

## CONSTRUCTION SPECIFICATION

### NV-97. POLYETHYLENE GEOMEMBRANE LINING

#### 1. SCOPE

The work shall consist of furnishing, transporting, and placing a high density polyethylene (HDPE) or a very flexible Polyethylene (VFDPE) geomembrane liner to the elevations, grades and cross sections as shown on the drawings or as staked in the field.

#### 2. MATERIALS

The geomembrane liner shall have a nominal thickness as specified on the drawings and be specifically manufactured to be suitable for use in exposed and buried conditions. The liner shall conform to the material properties in Table 1 through Table 4 as applicable.

#### 3. SHIPPING AND STORAGE

The geomembrane liner shall be shipped to the job site in a manner not to damage the rolls. The liner rolls shall be stored so they are protected from puncture, dirt, grease, water, moisture, mechanical abrasion, excessive heat, or other damage. The rolls shall be stored on a smooth surface (not wooden pallets) and not stacked more than two rolls high.

All geomembrane shall be free of damage or defect. Each package delivered to the job site shall bear the name of the material, the manufacturer's name or symbol, the quantity therein, and the thickness or weight of the material.

#### 4. SUBGRADE PREPARATION

The area to be lined shall be drained and allowed to dry until the surface is firm. It must support people and equipment that must travel over it during installation of the geomembrane liner. All cut and fill slopes shall be constructed in accordance with the drawings. Required subgrade fill shall be placed in layers with a maximum thickness of six (6) inches prior to compaction. The fill soils shall be disked or worked in such a manner as to obtain a maximum clod size of four (4) inches prior to compaction. Each layer shall be compacted by a minimum of one pass over the entire surface of the fill by a fully loaded rubber-tired scraper or a tamping roller. Operation of the compaction equipment will be continuous over the entire area during fill operations. Fill materials shall have a moisture content sufficient to insure the required compaction is achieved. The Technician shall approve the adequacy of fill moisture content and compaction.

The foundation area shall be smooth and free of projections that can damage the geomembrane. Stumps and roots shall be removed. Rocks (larger than 3/8" and all fractured rocks), hard clods, and other such material shall be removed, rolled with a smooth-wheeled vibratory roller, or covered with a compacted cushion of fine soil. No equipment tracks or footprints shall be present in the subgrade. In soils where rocks are prevalent, a non-woven geotextile cushion may be used when intimate contact between the underlying soil and geomembrane is not required. An anchor trench for the liner shall be excavated in accordance with the drawings.

## 5. PLACEMENT

The placement of the geomembrane liner shall be performed by the manufacturer or under the supervision of an authorized representative of the manufacturer.

The geomembrane liner rolls shall be deployed using a spreader bar assembly attached to a loader bucket or by other methods approved by the liner manufacturer. The method chosen to unroll the panels shall not cause scratches or crimps in the geomembrane and shall not damage the supporting soil or any underlying geotextile.

The liner shall not be deployed in the presence of excessive winds, or in temperatures colder than those recommended by the manufacturer.

The liner shall be loosely spread over the foundation with sufficient slack (approximately two percent) to accommodate thermal expansion and contraction expected during construction. Sufficient slack shall be provided near all points of solid anchorage (welds to embedment strips fixed in concrete and pipe penetrations, etc.) to accommodate thermal expansion and contraction expected prior to final acceptance of the work. Any damage due to inadequate slack in the liner shall be the responsibility of the geomembrane installer and shall be repaired.

Each panel shall be laid out and positioned to keep the number and length of the geomembrane field joints to a minimum and consistent with proper methods of geomembrane installation. The method used to place the panels shall minimize wrinkles (especially differential wrinkles between adjacent panels).

Seams shall be oriented down, not across the slope. No horizontal seams are allowed on the slopes or within five (5) feet of the toe or crest of a slope. Sharp corners shall be avoided. Up slope panel overlaps shall shingle down slope. Horizontal and T-shaped seams shall not be placed on slopes. All T-seams or seams where three or more panels come together shall include a minimum 24-inch diameter extrusion welded patch centered over the seam intersection and installed in accordance with this specification. No base T-shaped seam shall be closer than five (5) feet to the toe of the slope. Seams shall be aligned with the least possible number of wrinkles or "fishmouths." All fishmouths shall be cut out and the area repaired by patching.

Adequate loading (e.g., sand bags or similar items that will not damage the liner) shall be placed to prevent relocation of the compensating wrinkles or uplift of the liner by wind.

The top edge of the liner shall be placed in the anchor trench and anchored with compacted backfill. Compact the backfill by wheel rolling with light rubber-tired equipment or a manually directed power tamper.

