United States Department of Agriculture

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

POND SEALING OR LINING, GEOMEMBRANE OR GEOSYNTHETIC CLAY LINER

CODE 521

(sf)

DEFINITION

A liner for a water, wastewater, salt, manure, or similar agricultural by-product impoundment constructed using a geomembrane or a geosynthetic clay material.

PURPOSE

This practice is applied to–

- Reduce seepage losses from an impoundment for water conservation, including for irrigation or for providing water for livestock.
- Reduce pollution to surface and groundwater, including potential drinking water sources.
- Protect soil and water from contaminants or erosion.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where in-place natural soils have excessive seepage rates and pond lining or sealing is needed for water conservation or to protect surface or groundwater from contamination.

CRITERIA

General Criteria Applicable to All Purposes

Plan, design, and construct the liner to comply with all Federal, State, Tribal, and local laws and requlations.

Design

The structure to be lined must meet all applicable NRCS standards. All inlets, outlets, ramps, and other appurtenances may be installed before, during, or after the liner placement, but must be done in a manner that does not damage or impair the proper operation of the liner.

Design and install the liner in accordance with manufacturer recommendations. The installer or manufacturer must certify that the liner installation meets the material and installation requirements of the plans and specifications.

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

Materials
Geomembrane and geosynthetic clay liner (GCL) materials must meet the requirements in table 1.

Table 1: Requirements for geomembrane and geosynthetic clay liner materials

Type [1]	Name	Minimum Thickness (mil) [2]	
		Wastewater	Clear Water
HDPE	High Density Polyethylene	60	30
LLDPE	Linear Low-Density Polyethylene	60	30
LLDPE-R	Reinforced Linear Low-Density Polyethylene	45	24
PVC	Polyvinyl Chloride	40	30
EPDM	Ethylene Propylene Diene Terpolymer	45	45
FPP	Flexible Polypropylene	45	30
FPP-R	Reinforced Flexible Polypropylene	45 [3]	36
PE-R	Reinforced, Slit – Film, Woven Polyethylene	NR [3]	36
GCL	Geosynthetic Clay Liner	0.75 lbs./square foot	

[1] Geomembrane materials must meet the criteria in NRCS National Engineering Handbook (NEH), Part 642, Chapter 3, "Material Specification 594 – Geomembrane Liner." GCL materials must meet the criteria in NRCS NEH, Part 642, Chapter 3, "Material Specification 595 – Geosynthetic Clay Liner."

[2] 1 mil = 1/1000 inch

[3] NR – Not recommended for waste storage.

Safety
Include appropriate safety features in the design to minimize the hazards of the completed pond structure. Use warning signs, fences, ladders, texturing, ropes, bars, rails, and other devices, as appropriate, to ensure the safety of humans, wildlife, and livestock.

Gas venting
All geomembrane pond liners require vents at the crest of the side slopes with a spacing not to exceed 50 feet. Design and install gas venting systems or other gas pressure relief mechanisms in accordance with the manufacturer's recommendations. A gas venting system beneath non-buried geomembranes shall be installed if the pond is used to store wastewater or animal waste, if recommended by the manufacturer, or if the site investigation determines the potential for gas buildup under the liner. Site conditions conducive to gas production and "ballooning" include areas which have been subjected to seepage of animal waste into the

foundation soil, sites with organics in the soil, or fine-grained soils subjected to fluctuating groundwater levels. When incorporating a sloped pond bottom to manage gas venting, an adequate grade must be selected to overcome construction tolerances, differential settlement, and other elements of resistance such as stiff wrinkles. Because of the potential for the above-mentioned ballooning issues, a minimum bottom grade of 2 percent is required for ponds without a bottom gas venting system.

Groundwater drainage
Design the drainage and venting system beneath the geomembrane liner based on subsurface conditions such as soil type and groundwater levels. All geomembrane liners require a drainage system if the invert elevation of the pond is within 2 feet of the seasonal high water table. Hydrostatic pressures from

fluctuating groundwater levels or leakage through the liner may cause the liner to float. Incorporate a drainage system when the liner is susceptiple to uplift from groundwater.

