Part 642 – Specifications

Chapter 3 – National Standard Material Specifications

Material Specification 594—Geomembrane Liner

A. 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), and coated tape polyethylene (cPE) geomembrane liners and seams, gaskets, metal battens, bolts, embed channels, clamps, and sealant.

B. Material

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

(2) Gaskets, metal battens, clamps, bolts, embed channels, welding rod, adhesive, and sealant—Gasket material must 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 must be 0.25-inch-thick by 2-inch-wide stainless steel. Clamps must be 0.5-inch-wide stainless steel. Bolts must be stainless steel. The embed channel and welding rod must be compatible with the liner, as recommended by the manufacturer. Adhesive must be approved by the manufacturer and must consist of material with a life expectancy similar to the liner material. Sealant must be as recommended by the manufacturer. Silicone sealant may not be used with PVC liner materials.

(3) Vents and pipe boots—Vents and pipe boots must be compatible with the liner, as recommended by the liner manufacturer.

C. Liner Properties

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

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

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

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

(4) EPDM—The EPDM liner must meet the requirements specified in GRI Test Method GM21. Selected property values are reproduced in Figures 594-6 and 594-7 for nonreinforced and reinforced EPDM, respectively.

(5) PVC—The PVC liner must meet the requirements specified in ASTM D7176. Selected property values are reproduced in Figure 594-8.

(6) fPP and fPP-R—The fPP and fPP-R liners must meet the requirements specified in ASTM D7613. Selected property values are reproduced in Figures 594-9 and 594-10 for nonreinforced (fPP) and reinforced (fPP-R), respectively.

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

(7) cPE—The cPE liner must meet the requirements specified in GRI Test Method GM30 and in Figure 594-11. The cPE liner is manufactured from woven HDPE scrim (tape) with a PE coating on both sides.

Figure 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:				
Yield strength, lb/in	ASTM D6693 (Type IV)	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**:				
shear strength, lb/in	ASTM D6392	57	80	120
peel strength, lb/in		45	60	91

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

** Break must occur with an acceptable break code as specified in GRI Test Method GM19a.

Figure 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:				
yield strength, lb/in	ASTM D6693 (Type IV)	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**:				
shear strength, lb/in	ASTM D6392	57	80	120
peel strength, lb/in		45	60	91

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

** Break must occur with an acceptable break code as specified in GRI Test Method GM19a.

Figure 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:				
break strength, lb/in	ASTM 6693 (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**:				
shear strength, lb/in	ASTM D6392	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 must occur with an acceptable break code as specified in GRI Test Method GM19a.

Figure 594-4 Requirements for Textured 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
Asperity height, mills	ASTM D7466	10	10	10
Tensile properties:				
break strength, lb/in	ASTM D6693 (Type IV)	45	60	90
break elongation, %		250	250	250
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**:				
shear strength, lb/in	ASTM D6392	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 must occur with an acceptable break code as specified in GRI Test Method GM19a.

Figure 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:				
Strength, lb	ASTM D7004	150	200	250
Elongation, %		22	22	22
Tear resistance, lb	ASTM D5884	55	55	55
Puncture resistance, lb	ASTM D4833	65	75	85
Ply adhesion, lb	ASTM D6636	20	20	20
Coating thickness over scrim, mil	Manufacturer's data	7	10	12
Seam properties: **				
Shear strength, lb/in	ASTM D7747	60***	75	90
Peel strength, lb/in		30***	30	30

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

** Break must occur with an acceptable break code as specified in GRI Test Method GM19b.

*** 24 mil geomembrane nominal thickness shear and peel values are not listed in GRI GM 19b Table 1(a) so are interpolated from 36 and 45 mil values.

