GRI-GM21 Specification
Ethylene Propylene Diene Terpolymer (EPDM) Geomembranes

- specification is a result of NSF dropping its Standard 54 in 1997
- covers unreinforced and reinforced EPDM
- thicknesses 1.14 & 1.52 mm (45 & 60 mil)
- silent on method of manufacturing
- lists properties, test methods, test values and test frequencies
- covers ten (10) properties

Preliminary Comments

- definition of “formulation”
  The mixture of a unique combination of ingredients identified by type, properties and quantity. For EPDM geomembranes a formulation is defined as the exact percentages and types of resin(s), additives and carbon black.

- referenced quantities in specification:
  5,000 kg (10,000 lb);20,000 kg (40,000) lb and per formulation, or change therein

Physical Properties

1. thickness
2. specific gravity

Mechanical Properties

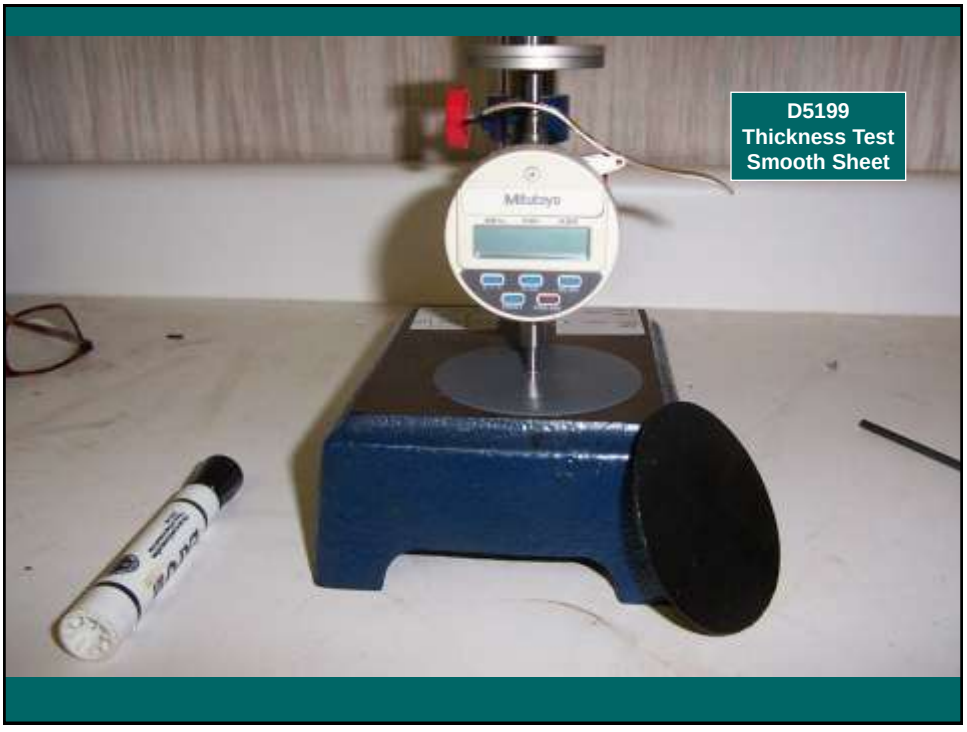
3. tensile
4. multiaxial
5. tear
6. puncture
7. brittleness temperature

Endurance Properties

8. oven aging
9. surface cracking
10. UV resistance

1. Thickness

- follows ASTM D5199
- dead weight micrometer with flat tip
- includes scrim when reinforced
- 10-specimens across width
- every 5,000 kg (10,000 lb)
- average must equal nominal
- lowest individual is –10%



2. Specific Gravity

- also called “density”
- follows ASTM D792
- immersion test compared to water
- 5 specimens across width
- every 5,000 kg (10,000 lb)
- only for NR (due to scrim in R)

3. Tensile Properties

- ASTM 882 for unreinforced (narrow strip)
- ASTM D751 for reinforced (grab)
- min. of 5 MD and 5 XMD

Property	Method	Unreinforced	Reinforced
strength	strip grab	7.6 MN/m^2 (1100 lb/in^2) n/a	n/a 730 N/mm (4200 lb/in.)
elongation	strip grab	500% n/a	n/a n/a

- every 5000 kg (10,000 lb)

