Section 31 05 19.16

Specification for Geomembranes for Earthwork

The following drop-in specifications is a sample guideline to be customized by the engineer for preparing site specific specification. This information is provided for reference purposes only and is not intended as a warranty or guarantee. Solmax assumes no liability in connection with the use of this information. Please contact Solmax for current material properties.

1 GENERAL

1.1 SCOPE

This drop-in specification covers the technical requirements for the Manufacturing and Installation of the geomembrane. All materials meet or exceed the requirements of this specification, and all work will be performed in accordance with the procedures provided in these project specifications

1.2 REFERENCES

A. American Society for Testing and Materials (ASTM)
   1. D 1004 Test Method for Initial Tear Resistance of Plastic Film and Sheeting
   2. D 1238 Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
   3. D 1505 Test Method for Density of Plastics by the Density-Gradient Technique
   4. D 1603 Test Method for Carbon Black in Olefin Plastics
   5. D 4218 Standard Test Method for Determination of Carbon Black in Polyethylene Compounds
   6. D 4833 Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
   7. D 5199 Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
   8. D 5397 Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test
   9. D 5596 Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
   10. D 5994 Standard Test Method for Measuring Core Thickness of Textured Geomembranes
   11. D 6392 Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
   12. D 6693 Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
   13. D 7240 Standard Practice for Leak Location using Geomembranes with an Insulating Layer in Intimate Contact with a Conductive Layer via Electrical Capacitance Technique (Conductive Geomembrane Spark Test)
   14. D 7466 Standard Test Method for Measuring the Asperity Height of Textured Geomembranes
   15. D 8117 Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by Differential Scanning Calorimetry

B. Geosynthetic Research Institute
   1. GRI GM 13 Test Properties, Testing Frequency and Recommended Warranty for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes
   2. GRI GM 17 Test Properties, Testing Frequency and Recommended Warranty for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes

1.3 DEFINITIONS

A. Lot - A quantity of resin (usually the capacity of one rail car) used in the manufacture of geomembranes. Finished roll will be identified by a roll number traceable to the resin lot used.
B. Construction Quality Assurance Consultant (CONSULTANT) - Party, independent from MANUFACTURER and INSTALLER that is responsible for observing and documenting activities related to quality assurance during the lining system construction.
C. ENGINEER- The individual or firm responsible for the design and preparation of the project's Contract Drawings and Specifications.
D. Geomembrane Manufacturer (MANUFACTURER) - The party responsible for manufacturing the geomembrane rolls.
E. Geosynthetic Quality Assurance Laboratory (TESTING LABORATORY) - Party, independent from the OWNER, MANUFACTURER and INSTALLER, responsible for conducting laboratory tests on samples of geosynthetics obtained at the site or during manufacturing, usually under the direction of the OWNER.
F. INSTALLER- Party responsible for field handling, transporting, storing, deploying, seaming and testing of the geomembrane seams.
G. Panel- Unit area of a geomembrane that will be seamed in the field that is larger than 100 ft2.
H. Patch - Unit area of a geomembrane that will be seamed in the field that is less than 100 ft2.
I. Subgrade Surface - Soil layer surface which immediately underlies the geosynthetic material(s).

1.4 SUBMITTALS POST-AWARD

A. Furnish the following product data, in writing, to ENGINEER prior to installation of the geomembrane material:
   1. Resin Data shall include the following.
      a. Certification stating that the resin meets the specification requirements (see Table 1.9B).
   2. Geomembrane Roll
      a. Statement certifying no recycled polymer and no more than 10% rework of the same type of material is added to the resin (product run may be recycled).
B. The INSTALLER shall furnish the following information to the ENGINEER and OWNER prior to installation:
   1. Installation layout drawings

a. Must show proposed panel layout including field seams and details
b. Must be approved prior to installing the geomembrane

2. Approved drawings will be for concept only and actual panel placement will be determined by site conditions.
3. Installer's Geosynthetic Field Installation Quality Assurance Plan

C. The INSTALLER will submit the following to the ENGINEER upon completion of installation:
1. Certificate stating the geomembrane has been installed in accordance with the Contract Documents
2. Material and installation warranties
3. As-built drawings showing actual geomembrane placement and seams including typical anchor trench detail

1.5 QUALITY ASSURANCE

A. The OWNER will engage and pay for the services of a Geosynthetic Quality Assurance Consultant and Laboratory to monitor geomembrane installation.

1.6 QUALIFICATIONS

A. MANUFACTURER
1. Geomembrane shall be manufactured by the following:
a. Solmax Geosynthetics LLC
b. Approved equal
2. MANUFACTURER shall have manufactured a minimum of 10,000,000 square feet of polyethylene geomembrane during the last year.

