USDA
NATURAL RESOURCES
CONSERVATION SERVICE

MARYLAND CONSERVATION
PRACTICE STANDARD

POND SEALING OR LINING, FLEXIBLE MEMBRANE

CODE 521A
(Reported by No.)

DEFINITION

A manufactured hydraulic barrier consisting of a functionally continuous sheet of synthetic or partially synthetic, flexible material.

PURPOSE

To control seepage from water and waste impoundments for water conservation and environmental protection.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where:

1. Ponds and water storage structures require treatment to control seepage rates within acceptable limits;

2. Waste storage and waste treatment facilities built in or of excavated earth require treatment to prevent the migration of contaminants from the site.

CONSIDERATIONS

If high water tables could adversely affect the proper functioning of the facility, interceptor or relief type drainage systems should be considered to control uplift pressures.

Effects upon components of the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge should be considered.

Consider the potential need for water management, including the following:.

1. Effects on the movement of silts, pathogens, and soluble materials carried by seepage toward the ground water;

2. Short-term and construction-related effects of this practice on the quality of the water resource;

3. Effects on wetlands or water-related wildlife habitats;

4. Effects on the visual quality of downstream water resources;

5. Effects on the use and management of nutrients and pesticides and their effect on surface and ground water quality.

CRITERIA

General Criteria

Water and waste impoundments to be lined shall be constructed according to the Maryland conservation practice standards for Pond (Code 378), Waste Storage Facility (Code 313), Waste Treatment Lagoon (Code 359), or other conservation practices standards as appropriate.

Comply with all federal, state, and local laws, rules, and regulations.

All inlets, outlets, ramps, and other appurtenances may be installed before, during, or after the liner placement, and performed in a manner that does not damage or impair the proper operation of the liner.

Subgrade Preparation - Prepare subgrade to conform to manufacturer's recommendations. The foundation area for flexible membrane linings shall be smooth and free of projections that can damage the lining. Remove stumps, roots,

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

rocks, hard clods, and other such materials to provide a smooth surface, or covered with a cushion of fine soil.

Meet or exceed the attached specifications for materials quality for polyethylene and rubber membranes (Tables 1 through 8). Polyvinyl chloride membranes shall meet the requirements of ASTM Specification D-3083 and Table 4.

The area to be lined shall be drained and allowed to dry until the surface is firm and can support the personnel and equipment that must travel over it during installation of the lining.

All bands and fills in the area to be lined must be sloped no steeper than 1 horizontal to 1 vertical for exposed linings, and 2½ to 1 for buried linings.

When needed, apply an effective soil sterilant to the subgrade at the rate recommended by the manufacturer.

Excavate and install an anchor trench completely around the area to be lined at the planned elevation of the top of the lining. The trench shall be 200 to 250 mm (8 to 10 inches) deep and about 300 mm (12 inches) wide.

Material - All flexible membranes shall be certified by the manufacturer to be suitable for the intended use.

Pigmented polyvinyl or polyethylene plastics, rubber, and similar materials that are highly resistant to bacteriological deterioration are acceptable base materials.

All lining material 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.

All materials are to meet the requirements indicated in Tables 1 through 8, as appropriate.

The following minimum criteria are also applicable:

Minimum Criteria for Membranes	
Type [1/]	**Limiting Parameter [2/]**
HDPE	40 mil thickness
LLDPE	40 mil thickness
PVC	30 mil thickness
GCL	0.75 lb./sq. ft (bentonite)
EPDM	45 mil thickness

[1/] Type of material:
HDPE = High Density Polyethylene
LLDPE = Linear Low Density Polyethylene
PVC= Polyvinyl Chloride
GCL = Geosynthetic Clay Liner
EPDM= Synthetic Rubber

[2/] For waste storage facilities >4 feet deep at design full level, use 60 mil HDPE.

Placement - Loosely spread membranes over the subgrade. Polyethylene film requires about 5 percent slack for satisfactory results.

Make all field splices according to the manufacturer's recommended technique, using materials furnished for this purpose. The joints shall be watertight and capable of maintaining their integrity throughout the expected life of the lining.

Place approximately 200 mm (8 inches) of the top of the lining in the anchor trench and anchor with compacted backfill.

