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Preparing Activity: NAVFAC Replacing without revision
NFGS of same number and date

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 25 June 2004

SECTION 02661N

POND AND RESERVOIR LINERS

09/99

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

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

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 02300 EARTHWORK and where required, Section 03330N CAST-IN-PLACE CONCRETE.

NOTE: The following information should be indicated 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: Issue (date) of references included in project specifications need not be more current than provided by the latest guide specification. Use of SpecsIntact automated reference checking is recommended for projects based on older guide specifications.

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 D 1149 | (1999) Rubber Deterioration - Surface Ozone Cracking in a Chamber |
| ASTM D 2136 | (2002) Coated Fabrics - Low-Temperature Bend Test |
| ASTM D 3020 | (1989) Polyethylene and Ethylene Copolymer Plastic Sheeting for Pond, Canal, and Reservoir Lining |
| ASTM D 3083 | (1989) Flexible Poly(Vinyl Chloride) Plastic Sheeting for Pond, Canal, and Reservoir Lining |
| ASTM D 413 | (1998; R 2002e1) Rubber Property - Adhesion to Flexible Substrate |
| ASTM D 751 | (2000) Coated Fabrics |

1.2 SUBMITTALS

NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G"

designation 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 projects.

Submittal items not designated with a "G" are considered as being for information only for Army projects and for Contractor Quality Control approval for Navy projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.] [for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Liner system

SD-03 Product Data

Liner

Seaming adhesive

Penetration assemblies

Filter fabric

SD-07 Certificates

Liner

Filter fabric

SD-08 Manufacturer's Instructions

Liner

Seaming adhesive

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.

PART 2 PRODUCTS

2.1 LINER

NOTE: This specification covers rubber and plastic liners. Plastic liners include polyethylene, ethylene copolymer, chlorosulfonated polyethylene, and poly (vinyl) chloride material. 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 Unsupported Plastic

ASTM D 3020 or ASTM D 3083, [_____] mm mils thick.

2.1.2 Supported Plastic

ASTM D 3020 or ASTM D 3083, [_____] mm mils thick, in plies with the center ply being a fabric scrim of [6 by 6, 0.111 g per meter] [6 by 6, 1000 denier] [8 by 8, 0.028 g per meter] [8 by 8, 250 denier] [10 by 10, 0.111 g per meter] [10 by 10, 1000 denier]polyester.

2.1.3 Chlorosulfonated Polyethylene Synthetic Rubber (CSPE)

NOTE: This paragraph is for one type of chlorosulfonated polyethylene (the generic name for the material "Hypalon," a Dupont trademark) synthetic rubber liner. As properties vary with thickness and amount of fabric reinforcement, modifications to this specification will be required if design requirements are different. Assure that modifications do not result in proprietary specifications.

0.90 mm36 mil supported with a fabric scrim of 10 by 10, 0.111 g per m 1000 denier polyester having the following material properties:

| Property | Test Method | Minimum Requirement |
|-----------|-------------|---------------------|
| Thickness | | |

| Property | Test Method | Minimum Requirement |
|--|--|---|
| 1. Total overall (mm) | ASTM D 751 | 0.85 |
| 2. Min. over scrim (mm) | Optical Method | 0.28 |
| Tensile Properties (each direction) | | |
| 1. Breaking Strength (Newton) | ASTM D 751 | 889.60 |
| 2. Elongation | ASTM D 751 | 30 percent |
| Tear Propagation (Newton) | ASTM D 751 Tongue Tear (200 by 200 mm) | 355.84 |
| Hydrostatic Resistance (kPa) | ASTM D 751 Method A Procedure 1 | 1723.5 |
| Bonded Seam Strength (Newton) | ASTM D 751 Modified (5 mm/sec.) | 711.70 |
| Ply Adhesion (N/m) | ASTM D 413 Machine Method, Type A (5 mm/sec.) | 8 (or film tearing bond) |
| Ozone Resistance | ASTM D 1149, (3 mm) bent loop, 100 pphm, 40 degrees C, 7 days | No cacks at 7 times magnifi- cation |
| Low Temperature | ASTM D 2136, (3 mm) mandrel, 4 hrs. @ -40 degrees C | pass |
| Property | Test Method | Minimum Requirement |
| Thickness | | |
| 1. Total overall (mils) | ASTM D 751 | 34 |
| 2. Min. over scrim (mils) | Optical Method | 11 |
| Tensile Properties (each direction) | | |
| 1. Breaking Strength (Pounds) | ASTM D 751 | 200 |
| 2. Elongation | ASTM D 751 | 30 percent |
| Tear Propagation (pounds) | ASTM D 751 Tongue Tear (8 by 8 in. sample) | 80 |

| Property | Test Method | Minimum Requirement |
|----------------------------------|--|--|
| Hydrostatic Resistance (psi) | ASTM D 751 Method A Procedure 1 | 250 |
| Bonded Seam Strength (pounds) | ASTM D 751 Modified (12 in./min.) | 160 |
| Ply Adhesion (lbs./in. width) | ASTM D 413 Machine Method, Type A (12 in./min.) | 8 (or film tearing bond) |
| Ozone Resistance | ASTM D 1149, 1/8" bent loop, 100 pphm, 104 degrees F, 7 days | No cracks at 7 times magnification |
| Low Temperature | ASTM D 2136, 1/8" mandrel, 4 hrs. @ -40 degrees F | pass |

2.2 SPLICING CEMENT

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

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.

2.4 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 that 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, no cloth should be specified with an open area less than 4 percent or an EOS with openings smaller 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 shall have a minimum tensile strength of 534 N 120 pounds. Allowable open area shall not exceed [36] [_____] percent and shall 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) shall 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 02300 EXCAVATION. 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 03300N 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, optimum moisture as specified in Section 02300 EXCAVATION.

3.2 CLEANING OF LINER SHEET

NOTE: Some liner material 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 0.91 mm three feet overlap in all directions. Overlap fabric at joints a minimum of 0.91 mm three 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 02300 EXCAVATION.] 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
will 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

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. 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 300 mm 12 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 Inspection

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

3.7.2 Field 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) shall not exceed the lesser of 0.063 Liters per second one gallon per minute or the amount given by the following formula. Q (Leakage rate in liters per second gallons per minute) equals A (Area of liner in thousands of square meters square feet) multiplied by the square root of H (Depth of liquid in meter feet), the product then divided by 65.12 80.

-- End of Section --