UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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11/14, CHG 2: 11/15

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USACE / NAVFAC / AFCEC / NASA	**UFGS-33 47 13 (November 2014)** **Change 2 - 11/15**
Preparing Activity: NAVFAC	**Superseding** **UFGS-33 47 13 (April 2006)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

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SECTION 33 47 13

POND AND RESERVOIR LINERS
11/14, CHG 2: 11/15

****
NOTE: This guide specification covers the requirements for rubber and plastic flexible pond and reservoir liners.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
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****
NOTE: This guide specification does not cover clay or other types of earth liners. General site preparation must be covered in other sections, preferably Section 31 00 00 EARTHWORK and where required, Section 03 30 00 CAST-IN-PLACE CONCRETE.
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****
NOTE: Show the following information on the project drawings:

1. Extent of liner.

2. Details of earth anchorage.

3. Details of anchorage to structures.

4. Thickness of earth cover.

****

PART 1 GENERAL

1.1 REFERENCES

****

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

****

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D413	(1998; R 2017) Standard Test Methods for Rubber Property - Adhesion to Flexible Substrate
ASTM D698	(2012; E 2014; E 2015) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))
ASTM D751	(2006; R 2011) Coated Fabrics
ASTM D4437/D4437M	(2016; R 2018) Standard Practice for Non-destructive Testing (NDT) for Determining the Integrity of Seams Used in Joining Flexible Polymeric Sheet Geomembranes
ASTM D6214/D6214M	(2013) Determining the Integrity of Field Seams Used in Joining Geomembranes by Chemical Fusion Methods
ASTM D6392	(2012; R 2018) Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods

ASTM D7002	(2016) Standard Practice for Leak Location on Exposed Geomembranes Using the Water Puddle System
ASTM D7006	(2013) Standard Practice for Ultrasonic Testing of Geomembranes
ASTM D7007	(2016) Standard Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earth Materials
ASTM D7176	(2006; R 2011) Non-Reinforced Polyvinyl Chloride (PVC) Geomembranes Used in Buried Applications
ASTM D7272	(2006; R 2018) Standard Test Method for Determining the Integrity of Seams Used in Joining Geomembranes by Pre-manufactured Taped Methods
ASTM D7408	(2012; R 2020) Non Reinforced PVC (Polyvinyl Chloride) Geomembrane Seams
ASTM D7700	(2015) Standard Guide for Selecting Test Methods for Geomembrane Seams

GEOSYNTHETIC INSTITUTE (GSI)

GSI GRI GM13	(2016) Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes
GSI GRI GM17	(2015) Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes
GSI GRI GM18	(2015) Test Methods, Test Properties and Testing Frequencies for Flexible Polypropylene (fPP and fPP-R) Nonreinforced and Reinforced Geomembranes
GSI GRI GM19	(2002; R 2013) Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes
GSI GRI GM21	(2016) Test Methods, Properties and Frequencies for Ethylene Propylene Diene Terpolymer (EPDM) Nonreinforced and Scrim Reinforced Geomembranes
GSI GRI GM25	(2009; R 2012) Test Methods, Test Properties and Testing Frequency for Reinforced Linear Low Density Polyethylene (LLDPE-R) Geomembranes

1.2 SUBMITTALS

****

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force, and NASA projects, or choose the second bracketed item for Army projects.

****

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Liner System; G[, [_____]]

SD-03 Product Data

Liner; G[, [_____]]

Seaming Adhesive

Penetration Assemblies; G[, [_____]]

Filter Fabric; G[, [_____]]

Sealants

SD-07 Certificates

Liner; G[, [_____]]

Filter Fabric

SD-08 Manufacturer's Instructions

Liner; G[, [_____]]

Seaming Adhesive

Sealants

SD-11 Closeout Submittals

Manufacturer's Warranty; G[, [_____]]

Installation Warranty; G[, [_____]]

1.3 DELIVERY AND STORAGE

Deliver liner [and filter fabric] to site in largest sizes possible to minimize field seaming. Protect from sunlight and other ultraviolet light sources during storage. Keep cements and adhesives from extreme cold or heat. Keep materials clean and dry.

