
USACE / NAVFAC / AFCEA / NASA UFGS-33 56 63 (April 2006)

Preparing Activity: USACE Replacing without change
UFGS-02662 (January 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated March 2008

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SECTION 33 56 63

FUEL IMPERMEABLE LINER SYSTEM 04/06

NOTE: This guide specification covers the requirements for a fuel impermeable liner system intended to serve a diked tank enclosure (petroleum applications only).

Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

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

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).

PART 1 GENERAL

NOTE: Coordinate specific dike and liner installation requirements with the latest published version of UFC 3-460-01.

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 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 A 194/A 194M | (2007) Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both |
| ASTM A 307 | (2007b) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength |
| ASTM C 920 | (2005) Standard Specification for Elastomeric Joint Sealants |
| ASTM D 2136 | (2002; R 2007) Coated Fabrics - Low-Temperature Bend Test |
| ASTM D 3776 | (2007) Mass Per Unit Area (Weight) of Fabric |
| ASTM D 413 | (1998; R 2002e1) Rubber Property - Adhesion to Flexible Substrate |
| ASTM D 4355 | (2007) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus |
| ASTM D 4491 | (1999a; R 2004e1) Water Permeability of Geotextiles by Permittivity |
| ASTM D 4533 | (2004) Trapezoid Tearing Strength of Geotextiles |
| ASTM D 4632 | (1991; R 2003) Grab Breaking Load and Elongation of Geotextiles |
| ASTM D 4751 | (2004) Determining Apparent Opening Size of a Geotextile |
| ASTM D 4833 | (2000e1) Index Puncture Resistance of |

| | |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | Geotextiles, Geomembranes, and Related Products |
| ASTM D 5261 | (1992; R 2003) Measuring Mass Per Unit Area of Geotextiles |
| ASTM D 5641 | (1994; R 2006) Geomembrane Seam Evaluation by Vacuum Chamber |
| ASTM D 696 | (2003) Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30 degrees C and 30 degrees C With a Vitreous Silica Dilatometer |
| ASTM D 751 | (2006) Coated Fabrics |
| ASTM E 228 | (2006) Linear Thermal Expansion of Solid Materials with a Vitreous Silica Dilatometer |
| ASTM E 96/E 96M | (2005) Standard Test Methods for Water Vapor Transmission of Materials |
| ASTM G 152 | (2006) Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials |
| ASTM G 153 | (2004) Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials |

1.2 SUBMITTALS

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.

Government approval is required for submittals with a "G" designation;
submittals not having a "G" designation are for [Contractor Quality Control
approval.] [information only. When used, a designation following the "G"
designation 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

Installation[; G][; G, [_____]]

SD-03 Product Data

Nonwoven Geotextile[; G][; G, [_____]]

Fuel Impermeable Liner[; G][; G, [_____]]

Outdoor Sealant

SD-06 Test Reports

Liner Vacuum Box Test[; G][; G, [_____]]

Liner Air Lance Test[; G][; G, [_____]]

SD-07 Certificates

Field Engineer Qualifications[; G][; G, [_____]]

Liner Manufacturer's Certification

Surface Preparation

SD-08 Manufacturer's Instructions

Liner Manufacturer's Installation Instructions

SD-10 Operation and Maintenance Data

Nonwoven Geotextile

Fuel Impermeable Liner

Include liner's routine maintenance requirements as well as
procedures for liner repair and troubleshooting.

1.3 QUALITY ASSURANCE

1.3.1 Material and Equipment Qualifications

Provide materials and equipment that are standard products of a manufacturer regularly engaged in the manufacturing of such products, that are of a similar material, design and workmanship. Materials and equipment shall have been in satisfactory commercial or industrial use for a minimum 2 years prior to bid opening. The 2 year period shall include applications of the equipment and materials under similar circumstances and of similar size. Materials and equipment shall have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period. Products having less than a 2 year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours, exclusive of the manufacturer's factory tests, can be shown.

1.3.2 Field Engineer Qualifications

**NOTE: Include any local regulatory requirements
that must be met by the Contractor.**

Provide a field engineer who has successfully completed manufacturer's training on handling and installing of the fuel impermeable liner to be installed. The engineer shall have at least one million square feet of liner installation experience. Submit a letter providing evidence of the field engineer's experience, training, and licensing. In regard to the field engineer's experience, include in the submittal a point of contact, a phone number, the address, the type of installation, and the current status of each installation mentioned.

