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GRI – GM34 Standard Specification*

Standard Specification for

“Test Methods, Test Properties and Testing Frequency for
Ethylene Interpolymer Alloy (EIA=PVC+KEE) 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 It is completely optional in this regard and can be superseded by other existing or new specifications on the subject matter in whole or in part.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 Ethylene Interpolymer Alloy (EIA=PVC+KEE) geomembranes with nominal thicknesses of 0.76 mm (30 mil), 0.91 mm (36 mil), 1.13 mm (45 mil) and 1.52 mm (60 mil). The material is neither smooth nor textured. It generally has either a file or satin finish on each surface and indentations because of geomembrane ply’s meeting between scrim intersections.
- 1.2 This specification sets forth a set of minima, physical, mechanical, chemical and endurance properties that must be met, or exceeded by the geomembrane being manufactured. In a few cases a range is specified. The EIA geomembranes made under this classification are formulated with Poly Vinyl Chloride (PVC) resin and are not primarily stabilized with liquid plasticizers. They are stabilized with Ketone-Ethylene-Ester (KEE) which is a polymeric plasticizer.
- 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.

*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>>. **Copyright © 2023 Geosynthetic Institute - All Rights Reserved**

- 1.4 This standard specification is intended to ensure good quality and performance of EIA geomembranes in general applications but is possibly not adequate for the complete specification in a specific situation. Additional tests, or more restrictive values for the 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 geosynthetic open literature, which is abundant on the subject. It should be mentioned that the specification identifies three categories (severe, moderate and typical) within each of the four thicknesses. These 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.

2. Referenced Documents

ASTM Standards

D 751 Test Methods for Coated Fabrics
D 882 Standard Test Method for Tensile Properties of Thin Plastic Sheeting
D1204 Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature
D 4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
D 4873 Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
D 5721 Standard Practice for Air-Oven Aging of Polyolefin Geomembranes
D 5884 Standard Test Method for Determining Tearing Strength of Internally Reinforced Geomembranes
D 6636 Determination of Ply Adhesion Strength of Reinforced Geomembranes
D 7238 Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus
D 7865 Guide for Identification, Packaging, Handling, Storage and Deployment of Fabricated Geomembrane Panels
D 8154 Standard Test Methods for H-NMR Determination of Ketone-Ethylene-Ester and Polyvinyl Chloride Contents in KEE-PVC Roofing Fabrics

GRI Standards

GM 16 Test Method for Observation of Surface Cracking of Geomembranes
GM24 Practice for Incubation and Subsequent Evaluation of Single 180° and Double 180° Folding of Geomembranes

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 follows 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.

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 1a and 1b.

4. Material Classification and Formulation

4.1 The resin shall be virgin material with no more than 10% rework. If rework is used, it must be like the parent material.

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

4.3 DOW makes over 25 KEES, which they brand as ELVALOY™. Five of which are routinely mixed with PVC to form EIA geomembranes for various applications. EIA geomembrane applications vary from the containment of potable water to hydrocarbons. This specification is silent in regard to application and specific KEE type.

5. Physical, Mechanical and Chemical Property Requirements

- 5.1 The geomembrane shall conform to the test property requirements prescribed in Table 1a and 1b.

Note 3: There are several tests often included in other EIA 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, Water Absorption, Ozone Resistance, Coefficient of Linear Expansion, Modulus of Elasticity, Resistance to Soil Burial, Low Temperature Impact, Tensile Impact, Stress Cracking, Seam Strength, Wide Width Tensile, Multi-Axial Burst, Water Vapor Transmission and Various Toxicity Tests.

