

Material Specification 594—Flexible Membrane Liner

1. Scope

This specification covers the quality of High Density Polyethylene (HDPE), Linear Low Density Polyethylene (LLDPE), Ethylene Propylene Diene Monomer (EPDM), Poly Vinyl Chloride (PVC), and Polypropylene (PP) flexible liner, 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. 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 made of the same material as the liner.

3. Liner properties

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 and LLDPE—The HDPE or LLDPE liner shall be manufactured from virgin polymer material and shall meet the property values specified in tables 594-1 through 594-4 as applicable.

EPDM—The EPDM liner shall be formulated from virgin compounding materials and shall meet the property values specified in tables 594-5 and 594-6 as applicable. Regrind, reworked, or trim materials shall be from the same manufacturer and the same formulation as the liner. Recycled materials shall not be allowed.

PVC—The PVC liner shall be manufactured from virgin polymers and other compounding materials and shall meet the property values specified in table 594-7 as applicable. Regrind, reworked, or trim materials shall be from the same manufacturer and the same formulation as the liner. No more than 10 percent regrind, reworked, or trim materials shall be used to manufacture the liner. Recycled materials shall not be allowed.

The PVC compound shall consist of 50- to 70-percent PVC resin, by weight. Liquid plasticizers shall be mixed until completely absorbed by the resin powder. Other additives shall be thoroughly mixed into the resin.

PP—The PP liner shall be manufactured from virgin polymer material and shall meet the property values specified in tables 594-8 and 594-9 as applicable.

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

Material Specification 594 Flexible Membrane Liner (continued)**Table 594-1** Requirements for smooth HPDE liner

Property	Test methods	Requirements*		
		----- nominal thickness -----		
		30 mil	40 mil	60 mil
Density, g/cc	ASTM D 1505	0.940	0.940	0.940
Tensile properties	ASTM D 6693 (type IV at 2 in/min)			
yield stress, lb/in		63	84	126
break stress, lb/in		114	152	228
yield elongation, %		12	12	12
break elongation, %		700	700	700
Tear resistance, lb	ASTM D 1004	21	28	42
Puncture resistance, lb	ASTM D 4833	54	72	108
Carbon black content, %	ASTM D 1603	2-3	2-3	2-3
Carbon black dispersion	ASTM D 5596	Cat 1-2	Cat 1-2	Cat 1-2
Seam properties	ASTM D 6392			
shear strength, lb/in		60	80	120
peel strength, lb/in**		39/FTB	52/FTB	78/FTB

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

** Film tear bond: A failure of one of the bonded sheets by tearing prior to complete separation in the bonded area.

Material Specification 594 Flexible Membrane 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 D 1505	0.940	0.940	0.940
Tensile properties	ASTM D 6693			
yield stress, lb/in	(type IV at 2 in/min)	63	84	126
break stress, lb/in		45	60	90
yield elongation, %		12	12	12
break elongation, %		100	100	100
Tear resistance, lb	ASTM D 1004	21	28	42
Puncture resistance, lb	ASTM D 4833	45	60	90
Carbon black content, %	ASTM D 1603	2-3	2-3	2-3
Carbon black dispersion	ASTM D 5596	Cat 1-2	Cat 1-2	Cat 1-2
Seam properties	ASTM D 6392			
shear strength, lb/in		60	80	120
peel strength, lb/in**		39/FTB	52/FTB	78/FTB

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

** Film tear bond: A failure of one of the bonded sheets by tearing prior to complete separation in the bonded area.

Material Specification 594 Flexible Membrane 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 D 1505	0.915	0.915	0.915
Tensile properties	ASTM D 6693			
break stress, lb/in	(type IV at 2 in/min)	114	150	228
break elongation, %		800	800	800
Tear resistance, lb	ASTM D 1004	16	22	33
Puncture resistance, lb	ASTM D 4833	42	56	84
Carbon black content, %	ASTM D 1603	2-3	2-3	2-3
Carbon black dispersion, %	ASTM D 5596	Cat 1-2	Cat 1-2	Cat 1-2
Seam properties	ASTM D 6392			
shear strength, lb/in		44	58	90
peel strength, lb/in**		37/FTB	50/FTB	75/FTB

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

** Film tear bond: A failure of one of the bonded sheets by tearing prior to complete separation in the bonded area.

Material Specification 594 Flexible Membrane 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 D 1505	0.915	0.915	0.915
Tensile properties	ASTM D 6693 (type IV at 2 in/min)			
break stress, lb/in		60	80	120
break elongation, %		350	350	350
Tear resistance, lb	ASTM D 1004	17	22	33
Puncture resistance, lb	ASTM D 4833	33	44	66
Carbon black content, %	ASTM D 1603	2-3	2-3	2-3
Carbon black dispersion, %	ASTM D 5596	Cat 1-2	Cat 1-2	Cat 1-2
Seam properties	ASTM D 4437 (1 in wide at 2 in/min)			
shear strength, lb/in		40	53	79
peel strength, lb/in**		33/FTB	44/FTB	66/FTB