B. INSTALLER
1. Installation shall be performed by a Solmax Approved Installer
2. INSTALLER shall have installed a minimum of [ ] square feet of HDPE geomembrane during the [ ] last years.
3. INSTALLER shall have worked in a similar capacity on at least [ ] projects similar in complexity to the project described in the contract documents, and with at least [ ] square feet of HDPE geomembrane installation on each project.
4. The Installation Supervisor
a. Shall have worked in a similar capacity on projects similar in size and complexity to the project described in the Contract Documents.
5. The INSTALLER shall provide a minimum of one Master Seamer for work on the project.
a. Must have completed a minimum of 1,000,000 square feet of geomembrane seaming work using the type of seaming apparatus proposed for the use on this Project.
6. On projects that include Solmax GSE Leak Location Conductive Geomembranes,
a. The Installation Supervisor, field QC personnel, and all welding technicians shall be familiar with Leak Location Conductive product installation guidelines.
b. The Installation Supervisor or a designated crew member shall be familiar with geoelectric leak survey test methods.

1.7 MATERIAL LABELING, DELIVERY, STORAGE AND HANDLING

A. Labeling - Each roll of geomembrane delivered to the site shall be labeled by the MANUFACTURER. The label will identify:
   a. manufacturer's name
   b. product identification
   c. thickness
   d. length
   e. width
   f. roll number
B. Delivery- Rolls of liner will be prepared to ship by appropriate means to prevent damage to the material and to facilitate off-loading.
C. Storage- The on-site storage location for geomembrane material, provided by the CONTRACTOR to protect the geomembrane from punctures, abrasions and excessive dirt and moisture should have the following characteristics:
   a. level (no wooden pallets)
   b. smooth
   c. dry
   d. protected from theft and vandalism
   e. adjacent to the area being lined
D. Handling- Materials are to be handled so as to prevent damage.

1.8 GEOMEMBRANE PROPERTIES

A. Material shall be smooth/textured polyethylene geomembrane as shown on the drawings.
B. Resin
   1. Resin shall be new, first quality, compounded and manufactured specifically for producing geomembrane.
   2. Natural resin (without carbon black) shall meet the following requirements:

Table 1.9B: Raw Material Properties

Property	Test Method	HDPE	LLDPE
Density (g/cm3)	ASTM D 1505	$\geq$0.932	$\geq$0.915
Melt Flow Index (g/10 min)	ASTM D 1238 (190/2.16)	$\leq$1.0	$\leq$1.0
OIT (minutes)	ASTM D 8117 (1 atm/200^{0}C)	$\geq$100	$\geq$100

C. Geomembrane Rolls
   1. Do not exceed a combined maximum total of 1 percent by weight of additives other than carbon black.
   2. Geomembrane shall be free of holes, pinholes as verified by on-line electrical detection, bubbles, blisters, excessive contamination by foreign matter, and nicks and cuts on roll edges.

3. Geomembrane material is to be supplied in roll form. Each roll is to be identified with labels indicating roll number, thickness, length, width and MANUFACTURER.
4. All liner sheets produced at the factory shall be inspected prior to shipment for compliance with the physical property requirements listed in section 1.09 D and be tested by an acceptable method of inspecting for pinholes. If pinholes are located, identified and indicated during manufacturing, these pinholes may be corrected during installation.

D. Smooth geomembrane shall meet the requirements shown in the following data sheets below:
   1. Table 1 for Smooth HDPE
   2. Table 2 for Smooth LLDPE

Table 1 (English): **Solmax GSE** HD (formerly Solmax HDPE Series) Smooth Geomembranes

Tested Property	Test Method	Frequency	Minimum Average Values				
			30 mil	40 mil	60 mil	80 mil	100 mil
Thickness, mil Lowest individual reading	ASTM D 5199	every roll	30 27	40 36	60 54	80 72	100 90
Density, g/cm^3 , (min.)	ASTM D 792	200,000 lbs	0.940	0.940	0.940	0.940	0.940
Tensile Properties (each direction) Strength at Break, lb/in-width Strength at Yield, lb/in-width Elongation at Break, % Elongation at Yield, %	ASTM D 6693, Type IV Dumbbell, 2 ipm G.L. 2.0 in G.L. 1.3 in	20,000 lbs	 122 66 700 13	 162 88 700 13	243132 700 13	 324 176 700 13	 405 220 700 13
Tear Resistance, lb	ASTM D 1004	45,000 lbs	21	28	42	56	70
Puncture Resistance, lb	ASTM D 4833	45,000 lbs	60	80	120	156	180
Carbon Black Content, % (Range) [(1)]	ASTM D 1603*/4218	20,000 lbs	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596	45,000 lbs	Note[(2)]	Note[(2)]	Note[(2)]	Note[(2)]	Note[(2)]
Notch Constant Tensile Load, hr	ASTM D 5397, Appendix	200,000 lbs	500	500	500	500	500
Oxidative Induction Time, min	ASTM D 8117	200,000 lbs	>100	>100	>100	>100	>100
Typical Roll Dimensions							
Roll Length[(3)], ft			1,120	870	560	430	340
Roll Width[(3)], ft			22.5	22.5	22.5	22.5	22.5
Roll Area, ft^2			25,200	19,575	12,600	9,675	7,650