1.3.3 Liner Manufacturer's Certification

Following the successful installation and testing of the liner, an authorized representative from the liner manufacturer shall submit a letter certifying that the liner installation and testing results are satisfactory and that each meets the company's quality expectations and warranty. Include in the letter the representative's name, address, phone number, and qualifications for being a manufacturer's representative.

1.4 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items. Store the liner in its original crates and if stored outdoors, place the crates on pallets and protected from the direct rays of the sun under a light-colored, heat-reflective, opaque cover in a manner that provides free-flowing air space between the crate and the cover.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Fuel Impermeable Liner

Provide an internally reinforced, flexible membrane liner that is factory

fabricated into widths that are designed to minimize field fabricated seams. Factory seams shall be made with a 50 mm 2 inch overlap plus or minus 6 mm 1/4-inch. Liner shall meet the following physical properties as a minimum. No substitute methods are allowed for verification of any property.

2.1.1.1 General Properties

NOTE: Indicate on the drawings the exact type of fuel that each liner system will be expected to contain.

The liner as specified herein is compatible with a variety of fuels and liquids. Note that the liner is specifically compatible with JP-4, JP-5, JP-8, diesel fuel, motor gasoline, kerosene, No. 2 Fuel Oil, and No. 6 Fuel Oil. If any other fuel is to be contained by the liner system, specifically coordinate with the liner manufacturers for any additional requirements that may need to be added.

Retard the growth of mildew and be compatible with the fuel to be contained.

2.1.1.2 Minimum Overall Finished Thickness

Provide a minimum 0.762 mm (30 mils) 30 mils overall finished thickness as measured in accordance with ASTM D 751.

2.1.1.3 Base Fabric Material

Construct base fabric material of aramid fibre, polyester, or nylon that has a minimum weight of 233 g/m² (7.5 oz/yd²) 7.5 oz/yd² as measured in accordance with ASTM D 3776.

2.1.1.4 Adhesion of Coating to Fabric

Provide a minimum adhesion of the coating to the fabric of 2.63 N/mm (15 lbf/inch) 15 lbf/inch when tested in accordance with ASTM D 751 or ASTM D 413.

2.1.1.5 Breaking Strength

Provide a minimum breaking strength of 2891 N (650 lbf) 650 lbf in both the warp and fill directions when tested in accordance with ASTM D 751, Grab Test Method.

2.1.1.6 Bursting Strength

Provide a minimum bursting strength of 4226 N (950 lbf) 950 lbf when tested in accordance with ASTM D 751, Ball Tip Method.

2.1.1.7 Hydrostatic Resistance

Provide a minimum hydrostatic resistance of 4137 kPa (600 psi) 600 psi when tested in accordance with ASTM D 751, Procedure A.

2.1.1.8 Trapezoid Tearing Strength

Provide a minimum trapezoid tearing strength of 222 N (50 lbf) 50 lbf in both the warp and fill directions when tested in accordance with ASTM D 4533.

2.1.1.9 Low Temperature Bend Test

Provide material flexibility down to a minimum temperature of -34 degrees C -30 degrees F when tested in accordance with ASTM D 2136.

2.1.1.10 Permeability (Fuel Resistance)

Provide a minimum permeability of 3.42 g/m2 (0.0112 oz/ft2) 0.0112 oz/ft2 over a 24-hour period when tested in accordance with ASTM E 96/E 96M, Procedure BW, Inverted Water Method, using kerosene instead of water.

2.1.1.11 Coefficient of Thermal Expansion

Provide a maximum coefficient of thermal expansion of 0.0000144 mm/mm/degree C (0.000008 inch/inch/degree F) 0.000008 in/in/degree F when tested in accordance with either ASTM E 228 or ASTM D 696.

2.1.1.12 Bonded Seam Strength

Provide a minimum bonded seam strength of 2891 N (650 lbf) 650 lbf when tested in accordance with ASTM D 751.

2.1.1.13 Dead Load Seam Shear Strength

Provide a minimum dead load seam shear strength of 1183 N at 21 degrees C 266 lbf at 70 degrees F and 591 N at 71 degrees C 133 lbf at 160 degrees F when tested in accordance with ASTM D 751.

2.1.1.14 Weathering Resistance

Provide no appreciable changes, stiffening or cracking of coating for a minimum of 8000 hours when tested in accordance with either ASTM G 152 or ASTM G 153.

2.1.2 Nonwoven Geotextile

NOTE: Include the installation of a geotextile underneath the secondary containment liner if the subgrade is rough or sharp in nature (i.e., sharp limestone or granite rock, rough gunnite, rough or exposed concrete aggregate, etc.). Delete this paragraph if the subgrade is smooth compacted soil, rounded stone, smooth finish concrete, etc.

