Construction Specification
202 Polyrthylene Geomembrane Lining

SCOPE

The work shall consist of furnishing, transporting, and placing a high density polyethylene (HDPE), linear low density polyethylene (LLDPE), or polyolefin alloy (a coextruded liner consisting of an LLDPE core and HDPE exterior on both sides) geomembrane liner to the elevations, grades and cross sections as shown on the drawings or as staked in the field.

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 6 as applicable.

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. Damaged liner material shall be repaired or replaced. 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.

SUBGRADE PREPARATION

The area to be lined shall be drained and allowed to dry until the surface is firm. The surface 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 accordance with Wisconsin Construction Specification 204, Earthfill For Waste Storage Facilities.

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. A non-woven geotextile cushion may be used in ponds that are not a component of a waste management system. Surface deformations from equipment tracks or footprint indentations shall not exceed 1 inch. Standing water, mud, and snow shall be removed prior to liner placement.

An anchor trench for the liner shall be excavated and backfilled in accordance with the drawings. The trench corners shall be slightly rounded to prevent sharp bends in the liner.

PLACEMENT

The placement of the geomembrane liner shall be performed by an experienced Contractor. The installation shall comply with the manufacturer's procedures and specifications. Continuous inspection shall be provided by an experienced third party (not an employee of the Contractor or membrane suppliers) for all deployment, seaming, seam testing, and concrete placement.

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 rolls shall not be deployed by allowing the roll to run freely down the slope.

The liner shall not be placed in the presence of excessive winds, during foggy conditions, or precipitation events. The liner shall not be placed when the temperature is less than 50 degrees Fahrenheit unless approved by the manufacturer.

The liner shall be loosely spread over the foundation with sufficient slack 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 along field seams. Wrinkles shall not exceed 6 inches in height or “fold over.”

Seams shall be oriented down, not across the slope. No horizontal seams are allowed on the side slopes or within 5 feet of the toe or crest of a side slope. Sharp corners shall be avoided. On the floor of a facility, up slope panel overlaps shall shingle down slope. Horizontal and T-shaped seamsshall not be placed on slopes. All T-seams or seams where three or more panels come together shallinclude a minimum 24-inch diameter extrusion welded patch centered over the seam intersection andinstalled in accordance with this specification. No base T-shaped seam shall be closer than 5 feet to the toe of the side slope. Seams shall be aligned with the least possible number of wrinkles or “fish mouths.” All fish mouths 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.

Construction equipment contact shall not be allowed to operate directly 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.

SEAMING

SEAMING SHALL NOT BE ALLOWED DURING PRECIPITATION EVENTS. PARALLEL WELDS MUST BE SEPARATED BY A DISTANCE OF AT LEAST 6”.

All areas that are to become seam interfaces will be cleansed of dust and dirt. Seaming shall not take place unless the geomembrane material is dry. Seaming shall not be attempted when the ambient sheet temperature is below 45° F or above 90° F unless it can be demonstrated that competent welds can be achieved down to 32° F or up to 125° F sheet temperature.

1. Hot-Wedge Seams
   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.

2. 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 by light grinding, preheated and pressed together to align for welding. Minimum overlap of liner panels shall be 3 inches.

SEAM TESTING

1. Trial Weld 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. Trial welds shall be completed using scraps of material from the liner installation. Six specimens from each trial weld shall be cut from the trial weld and tested in the field by a tensiometer in shear and peel modes. Four specimens shall be tested in peel and two specimens shall be tested in shear. The installer shall supply calibration certification for the field tensiometer. Test seams shall meet the material properties in Table 1 through Table 6 as applicable. Each specimen shall be 1 inch wide and be tested at a grip separation rate of 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.

2. Non-Destructive Seam Testing

   The installer shall non-destructively test all field seams over their full lengths. Seam testing shall be performed as the work progresses.

   a. Air Pressure Tests shall be performed in accordance with ASTM D 5820 on all double-wedge fusion seams. The air pressure test equipment and procedures shall conform to this specification and the liner manufacturer's specification. The air channel shall be pressurized to 25-30 psi and monitored for 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 end of the seam opposite from the end of the seam that pressure was applied. 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 repaired failing seam areas shall be bounded by passing tests.

   b. Vacuum Box Tests shall be performed in accordance with ASTM D 5641 on all extrusion welds. The vacuum box equipment and procedures shall conform to this specification and the liner manufacturer's 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 3 inches between each test interval. All defects shall be marked for repair. All repaired failing seam areas shall be bounded by passing tests.

   c. Air Lance Tests shall be performed in accordance with ASTM D 4437 on all single-track fusion welds utilizing an air nozzle directed on the upper seam edge and surface to detect loose edges, riffles, or other undesirable seam conditions. Utilize a minimum of 50 psi air supply directed through a 3/16-inch nozzle, held not more than 2 inches from the seam edge and directed at the seam edge.