Leakage detection
A leak detection system is optional for waste storage facilities using a geomembrane liner on Group II, III, or IV soil types at least 2 feet deep and having an estimated permeability of 5×10^{-5} cm/sec or lower. See table 10D-5 on page 10D-6 of the National Engineering Handbook Part 651 Agriculture Waste Management Field Handbook.

A leak detection system is required for waste storage facilities using a geomembrane liner on Group I or II soil types having an estimated permeability greater than 5×10^{-5} cm/sec.

A leak detection system must be able to detect a change in geomembrane leakage electronically or intercept leakage with a constructed 5×10^{-5} cm/sec or lower permeability restrictive soil layer and collect the leakage in a collection pipe. The collection pipe is either periodically pumped or flows to a monitoring tank. The low permeability soil layer must be at least 12” thick and be separated from the geomembrane liner by a permeable layer which allows the leakage to flow to a collection pipe. Alternatively, a secondary geomembrane liner that is at least 15 ml thick may be used in place of a restrictive soil layer.

Cushion
Place a cushion layer between the liner and exposed sharp angular stones that could damage the liner. This includes angular particles and concretions greater than 3/8 inch for geomembrane liners and 1/2 inch for GCLs. The cushion may be a 10-ounce-per-square-yard or heavier nonwoven geotextile or a layer at least 6 inches thick of soil meeting the particle size and shape requirements of the subgrade. Geotextile cushion material must meet the requirements of the Geosynthetic Research Institute (GRI) Test Method GT12(a). Follow the manufacturer’s recommendations for any additional protective measures.

Subgrade preparation
Prepare the subgrade to conform to manufacturer’s recommendations. The subgrade materials must be free from sharp, angular stones, and the surface free from oversized particles, or any objects that could damage the liner. If angular particles are present, treat the subgrade by placing a cushion layer between the subgrade and the liner. The subgrade surface must provide a smooth, flat, and unyielding foundation for the liner. No standing water, mud, vegetation, snow, frozen subgrade, or excessive moisture may be present at the time of liner placement.

Liner protection
Protect liners from mechanical damage from all sources, including equipment access points

and agitation operations. If pond management plans indicate locations where agitation operations may result in abrasion or other mechanical damage to the liner, provide protective measures. Measures to ensure the integrity of the liner include increasing the liner thickness above the minimum values listed in table 1 or providing protective ramps and aprons at agitation locations. For GCL liners, analyze the wastewater, subgrade soil, and cover soil to ensure that undesirable cation exchange (calcium and magnesium for sodium) will not occur in the GCL.

Anchorage
Anchor the liner to prevent uplift due to wind or slippage down the side slope, in accordance with manufacturer's recommendations. For HDPE and LLDP, allow a period of at least 24 hours before backfilling the anchor trench, or follow manufacturer recommendations, to allow for thermal expansion and contraction.

Penetrations
Install penetrations through the liner in accordance with manufacturer's recommendations. Penetrations associated with waste storage must be watertight. Evaluate pipes for buoyancy forces and provide anchorage as needed.

Cover soil
Cover PVC liners and GCLs with a minimum of 12 inches of soil measured perpendicular to the finished surface. Cover soil may be used on other liners but is not required unless essential for the proper performance, protection, and durability of the installation. Do not use cover soil that contains sharp, angular stones or any objects that could damage the liner. The maximum allowable particle size of soil cover material is 3/8 inch for geomembrane liners and 1/2 inch for GCLs. Use cover materials that are stable against slippage down the slope under all operational and exposure conditions, such as rapid drawdown or saturation by precipitation or snowmelt.

Place cover soil within 24 hours after placement and anchorage of the liner to minimize the potential for damage from various sources, including precipitation, wind, and ultraviolet light exposure.