- 5.2 The values listed in the table of this specification are to be interpreted according to the designated test method.
- 5.3 This specification is structured around the geomembrane having at least a standard 9 X 9 polyester reinforced fabric scrim at its core (i.e., in the middle of its cross section). The scrim should be encapsulated. The scrim should not be exposed from the geomembrane plies, nor shall it be folded upon itself. Most manufacturers of EIA geomembranes have a stable of scrims with varying strengths to satisfy any customers' request.
- 5.4 The properties of the EIA geomembrane shall be tested at the minimum frequencies shown in Table 1a and 1b. If the specific manufacturer's quality control guide is more stringent and is certified accordingly, it must be followed in like manner.

6. Workmanship and Appearance

- 6.1 All geomembranes shall have good appearance qualities. It shall be free from such defects that would affect the specified properties of the geomembrane. It shall be free from agglomerates or unevenness.
- 6.2 The scrim should be continuous and centered within the cross section of the material. Encapsulation may be necessary for some geomembranes made with non-coated scrim.
- 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 1a and 1b. If no sampling protocol is stipulated in the 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 1a and 1b.
 - 7.3 The average of the test results should be calculated per the standard cited and compared to the minimum value listed in the table, hence the values listed are the minimum average values and are designated as "min. ave." unless otherwise indicated (i.e., max ave. or range)
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, Handling, Identification and Storage
- 9.1 The rolls must be adequately protected for safe transportation to the point of delivery, unless otherwise specified in the contract or order.
 - 9.2 The geomembrane shall be rolled onto a substantial core or core segments and held firm by dedicated straps/slings, or other suitable means. Packaging, Handling, Identification and Storage of the materials should be done in accordance with ASTM D4873 and D7865.
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 1a – Poly Vinyl Chloride-Ethylene Interpolymer Alloy (PVC-EIA) Geomembrane (ENGLISH UNITS)

System Properties (Composite EIA plus scrim)	Test Method	English Imperil			English Imperil			English Imperil			English Imperil			Testing Frequency (minimum)
		30 mil			36 mil			45 mil			60 mil			
Thickness (min. ave.) - mils • lowest individual of 10 values - %	D751	nom. -10			nom. -10			nom. -10			nom. -10			per roll
Fabric Scrim Type	NA	Polyester			Polyester			Polyester			Polyester			per roll
Finished Coated Mass/Unit Area (min. ave.)	D 751	28 osy			30 osy			40 osy			56 osy			per roll
CONDITION (1)	-----	S	M	T	S	M	T	S	M	T	S	M	T	-----
Grab Tensile Properties (min. ave.) (2) • strength • elongation	D751	200 lbs. 20%	200 lbs. 20%	200lbs. 20%	200 lbs. 20%	200 lbs. 20%	200 lbs. 20%	250 lbs. 20%	250 lbs. 20%	250 lbs. 20%	250 lbs. 20%	250 lbs. 20%	250 lbs. 20%	50,000 lbs.
Trouser Tear Resistance (min. ave.) (2)	D 5884	35 lbs.	30 lbs.	25 lbs.	55 lbs.	50 lbs.	45 lbs.	60 lbs.	55 lbs.	50 lbs.	65 lbs.	60 lbs.	55 lbs.	50,000 lbs.
Hydrostatic Burst (min. ave.)	D 751	350 psi	300 psi	250 psi	550 psi	500 psi	450 psi	700 psi	650 psi	600 psi	800 psi	750 psi	700 psi	50,000 lbs.
Puncture Resistance (min. ave.)	D 4833	125 lbs.	100 lbs.	75 lbs.	200 lbs.	175 lbs.	150 lbs.	275 lbs.	250 lbs.	225 lbs.	300 lbs.	275 lbs.	250 lbs.	50,000 lbs.
Ply Adhesion (min. ave.) (2)	D6636	15 lbs./in.			15 lbs./in.			20 lbs./in.			20 lbs./in.			50,000 lbs.
Dimensional Stability (max. ave.) (3)	D 1204	1.0%			1.0%			1.0%			1.0%			50,000 lbs.
EIA Only Properties														
1H-NMR Determination of PVC and KEE content	D 8154	PVC 30% KEE 10%			PVC 30% KEE 10%			PVC 30% KEE 10%			PVC 30% KEE 10%			per each formulation
Chlorinated water resistance star fold at 50°C (4&6) Pass/Fail after 90 days by GRI GM16 and ASTM D882 strip tensile properties	GRI GM24	Pass (i.e., no cracks observed) retained 80%			Pass (i.e., no cracks observed) retained 80%			Pass (i.e., no cracks observed) retained 80%			Pass (i.e., no cracks observed) retained 80%			per each formulation
Oven Aging at 85°C (6) Pass/Fail after 90 days by GRI GM16 and ASTM D882 strip tensile properties	D 5721	Pass (i.e., no cracks observed) retained 80%			Pass (i.e., no cracks observed) retained 80%			Pass (i.e., no cracks observed) retained 80%			Pass (i.e., no cracks observed) retained 80%			per each formulation
UV Resistance (5&6) Pass/Fail after 10,000 light hours by GRI GM16 and ASTM D882 strip tensile properties	D 7238	Pass (i.e., no cracks observed) retained 80%			Pass (i.e., no cracks observed) retained 80%			Pass (i.e., no cracks observed) retained 80%			Pass (i.e., no cracks observed) retained 80%			per each formulation