NOTES:

- [(1)] Solmax GSE geomembranes with conductive or colored surfaces may have an overall ash content of 3.0% due to the surface finish layer(s). These values apply to the black layer only.
- [(2)] Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- [(3)] Roll lengths and widths have a tolerance of ± 1%.
- Solmax HD Smooth is available in rolls weighing approximately 4,000 lb.
- All Solmax geomembranes have dimensional stability of ±2% when tested according to ASTM D 1204 and LTB of <-77° C when tested according to ASTM D 746.
- *Modified.

Table 1 (Metric): **SOLMAX GSE** HD (formerly Solmax HDPE Series) Smooth Geomembranes

Tested Property	Test Method	Frequency	Minimum Average Values				
			0.75 mm	1.0 mm	1.5 mm	2.0 mm	2.5 mm
Thickness, mm Lowest individual reading	ASTM D 5199	every roll	0.75 0.68	1.00 0.90	1.50 1.35	2.00 1.80	2.50 2.25
Density, g/cm^3 , (min.)	ASTM D 792	90,000 kg	0.940	0.940	0.940	0.940	0.940
Tensile Properties (each direction) Strength at Break, kN/m-width Strength at Yield, kN/m-width Elongation at Break, % Elongation at Yield, %	ASTM D 6693, Type IV Dumbbell, 50 mm/min G.L. 50 mm G.L. 33 mm	9,000 kg	 21 12 700 13	 28 15 700 13	 43 23 700 13	 57 31 700 13	 71 39 700 13
Tear Resistance, N	ASTM D 1004	20,000 kg	93	125	187	250	377
Puncture Resistance, N	ASTM D 4833	20,000 kg	267	356	534	695	800
Carbon Black Content, % (Range) [(1)]	ASTM D 1603*/4218	9,000 kg	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596	20,000 kg	Note[(2)]	Note[(2)]	Note[(2)]	Note[(2)]	Note[(2)]
Notch Constant Tensile Load, hr	ASTM D 5397, Appendix	90,000 kg	500	500	500	500	500
Oxidative Induction Time, min	ASTM D 8117	90,000 kg	>100	>100	>100	>100	>100
Typical Roll Dimensions							
Roll Length[(3)], ft			1,120	870	560	430	340
Roll Width[(3)], ft			22.5	22.5	22.5	22.5	22.5
Roll Area, ft^2			25,200	19,575	12,600	9,675	7,650

NOTES:

- [(1)]SOLMAX GSE geomembranes with conductive or colored surfaces may have an overall ash content of 3.0% due to the surface finish layer(s). These values apply to the black layer only.
- [(2)] Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- [(3)] Roll lengths and widths have a tolerance of ± 1%.
- SOLMAX HD Smooth is available in rolls weighing approximately 4,000 lb.
- All SOLMAX geomembranes have dimensional stability of ±2% when tested according to ASTM D 1204 and LTB of <-77° C when tested according to ASTM D 746.
- *Modified.

Table 2 (English): **SOLMAX GSE** LL (formerly Solmax LLDPE Series) Smooth Geomembranes

Tested Property	Test Method	Frequency	Minimum Average Value			
			40 mil	60 mil	80 mil	100 mil
Thickness, mil Lowest individual reading	ASTM D 5199	every roll	40 36	60 54	80 72	100 90
Density, g/cm^3 (max.)	ASTM D 792	200,000 lbs	0.939	0.939	0.939	0.939
Tensile Properties (each direction) Strength at Break, lb/in-width Elongation at Break, %	ASTM D 6693, Type IV Dumbbell, 2 ipm G.L. 2.0 in	20,000 lbs	 168 800	 252 800	 320 800	 400 800
Tear Resistance, lb	ASTM D 1004	45,000 lbs	22	34	46	57
Puncture Resistance, lb	ASTM D 4833	45,000 lbs	62	93	124	155
Carbon Black Content, % (Range) [(1)]	ASTM D 1603*/4218	20,000 lbs	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596	45,000 lbs	Note[(2)]	Note[(2)]	Note[(2)]	Note[(2)]
Oxidative Induction Time, min	ASTM D 8117	200,000 lbs	>100	>100	>100	>100
Typical Roll Dimensions						
Roll Length[(3)], ft			870	560	430	340
Roll Width[(3)], ft			22.5	22.5	22.5	22.5
Roll Area, ft^2			19,575	12,600	9,675	7,650