Liner Covering - Use select soil materials as a cover for liners where required for the proper performance, protection, and durability of the installation. For covered membranes, use material for the protective cover that is free of large sharp rocks, sticks, and other objects that can puncture the lining. Maximum allowable particle size of soil cover material is 3/8-inch (10 mm), unless the liner is cushioned by a needle-punched, nonwoven geotextile. Place the cover to the specified depth without damage to the membrane. Cover materials shall be stable under all operational and exposure conditions.

Follow the manufacturer's recommendations with regard to protection from weather and exposure.

Venting - Venting is required if gas build up under the liner is anticipated. When venting is used, follow manufacturer recommendations regarding vent type and spacing.

Fencing - Fence all structures to protect the liner from damage and for the safety of humans, livestock, wildlife, and pets.

Vegetation - Shape and smooth the finished area and all disturbed areas and stabilize immediately after construction as required on the construction plans and in accordance with Maryland conservation practice standard for Critical Area Planting (Code 342). Use caution when mowing and when performing maintenance activities to avoid cutting or damaging the flexible membrane.

Additional Criteria for Waste Storage Ponds (Code 313) and Waste Treatment Lagoons (Code 359)

Investigate and treat the foundations under Waste Storage Ponds (Code 313) and Waste Treatment Lagoons (Code 359) as required in their respective practice standards.

Design all waste storage ponds and treatment lagoons with leak detection systems. Use a nonwoven geotextile pad or other flow medium to collect leakage from under the entire flexible membrane liner and direct it to a collection pipe. Slope the sides and bottom of the pond or lagoon to the trench containing the collection pipe. Outlet the collection pipe into an accessible sump or at the ground surface at least 50 feet from a stream or other water body. The leak detection system shall be separate and isolated from any drainage system that is installed around or under the facility.

SPECIFICATIONS

Plans and specifications for sealing water and waste impoundments with flexible membrane linings shall be in keeping with this standard and shall describe the site-specific requirements for applying the practice to achieve its intended purpose.

OPERATION AND MAINTENANCE

Prepare an operation and maintenance plan for the flexible liner and review with the landowner or operator prior to construction.

As a minimum include the following information:

1. Precautions to be taken to avoid damage to the flexible membrane during normal operation of the facility;
2. Recommended liner repair procedures;
3. Drawdown restrictions to assure slope stability of cover soil;
4. Procedures for repairing or replacing cover soil;
5. Monitoring requirements for leak detection systems under waste storage ponds and treatment lagoons;
6. Emergency action plans for containing and controlling discharge from leak detection systems.

Table 1.— Requirements for polyethylene and ethylene co-polymer plastic film.

Test Description		Requirements		Test Method
Property	Units	Type I polyethylene	Type II co-polymer	
Tensile strength, each direction, (minimum average)	lbs/in^2	1800	2000	ASTM-D-882, Method "A"
Ultimate elongation, each direction, (minimum avg.)	pct	500	500	ASTM-D-882, Method "A"
Impact resistance, (minimum average)	g/mil	45	65	ASTM-D-1709, Method "B"
Water vapor permeability	perm-mil	0.7	1.5	ASTM-E-96
Tear resistance, each direction, (minimum)	g/mil	80	80	ASTM-D-1922
Soil burial:				
Tensile strength change, each direction, (maximum)	pct	5	5	ASTM-D-3083
Elongation loss, each direction, (maximum)	pct	20	20	ASTM-D-3083
Luminous transmittance, (maximum)	pct	1.0	1.0	Nat. Bureau of Stds. Pub. PS-17

Table 2.— Requirements for reinforced rubber sheeting.

Test Description		Requirements		Test Method
Property	Units	Up to 20 mil thick	20 mil thick and greater	
Breaking strength, (minimum):				
Warp direction	lbs/in	75	100	ASTM-D-751
Fill direction	lbs/in	75	100	ASTM-D-751
Ultimate elongation, warp direction, (maximum)	pct	30	30	ASTM-D-751
Ozone resistance, procedure "B" 50 pphm, 100°F	days	7	7	ASTM-D-1149 and ASTM-D-518
Hydrostatic strength retained after ozone exposure, 7 days (Mullen)	pct	100	100	Federal Specification CCC 191b, Method 5512 and ASTM-D-518
Heat aging, 7 days at 212°F:				
Tensile strength retained	pct	90	90	ASTM-D-573
Elongation retained	pct	90	90	ASTM-D-573
Tear resistance, warp or fill direction, (minimum)	lbs	8	8	ASTM-D-751 (tongue)
Hydrostatic burst (Mullen), (minimum)	lbs/in^2	100	175	ASTM-D-751
Dimensional stability, 7 days at 212°F, change in length or width	pct	±1.0	±1.0	(See Footnote 1.)
Low-temperature flexibility (optional) No cracking or flaking	°F	-40	-40	Federal Specification CCC 191b, Method 5874
Commercial field splice strength Shear force, (minimum tensile)	pct	75	75	Commercial field splice 1-inch wide strip, pulled in shear at 10 in./min, after 7 days cure at room temperature.

