

Material Specification 594—Geomembrane Liner

1. Scope

This specification covers the quality of High Density Polyethylene (HDPE), Linear Low Density Polyethylene (LLDPE), Ethylene Propylene Diene Terpolymer (EPDM), Poly Vinyl Chloride (PVC), Flexible Polypropylene (fPP), woven Polyethylene (PE-R) geomembrane liners, seams, gaskets, metal battens, bolts, embed channels, clamps, and sealant.

2. Material

Liner—The liner shall have a nominal thickness as specified. The liner shall be manufactured to be suitable for use in the specified exposed or buried conditions. It shall conform to the requirements of this specification, Construction Specification 97, and the requirements shown on the drawings.

Gaskets, metal battens, clamps, bolts, embed channels, welding rod, adhesive, and sealant—Gasket material shall be neoprene, closed-cell medium, 0.25 inch thick, with adhesive on one side, or other gasket material as approved by the liner manufacturer. Metal battens shall be 0.25-inch-thick by 2-inch-wide stainless steel. Clamps shall be 0.5-inch-wide stainless steel. Bolts shall be stainless steel. The embed channel and welding rod shall have the same properties as the liner, as recommended by the manufacturer. Adhesive shall be approved by the manufacturer and shall consist of material with a life expectancy similar to the liner material. Sealant shall be as recommended by the manufacturer. Silicone sealant shall not be used with PVC liner materials.

Vents and pipe boots—Vents and pipe boots shall be compatible with the liner, as recommended by the liner manufacturer.

3. Liner properties

The liner shall be manufactured from virgin polymers and other compounding materials. Re grind, reworked, or trim materials shall be from the same manufacturer and the same formulation as the liner. Recycled materials shall not be allowed. The liner shall be uniform in color, thickness, and surface texture. The liner shall be resistant to fungal or bacterial attack and free of cuts, abrasions, holes, blisters, contaminants, and other imperfections.

HDPE—The HDPE liner shall meet the requirements specified in Geosynthetics Research Institute (GRI) Test Method GM13. Selected property values are reproduced in tables 594–1 and 594–2 for smooth and textured HDPE, respectively.

LLDPE—The LLDPE liner shall meet the requirements specified in GRI Test Method GM17 (smooth and textured LLDPE) and GM25 (reinforced LLDPE). Selected property values are reproduced in tables 594–3 through 594–5 for smooth, textured, and reinforced LLDPE, respectively.

A reinforced LLDPE liner shall consist of one ply of reinforcing polyester (scrim) between two sheets of LLDPE. The polyester scrim shall be of an open weave that permits strike-through of the LLDPE.

EPDM—The EPDM liner shall meet the requirements specified in GRI Test Method GM21. Selected property values are reproduced in tables 594–6 and 594–7 for nonreinforced and reinforced EPDM, respectively.

PVC—The PVC liner shall meet the requirements specified in ASTM D7176. Selected property values are reproduced in table 594–8.

fPP—The fPP liner shall meet the requirements specified in GRI Standard GM18. Selected property values are reproduced in tables 594–9 and 594–10 for nonreinforced and reinforced fPP, respectively.

A reinforced fPP liner shall consist of one ply of reinforcing polyester (scrim) between two sheets of fPP. The polyester scrim shall be of an open weave that permits strike-through of the fPP.

PE-R—The PE-R liner shall be manufactured from woven HDPE scrim with a PE coating on both sides and shall meet the property values specified in table 594–11.

Material Specification 594 Geomembrane liner—continued**Table 594-1** Requirements for smooth HDPE liner

Property	Test methods	Requirements*		
		----- nominal thickness -----		
		30 mil	40 mil	60 mil
Density, g/cc	ASTM D1505/D792	0.940	0.940	0.940
Tensile properties	ASTM D6693 (Type IV)			
yield strength, lb/in		63	84	126
break strength, lb/in		114	152	228
yield elongation, %		12	12	12
break elongation, %		700	700	700
Tear resistance, lb	ASTM D1004	21	28	42
Puncture resistance, lb	ASTM D4833	54	72	108
Carbon black content, %	ASTM D1603	2.0-3.0	2.0-3.0	2.0-3.0
Seam properties	ASTM D6392			
shear strength, lb/in		57	80	120
peel strength, lb/in**		45**	60**	91**

* All values, unless specified otherwise, are minimum average roll values as reported for the test method.