NOTES:

- [(1)] Solmax GSE geomembranes with conductive or colored surfaces may have an overall ash content of 3.0% due to the surface finish layer(s). These values apply to the black layer only.
- [(2)] Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- [(3)] for Solmax HD Textured is conducted on representative smooth geomembrane samples.
- [(4)] Roll lengths and widths have a tolerance of ± 1%.
- Solmax HD Smooth is available in rolls weighing approximately 4,000 lb.
- All Solmax geomembranes have dimensional stability of ±2% when tested according to ASTM D 1204 and LTB of <-77° C when tested according to ASTM D 746.
- *Modified.

Table 2 (Metric): **SOLMAX GSE** LL (formerly Solmax LLDPE Series) Smooth Geomembranes

Tested Property	Test Method	Frequency	Minimum Average Value			
			1.00mm	1.50mm	2.00mm	2.50mm
Thickness, mm Lowest individual reading	ASTM D 5199	every roll	1.00 0.90	1.50 1.35	2.00 1.80	2.50 2.25
Density, g/cm^3 (max.)	ASTM D 792	90,000 kg	0.939	0.939	0.939	0.939
Tensile Properties (each direction) Strength at Break, kN/m-width Elongation at Break, %	ASTM D 6693, Type IV Dumbbell, 50 mm/min G.L. 50 mm	9,000 kg	 29 800	 44 800	 56 800	 70 800
Tear Resistance, N	ASTM D 1004	20,000 kg	100	150	205	255
Puncture Resistance, N	ASTM D 4833	20,000 kg	275	415	550	690
Carbon Black Content, % (Range) (1)	ASTM D 1603*/4218	9,000 kg	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596	20,000 kg	Note(2)	Note(2)	Note(2)	Note(2)
Oxidative Induction Time, min	ASTM D 8117	90,000 kg	>100	>100	>100	>100
Typical Roll Dimensions						
Roll Length(3), ft			870	560	430	340
Roll Width(3), ft			22.5	22.5	22.5	22.5
Roll Area, ft^2			19,575	12,600	9,675	7,650

NOTES:

- (1) Solmax GSE geomembranes with conductive or colored surfaces may have an overall ash content of 3.0% due to the surface finish layer(s). These values apply to the black layer only.
- (2) Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- (3) NCTL for Solmax HD Textured is conducted on representative smooth geomembrane samples.
- (4) Roll lengths and widths have a tolerance of ± 1%.
- Solmax HD Smooth is available in rolls weighing approximately 4,000 lb.
- All Solmax geomembranes have dimensional stability of ±2% when tested according to ASTM D 1204 and LTB of <-77° C when tested according to ASTM D 746.
- *Modified.

E. Textured surfaced geomembrane shall meet the requirements shown in the following data sheets below.

1. Table 3 for coextruded textured HDPE
2. Table 4 for coextruded textured LLDPE

Table 3 (English): **SOLMAX GSE** HD (formerly Solmax HDPE Series) Textured Geomembrane

Tested Property	Test Method	Frequency	Minimum Average Values				
			30 mil	40 mil	60 mil	80 mil	100 mil
Thickness, mil Lowest individual reading	ASTM D 5994	every roll	30 27	40 36	60 54	80 72	100 90
Density, g/cm^3, (min.)	ASTM D 792	200,000 lbs	0.940	0.940	0.940	0.940	0.940
Tensile Properties (each direction) Strength at Break, lb/in-width Strength at Yield, lb/in-width Elongation at Break, % Elongation at Yield, %	ASTM D 6693, Type IV Dumbbell, 2 ipm G.L. 2.0 in G.L. 1.3 in	20,000 lbs	 66 66 150 12	 88 88 150 12	 132 132 150 12	 176 176 150 12	 220 220 150 12
Tear Resistance, lb	ASTM D 1004	45,000 lbs	23	30	45	60	75
Puncture Resistance, lb	ASTM D 4833	45,000 lbs	68	90	120	152	180
Carbon Black Content, % (Range) [1]	ASTM D 1603*/4218	20,000 lbs	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596	45,000 lbs	Note[2]	Note[2]	Note[2]	Note[2]	Note[2]
Asperity Height, mil	ASTM D 7466	second roll	16	16	16	16	16
Notch Constant Tensile Load[3], hr	ASTM D 5397, Appendix	200,000 lbs	500	500	500	500	500
Oxidative Induction Time, min	ASTM D 8117	200,000 lbs	>100	>100	>100	>100	>100
Typical Roll Dimensions							
Roll Length[4], ft	Double-Sided Textured Single-Sided Textured		830 1,010	700 780	520 540	400 410	330 330
Roll Width[4], ft			22.5	22.5	22.5	22.5	22.5
Roll Area, ft^2	Double-Sided Textured Single-Sided Textured		18,675 22,725	15,750 17,550	11,700 12,150	9,000 9,225	7,425 7,425