1.4 QUALITY ASSURANCE

1.4.1 Required Drawing

Submit drawing of liner system indicating sheet and seam layout, anchorage details, and penetration details.

1.5 WARRANTY

****

NOTE: Manufacturers typically provide prorated material warranties ranging from 1 to 30 years depending on the specific application. Installation warranties are generally specified as one to five years in length.

****

1.5.1 Manufacturer's Warranty

Provide the Manufacturer's Warranty to the Contracting Officer. Ensure Warranty is valid for a minimum of [2] [5] [_____] years from the date of project closeout, showing the Government as warranty recipient.

1.5.2 Installation Warranty

Provide the Installation Warranty to the Contracting Officer, along with final test reports. Ensure Warranty is valid for a minimum of [2] [5] [_____] years from the date of project closeout, showing the Government as warranty recipient.

PART 2 PRODUCTS

2.1 LINER

****
NOTE: This specification covers rubber and plastic reinforced and unreinforced geomembranes. Plastic liners include polyethylene, ethylene copolymer, High Density Polyethylene, Linear Low Density Polyethylethylen, Flexible Polypropylene. Rubber liners include Ethylene Propylene Diene Terpolymer. Allow use of as many of the above types of materials as design considerations allow. Such considerations include cost, foundation conditions, chemical compatibility between liner and stored product. Fabric reinforced liners are available and are useful where extra strength is needed. Do not use the extra strength of fabric reinforcement as a replacement for an appropriate thickness of subgrade or base.
****

2.1.1 High Density Polyethylene (HDPE)

[Smooth] [Textured] HDPE manufactured in accordance with and conforming to GSI GRI GM13, [_____] mm mils thick.

2.1.2 Linear Low Density Polyethylene (LLDPE)

[Smooth] [Textured] LLDPE manufactured in accordance with and conforming to GSI GRI GM17, [_____] mm mils thick.

2.1.3 Flexible Polypropylene (fPP and fPP-R)

[Unreinforced] [Reinforced] fPP manufactured in accordance with and conforming to GSI GRI GM18, [_____] mm mils thick.

2.1.4 Ethylene Propylene Diene Terpolymer(EPDM)

[Unreinforced] [Reinforced] EPDM manufactured in accordance with and conforming to GSI GRI GM21,[1.12 mm 45 mils][1.5 mm 60 mils] thick.

2.1.5 Reinforced Linear Low Density Polyethylene (LLDPE-R)

Reinforced LLDPE-R manufactured in accordance with and conforming to GSI GRI GM25, [_____] mm mils thick.

2.1.6 Polyvinyl Chloride (PVC)

PVC manufactured in accordance with and conforming to ASTM D7176, [_____] mm mils thick.

2.2 ACCESSORIES

2.2.1 ADHESIVE

Provide seaming adhesive compatible with type of liner used as recommended by manufacturer.

2.2.2 SEALANT

Provide sealants compatible with the type of liner used as recommended by manufacture. The use of silicone sealant is not allowed with PVC liner materials.

2.2.3 PENETRATIONS

Provide manufacturer's standard factory fabricated penetration assemblies. Make penetration assemblies of the same base material as liner and at least 1.12 mm 45 mils thick.

2.3 FILTER FABRIC

****

NOTE: Filter fabric is a useful material to provide: 1) a better subgrade; 2) a path for water or gas migration; 3) and a convenient material for drainage when a double liner system is used. Specify cloth that retains the soil being protected, yet has openings large enough to permit drainage and prevent clogging. Select the "equivalent opening sizes" (EOS) and "percent open area" based on the following criteria:

1. Filter cloth adjacent to granular materials containing 50 percent or less by weight fines (materials passing 75 micrometers (No. 200) sieve):

a. The 85 percent size of the soil, divided by the nearest opening size of EOS sieve (nearest U.S. Standard Sieve) is equal to or greater than one.

b. Open area not to exceed 36 percent.

