m^2)	-	9.1	7.2	4.8	
Grab Tensile	D7004				
Strength (N), min. ave.	(each direction)	1100	890	670	15,000 kg
Elongation (%), min. ave.	(each direction)	22	22	22	15,000 kg
Tongue Tear (N), min. ave.	D5884 (each direction)	240	240	240	15,000 kg
Index Puncture (N), min. ave.	D4833	380	330	290	15,000 kg
Ply Adhesion (N), min. ave.[1]	D6636	90	90	90	15,000 kg
Oxidative Induction Time (OIT)[2]					
(a) Standard OIT	D3895	←	100	→	formulation
—or—					
(b) High Pressure OIT	D5885		400		
Oven Aging at 85°C[2]	D5721				
(a) Standard OIT - % retained after 90 days[3]	D3895	←	35	→	formulation
—or—					
(b) High Pressure OIT - % retained after 90 days[3]	D5885		60		
UV Resistance[4][5]	D7238				
(a) Standard OIT[6]	D3895	←	N/R[5]	→	formulation
—or—					
(b) High Pressure OIT - % retained after 1600 hours	D5885		35		

Notes:

(1) Alternatively, an acceptable ply adhesion is to have a film tearing bond occur within the sheet material.

(2) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant effectiveness in the geomembrane.

(3) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(4) UV resistance is based on percent retained value regardless of the original HP-OIT value.

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

(6) 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.

REVISION SCHEDULE

GRI-GM25

Test Methods, Test Properties and Testing Frequency for Reinforced Linear Low Density Polyethylene (LLDPE-R) Geomembranes

Adopted: September 18, 2009

Revision 1: September 28, 2009: Allowed for "film tearing bond" in ply adhesion testing and adjustment of table footnotes

Revision 2: January 18, 2010: Corrected misprint of HP-OIT 1600 days to 1600 hours

Revision 3: October 3, 2011: Expanded types of comonomers in the definition of LLDPE.

Revision 4: December 18, 2012: Added Note 2.