** Break shall occur in a ductile mode in the geomembrane adjacent to the seam.

Material Specification 594 Geomembrane liner—continued**Table 594-2** Requirements for textured HDPE liner

Property	Test methods	Requirements*		
		----- nominal thickness -----		
		30 mil	40 mil	60 mil
Density, g/cc	ASTM D1505/D792	0.940	0.940	0.940
Asperity height, mills	ASTM D7466	10	10	10
Tensile properties	ASTM D6693 Type IV			
yield strength, lb/in		63	84	126
break strength, lb/in		45	60	90
yield elongation, %		12	12	12
break elongation, %		100	100	100
Tear resistance, lb	ASTM D1004	21	28	42
Puncture resistance, lb	ASTM D4833	45	60	90
Carbon black content, %	ASTM D1603	2.0–3.0	2.0–3.0	2.0–3.0
Seam properties	ASTM D6392			
shear strength, lb/in		57	80	120
peel strength, lb/in		45**	60**	91**

* All values, unless specified otherwise, are minimum average roll values as reported by the specified test method.

** Break shall occur in a ductile mode in the geomembrane adjacent to the seam.

Material Specification 594 Geomembrane liner—continued**Table 594-3** Requirements for smooth LLDPE liner

Property	Test methods	Requirements*		
		----- nominal thickness -----		
		30 mil	40 mil	60 mil
Density, g/cc	ASTM D1505/D792	0.939	0.939	0.939
Tensile properties	ASTM D6693			
break strength, lb/in	Type IV	114	152	228
break elongation, %		800	800	800
Tear resistance, lb	ASTM D1004	16	22	33
Puncture resistance, lb	ASTM D4833	42	56	84
Carbon black content, %	ASTM D1603	2.0–3.0	2.0–3.0	2.0–3.0
Seam properties	ASTM D6392			
shear strength, lb/in		45	60	90
peel strength, lb/in**		38**	50**	75**

* All values, unless otherwise specified, are minimum average roll values as reported for each test method.

** Break shall occur in a ductile mode in the geomembrane adjacent to the seam.

Material Specification 594 Geomembrane liner—continued**Table 594-4** Requirements for textured LLDPE liner

Property	Test methods	Requirements*		
		----- nominal thickness -----		
		30 mil	40 mil	60 mil
Density, g/cc	ASTM D1505	0.939	0.939	0.939
Asperity height, mills	ASTM D7466	10	10	10
Tensile properties	ASTM D6693			
break strength, lb/in	Type IV	45	60	90
break elongation, %		250	250	250
Tear resistance, lb	ASTM D1004	16	22	33
Puncture resistance, lb	ASTM D4833	33	44	66
Carbon black content, %	ASTM D1603	2.0–3.0	2.0–3.0	2.0–3.0
Seam properties	ASTM D6392			
shear strength, lb/in		45	60	90
peel strength, lb/in**		38**	50**	75**

* All values, unless otherwise specified, are minimum average roll values as reported for each test method.

** Break shall occur in a ductile mode in the Geomembrane adjacent to the seam.

Material Specification 594 Geomembrane liner—continued**Table 594-5** Requirements for reinforced LLDPE liner

Property	Test methods	Requirements*		
		----- nominal thickness -----		
		24 mil	36 mil	45 mil
Mass per unit area, lb/ft ²	ASTM D5261	0.10	0.15	0.19
Grab tensile properties	ASTM D7004			
strength, lb (each direction)		150	200	250
elongation, % (each direction)		22	22	22
Tear resistance, lb (each direction)	ASTM D5884	55	55	55
Puncture resistance, lb	ASTM D4833	65	75	85
Ply adhesion, lb	ASTM D6636	20	20	20
Coating thickness over manufacturer's scrim, mil	Manufacturer's data	7	10	12
Seam properties				
shear strength, lb/in	ASTM D751	45	60	90
peel strength, lb/in**	ASTM D413	38**	50**	75**

* All values, unless otherwise specified, are minimum average roll values as reported for each test method.

** Break shall occur in a ductile mode in the geomembrane adjacent to the seam.

Material Specification 594 Geomembrane liner—continued**Table 594-6** Requirements for nonreinforced EPDM liner

Property	Test methods	Requirements*	
		-- nominal thickness --	
		45 mil	60 mil
Tensile properties	ASTM D412		
break strength, lb/in ²		1200	1200
break elongation, %		300	300
Tear resistance, lb	ASTM D1004	12	15
Puncture resistance, lb	ASTM D4833	30	40
Brittleness temperature, °F	ASTM D2136	<-49	<-49
Seam properties	ASTM D7272		
shear strength, lb/in		35	35
peel strength, lb/in		8	8

* All values, unless specified otherwise, are minimum average roll values as reported for the test method.