- (1) (S) Severe, (M) Moderate, (T) Typical
- (2) Regardless of machine direction (MD) or cross machine direction (XMD).
- (3) Incubated at 100°C ± 1°C for one hour.
- (4) Incubated at 50°C ± 1°C at 10 ppm chlorine concentration in distilled deionized water. Samples are dried and solution is changed once a week during incubation.
- (5) The conditions of the UV Fluorescent exposure method should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
- (6) Tested on unreinforced geomembrane specimens (EIA Only) via ASTM D882

Table 1b – Poly Vinyl Chloride-Ethylene Interpolymer Alloy (PVC-EIA) Geomembrane (SI METRIC UNITS)

System Properties (Composite EIA plus scrim)	Test Method	Metric			Metric			Metric			Metric			Testing Frequency (minimum)
		0.76 mm			0.91 mm			1.13 mm			1.52 mm			
Thickness (min. ave.) - mils • lowest individual of 10 values - %	D751	nom. -10			nom. -10			nom. -10			nom. -10			per roll
Fabric Scrim Type	NA	Polyester			Polyester			Polyester			Polyester			per roll
Finished Coated Mass/Unit Area (min. ave.)	D 751	949 g/m2			1017 g/m2			1356 g/m2			1899 g/m2			per roll
CONDITION (1)	----	S	M	T	S	M	T	S	M	T	S	M	T	----
Grab Tensile Properties (min. ave.) (2) • strength • elongation	D751	890 N 20%	890 N 20%	890 N 20%	890 N 20%	890 N 20%	890 N 20%	1112 N 20%	1112 N 20%	1112 N 20%	1112 N 20%	1112 N 20%	1112 N 20%	22,680 kg
Trouser Tear Resistance (min. ave.) (2)	D 5884	156 N	133 N	111 N	245 N	222 N	200 N	267 N	245 N	222 N	289 N	267 N	245 N	22,680 kg
Hydrostatic Burst (min. ave.)	D 751	2413 kPa	2068 kPa	1723 kPa	3792 kPa	3447 kPa	3102 kPa	4826 kPa	4481 kPa	4137 kPa	5516 kPa	5171 kPa	4826 kPa	22,680 kg
Puncture Resistance (min. ave.)	D 4833	556 N	444 N	334 N	890 N	778 N	667 N	1223 N	1112 N	1001 N	1334 N	1223 N	1112 N	22,680 kg
Ply Adhesion (min. ave.) (2)	D6636	2.6 N/mm			2.6 N/mm			3.5 N/mm			3.5 N/mm			22,680 kg
Dimensional Stability (max. ave.) (2)	D 1204	1.0%			1.0%			1.0%			1.0%			22,680 kg
EIF Only Properties														
IH-NMR Determination of PVC and KEE content	D 8154	PVC 30% KEE 10%			PVC 30% KEE 10%			PVC 30% KEE 10%			PVC 30% KEE 10%			per each formulation
Chlorinated water resistance star fold at 50°C (4&6) Pass/Fail after 90 days by GRI GM16 and ASTM D882 grab tensile properties	GRI GM24	Pass (i.e., no cracks observed) retained 80%			Pass (i.e., no cracks observed) retained 80%			Pass (i.e., no cracks observed) retained 80%			Pass (i.e., no cracks observed) retained 80%			per each formulation
Oven Aging at 85°C (6) Pass/Fail after 90 days by GRI GM16 and ASTM D822 strip tensile properties	D 5721	Pass (i.e., no cracks observed) retained 80%			Pass (i.e., no cracks observed) retained 80%			Pass (i.e., no cracks observed) retained 80%			Pass (i.e., no cracks observed) retained 80%			per each formulation
UV Resistance (5&6) Pass/Fail after 10,000 light hours by GRI GM16 and ASTM D882 strip tensile properties	D 7238	Pass (i.e., no cracks observed) retained 80%			Pass (i.e., no cracks observed) retained 80%			Pass (i.e., no cracks observed) retained 80%			Pass (i.e., no cracks observed) retained 80%			per each formulation