[1/] A 1-ft^2 sample, 10-inch bench marks in warp and fill direction, placed on aluminum or stainless plate in changing air over.

Table 3.— Requirements for unreinforced rubber sheeting.

Test Description		Requirements [1/]		Test Method
Property	**Units**	**Type A**	**Type B**	
Tensile strength, (minimum)	lbs/in^2	1,200	1,200	ASTM-D-412
Modulus at 300% elongation, (minimum)	lbs/in^2	600	600	ASTM-D-412
Ultimate elongation, (minimum)	pct	300	300	ASTM-D-412
Shore "A" hardness		60 ± 10	60 ± 10	ASTM-D-2240
Ozone resistance, procedure "A":				
No cracks, 50 pphm, 100°F, 20% elongation	days	7	—	ASTM-D-1149 and ASTM-D-518
No cracks, 100 pphm, 100°F, 50% elongation	days	—	7	ASTM-D-1149 and ASTM-D-518
Heat aging, 7 days at 212°F:				
Tensile strength retained	pct	75	75	ASTM-D-573
Elongation retained	pct	75	75	ASTM-D-573
Water vapor permeability at 80°F, (maximum)	perm-mil	0.002	0.05	ASTM-E-96 (procedure BW)
Tear resistance, (minimum)	lbs/in^2	150	150	ASTM-D-624 Die "B"
Dimensional stability, 7 days at 212°F, change in length or width	pct	±0.5	±0.5	
Commercial field splice strength Shear force, minimum tensile	pct	60	60	Commercial field splice 1-inch wide strip, pulled in shear at 10 in./min, after 7 days cure at room temperature

[1/] Type "A" sheeting is recommended for general purposes outdoor use. Type "B" material is recommended for use if an extreme outdoor environment requires a highly weatherable lining.

Table 4.— Requirements for polyvinyl chloride plastic sheeting.

Test Description		Requirements	Test Method
Property	**Units**		
Tensile strength, each direction, (minimum average)	lbs/in^2	2,000	ASTM-D-882
Elongation at break, (minimum)	pct	250	ASTM-D-882, Method "A"
Volatile loss, (maximum)	pct	0.7	ASTM-D-882, Method "A"
Tear resistance, each direction, (minimum)	g/mil	160	ASTM-D-1922
Resistance to soil burial (percent change maximum in original value):			
Breaking factor	pct	-5	ASTM-D-3083 (120-day soil burial)
Elongation at break	pct	-20	ASTM-D-3083 (120-day soil burial)
Modulus at 100% elongation	pct	±10	ASTM-D-3083 (120-day soil burial)
Bonded seam strength, percent breaking factor	pct	80	ASTM-D-3083 Para. 9.3 (1-inch width)

Table 5.— Requirements for unreinforced chlorsulfonated polyethylene.

Test Description		Requirements	Test Method
Property	**Units**		
Tensile strength, minimum	lbs/in^2	1,000	ASTM-D-412
Ultimate elongation, minimum	pct	250	ASTM-D-412
Ozone resistance, 50 pphm, 20% strain, 100°F, 8,000 hr	pct	±0	ASTM-D-1149
Heat aging, 14 days at 212°F:			
Tensile strength, minimum	lbs/in^2	1,000	ASTM-D-412
Elongation at break	pct	150	ASTM-D-412
Tear resistance, minimum	lbs/in	250	ASTM-D-624, Die "B"
Commercial field splice strength Shear force, minimum tensile	pct	60	ASTM-D-882, Method "A", 7 days cure
Weight change after 7 days a 70 °F in water, (maximum)	pct	5	ASTM-D-471

Table 6.— Requirements for reinforced chlorsulfonated polyethylene.