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

** Film tear bond: A failure of one of the bonded sheets by tearing prior to complete separation in the bonded area.

Material Specification 594 Flexible Membrane Liner (continued)**Table 594-5** Requirements for nonreinforced EPDM liner

Property	Test methods	Requirements*	
		-- nominal thickness --	
		45 mil	60 mil
Specific gravity	ASTM D 792	1.1	1.1
Tensile properties	ASTM D 882		
break stress, lb/in	(Type IV at 20 in/min)	50	50
break elongation, %		400	400
Tear resistance, lb	ASTM D 1004	9	11
Puncture resistance, lb	ASTM D 4833	35	60
Low temperature brittleness, °F	ASTM D 1790	<45	<45
Seam properties	ASTM D413/D4437		
shear strength, lb/in**	(NSF modified 20 in/min strain rate)	35	35
peel strength, lb/in***		14	14

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

** At 200 percent strain.

*** Cohesive bond mode.

Material Specification 594 Flexible Membrane Liner (continued)**Table 594-6** Requirements for reinforced EPDM liner

Property	Test methods	Requirements* nominal thickness 45 mil
Specific gravity	ASTM D 792	1.1
Tensile properties	ASTM D 751 Method A	125
Tear resistance, lb	ASTM D 5884 Method B	130
Puncture resistance, lb	FTMS 101C Method 2031	45
Ply adhesion, lb/in	ASTM D 413 Machine method	7
Low temperature brittleness, °F	ASTM D 1790	< -45
Seam properties		
shear strength, lb/in**	ASTM D 751	35
peel strength, lb/in***	ASTM D 413	14

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

** At 200 percent strain.

*** Cohesive bond mode.

Material Specification 594 Flexible Membrane Liner (continued)**Table 594-7** Requirements for PVC liner

Property	Test methods	Requirements* -- nominal thickness --	
		30 mil	40 mil
Specific gravity	ASTM D 792	1.2	1.2
Tensile properties	ASTM D 882		
break strength, lb/in	(MD and XD)	73	97
elongation at break, %		350	400
Tear resistance, lb	ASTM D 1004	8.5	10.5
Low temperature brittleness, °C	ASTM D 1790	< -29	< -29
Dimensional stability, % (maximum)	ASTM D 1204	3	3
Hydrostatic resistance, lb/in ²	ASTM D 751 Method A	100	120
Seam properties	ASTM D 6392/D 6214/D 4437 **		
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.

MD Machine direction

XD Cross-machine direction

** ASTM D 6392 shall be used for thermally welded seams, D 6214 for chemically welded seams, and D 4437 for all other types.

Material Specification 594 Flexible Membrane Liner (continued)**Table 594-8** Requirements for unreinforced PP liner

Property	Test methods	Requirements*		
		----- nominal thickness -----		
		30 mil	40 mil	60 mil
Specific gravity	ASTM D 792	0.90	0.90	0.90
Tensile Properties	ASTM D 638			
break stress, lb/in	(Type IV at 20 in/min)	60	72	130
break elongation, %		600	600	600
Tear resistance, lb	ASTM D 1004	9	11	16
Puncture resistance, lb	ASTM D 4833	28	35	65
Carbon black content, %	ASTM D 1603	2-4	2-4	2-4
Carbon black dispersion	ASTM D 5596	Cat 1-2	Cat 1-2	Cat 1-2
Low temperature brittleness, °C	ASTM D 1790	<-40	<-40	<-40
Seam properties	ASTM D 6392/D6214/D 4437 ***			
shear strength, lb/in		35	45	55
peel strength, lb/in***		20/FTB	30/FTB	40/FTB

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

** ASTM D 6392 shall be used for thermally welded seams, D 6214 for chemically welded seams, and D 4437 for all other types.

*** Film tear bond: A failure of one of the bonded sheets by tearing prior to complete separation in the bonded area.

Material Specification 594 Flexible Membrane Liner (continued)**Table 594-9** Requirements for reinforced PP liner

Property	Test methods	Requirements*	
		--- nominal thickness ---	
		36 mil	45 mil
Specific gravity	ASTM D 792	0.90	0.90
Tensile properties	ASTM D 751 Method A	225	225
Tear resistance, lb	ASTM D 5884 Method B	55	75
Puncture resistance, lb	FTMS 101C Method 2031	200	250
Ply adhesion, lb/in	ASTM D 413 Machine Method	20	20
Carbon black content, %	ASTM D 1603	2-4	2-4
Carbon black dispersion	ASTM D 5596	Cat 1-2	Cat 1-2
Low temperature brittleness, °C	ASTM D 2136	< -40	< -40
Seam properties			
shear strength, lb/in	ASTM D 751	160	200
peel strength, lb/in**	ASTM D 413	20/FTB	20/FTB

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

** Film tear bond: A failure of one of the bonded sheets by tearing prior to complete separation in the bonded area.