- (1) (S) Severe, (M) Moderate, (T) Typical
- (2) Regardless of machine direction (MD) or cross machine direction (XMD).
- (3) Incubated at 100°C ± 1°C for one hour.
- (4) Incubated at 50°C ± 1°C at 10 ppm chlorine concentration in distilled deionized water. Samples are dried and solution is changed once a week during incubation.
- (5) The conditions of the UV Fluorescent exposure method should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
- (6) Tested on unreinforced geomembrane specimens (EIA Only) via ASTM D882

**Revision Schedule for PVC-EIA
Specification per GRI-GM34**

1. Original 1/15/1995, Revised and updated NSF 54 for EIA
2. Revision #1, 2/22/2000, Updated away from carbon arc endurance testing
3. Revision #2, 6/10/2005, Inserted ASTM D1603 ash content and eliminated ASTM D 2136 Test Method for Coated Fabrics – Low Temperature Bend Test
4. Revision #3, 4/4/2022, condensed table from two to one grade of EIA. Deleted 45 mil (1.143 mm) material from the table.
5. Revision #4, 4/29/2022, incorporated comments by various GSI members and added 45 mil (1.143 mm) back to the table
6. Revision #5, 5/15/2022, added 30 mil (0.76 mm) and 60 mil (1.52 mm) EIA/KEE geomembrane to the table and introduce a chlorinated water challenge to the durability section of the specification.
7. Revision #6, 1/20/2022, Revised title to PVC-EIA geomembranes. Deleted ASTM D1603 and added ASTM D8154 and ISO 182-part 1. Also, all durability challenges are to be performed on nonreinforced PVC-EIA geomembrane and evaluated for percent strength and elongation retention via ASTM D882.
8. Revision #7, 2/3/2023, Updated scope, edited the mechanical properties to include severe, moderate and typical categories-properties (this allows for different scrim configurations) and lowered the PVC and EIA content to 40 and 25 percent from 45 and 30 respectively obtained from ASTM D8154 testing.
9. Revision #8, 3/7/2023, Changed title, added description of KEE in section 4.3, lowered grab strength to accommodate the flexibility of various scrims, and lowered PVC and EIA content to 30 and 10 percent respectively.
10. Revision #9, 7/13/2023, Struck flawed ISO 182-1 Congo red thermal stability test, reorganized Table 1a and b into “system” (i.e., composite EAI plus scrim) and “EIA only” properties, replaced ASTM D751 tear with ASTM D5884 tear.