2. Filter cloths adjacent to all other type soils:

a. EOS no larger than the openings in the U.S. Standard Sieve 212 micrometers No. 70.

b. Open area not to exceed 10 percent.

To reduce the chance of clogging, specify cloth with an open area equal to or greater than 4 percent or an EOS with openings equal to or greater than the openings of a U.S. Standard Sieve Sized 150 micrometers No. 100.

****

Provide a permeable, synthetic barrier sheet resistant to mildew, chemicals in soil, stable under freeze-thaw cycles, which will not shrink or expand under wet conditions, and will not unravel or become clogged during use. Filter cloth must have a minimum tensile strength of 534 N 120 pounds. Allowable open area must not exceed [36] [_____] percent and must not be less than [4] [_____] percent. Percent open area is defined as the summation of open areas divided by total area of filter cloth. Equivalent Opening Size (EOS) must not be finer than the U.S. Standard sieve [212] micrometers [_____] No. [70] [_____].

PART 3 EXECUTION

3.1 SURFACE PREPARATION

3.1.1 Soil or Granular Subgrade

****

NOTE: Earth subgrades should be sloped from 0.5 to 1.0 percent. Sloped subgrade provides a path for water or gas escape particularly if filter fabric or a double liner with drainage system is used.

****

Prepare subgrade in accordance with Section 31 00 00 EARTHWORK. Remove vegetation, boulders and rocks larger than 20 mm 3/4 inch in size and other sharp objects. Fill in holes, including stake holes. Inspect subgrade surface and correct defects prior to continuing construction.

3.1.2 Concrete

Provide concrete surfaces and pipe anchorages in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE. Provide smooth surfaces with no sharp projections or abrupt surface changes. Compact earth within 300 mm 12 inches of any concrete surfaces to 100 percent maximum density, in accordance with ASTM D698.

3.2 CLEANING OF LINER SHEET

****

NOTE: Some liner materials are manufactured with a surface bloom or surface cure that must be removed prior to making seams. Consult with liner manufacturers.

****

Clean liner sheets of dust, dirt, and other foreign matter. Carefully clean area (both mating surfaces) of seams. [Remove surface [bloom] or [cure] with solvent recommended by manufacturer.]

3.3 FILTER FABRIC INSTALLATION

****

NOTE: Use bracketed sentence when fill is placed between filter fabric and plastic or rubber liner.

****

Place synthetic fiber filter fabric on prepared subgrade. Repair damaged fabric by placing an additional layer of fabric to cover the damaged area a minimum of 900 mm 3 feet overlap in all directions. Overlap fabric at joints a minimum of 900 mm 3 feet. [Obtain approval of filter fabric installation before placing fill. Place fill on fabric in the direction of overlaps and compact as specified in Section [31 00 00 EARTHWORK][31 23 00.00 20 EXCAVATION AND FILL]]. Follow manufacturer's recommended installation procedures.

3.4 LINER INSTALLATION

3.4.1 Placement

****

NOTE: Additional wording may be needed when surface below liner could cause damage or areas where wind conditions or pond geometry will cause obvious problems during placement. Time in bracketed clause can be varied depending upon climatic conditions.

****

Position liner on previously prepared surface [or filter fabric] as indicated. Unroll or unfold carefully. Avoid stretching. Allow liner to lie in a relaxed state [for a minimum of 1/2 hour] prior to seaming.

3.4.2 Seams and Laps

****

NOTE: During design, consider configurations that require as few seams as possible, with no seams located in areas of maximum stress. Certain types of liners, particularly cured rubber sheeting, may require sealing edges of supported liners with seaming adhesive and liner. Sealing edges of supported liners with seaming adhesive is required where scrim is exposed. Include additional safety requirements appropriate for individual types of seaming adhesive specified.

****

Provide personnel handling or applying seaming adhesive with protective clothing and other appropriate safety equipment. Apply seaming adhesive and make field seam. Make lap or seam [_____] [150 mm 6 inches] wide. Seal lap or seam using rollers or hand pressure removing any wrinkles at that time. A plank or board may be used for back-up during sealing but remove prior to completion of installation. [For supported liners apply splicing cement to cut edges of liner and seal with a strip of unsupported liner of same material as liner.] [For supported liners apply splicing cement to cut edges (exposed scrim) of liner.]