3. Destructive Seam Testing

   Samples for destructive seam testing in a laboratory shall be cut at no more than one sample per 500 feet of seam per welder and operator combination. The location of the samples shall be marked in the field by the Technician or third party quality assurance professional. The samples shall be a minimum of 36 inches long and shall be cut from the liner by the geomembrane installer. 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. A minimum of three coupons for shear and three for peel shall be tested in the field. Both the inside and outside track of double fusion welds shall be tested in peel. If the coupons tested in the field meet applicable seam property requirements in Tables 1 through 6, the Contractor shall forward the remaining laboratory portion of the sample to the laboratory for testing. The Contractor shall provide copies of the laboratory testing results to the owner and to the third party inspector or Technician. If the field coupons do not meet project requirements, the laboratory portion of the sample shall be discarded and the seam shall be repaired in accordance with Section 9. Likewise, if the laboratory test results demonstrate that the seam does not meet project requirements, the seam shall be repaired in accordance with Section 9. Repair holes in the liner resulting from destructive seam sampling immediately and vacuum test in accordance with procedures described in this specification.

APPURTENANCES

1. Gas Vents or Vent Pipes shall be installed in accordance with the drawings to provide gas release for the liner system.
2. 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.
3. Egress Strips shall be installed at the locations shown on the drawings.

REPAIRS

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

1. Tears, Punctures, Material Defects

   All tears, punctures, or 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 cleaned no more than 15 minutes prior to the repair. All patches shall be made of the same liner material and extend a minimum of 6 inches beyond the edges of the defect area. Patches shall have rounded corners and shall be seamed to the liner. Small holes less than 1/4 inch in diameter shall be repaired by applying a bead of welding extrudent.

1. 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 6 inches in all directions.

PLACEMENT OF CONCRETE OR GROUT PILLOWS

Placement of concrete pads and ramps shall be in accordance with the drawings and shall conform to Wisconsin Construction Specification 4.

1. Concrete Joined to the Geomembrane

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

   Concrete ramps, pads, and appurtenances shall have approved premanufactured geomembrane embedment strips cast into the concrete per the 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. Joints between the strips shall be extrusion welded or an approved expanding sealant material placed under the joint.

   Stainless steel batten strips shall be installed as shown on the drawings and the liner manufacturer's recommendations. The battens shall be bolted to concrete at no more than 6-inch intervals using stainless steel bolts. Bolt spacing may be increased to 12 inches above the liquid level.

2. Concrete or Grout Pillows Placed Over the Geomembrane

   Concrete or grout pillow pads, ramps, and appurtenances shall be constructed in a manner that does not puncture the geomembrane and does not jeopardize the integrity or performance of the geomembrane liner in any way.

   The Contractor shall submit shop drawings, which include all details necessary to ensure compliance with this specification, to the Engineer at least five business days prior to the anticipated date of concrete construction. Concrete or grout pillow construction shall not occur until the Contractor obtains written approval of the shop drawings from the Engineer.

CONSTRUCTION QUALITY ASSURANCE

A quality assurance plan for the installation of the geomembrane and all appurtenances shall be submitted to the Engineer for approval at least five business days prior to installation.

All geomembrane placement, seaming, seam testing, and repair, as well as concrete construction shall be completed under the continuous observation of a qualified independent third party quality assurance inspector under the direction of a Professional Engineer registered in Wisconsin. The quality assurance inspector shall not be an employee of the Contractor, owner, or geomembrane supplier.

A construction quality assurance report shall be prepared and submitted to the owner, cost sharing agency, and/or permitting agencies as appropriate. The report shall include, at a minimum:

- A panel layout diagram showing the location of panels and the seam numbering system used.
- Documentation that the entire length of all seams has been non-destructively tested by air channel tests or vacuum box tests as applicable.
- Documentation that all seams that did not initially pass the non-destructive test have been repaired and that the repair has passed a non-destructive test.
- Documentation that the destructive seam samples have been taken at the required frequency, have been tested in an off-site laboratory, and have met the project requirements.
- Documentation that seams have been repaired where laboratory destructive seam sample testing has indicated that seams did not initially meet project requirements.
- Documentation that the entire surface of the liner has been observed and that all blemishes, punctures, fish mouths, and other irregularities that could jeopardize the performance of the liner have been acceptably repaired.