Motorized equipment contact and/or traffic shall not be allowed on the liner. Portable generators may be positioned on the lined area provided that the liner is protected by an adequate cushion of geotextile or an additional layer of liner material. The installer shall not refuel generators or other equipment that uses petroleum products while the equipment is

located on the liner. Equipment shall be maintained such that no petroleum products come into contact with the liner.

No equipment or tools shall damage the liner by handling, traffic, or by other means. Personnel working on the liner shall not smoke, wear damaging shoes, or engage in other activities that could damage the liner. Use of metal tools shall be kept to a minimum.

## 6. SEAMING

SEAMING SHALL NOT BE ALLOWED DURING PRECIPITATION EVENTS.

PARALLEL WELDS MUST BE SEPARATED BY A DISTANCE OF AT LEAST 12”.

### a. Double-Wedge Fusion Seam

Field seams shall be made by overlapping adjacent liner panels a minimum of 4 inches and fusion welding the overlapped sheets using double-wedge fusion welders. Seams between panels shall be field welded using the Installer's seaming apparatus and technique.

Prior to fusion seaming, all areas that are to become seam interfaces will be cleansed of dust and dirt. Seam joining shall not take place unless the sheet is dry. Seam joining should not be attempted when the ambient sheet temperature is below 45°F or above 90°F. Seam joining may take place if it can be demonstrated that competent welds can be achieved down to 32°F or up to 125°F sheet temperature.

### b. Fillet Extrusion Seams

Extrusion welding shall be used only at areas which cannot be welded by using the double-wedge fusion welder (i.e., repairs, T-seams, etc.). For extrusion welds the liner shall be abraded, preheated and pressed together to align for welding. Minimum overlap of liner panels shall be three (3) inches.

## 7. SEAM TESTING

### a. Seam Testing

Seam tests shall be conducted under field conditions by the Installer at the beginning of each seaming period, once in the morning and once in the afternoon. Three specimens shall be tested by a tensiometer in shear and peel modes. The installer shall supply calibration certification for the field tensiometer. Test seams shall meet the material properties in Table 1 through Table 4 as applicable. Each specimen shall be 1 inch wide with the grip separation rate of two (2) inches per minute. All peel tests shall result in Film Tear Bond (FTB) failure. Both the inside and outside track of double fusion welds shall be tested.

b. Non-Destructive Seam Testing

The Installer shall non-destructively test all field seams over their full lengths and furnish all test equipment.

(1) Air Pressure Tests shall be performed on all double-wedge fusion seams. The air pressure test equipment and procedures shall conform to this specification and the liner manufacturer specification. Seal both ends of the seam to be tested. Insert the pressure needle into the seam's air channel. Pressurize the air channel through the needle to 25-30 psi. Monitor any pressure loss for 5 minutes. A loss of pressure in excess of 4 psi or a continuous loss of pressure is an indication of a leak. Terminate the test by relieving the pressure from the opposing end of the seam. The pressure shall immediately drop to zero upon opening the opposing end of the seam. If not, the seam channel shall be checked for obstructions and re-tested. All defects shall be marked for repair. All areas with failing air pressure tests shall be repaired by capping. All failing seams shall be bounded by passing tests.

(2) Vacuum Box Tests shall be performed on all extrusion welds. The vacuum box equipment and procedures shall conform to this specification and the liner manufacturer specification. Apply soapy water solution to the seam area to be tested. The vacuum box, equipped with a transparent viewing window, shall be centered over the seam area and a vacuum of 3-5 psi shall be drawn. The seam area shall be visually monitored for any soap bubbles for 15 seconds. Seam testing shall continue by overlapping a minimum of three (3) inches between each test interval. All defects shall be marked for repair.

c. Destructive Seam Testing

Seam samples for destructive testing shall be cut at one sample per 500 feet of weld. Label each sample and document the location of that sample. Samples for destructive testing shall be obtained for every 500 feet of seam per welder and operator combination. Both the inside and outside track of double fusion welds shall be tested in peel. A minimum of three coupons for shear and three for peel shall be tested. Destructive samples shall be divided into two portions with one being tested in the field and one sent to an independent testing laboratory for verification. Test seams shall meet the material properties in Table 1 through Table 4 as applicable. Each specimen shall be 1 inch wide with the grip separation rate of two (2) inches per minute. All peel tests shall result in Film Tear Bond (FTB). Repair holes in liner resulting from destructive seam sampling immediately and vacuum test in accordance with procedures described in this specification.

8. APPURTENANCES

a. Gas Vents or Vent Pipes shall be installed in accordance with the drawings to provide adequate venting for the liner system.

b. Pipe Boots for all pipes shall be fabricated in the field from the same liner as shown on the drawings. Pipe boots shall be clamped to the pipe as shown on the drawings to provide a leak-free attachment.

c. Egress Strips shall be installed at the locations shown on the drawings

## 9. REPAIRS

All defective liner and seams shall be repaired and non-destructively tested prior to completion of the installation.