ASTM D882
Press, Die and
Test Specimens

D882
“Narrow Strip”
Test in Progress
for Nonreinforced

ASTM D751 – Grab Tensile Test in Progress for Reinforced

4. Multiaxial Tension
(also called axisymmetric)

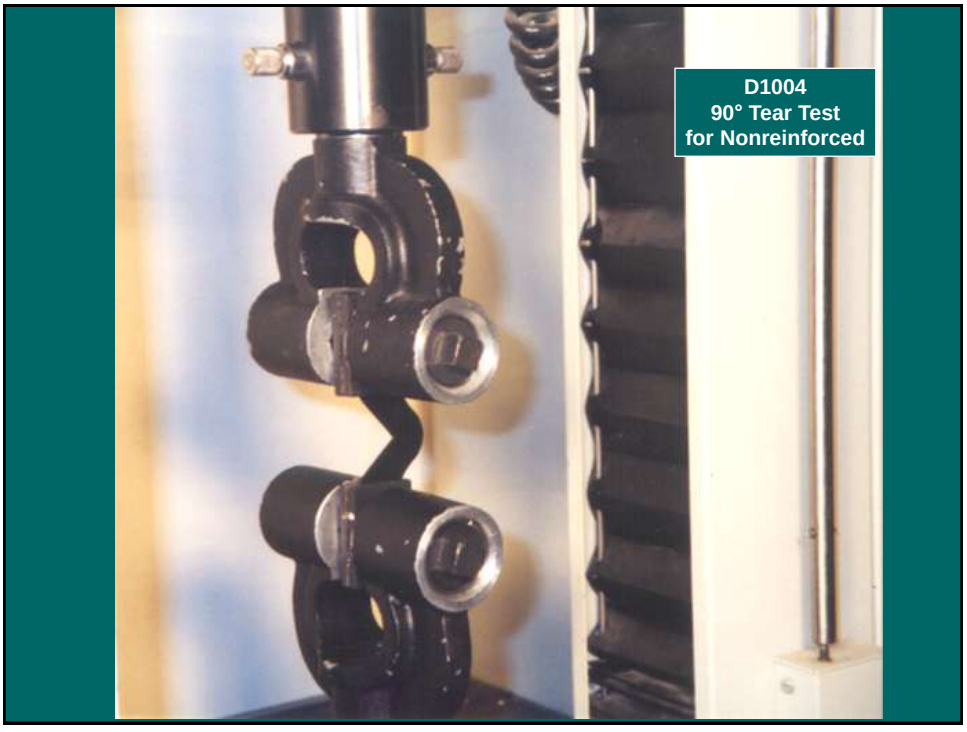
- follows ASTM D5617
- it's a huge "burst" type of test
- simulates out-of-plane deformation
- measures pressure and deformation
- calculations give strength and elongation
- spec only requires elongation ≥ 100%
- only for nonreinforced EPDM
- required for each formulation




Behavior of EPDM Nonreinforced Geomembrane Under Axi-Symmetric Pressure per ASTM D5617

5. Tear Resistance

- **uses ASTM D1004 (90 deg. tear test) for nonreinforced – 10 MD and 10 XMD**
- **uses ASTM D5884 (tongue tear test) for reinforced – 5 MD and 5 XMD**
- **nonreinforced ≥ 35 N/mm (200 lb/in.)**
- **reinforced ≥ 500 N/mm (2800 lb/in.)**
- **every 5000 kg (10,000 lb)**


D1004
90° Tear Test
for Nonreinforced


D5884
Tongue Tear
for Reinforced

6. Puncture Resistance

- follows ASTM D4833
- called “pin” puncture
- min. ave. of 15 tests
- nonreinforced ≥ 117 N/mm (667 lb/in.)
- reinforced ≥ 240 N/mm (1300 lb/in.)
- every 20,000 kg (40,000 lb)

ASTM D4833 – “Pin” Puncture Resistance

7. Low Temperature Flexibility

- follows ASTM D2136
- must resist cracking at -45°C (-49°F)
- incubation for 4-hours followed by bending over a mandrel
- bent over 3.2 mm (1/8 in.) mandrel
- performed per formulation