BASIS OF ACCEPTANCE

The acceptability of the geomembrane liner shall be determined by inspections to check compliance with all the provisions of this specification, with respect to the drawings, markings, the appurtenances, and the minimum installation requirements.

The installer 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 for a minimum of two years.

TABLE 1 Requirements for Smooth HDPE Geomembrane Liner Nominal Thickness: 40 mil and 60

Property	Test Method	Minimum Average Roll Values[1]	
		40 mil	**60 mil**
Density, g/cc	ASTM D 1505 / D 792	≤ 0.940	≤ 0.940
yield stress, lb/in	ASTM D 6693 (Type IV at 2 in/min)	84	126
break stress, lb/in		152	228
yield elongation, %		12	12
break elongation, %		700	700
Tear Resistance, lb.	ASTM D 1004	28	42
Puncture Resistance, lb.	ASTM D 4833	72	108
Carbon Black Content, %	ASTM D 1603	2-3	2-3
Carbon Black Dispersion	ASTM D 5596	Category 1 or 2	
Seam Properties:	ASTM D 6392		
Fusion Welds			
shear strength, lb/in		80	120
peel strength, lb/in		60 Note 2	91 Note 2
Extrusion Welds	ASTM D 6392		
shear strength, lb/in		80	120
peel strength, lb/in		52 Note 2	78 Note 2

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

[2] Break must occur with an acceptable break code as specified in GRI Specification GM19a.

TABLE 2 Requirements for Textured HDPE Geomembrane Liner Nominal Thickness: 40 mil and 60 mil

Property	Test Method	Minimum Average Roll Values[1]	
		40 mil	**60 mil**
Asperity Height, mils	ASTM D 7466	10	10
Density, g/cc	ASTM D 1505 / D 792	≤ 0.940	≤ 0.940
Tensile Properties:	ASTM D 6693 (Type IV at 2 in/min)		
yield stress, lb/in		84	126
break stress, lb/in		60	90
yield elongation, %		12	12
break elongation, %		100	100
Tear Resistance, lb.	ASTM D 1004	28	42
Puncture Resistance, lb.	ASTM D 4833	60	90
Carbon Black Content, %	ASTM D 1603	2-3	2-3
Carbon Black Dispersion	ASTM D 5596	Category 1 or 2	
Seam Properties:	ASTM D 6392		
Fusion Welds			
shear strength, lb/in		80	120
peel strength, lb/in		60 Note 2	91 Note 2
Extrusion Welds	ASTM D 6392		
shear strength, lb/in		80	120
peel strength, lb/in		52 Note 2	78 Note 2

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

[2] Break must occur with an acceptable break code as specified in GRI Specification GM19a.

TABLE 3 Requirements for Smooth LLDPE Geomembrane Liner Nominal Thickness: 40 mil and 60 mil

Property	Test Method	Minimum Average Roll Values[1]	
		40 mil	**60 mil**
Density, g/cc	ASTM D 1505 / D 792	≤ 0.939	≤ 0.939
Tensile Properties:			
break stress, lb/in	ASTM D 6693	152	228
break elongation, %	(Type IV at 2 in/min)	800	800
Tear Resistance, lb.	ASTM D 1004	22	33
Puncture Resistance, lb.	ASTM D 4833	56	84
Carbon Black Content, %	ASTM D 1603	2-3	2-3
Carbon Black Dispersion, %	ASTM D 5596	Category 1 or 2	
Seam Properties:			
Fusion Welds			
shear strength, lb/in	ASTM D 6392	60	90
peel strength, lb/in		50 Note 2	75 Note 2
Extrusion Welds			
shear strength, lb/in	ASTM D 6392	60	90
peel strength, lb/in		44 Note 2	66 Note 2

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

[2] Break must occur with an acceptable break code as specified in GRI Specification GM19a.