### a. Tears, Punctures, Material Defects

All tears, punctures, material defects in the liner shall be repaired by installation of a patch over the defective area. Surfaces of the liner to be patched shall be abraded and cleaned no more than 15 minutes prior to the repair. No more than 10% of the thickness of the liner may be removed by abrading. All patches shall be round or oval, made of the same liner material and extend a minimum of six (6) inches beyond the edges of the defect area. Patches shall have their top edges beveled with an angle grinder prior to extrusion welding to the liner. Small holes less than 1/4 inch shall be repaired by extrusion cap welding.

### b. Seam Repair

All failed seams shall be repaired by installing a cap strip over the entire length of the failed seam. The cap strip shall be of the same liner material and shall extend beyond the failed seam a minimum of six (6) inches in all directions.

## 10. PLACEMENT OF CONCRETE

CONCRETE PADS, RAMPS AND APPURTENANCES SHALL BE CONSTRUCTED PRIOR TO PLACING THE GEOMEMBRANE LINER.

Concrete ramps, pads, and appurtenances shall have approved pre-manufactured geomembrane embedment strips cast into the concrete per manufacturer's specifications. The concrete contractor shall obtain the embedment strips from the liner installer along with the manufacturer's installation instructions.

The embedment strips shall be stored at locations where excessive heat or sunlight will not cause deformation of the strip. The embedment strips shall be fully embedded into the concrete with no gaps between the strips. Stainless steel batten strips shall be installed in high stress areas as shown on the drawings.

Placement of concrete pads and ramps shall be in accordance with the drawings and shall conform to Construction Specification NV-31, Reinforced Concrete. All reinforcement shall be deformed steel bars and shall be placed on flat-footed plastic rebar chairs. Welded wire mesh will not be allowed. All reinforcement steel splices shall be fully tied to avoid loose ends. On slopes, concrete shall have a low slump to prevent sloughing down slope during placement.

## 11. FINAL TESTS AND INSPECTION

Upon completion of the work, the installation shall be subjected to a final inspection. All work in the system therein being tested shall be complete, cleaned and ready for use. The work shall meet the requirements as to the line, grade, cleanliness and workmanship. Any discrepancies shall be repaired.

## 12. BASIS OF ACCEPTANCE

The acceptability of the reinforced concrete shall be determined by inspection to check compliance with all the provisions of this specification, with respect to the drawings, and the minimum installation requirements.

Materials used shall be certified as meeting the requirements of this specification. The installing Contractor shall certify that the installation complies with the requirements of this specification. A written guarantee shall be furnished that protects the Owner against defective workmanship and materials for no less than one year.

**TABLE 1**

**Requirements for Smooth HDPE Geomembrane Liner**

Nominal Thickness: 40 mil, 60 mil, 80 mil, 100 mil

Property	Test Method	Minimum Average Roll Values <sup>1/</sup>			
		40 mil	60 mil	80 mil	100 mil
Thickness, mil	ASTM D 5199	36	54	72	90
Density, g/cc	ASTM D 1505	0.940	0.940	0.940	0.940
Tensile Properties	ASTM D 638 (Type IV at 2 in/min)				
yield stress, lb/in		80	120	160	210
break stress, lb/in		150	220	300	380
yield elongation, %		12	12	12	12
break elongation, %		700	700	700	700
Tear Resistance, lb	ASTM D 1004	28	42	144	180
Puncture Resistance, lb	ASTM D 4833	70	90	140	180
Carbon Black Content, %	ASTM D1603	2-3	2-3	2-3	2-3
Carbon Black Dispersion, %	ASTM D 5596	8 in Category 1 and 2 10 in Category 1,2, and 3			
Seam Properties	ASTM D 4437 (1 inch wide at 2 in/min)				
fusion shear strength, lb/in		80	120	160	200
fusion peel strength, lb/in		55 FTB <sup>2/</sup>	80 FTB <sup>2/</sup>	110 FTB <sup>2/</sup>	140 FTB <sup>2/</sup>
extrusion shear strength, lb/in		80	120	160	200
Extrusion peel strength, lb/in		50	75	95	120

<sup>1/</sup> Minimum Average Roll Values (MARV: Calculated as the mean minus two standard deviation, yielding a 95% confidence level that the table value will be equaled or exceeded.

<sup>2/</sup> Film Tear Bond (FTB): A failure of one of the bonded sheets by tearing prior to complete separation in the bonded area.