Material Specification 594 Geombrane liner—continued**Table 594-7** Requirements for reinforced EPDM liner

Property	Test methods	Requirements* nominal thickness
		45 mil
Tensile break strength, lb	ASTM D751	190
Tear resistance, lb	ASTM D5884	130
Puncture resistance, lb	ASTM D4833	60
Brittleness temperature, °F	ASTM D2136	< -49
Seam properties:	ASTM D7272	
shear strength, lb/in**		35
peel strength, lb/in***		8

* All values, unless specified otherwise, are minimum average roll values as reported for the test method.

Material Specification 594 Geombrane liner—continued**Table 594-8** Requirements for PVC liner

Property	Test methods	Requirements*	
		- - nominal thickness - -	
		30 mil	40 mil
Specific gravity	ASTM D792	1.2	1.2
Tensile properties:	ASTM D882		
Break strength, lb/in		73	97
Break elongation, %		380	400
Tear strength, lb	ASTM D1004	8	10
Low temperature impact, °C	ASTM D1790	< -29	<-29
Dimensional stability, % (maximum)	ASTM D1204	3	3
Hydrostatic resistance, lb/in ²	ASTM D751	100	120
Seam properties:	ASTM D 882		
Shear strength, lb/in		58	77
Peel strength, lb/in		15	15

* All values, unless specified otherwise, are minimum average roll values as reported for the test method.

Material Specification 594 Geombrane liner—continued**Table 594-9** Requirements for nonreinforced fPP liner

Property	Test methods	Requirements* -- nominal thickness --	
		30 mil	40 mil
Mass per unit area, lb/ft ²	ASTM D5261	0.12	0.16
Tensile properties:	ASTM D6693		
Break strength, lb/in	(Type IV)	60	72
Break elongation, %		700	700
Tear resistance, lb	ASTM D1004	10	12
Puncture resistance, lb	ASTM D4833	25	30
Carbon black content, %	ASTM D4218	2-3	2-3
Brittleness temperature, °C	ASTM D2136	<-40	<-40
Seam properties:	ASTM D6392/D6214**		
Shear strength, lb/in		25	30
Peel strength, lb/in		20***	20***

* All values, unless specified otherwise, are minimum average roll values as reported for the test method.

** ASTM D6392 shall be used for thermally welded seams and D6214 for chemically welded seams.

*** Break shall occur in a ductile mode in the geomembrane adjacent to the seam.

Material Specification 594 Geombrane liner—continued**Table 594-10** Requirements for reinforced PP liner

Property	Test methods	Requirements*	
		--- nominal thickness ---	
		36 mil	45 mil
Mass per unit area, lb/ft ²	ASTM D5261	0.15	0.18
Tensile properties:			
Grab strength, lb	ASTM D7004	200	250
Break elongation, %	ASTM D751	22	22
Tear resistance, lb	ASTM D5884	55	55
Puncture resistance, lb	ASTM D 4833	75	85
Ply adhesion, lb	ASTM D 6636	15	15
Carbon black content, %	ASTM D4218	2-3	2-3
Brittleness temperature, °C	ASTM D2136	< -40	< -40
Coating thickness over scrim, mil	ASTM D7613 (Annex A1)	10	12
Seam properties:			
Shear strength, lb/in	ASTM D751	200	200
Peel strength, lb/in	ASTM D413	20**	20**

* All values, unless specified otherwise, are minimum average roll values as reported for the test method.

** Break shall occur in a ductile mode in the geomembrane adjacent to the seam.

Material Specification 594 Geomembrane liner—continued**Table 594-11** Requirements for reinforced, slit film, woven PE liner

Property	Test methods	Requirements* nominal thickness 24 mil
Mass per unit area, oz/yd ²	ASTM D1910	12
Tensile properties:		
Grab strength, lb/in (either direction)	ASTM D751	330
Break elongation, % (either direction)	ASTM D751	29
Tear resistance, lb (either direction)	ASTM D751	74
Puncture resistance, lb/in ²	ASTM D4833	182
Carbon black content, %	ASTM D1603	2-3
Brittleness temperature, °C	ASTM D2136	-40
Hydrostatic resistance, lb/in ²	ASTM D751A	310
Coating thickness over manufacturer's data scrim, mil		4
Seam properties:		
Shear strength, lb/in	ASTM D 751	188**
Peel strength, lb/in	ASTM D 413	7**

* All values, unless specified otherwise, are minimum average roll values as reported for the test method.

** Break shall occur in a ductile mode in the geomembrane adjacent to the seam.