TABLE 4 Requirements for Textured LLDPE Geomembrane Liner Nominal Thickness: 40 mil and 60 mil

Property	Test Method	Minimum Average Roll Values[1]	
		40 mil	**60 mil**
Asperity Height, mils	ASTM D 7466	10	10
Density, g/cc	ASTM D 1505 / D 792	≤ 0.939	≤ 0.939
Tensile Properties			
break stress, lb/in	ASTM D 6693	60	90
break elongation, %	(Type IV at 2 in/min)	250	250
Tear Resistance, lb.	ASTM D 1004	22	33
Puncture Resistance, lb.	ASTM D 4833	44	66
Carbon Black Content, %	ASTM D 1603	2-3	2-3
Carbon Black Dispersion, %	ASTM D 5596	Category 1 or 2	
Seam Properties:			
Fusion Welds			
shear strength, lb/in	ASTM D 6392	60	90
peel strength, lb/in		50 Note 2	75 Note 2
Extrusion Welds			
shear strength, lb/in	ASTM D 6392	60	90
peel strength, lb/in		44 Note 2	66 Note 2

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

[2] Break must occur with an acceptable break code as specified in GRI Specification GM19a.

TABLE 5 Requirements for Polyolefin Alloy Geomembrane Smooth Liner Nominal Thickness: 40, 50 and 60 mil

Property	Test Method	Minimum Average Roll Values[1]		
		40 mil	**50 mil**	**60 mil**
Density, g/cc	ASTM D 1505 / D 792	≤0.939	≤0.939	≤0.939
Tensile Properties: break stress, lb./in break elongation, %	 ASTM D 6693 (Type IV at 2 in/min)	 180 800	 220 800	 255 800
Tear Resistance, lb.	ASTM D 1004	22	27	33
Puncture Resistance, lb.	ASTM D 4833	67	75	90
Multiaxial Elongation, %.	ASTM D 5617	80	80	80
Oxidative Induction Time (OIT), min.	D3895	200	200	200
High Pressure Oxidative Induction Time (HPOIT), min.	D5885	2000	2000	2000
Stress Cracking, hours.	D5397, appendix	1000	1000	1000
Carbon Black Content, %.	ASTM D 1603	2-3	2-3	2-3
Carbon Black Dispersion	ASTM D 5596	Category 1 or 2		
Toxicity to Aquatic Organisms.	Environment Canada RM - 13 & 14	No toxic effects were found on Rainbow Trout and Daphnia Magna after the exposure period.		
UV resistance, % tensile retained after 30,000 hours	ASTM D4329	90%		
Potable water.	NSF61	Pass, visit nsf.org		
Seam Properties: Fusion Welds				
shear strength, lb/in	ASTM D 6392	60	75	90
peel strength, lb/in		50 Note 2	63 Note 2	75 Note 2
Extrusion Welds				
shear strength, lb/in	ASTM D 6392	60	75	90
peel strength, lb/in		44 Note 2	57 Note 2	66 Note 2

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

[2] Break must occur with an acceptable break code as specified in GRI Specification GM19a.

TABLE 6 Requirements for Polyolefin Alloy Geomembrane Single- or Double-Sided Textured Liner Nominal Thickness: 40, 50 and 60 mil

Property	Test Method	Minimum Average Roll Values[1]		
		40 mil	**50 mil**	**60 mil**
Asperity Height, mil	ASTM D 5994 / D 792	16	16	16
Density, g/cc	ASTM D 1505	≤0.939	≤0.939	≤0.939
Tensile Properties	ASTM D 6693 (Type IV at 2 in/min)			
break stress, lb./in		60	75	90
break elongation, %		250	250	250
Tear Resistance, lb.	ASTM D 1004	22	27	33
Puncture Resistance, lb.	ASTM D 4833	44	55	66
Multiaxial Elongation, %.	ASTM D 5617	50	50	50
Oxidative Induction Time (OIT), min.	D3895	200	200	200
High Pressure Oxidative Induction Time (HPOIT), min.	D5885	2000	2000	2000
Stress Cracking, hours.	D5397, appendix	1000	1000	1000
Carbon Black Content, %.	ASTM D 1603	2-3	2-3	2-3
Carbon Black Dispersion	ASTM D 5596	Category 1 or 2		
Toxicity to Aquatic Organisms.	Environment Canada RM - 13 & 14	No toxic effects were found on Rainbow Trout and Daphnia Magna after the exposure period.		
UV resistance, % tensile retained after 30,000 hours	ASTM D4329	90%		
Potable water.	NSF61	Pass, visit nsf.org		
Seam Properties:	ASTM D 6392			
Fusion Welds				
shear strength, lb/in		60	75	90
peel strength, lb/in		50 Note 2	63 Note 2	75 Note 2
Extrusion Welds	ASTM D 6392			
shear strength, lb/in		60	75	90
peel strength, lb/in		44 Note 2	57 Note 2	66 Note 2

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

[2] Break must occur with an acceptable break code as specified in GRI Specification GM19a.

Specific Site Requirements