3.4.3 Repairs

Make repairs to liner with same material as liner. Extend patch 150 mm 6 inches in all directions from puncture. Use same method as for seams.

3.5 ANCHORAGE

3.5.1 Earth Anchorage

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NOTE: Earth anchorage at perimeter of reservoir is the preferred method of providing anchorage. Where concrete is used as trench backfill modify paragraph accordingly.

****

Make perimeter trench [a minimum of 300 mm 12 inches wide by 300 mm 12 inches deep] [as indicated]. After installation of liner in reservoir is

complete, place liner in perimeter trench and backfill trench.

3.5.2 Anchorage to Structures

****
NOTE: Placement of structures within liner area and penetration of liner by piping is not recommended. Where such items are required, close attention to details of design and construction are required.
****

Remove curing compounds and coatings from structures in joint areas. Use bonding adhesive recommended by manufacturer to make joints. Make joint to structures [at least 300 mm 12 inches wide.] [the width indicated. Use batten strips of stainless steel bars to reinforce joint.]

3.6 BACKFILL OVER LINER

****
NOTE: Where earth covering is used, side slopes of 3:1 or less are generally required.
****

Cover installed liner with earth to depth [indicated.] [of 450 mm 18 inches.] [Cover liner within time limits specified by liner manufacturer.] Place earth on liner using rubber tired or tracked vehicles. Drive only on earth cover. Correct any damage to liner caused by covering operations.

3.7 FIELD QUALITY CONTROL

3.7.1 Tests

Use ASTM D7700 to determine appropriate test methods necessary to evaluate geomembrane seams for materials listed in this specification. [Take one destructive field seam sample per [500 meters 1640 feet] [_____] meters feet of seam.] [Perform an electrical leak detection survey.]

3.7.1.1 Nondestructive testing (NDT)

3.7.1.1.1 Nonreinforced testing

Perform NDT in accordance with ASTM D4437/D4437M. For HDPE, LLDPE, fPP and PVC use ASTM D7006 for ultrasonic testing of materials and seams. For PVC, ASTM D7006 is only applicable to factory seam testing.

3.7.1.1.2 Reinforced testing

Perform NDT in accordance with ASTM D4437/D4437M.

3.7.1.2 Destructive testing

Perform destructive testing in accordance with GSI GRI GM19.

3.7.1.2.1 Nonreinforced testing

For HDPE, LLDPE, and fPP perform destructive testing in accordance with ASTM D6392.

[For EPDM perform destructive testing in accordance with ASTM D7272.

][For PVC perform destructive testing in accordance with ASTM D7408.

]3.7.1.2.2 Reinforced testing

For reinforced geomembranes materials listed in this specification perform destructive testing in accordance with ASTM D751, ASTM D6214/D6214M, and ASTM D6392.

[3.7.1.3 Adhesion to Flexible Substrate

For EPDM perform adhesion test in accordance with ASTM D413.

]3.7.1.4 Electrical Leak Location

For HDPE, LLDPE, fPP and PVC provide electrical leak location in accordance with ASTM D7002 and ASTM D7007.

3.7.1.5 Leakage Testing

****

NOTE: Use this paragraph when required to determine whether liner has an acceptable amount of leakage. A liner with no leakage is in a practical sense, not possible. Also, the cost of performing leakage testing may be high depending on the size of the pond or reservoir.

****

Test pond or reservoir for leakage. Determine leakage rate. Leakage rate (Q) must not exceed the lesser of 4 liters 1 gallon per minute or the amount given by the following formula. Q (Leakage rate in gallons per minute) equals A (Area of liner in thousands of square feet) multiplied by the square root of H (Depth of liquid in feet), the product then divided by 80.

3.7.2 Inspection

Inspect completed liner for pinholes, punctures, and tears. Inspect seams and joints for unbonded areas. Repair defects as specified herein.

-- End of Section --