Test Description		Requirements (30 mils thick and greater)	Test Method
Property	**Units**		
Breaking strength, (minimum):			
Rubber	lbs/in	100	ASTM-D-751
Fabric	lbs/in	75	ASTM-D-751
Ultimate elongation, (maximum):			
Rubber	pct	150	ASTM-D-751
Fabric	pct	20	ASTM-D-751
Ozone resistance, 50 pphm, 20% strain, 100°F, 8,000 hr	pct	±0	ASTM-D-1149
Hydrostatic strength retained after ozone exposure, 7 days (Mullen)	pct	100	Federal Specification CCC 191b, Method 5512, ASTM-D-518
Heat aging, 14 days at 212°F of original:			
Tensile strength, (minimum)	pct	90	
Elongation at break	pct	90	
Tear resistance, warp or fill direction, (minimum)	lbs	10	ASTM-D-751 (Tongue)
Puncture resistance, pounds, (minimum)	lbs	120	FTMS 101B, Method 2031
Commercial field splice strength Shear force, percent of minimum break	pct	75	ASTM-D-882, 7 days cure

Table 7.— Requirements for high density polyethylene (HDPE).

Test Description		Requirements		Test Method
Property	**Units**	**80 mils**	**100 mils**	
Minimum tensile properties, each direction:				
1. Tensile strength yield	lbs/in width	120	150	ASTM-D-638
2. Tensile strength at break	lbs/in width	120	150	ASTM-D-638
3. Elongation at yield	pct	10	10	ASTM-D-638
4. Elongation at break	pct	500	500	ASTM-D-638
5. Modulus of elasticity	lbs/in^2	80,000	80,000	ASTM-D-638
Tear resistance, (minimum)	lbs	40	50	ASTM-D-1004
Low temperature	°F	-40	-40	ASTM-D-746
Dimensional stability, each direction, (percent change, maximum)	pct	±3	±3	ASTM-D-1204, 212 °F, 15 min.
Resistance to soil burial [1/] (percent change, maximum, in original value):				
1. Tensile strength yield	pct	±10	±10	ASTM-D-3083 (120-day soil burial)
2. Tensile strength at break	pct	±10	±10	ASTM-D-3083 (120-day soil burial)
3. Elongation at yield	pct	±10	±10	ASTM-D-3083 (120-day soil burial)
4. Elongation at break	pct	±10	±10	ASTM-D-3083 (120-day soil burial)
5. Modulus of elasticity	pct	±10	±10	ASTM-D-3083 (120-day soil burial)
Bonded seam strength [2/] (factory seam, breaking factor)	lbs/in width	108	135	ASTM-D-3083
Environmental stress crack, (minimum)	hrs	500	500	ASTM-D-1693

[1/] Test value of "after exposure" sample is based on pre-cut sample dimension; 120-day test is required for initial certification.
[2/] Factory bonded seam strength is the responsibility of the fabricator.

Table 8.— Requirements for supported extruded polyurethane.