NOTES:

- [1] Solmax GSE geomembranes with conductive or colored surfaces may have an overall ash content of 3.0% due to the surface finish layer(s). These values apply to the black layer only.
- [2] Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- [3] NCTL for Solmax HD Textured is conducted on representative smooth geomembrane samples.
- [4] Roll lengths and widths have a tolerance of ± 1%.
- Solmax HD Smooth is available in rolls weighing approximately 4,000 lb.
- All Solmax geomembranes have dimensional stability of ±2% when tested according to ASTM D 1204 and LTB of <-77° C when tested according to ASTM D 746.
- *Modified.

Table 3 (Metric): **SOLMAX GSE** HD (formerly Solmax HDPE Series) Textured Geomembrane

Tested Property	Test Method	Frequency	Minimum Average Values				
			0.75mm	1.00mm	1.50mm	2.00mm	2.50mm
Thickness, mm Lowest individual reading	ASTM D 5994	every roll	0.75 0.71	1.00 0.90	1.50 1.35	2.00 1.80	2.50 2.25
Density, g/cm^3 , (min.)	ASTM D 792	90,000 kg	0.940	0.940	0.940	0.940	0.940
Tensile Properties (each direction) Strength at Break, kN/m-width Strength at Yield, kN/m-width Elongation at Break, % Elongation at Yield, %	ASTM D 6693, Type IV Dumbbell, 50 mm/min G.L. 50 mm G.L. 33 mm	9,000 kg	 12 12 150 12	 88 88 150 12	 23 23 150 12	 31 31 150 12	 39 39 150 12
Tear Resistance, N	ASTM D 1004	20,000 kg	100	30	200	265	335
Puncture Resistance, N	ASTM D 4833	20,000 kg	300	90	535	675	800
Carbon Black Content, % (Range) [(1)]	ASTM D 1603*/4218	9,000 kg	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596	20,000 kg	Note[(2)]	Note[(2)]	Note[(2)]	Note[(2)]	Note[(2)]
Asperity Height, mil	ASTM D 7466	second roll	0.40	0.40	0.40	0.40	0.40
Notch Constant Tensile Load[(3)], hr	ASTM D 5397, Appendix	90,000 kg	500	500	500	500	500
Oxidative Induction Time, min	ASTM D 8117	90,000 kg	>100	>100	>100	>100	>100
Typical Roll Dimensions							
Roll Length[(4)], ft	Double-Sided Textured Single-Sided Textured		830 1,010	700 780	520 540	400 410	330 330
Roll Width[(4)], ft			22.5	22.5	22.5	22.5	22.5
Roll Area, ft^2	Double-Sided Textured Single-Sided Textured		18,675 22,725	15,750 17,550	11,700 12,150	9,000 9,225	7,425 7,425

NOTES:

- [(1)] Solmax GSE geomembranes with conductive or colored surfaces may have an overall ash content of 3.0% due to the surface finish layer(s). These values apply to the black layer only.
- [(2)] Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- [(3)] NCTL for Solmax HD Textured is conducted on representative smooth geomembrane samples.
- [(4)] Roll lengths and widths have a tolerance of ± 1%.
- Solmax HD Smooth is available in rolls weighing approximately 4,000 lb.
- All Solmax geomembranes have dimensional stability of ±2% when tested according to ASTM D 1204 and LTB of <-77° C when tested according to ASTM D 746.
- *Modified.

Table 4 (English): **SOLMAX GSE** LL (formerly Solmax LLDPE Series) Textured Geomembrane