The cover soil and liner shall be stable at the designed side slope. Side slopes shall be no steeper than 2:1. Install liners according to manufacturers' specifications. GCLs used for waste storage liners are required to have a geofilm/geomembrane. Designs for GCLs without a geofilm/geomembrane shall include seepage rate calculations which factor in the hydrated liner thickness, permeability and hydraulic head.

Cover soil for GCLs must provide uniform confinement pressure as recommended by the manufacturer. Do not install a drainage layer or venting system beneath a GCL, as they could compromise the liner.

CONSIDERATIONS

Designs for waste storage facilities should consider leakage through the liner due to liner damage. Giroud and Bonaparte (1989) recommends designing the drainage system based on a frequency of one hole (0.16 square-inch) per acre of surface area. Therefore, drainage and venting systems are strongly recommended for all waste storage facilities.

Dielectric testing can be used to identify and locate leaks in non-conductive liner materials.

Minimize the number of penetrations through the liner for pond management appurtenances. Detail the trenching and backfilling of pipes to prevent charging of the underside of the liner with

subsurface water.

Minimize unwanted animal access to the liner and appurtenances. Consider large animals that may puncture the liner or become trapped and small animals that access openings and can destabilize slopes.

Incorporate appropriate safety measures when the liner conceals a void. Concealed voids are common hazards when anchor trenches have not been backfilled.

When lids are used for observation wells and other access locations, use a weight that allows for ease of removal while also protecting against unintentional access.

For waste water HDPE liners with penetrations over 2 inches in diameter, consider using concrete pads with liner embedment to fortify the connections and area subject to pipe discharge.

PVC geomembranes are not recommended for aquatic production. The stabilizers in the PVC liner material leach out and may be harmful to aquatic species. Consult with manufacturers before selecting a geomembrane material used for aquatic production.

Where access is needed, consider installing concrete ramps with embedded channels to connect the liner. Pond corners are typically good locations for concrete ramps due to the flatter slopes. Consider placing the access ramp at a corner location.

If the entire waste storage pond is lined and access is needed on the bottom, consider placing concrete over the liner, bedded with geotextile.

Consider the use of a geosynthetic such as a geonet or geocomposite under the liner to facilitate collection, drainage of liquids, and venting of gas. If geocomposite materials are used for drainage and/or venting, use materials recommended by the manufacturer in the system design. Use GRI Standard GC8, “Standard Guide for the Allowable Flow Rate of a Drainage Geocomposite” to determine the allowable flow rate of the geocomposite. Slope the pond bottom a minimum of 2 percent to permit positive flow of the liquids or gases. In most cases, the geocomposite will serve both purposes of drainage and venting. For large impoundments, the bottom may need to be sloped in multiple directions in order to decrease the required drainage and venting flow travel distances.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for a geomembrane or GCL for a pond or a waste storage impoundment that describe the requirements for applying the practice to achieve its intended purpose. As a minimum, include—

- Layout of the containment structure, collection points, waste transfer locations or pipelines, and topography of the site.
- Soils and groundwater investigation.
- Subgrade details, including tolerances on smoothness of the finished grade.
- Required properties of selected liner, geosynthetics, and cushion materials.
- Quantities of liner materials, cover soil, and geosynthetic materials as needed.
- Subsurface drainage and venting details.
- Construction and material specifications.
- Safety requirements for installed liner.

- Details of liner installation, seaming requirements, and requirements for attachments and appurtenances.
- Minimum qualifications of installers and quality control testing requirements.
- Warranty requirements, if desired.
- Fence and signage requirements, if required.