Figure 594-6 Requirements for Nonreinforced EPDM Liner

Property	Test methods	Requirements* Nominal thickness	
		45 mil	60 mil
Tensile properties:			
Tensile strength, lb/in^2	ASTM D412, Die C	1305	1305
Ultimate elongation, %		300	300
Tear resistance, lb/in	ASTM D624, Die C	150	230
Puncture resistance, lb	ASTM D4833	30	40
Brittleness point, °F	ASTM D2137	< -49	< -49
Seam properties:			
Shear strength, lb/in	ASTM D7272	35	35
Peel strength, lb/in		8	8

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

Figure 594-7 Requirements for Reinforced EPDM Liner

Property	Test methods	Requirements nominal thickness*	
		45 mil	60 mil
Grab tensile strength, lb	ASTM D7004	90	90
Tearing strength, lb	ASTM D5884	130	170
Puncture resistance, lb	ASTM D4833	60	80
Brittleness point, °F	ASTM D2137	< -49	< -49
Seam properties:			
Shear strength, lb/in	ASTM D7272	35	35
Peel strength, lb/in		8	8

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

Figure 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:			
Break strength, lb/in	ASTM D882	73	97
Break elongation, %		380	430
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:			
Shear strength, lb/in	ASTM D7408	58	77
Peel strength, lb/in		15	15

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

Figure 594-9 Requirements for Nonreinforced fPP Liner

Property	Test methods	Requirements* Nominal thickness		
		30 mil	40 mil	60 mil
Thickness, in.	ASTM D5199	0.027	0.035	0.054
Tensile properties:				
Tensile strength, lb/in	ASTM D6693	60	60	96
Ultimate elongation, %		700	600	600
Tear resistance, lb	ASTM D1004	10	10	18
Puncture resistance, lb	ASTM D4833	25	25	40
Low temperature bend, °C	ASTM D2136	-40	-40	-40
Seam properties**:				
Shear strength, lb/in	ASTM D6392, D6214***	25	30	40****
Peel strength, lb/in		20	25	35****

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

** Break must occur with an acceptable break code as specified in GRI Test Method GM19a.

*** ASTM D 6392 is used for thermally welded seams and D 6214 for chemically welded seams.

**** 60 mil geomembrane nominal thickness shear and peel values are not listed in GRI GM 19a Table 3(a) so are interpolated from 30 and 40 mil values.

Figure 594-10 Requirements for Reinforced fPP Liner

Property	Test methods	Requirements* Nominal thickness			
		30 mil	36 mil	45 mil	60 mil
Thickness, in.	ASTM D5199	0.027	0.032	0.040	0.054
Tensile properties:					
Grab tensile strength, lb.	ASTM D7004	170	200	250	250
Grab elongation, %		15	15	15	15
Tearing strength, lb	ASTM D5884	50	55	70	70
Puncture resistance, lb	ASTM D4833	50	75	85	90
Ply adhesion, lb/in.	ASTM D6636	15	15	15	15
Low temperature bend, °C	ASTM D2136	-40	-40	-40	-40
Coating thickness over scrim, mil	ASTM D7613 (Annex A1)	8	10	13	18
Seam properties**:					
Shear strength, lb/in.	ASTM D7747	40***	50	60	70
Peel strength, lb/in.		25***	25	25	25

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

** Break must occur with an acceptable break code as specified in GRI Test Method GM19b.

*** 30 mil geomembrane nominal thickness shear and peel values are not listed in GRI GM 19b Table 4(a) so are interpolated from 36, 45, and 60 mil values.

Figure 594-11 Requirements for cPE Liner

Property	Test methods	Requirements* nominal thickness		
		24 mil	30 mil	40 mil
Thickness, in.	ASTM D751	0.022	0.027	0.036
Weight, oz/yd^2		10	15	18
Tensile properties:				
Strip tensile strength, lb.	ASTM D7003	200	225	250
Strip tensile elongation, %		20	20	20
Tongue Tear, lb.	ASTM D5884	50	50	50
CBR puncture, lb.	ASTM D6241	400	700	1000
Pin puncture, lb.	ASTM D4833	160	180	220
Hydrostatic resistance, lb./in^2	ASTM D751	300	500	700
Dimensional stability, % change (maximum)	ASTM D1204	3	3	3
Water vapor transmission, g/m^2-day (maximum)	ASTM E96	0.5	0.4	0.3
Seam properties**:				
Shear strength, lb/in.	ASTM D7747	30	60	90
Peel strength, lb/in.		10	10	10

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

** Break must occur with an acceptable break code as specified in GRI Test Method GM19b.