Tested Property	Test Method	Frequency	Minimum Average Values			
			40 mil	60 mil	80 mil	100 mil
Thickness, mil Lowest individual reading	ASTM D 5199	every roll	40 36	60 54	80 72	100 90
Density, g/cm^3 (max.)	ASTM D 792	200,000 lbs	0.939	0.939	0.939	0.939
Tensile Properties (each direction) Strength at Break, lb/in-width Elongation at Break, %	ASTM D 6693, Type IV Dumbbell, 2 ipm G.L. 2.0 in	20,000 lbs	 100 250	 132 400	 176 400	 220 400
Tear Resistance, lb	ASTM D 1004	45,000 lbs	25	37	50	60
Puncture Resistance, lb	ASTM D 4833	45,000 lbs	56	84	112	140
Carbon Black Content, % (Range) [(1)]	ASTM D 1603*/4218	20,000 lbs	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596	45,000 lbs	Note[(2)]	Note[(2)]	Note[(2)]	Note[(2)]
Asperity Height, mil	ASTM D 7466	second roll	16	16	16	16
Oxidative Induction Time, min	ASTM D 8117	200,000 lbs	>100	>100	>100	>100
Typical Roll Dimensions						
Roll Length[(2)], ft	Double-Sided Textured Single-Sided Textured		700 650	520 420	400 320	330 250
Roll Width[(2)], ft			22.5	22.5	22.5	22.5
Roll Area, ft^2	Double-Sided Textured Single-Sided Textured		15,750 14,625	11,700 9,450	9,000 7,200	7,425 5,625

NOTES:

- [(1)] Solmax GSE geomembranes with conductive or colored surfaces may have an overall ash content of 3.0% due to the surface finish layer(s). These values apply to the black layer only.
- [(2)] Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- [(3)] NCTL for Solmax HD Textured is conducted on representative smooth geomembrane samples.
- [(4)] Roll lengths and widths have a tolerance of ± 1%.
- Solmax HD Smooth is available in rolls weighing approximately 4,000 lb.
- All Solmax geomembranes have dimensional stability of ±2% when tested according to ASTM D 1204 and LTB of <-77° C when tested according to ASTM D 746.
- *Modified.

Table 4 (Metric): **SOLMAX GSE** LL (formerly Solmax LLDPE Series) Textured Geomembrane

Tested Property	Test Method	Frequency	Minimum Average Values			
			1.00mm	1.50mm	2.00mm	2.50mm
Thickness, mm Lowest individual reading	ASTM D 792	every roll	1.00 0.90	1.50 1.35	2.00 1.80	2.50 2.25
Density, g/cm^3 (max.)	ASTM D 1505	90,000 kg	0.939	0.939	0.939	0.939
Tensile Properties (each direction) Strength at Break, kN/m-width Elongation at Break, %	ASTM D 6693, Type IV Dumbbell, 50 mm/min G.L. 50 mm	9,000 kg	 18 250	 23 400	 31 400	 39 400
Tear Resistance, N	ASTM D 1004	20,000 kg	110	165	220	265
Puncture Resistance, N	ASTM D 4833	20,000 kg	250	375	500	625
Carbon Black Content, % (Range) [(1)]	ASTM D 1603*/4218	9,000 kg	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596	20,000 kg	Note[(2)]	Note[(2)]	Note[(2)]	Note[(2)]
Asperity Height, mm	ASTM D 7466	second roll	0.40	0.40	0.40	0.40
Oxidative Induction Time, min	ASTM D 8117	90,000 kg	>100	>100	>100	>100
Typical Roll Dimensions						
Roll Length[(2)], ft	Double-Sided Textured Single-Sided Textured		700 650	520 420	400 320	330 250
Roll Width[(2)], ft			22.5	22.5	22.5	22.5
Roll Area, ft^2	Double-Sided Textured Single-Sided Textured		15,750 14,625	11,700 9,450	9,000 7,200	7,425 5,625

NOTES:

- [(1)] Solmax GSE geomembranes with conductive or colored surfaces may have an overall ash content of 3.0% due to the surface finish layer(s). These values apply to the black layer only.
- [(2)] Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- [(3)] NCTL for Solmax HD Textured is conducted on representative smooth geomembrane samples.
- [(4)] Roll lengths and widths have a tolerance of ± 1%.
- Solmax HD Smooth is available in rolls weighing approximately 4,000 lb.
- All Solmax geomembranes have dimensional stability of ±2% when tested according to ASTM D 1204 and LTB of <-77° C when tested according to ASTM D 746.
- *Modified.

F. Extrudate Rod or Bead

1. Extrudate material shall be made from same type resin as the geomembrane.
2. Additives shall be thoroughly dispersed.
3. Materials shall be free of contamination by moisture or foreign matter.

1.10 EQUIPMENT

A. Welding equipment and accessories shall meet the following requirements:
   1. Gauges showing temperatures in apparatus such as extrusion welder or fusion welder shall be present.
   2. An adequate number of welding apparati shall be available to avoid delaying work.
   3. Power source must be capable of providing constant voltage under combined line load.