OPERATION AND MAINTENANCE

Prepare a plan for O&M of the liner and structure consistent with the purposes of the type of liner chosen, intended life, safety requirements, and design criteria. Include site-specific information regarding design capacity and liquid level of the structure and repair procedures for liner material. Maintenance activities required for this practice consist of those operations necessary to prevent and repair damage to the geomembrane or GCL. These include, but are not limited to—

- Excluding animals and equipment from the treated area.
- Repairing damage to the liner and restoring the liner and cover to its original thickness and condition.
- Removing roots from trees and large shrubs at first appearance.
- Monitoring leak-detection system.
- Protecting the liner during filling and agitation procedures.

Provide guidance on items to inspect periodically, including—

- Visible portions of the liner for tears, punctures, or other damage.
- Liner interface with inlets, outlets, ramps, or other appurtenances for damage.
- Liquid level in the structure.
- Ballooning of the liner indicating presence of gas beneath the liner.

REFERENCES

ASTM D 5887, Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter.

ASTM D 5890, Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay

Liners. ASTM D 5891, Test Method for Fluid Loss of Clay Component of Geosynthetic Clay

Liners.

ASTM D 5993, Test Method for Measuring of Mass Per Unit of Geosynthetic Clay

Liners. ASTM D 6102, Guide for Installation of Geosynthetic Clay Liners.

ASTM D 6214, Test Method for Determining the Integrity of Field Seams Used in Joining Geomembranes by Chemical Fusion Methods.

ASTM D 6392, Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.

ASTM D 6497, Guide for Mechanical Attachment of Geomembrane to Penetrations or Structures.

ASTM D 7176, Specification for Non-Reinforced Polyvinyl Chloride (PVC) Geomembranes Used in Buried Applications.

ASTM D 7272, Test Method for Determining the Integrity of Seams Used in Joining Geomembranes by Pre-manufactured Taped Methods.

ASTM D 7408, Specification for Non Reinforced PVC (Polyvinyl Chloride) Geomembrane Seams.

ASTM D 7465, Specification for Ethylene Propylene Diene Terpolymer (EPDM) Sheet Used in Geomembrane Applications.

Bonaparte, R., Koerner, R.M., and Daniel, D.E. 2002. Assessment and Recommendations for Improving the Performance of Waste Containment Systems.

Daniel, D. E. and Koerner, R. M. 2006. 2nd Edition, Waste Containment Facilities: Guidance for Construction, Quality Assurance and Quality Control of Liner and Cover Systems, ASCE Press, New York, New York, 354 pgs.

Geosynthetic Research Institute, GRI Standard GC8, Standard Guide for the Allowable Flow Rate of a Drainage Geocomposite.

Geosynthetic Research Institute, GRI Test Method GT12(a) – ASTM Version, Test Methods and Properties for Nonwoven Geotextiles Used as Protection (or Cushioning) Materials.

Geosynthetic Research Institute, GRI Test Method GM13, Standard Specification for Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes.

Geosynthetic Research Institute, GRI Test Method GM17, Standard Specification for Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes.

Geosynthetic Research Institute, GRI Standard GM18, Standard Specification for Test Methods, Test Properties and Testing Frequencies for Flexible Polypropylene (fPP and fPP-R) Nonreinforced and Reinforced Geomembranes.

Geosynthetic Research Institute, GRI Test Method GM19a, 19b, Standard Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes.

Geosynthetic Research Institute, GRI Test Method GM21, Standard Specification for Test Methods, Properties, and Frequencies for Ethylene Propylene Diene Terpolymer (EPDM) Nonreinforced and Scrim Reinforced Geomembranes.

Geosynthetic Research Institute, GRI Test Method GM25, Standard Specification for Test Methods, Test Properties and Testing Frequency for Reinforced Linear Low Density Polyethylene (LLDPE-R) Geomembranes.

Giroud, J.P., and R. Bonaparte. 1989. Leakage through liners constructed with geomembranes—Part 1. Geomembrane Liners. *In* Geotextiles and Geomembranes, Vol. 8, pgs. 27–67.

Koerner, R.M. 2012. Designing with Geosynthetics, 6th ed. Pearson Prentice Hall, Upper Saddle River, NJ.

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