**TABLE 2****Requirements for Textured HDPE Geomembrane Liner**Nominal Thickness: 40 mil, 60 mil, 80 mil, 100 mil

Property	Test Method	Minimum Average Roll Values <sup>1/</sup>			
		40 mil	60 mil	80 mil	100 mil
Thickness, mil	ASTM D 5199	34	51	68	85
Density, g/cc	ASTM D 1505	0.940	0.940	0.940	0.940
Tensile Properties	ASTM D 638 (Type IV at 2 in/min)				
yield stress, lb/in		80	120	160	210
break stress, lb/in		80	120	160	210
yield elongation, %		12	12	12	12
break elongation, %		200	200	200	200
Tear Resistance, lb	ASTM D 1004	25	40	55	70
Puncture Resistance, lb	ASTM D 4833	70	90	120	150
Carbon Black Content, %	ASTM D1603	2-3	2-3	2-3	2-3
Carbon Black Dispersion, %	ASTM D 5596	8 in Category 1 and 2 10 in Category 1,2, and 3			
Seam Properties	ASTM D 4437 (1 inch wide at 2 in/min)				
fusion shear strength, lb/in		80	120	160	200
fusion peel strength, lb/in		55 FTB <sup>2/</sup>	80 FTB <sup>2/</sup>	110 FTB <sup>2/</sup>	140 FTB <sup>2/</sup>
extrusion shear strength, lb/in		80	120	160	200
Extrusion peel strength, lb/in		50	75	100	120

<sup>1/</sup> Minimum Average Roll Values (MARV: Calculated as the mean minus two standard deviation, yielding a 95% confidence level that the table value will be equaled or exceeded.

<sup>2/</sup> Film Tear Bond (FTB): A failure of one of the bonded sheets by tearing prior to complete separation in the bonded area.

**TABLE 3****Requirements for Smooth VFPE Geomembrane Liner**Nominal Thickness: 40 mil, 60 mil, 80 mil

Property	Test Method	Minimum Average Roll Values <sup>1/</sup>		
		40 mil	60 mil	80 mil
Thickness, mil	ASTM D 5199	36	54	72
Density, g/cc	ASTM D 1505	0.915	0.915	0.915
Tensile Properties	ASTM D 638 (Type IV at 2 in/min)			
Yield stress, lb/in		N/A	N/A	N/A
break stress, lb/in		150	225	300
yield elongation, %		13	13	13
break elongation, %		800	800	800
Tear Resistance, lb	ASTM D 1004	20	32	44
Puncture Resistance, lb	ASTM D 4833	50	75	100
Carbon Black Content, %	ASTM D1603	2-3	2-3	2-3
Carbon Black Dispersion, %	ASTM D 5596	8 in Category 1 and 2 10 in Category 1,2, and 3		
Seam Properties	ASTM D 4437 (1 inch wide at 2 in/min)			
fusion shear strength, lb/in		55	84	120
fusion peel strength, lb/in		45 FTB <sup>2/</sup>	65 FTB <sup>2/</sup>	90 FTB <sup>2/</sup>
extrusion shear strength, lb/in		55	84	120
extrusion peel strength, lb/in		45	65	90

<sup>1/</sup> Minimum Average Roll Values (MARV: Calculated as the mean minus two standard deviation, yielding a 95% confidence level that the table value will be equaled or exceeded.

<sup>2/</sup> Film Tear Bond (FTB): A failure of one of the bonded sheets by tearing prior to complete separation in the bonded area.

**TABLE 4****Requirements for Textured VFPE Geomembrane Liner**Nominal Thickness: 40 mil, 60 mil, 80 mil

Property	Test Method	Minimum Average Roll Values <sup>1/</sup>		
		40 mil	60 mil	80 mil
Thickness, mil	ASTM D 5199	36	54	72
Density, g/cc	ASTM D 1505	0.915	0.915	0.915
Tensile Properties	ASTM D 638 (Type IV at 2 in/min)			
Yield stress, lb/in		N/A	N/A	N/A
break stress, lb/in		80	105	160
yield elongation, %		13	13	13
break elongation, %		350	350	350
Tear Resistance, lb	ASTM D 1004	20	32	45
Puncture Resistance, lb	ASTM D 4833	50	75	100
Carbon Black Content, %	ASTM D1603	2-3	2-3	2-3
Carbon Black Dispersion, %	ASTM D 5596	8 in Category 1 and 2 10 in Category 1,2, and 3		
Seam Properties	ASTM D 4437 (1 inch wide at 2 in/min)			
fusion shear strength, lb/in		50	75	100
fusion peel strength, lb/in		40 FTB <sup>2/</sup>	60 FTB <sup>2/</sup>	85 FTB <sup>2/</sup>
extrusion shear strength, lb/in		50	75	100
extrusion peel strength, lb/in		40	60	85

<sup>1/</sup> Minimum Average Roll Values (MARV): Calculated as the mean minus two standard deviation, yielding a 95% confidence level that the table value will be equaled or exceeded.

<sup>2/</sup> Film Tear Bond (FTB): A failure of one of the bonded sheets by tearing prior to complete separation in the bonded area.