1.11 DEPLOYMENT

A. Assign each panel a simple and logical identifying code. The coding system shall be subject to approval and shall be determined at the job site.
B. Visually inspect the geomembrane during deployment for imperfections and mark faulty or suspect areas.
C. Deployment of geomembrane panels shall be performed in a manner that will comply with the following guidelines:
   1. Geomembranes shall be installed according to site-specific specifications, and SOLMAX Leak Location Conductive should be installed with the conductive layer down.
      Note: A spark tester or ohm meter can be used to determine conductive layer.
   2. Unroll geomembrane using methods that will not damage geomembrane and will protect underlying surface from damage (spreader bar, protected equipment bucket).
   3. Place ballast (commonly sandbags) on geomembrane which will not damage geomembrane to prevent wind uplift.
   4. Personnel walking on geomembrane shall not engage in activities or wear shoes that could damage it. Smoking will not be permitted on the geomembrane.
   5. Do not allow heavy vehicular traffic directly on geomembrane. Rubber-tired ATV's and trucks are acceptable if wheel contact is less than 8 psi.
   6. Protect geomembrane in areas of heavy traffic by placing protective cover over the geomembrane.
D. Sufficient material (slack) shall be provided to allow for thermal expansion and contraction of the material.

1.12 FIELD SEAMING

A. Seams shall meet the following requirements:
   1. To the maximum extent possible, orient seams parallel to line of slope, i.e., down and not across slope.

2. Minimize number of field seams in corners, odd-shaped geometric locations and outside corners.
3. Slope seams (panels) shall extend a minimum of five-feet beyond the grade break into the flat area.
4. Use a sequential seam numbering system compatible with panel numbering system that is agreeable to the CONSULTANT and INSTALLER.
5. Align seam overlaps consistent with the requirements of the welding equipment being used. A 6-inch overlap is commonly suggested.

B. During Welding Operations
1. Provide at least one Master Seamer who shall provide direct supervision over other welders as necessary.

C. Extrusion Welding
1. Hot-air tack adjacent pieces together using procedures that do not damage the geomembrane.
2. Clean geomembrane surfaces by disc grinder or equivalent.
3. Purge welding apparatus of heat-degraded extrudate before welding.

D. Hot Wedge Welding
1. Welding apparatus shall be a self-propelled device equipped with an electronic controller which displays applicable temperatures.
2. Clean seam area of dust, mud, moisture and debris immediately ahead of hot wedge welder.
3. Protect against moisture build-up between sheets.

E. Trial Welds
1. Perform trial welds on geomembrane samples to verify welding equipment is operating properly.
2. Make trial welds under the same surface and environmental conditions as the production welds, i.e., in contact with subgrade and similar ambient temperature.
3. Minimum of two trial welds per day, per welding apparatus, one made prior to the start of work and one completed at mid shift.
4. Cut four, one-inch wide by six-inch long test strips from the trial weld.
5. Quantitatively test specimens for peel adhesion, and then for shear strength.
6. Trial weld specimens shall pass when the results shown in the following tables for HDPE and LLDPE are achieved in both peel and shear test.

Table 1.12.6A: Minimum Weld Values for HDPE Geomembranes (English)

Property	Test Method	30	40	60	80	100	120
Peel Strength (fusion), ppi Peel Strength (extrusion), ppi	ASTM D 6392 ASTM D 6392	49 39	65 52	98 78	130 104	162 130	196 157
Shear Strength (fusion & ext.), ppi	ASTM D 6392	61	81	121	162	203	242

Table 1.2.6B: Minimum Weld Values for LLDPE Geomembranes (English)

Property	Test Method	30	40	60	80	100
Peel Strength (extrusion), ppi	ASTM D 6392	36	48	72	96	120
Peel Strength (fusion), ppi	ASTM D 6392	38	50	75	100	125
Shear Strength (fusion & ext.), ppi	ASTM D 6392	45	60	90	120	150

a. The break, when peel testing, occurs in the liner material itself, not through peel separation (FTB).
b. The break is ductile.

7. Repeat the trial weld, in its entirety, when any of the trial weld samples fail in either peel or shear.
8. No welding equipment or welder shall be allowed to perform production welds until equipment and welders have successfully completed trial weld.

F. Seaming shall not proceed when ambient air temperature or adverse weather conditions jeopardize the integrity of the liner installation. INSTALLER shall demonstrate that acceptable seaming can be performed by completing acceptable trial welds.

G. Defects and Repairs
1. Examine all seams and non-seam areas of the geomembrane for defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter.
2. Repair and non-destructively test each suspect location in both seam and non-seam areas. Do not cover geomembrane at locations that have been repaired until test results with passing values are available.

1.13 FIELD QUALITY ASSURANCE

A. MANUFACTURER and INSTALLER shall participate in and conform to all terms and requirements of the Owner's quality assurance program. CONTRACTOR shall be responsible for assuring this participation.

B. Quality assurance requirements are as specified in this Section and in the Field Installation Quality Assurance Manual if it is included in the contract.