Test Description		Supported finished material [1/]				Test Method
Property	**Units**	**Type 1**	**Type 2**	**Type 3**	**Type 4**	
Thickness, overall, (minimum)	mils	25	45	30	70	ASTM-D-751
Minimum tensile properties						
Breaking strength, (minimum):						
1. Fabric TD	lbs	50	70	110	100	ASTM-D-751
2. Fabric MD	lbs	70	120	120	140	ASTM-D-751
3. Composite MD	lbs	90	160	130	220	ASTM-D-751
4. Composite TD	lbs	75	160	130	160	ASTM-D-751
Tear strength, (minimum), composite:						
1. Initial	lbs	2.5	4.5	35	4.5	ASTM-D-751, Tongue method, 8 x 8-inch sample
2. After heat aging	lbs	2.5	4.5	35	4.5	ASTM-D-751, Tongue method, 8 x 8-inch sample, 212°F, 30 days
Low temperature composite	°F	-40	-40	-40	-40	ASTM-D-2136, 1/8 in. mandrel, 4-hr, Pass
Unsupported sheet, 100 mils	°F	Below -60	Below -60	Below -60	Below -60	
Dimensional stability (each direction, percent change maximum)	pct	-0.8	-0.5	-1.3	-0.7	ASTM-D-1204, 212°F, 1 hr
Resistance to soil burial [2/] (percent change maximum in original values):						
1. Unsupported sheet						
a. Breaking factor	pct	+15	+15	+15	+15	ASTM-D-3083, 365-day soil burial, 30-mil sheet (as modified in Appendix A)
b. Elongation at break	pct	-15	-15	-15	-15	ASTM-D-3083, 365-day soil burial, 30-mil sheet (as modified in Appendix A)
c. Initial modulus	pct	+30	+30	+30	+30	ASTM-D-3083, 365-day soil burial, 30-mil sheet (as modified in Appendix A)
2. Membrane fabric breaking factor	pct	TBD	TBD	TBD	TBD	ASTM-D-751
Bonded seam strength, (minimum)	lbs	greater than single layer				ASTM-D-751 (as modified in Appendix A, 12 in./min)
Hydrostatic resistance, (minimum)	lbs/in^2	80	210	250	280	ASTM-D-751 Method A Procedure I
Ozone resistance		N/A	N/A	N/A	N/A	ASTM-D-1149, (as modified in 7 days, 100 pphm 104°F, 1/8 in. bent loop)
Ply adhesion, each direction, (minimum)	lbs/in^2	N/A	N/A	N/A	N/A	ASTM-D-413, Machine Method Type A
Volatile loss (unsupported)	pct	0.4	0.4	0.4	0.4	ASTM-D-1203, Method A, 30-mil sheet
Puncture resistance	lbs	25	50	45	70	FTMS 101B (Method 2065)

[1/] Supporting fabrics:
Type 1: Nylon 6.6 2.0 oz/yd^2
Type 2: Polypropylene 3.1 oz/yd^2
Type 3: Composite of 2 layers 0.5 oz/yd^2 nylon 6.6 plus 5x5 1000d polyester scrim (4.1 oz/yd^2 total)
Type 4: Polypropylene 4.4 oz/yd^2

[2/] Test value of "after exposure" sample is based on pre-cut dimension; 120-day test is required for initial certification.

SUPPORTING DATA AND DOCUMENTATION

Field Data and Survey Notes

The following is a list of the minimum data needed:

1. System plan sketch;
2. Topographic survey of the site showing elevations and control features;
3. Soils investigation showing seasonal high water table, location of test holes, and gradation and classification of soils to be sealed.

Design Data

Record on appropriate engineering paper. For guidance on the preparation of engineering plans see Chapter 5 of the EFH, Part 650. The following is a list of the minimum required design data:

1. Statement concerning location and type of leaks or excessive permeability and description of foundation preparation to be made;
2. All required permits and documentation on file with the design information;
3. Plan view including, location map, all system components, material and construction specifications;
4. Type and thickness of membrane supported by structure and membrane design, method of joint sealing and testing, construction drawings, and component details;
5. Quantities estimate;
6. Job class on plan;
7. Details of foundation drainage, when required;
8. Planting plan. This must meet the criteria, specifications, and documentation requirements of the Maryland conservation practice standard for Critical Area Planting, Code 342.

Construction Check Data/As-built

Record on survey notepaper, SCS-ENG-28, or other appropriate engineering paper. Survey data will be plotted on plans in red. The following is a list of minimum data needed for As-builts:

1. Documentation of site visits on CPA-6. Include the date, who performed the inspection, specifics as to what was inspected, all alternatives discussed, and decisions made and by whom;
2. Actual dimensions of installed structure;
3. Verification of adequate foundation preparation;
4. Documentation of installation of foundation drainage;
5. Certification by the manufacturer that the membrane is suitable for the intended use, Certification statement from the contractor(s) that they have installed/assembled the membrane in accordance with the plans and specifications;
6. Statement on seeding and fencing;
7. Final quantities and documentation for quantity changes, and materials certification;
8. Sign and date checknotes and plans by a person with appropriate approval authority. Include statement that practice meets or exceeds plans and NRCS practice standards.

REFERENCES

1. USDA, Natural Resources Conservation Service, *Maryland Field Office Technical Guide, Section IV, Standards and Specifications*;
2. USDA Natural Resources Conservation Service, *National Engineering Handbook, Part 650 Chapter 4, "Elementary Soil Engineering" and Chapter 11, "Ponds and Reservoirs."*