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## PART 1 GENERAL

### 1.1 REFERENCES

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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 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.

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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	(2007) Standard Test Method for Rubber Deterioration - Surface Ozone Cracking in a Chamber
ASTM D 2136	(2002; R 2007) 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 2007) Rubber Property - Adhesion to Flexible Substrate
ASTM D 751	(2006) Coated Fabrics

### 1.2 SUBMITTALS

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NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals

required for the project. Submittals should be kept to the minimum required for adequate quality control.

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, Air Force, and NASA projects.

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

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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 01 33 00 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

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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.  
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##### 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)

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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.

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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		
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. at minus 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)		

Property	Test Method	Minimum Requirement
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
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. at minus 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

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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.

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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

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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.

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Prepare subgrade in accordance with Section 31 00 00 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 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, optimum moisture as specified in Section 31 00 00 EXCAVATION.

### 3.2 CLEANING OF LINER SHEET

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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.  
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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

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NOTE: Use bracketed sentence when fill is placed between filter fabric and plastic or rubber liner.  
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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 31 00 00 EXCAVATION.] Follow manufacturer's recommended installation procedures.

### 3.4 LINER INSTALLATION

#### 3.4.1 Placement

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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.  
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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

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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.  
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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.  
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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

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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.  
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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

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

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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.  
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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.

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