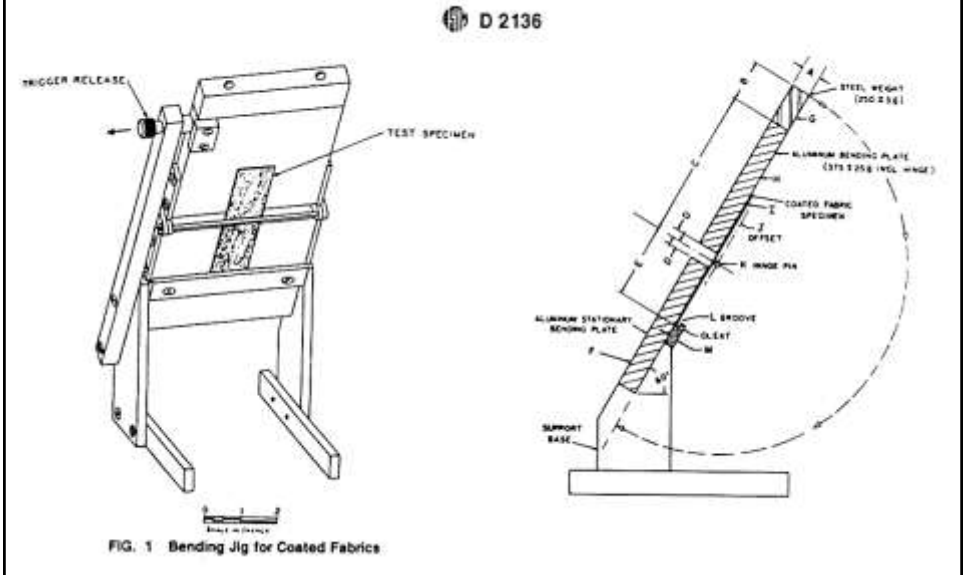


FIG. 1 Bending Jig for Coated Fabrics

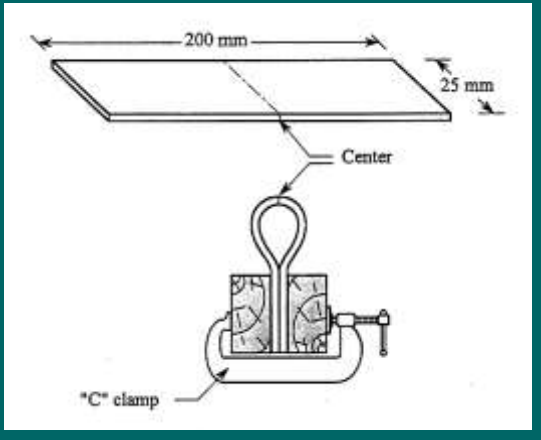
8. Oven Aging

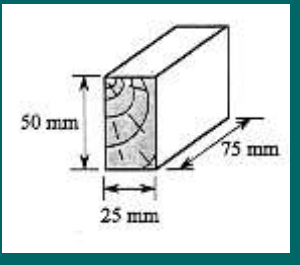
- assessment of thermal stability
- follows ASTM D5721
- samples in forced air oven at 100°C for 170 hrs
- NR: 90% str. ret. & 75% elong. ret.
- R: 90% str. ret.
- frequency is per formulation

D5721 Forced Air Oven

9. In Addition to Str./Elong. Criteria

- incubated specimen cannot crack
- follows GRI GM16 test method
- 180 deg. bending within a holder
- visual observation for cracks at 7X magnification results in “go” or “no-go” test





Test Specimen as Removed from Weathering Device, Bent 180 deg. and Clamped Between Two Wooden Blocks Using a “C” Clamp

10. Ultraviolet Resistance

- assessment of UV stability of the formulation
- uses a laboratory weatherometer
- xenon arc for 2000 hr. at 80°C
- alternatively, UV fluorescent for 7500 hr.
- NR: 90% str. ret. & 75% elong. ret.
- R: 90% str. ret.
- also, no cracking after incubation per GRI GM16
- frequency is per formulation

Typical Xenon Arc Weatherometer

Interior Chamber of Xenon Arc Weatherometer

ASTM D7238 Ultraviolet Fluorescent Weatherometer

Regarding the Warranty

- warranty is included for 20-years
- mainly, for geomembranes used in exposed conditions
- GM21 is silent on any type of installation warranty (this is a major concern but beyond a MQC spec)

Concluding Comments

- specification addresses both covered and exposed EPDM installations
- this is MQC specification i.e., the manufacturers required tests, minimum values and frequencies
- if MQA project specific spec is more restrictive, manufacturer may ask for additional compensation

The Basic Tables Follow

EPDM & EPDM-R – SI Units
EPDM & EPDM-R – English Units

Note: The most recent version of this specification (text and tables) is available on the GSI Web Site <geosynthetic-institute.org>.

S.I. Units

Table 1(a) – Ethylene Propylene Diene Terpolymer (EPDM) – Non-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, kN/m² (min.) • break elongation, % (min.)	D 882	 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 no cracks	 90 75	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 no cracks 90 75 no cracks	 90 75 90 75	per formulation [2]

(1) machine direction (MD) and cross machine direction (CMD) 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.

English Units

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 882	 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 no cracks	 90 75	per formulation [2]
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 D7238 D 882 D 882 GM16	 90 75 no cracks 90 75 no cracks	 90 75	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.

S.I. Units

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 no cracks	 90	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 no cracks 90 no cracks	 90 90	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 -10%	60 -10%	40,000 lb
Tensile Properties [1] [2] • break strength, lb (min.)	D 751	190	250	40,000 lb
Tear Resistance, lb [1] (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 no cracks	90	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 no cracks 90 no cracks	90 90	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