C. Field Testing
1. Non-destructive testing may be carried out as the seaming progresses or at completion of all field seaming.
a. Vacuum Testing
1) Shall be performed in accordance with ASTM D 5641, Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber.
b. Air Pressure Testing
1) Shall be performed in accordance with ASTM D 5820, Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes.
c. Spark Testing
1) Shall be performed accordance with ASTM D 7240 Standard Practice for Leak Location using Geomembranes with an Insulating Layer in

Intimate Contact with a Conductive Layer via Electrical Capacitance Technique (Conductive Geomembrane Spark Test).

d. Other approved methods.

2. Destructive Testing (performed by CONSULTANT with assistance from INSTALLER)
   a. Location and Frequency of Testing
      1) Collect destructive test samples at a frequency of one per every 500 lineal feet of seam length.
      2) Test locations will be determined after seaming.
      3) Exercise Method of Attributes as described by GRI GM-14 (Geosynthetic Research Institute, http://www.geosynthetic-institute.org) to minimize test samples taken.
   b. Sampling Procedures are performed as follows:
      1) INSTALLER shall cut samples at locations designated by the CONSULTANT as the seaming progresses in order to obtain field laboratory test results before the geomembrane is covered.
      2) CONSULTANT will number each sample, and the location will be noted on the installation as-built.
      3) Samples shall be twelve (12) inches wide by minimal length with the seam centered lengthwise.
      4) Cut a 2-inch wide strip from each end of the sample for field-testing.
      5) Cut the remaining sample into two parts for distribution as follows:
         a) One portion for INSTALLER, 12-inches by 12 inches
         b) One portion for the Third Party laboratory, 12-inches by 18-inches
         c) Additional samples may be archived if required.
      6) Destructive testing shall be performed in accordance with ASTM D 6392, Standard Test Method for Determining the Integrity of Non-Reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.
      7) INSTALLER shall repair all holes in the geomembrane resulting from destructive sampling.
      8) Repair and test the continuity of the repair in accordance with these Specifications.

3. Failed Seam Procedures
   a) If the seam fails, INSTALLER shall follow one of two options:
      1) Reconstruct the seam between any two passed test locations.
      2) Trace the weld to intermediate location at least 10 feet minimum or where the seam ends in both directions from the location of the failed test.
   b) The next seam welded using the same welding device is required to obtain an additional sample, i.e., if one side of the seam is less than 10 feet long.
   c) If sample passes, then the seam shall be reconstructed or capped between the test sample locations.
   d) If any sample fails, the process shall be repeated to establish the zone in which the seam shall be reconstructed.

1.14 REPAIR PROCEDURES

A. Remove damaged geomembrane and replace with acceptable geomembrane materials if damage cannot be satisfactorily repaired.

B. Repair any portion of unsatisfactory geomembrane or seam area failing a destructive or non-destructive test.
C. INSTALLER shall be responsible for repair of defective areas.
D. Agreement upon the appropriate repair method shall be decided between CONSULTANT and INSTALLER by using one of the following repair methods:
    1. Patching- Used to repair large holes, tears, undispersed raw materials and contamination by foreign matter.
    2. Abrading and Re-welding- Used to repair short section of a seam.
    3. Spot Welding- Used to repair pinholes or other minor, localized flaws or where geomembrane thickness has been reduced.
    4. Capping- Used to repair long lengths of failed seams.
    5. Flap Welding- Used to extrusion weld the flap (excess outer portion) of a fusion weld in lieu of a full cap.
    6. Remove the unacceptable seam and replace with new material.
E. The following procedures shall be observed when a repair method is used:
    1. All geomembrane surfaces shall be clean and dry at the time of repair.
    2. Surfaces of the polyethylene which are to be repaired by extrusion welds shall be lightly abraded to assure cleanliness.
    3. Extend patches or caps at least 6 inches for extrusion welds and 4 inches for wedge welds beyond the edge of the defect, and around all corners of patch material.
F. Repair Verification
    1. Number and log each patch repair (performed by CONSULTANT).
    2. Non-destructively test each repair using methods specified in this Specification.

1.15 MEASUREMENT AND PAYMENT

A. Payment for geomembrane installation will be as per contract unit price per square foot, as measured parallel to liner surface, including designed anchor trench material and is based upon net lined area.

B. Net lined area is defined to be the true area of all surfaces to be lined plus designed burial in all anchor trenches, rubsheets, and sacrificial layers.
C. Prices shall include full compensation for furnishing all labor, material, tools, equipment, and incidentals.
D. Prices also include doing all the work involved in performing geomembrane installation completely as shown on the drawing, as specified herein, and as directed by the ENGINEER.

END OF SECTION