Provide a nonwoven, polypropylene, needle punched geotextile fabric. Geotextile shall meet the following physical properties as a minimum. No substitute methods are allowed for verification of any property.

2.1.2.1 General Properties

Retard the growth of mildew and be compatible with the soil in contact.

2.1.2.2 Nominal Unit Weight

Provide a nominal unit weight of 407 g/m² (12 oz/yd²) 12 oz/yd² as measured in accordance with ASTM D 5261.

2.1.2.3 Grab Tensile Strength

Provide a minimum grab tensile strength of 1335 N (300 lbf) 300 lbf when tested in accordance with ASTM D 4632.

2.1.2.4 Grab Tensile Elongation

Provide a minimum grab tensile elongation of 50 percent when tested in accordance with ASTM D 4632.

2.1.2.5 Puncture Strength

Provide a minimum puncture strength of 778 N (175 lbf) 175 lbf when tested in accordance with ASTM D 4833.

2.1.2.6 Trapezoid Tear Strength

Provide a minimum trapezoid tear strength of 512 N (115 lbf) 115 lbf when tested in accordance with ASTM D 4533.

2.1.2.7 Ultraviolet (UV) Resistance

Maintain 70 percent of its original strength after 500 hours of testing in accordance with ASTM D 4355.

2.1.2.8 Permittivity

Provide a maximum permittivity of 0.9 sec⁻¹ when tested in accordance with ASTM D 4491.

2.1.2.9 Allowable Water Flow Rate

Allow a maximum water flow rate of 2649 L/min/m² (65 gpm/ft²) 65 gpm/ft² when tested in accordance with ASTM D 4491.

2.1.2.10 Apparent Opening Size (AOS)

Provide an AOS of 0.15 mm 100 sieve when tested in accordance with ASTM D 4751.

2.2 COMPONENTS

2.2.1 Liner Fittings

Provide liner fittings (for example, boots and sleeves) that are factory prefabricated components produced from the same manufacturer that produces the fuel impermeable liner. Fittings shall have the same fabrication characteristics as the liner.

2.2.2 Sand Bags

NOTE: For liners exposed to the elements, show bags
to be permanently placed on top of the liner at

regularly spaced intervals in order to keep the liner held down in the event of strong winds. A typical location for such bags would be at the base of a dike wall/berm.

Suggest bags be filled with dry, clean sand however if sand is not readily available at the project site, then require the bags to be filled with another more indigenous material. The material selected should not have any sharp points or edges.

Provide bags fabricated of the same material as the liner. Provide approximately 23 kg 50 lbs of [dry, clean sand] [_____] inside of each bag. Completely seal each bag using the same field seam weld procedures used on the liner's field seams.

2.3 ACCESSORIES

2.3.1 Stainless Steel Mounting Strip

NOTE: Show mounting strips around the perimeter of liner terminations on vertical concrete structures. The strips prevent the nut on the concrete anchor from penetrating and damaging the liner.

Provide 5 mm 3/16-inch thick by 50 mm 2 inches wide stainless steel mounting strips. Provide pre-punched bolt holes in the strip at [_____] [305 mm 12 inches] on center to accommodate the concrete anchor bolts.

2.3.2 Concrete Anchor Bolts

Anchor bolts shall conform to ASTM A 307, Grade C, hot-dipped galvanized. Provide each anchor bolt with stainless steel nuts and washers that conform to ASTM A 194/A 194M, Grade 8.

2.3.3 Outdoor Sealant

Outdoor sealant shall conform to ASTM C 920, Type S, Grade NS, Class 25.

PART 3 EXECUTION

3.1 INSTALLATION

Equipment/parts subject to degradation or requiring adjustment, inspection or repair shall be accessible and capable of convenient removal. Prior to any fabrication or erection, submit detailed drawings that show the proposed panel layout of the liner over the entire containment area. As a minimum, indicate the direction and location of factory and field fabricated seams, the termination of the panels at the perimeter of lined areas, details and methods of sealing around penetrations, details and methods for anchoring, and any applicable site specific installation instructions.

3.1.1 Field Engineer

Provide a field engineer to supervise the complete installation of the

liner and perform each liner inspection and test.

3.1.2 Surface Preparation

NOTE: Include the first bracketed sentence if a
geotextile is not needed in the project. Include
the second set of bracketed sentences if a
geotextile is required for the project.

[Surfaces to be covered shall be free of vegetation, rocks, debris, etc., graded true, and be smooth with no abrupt projections.] [Install the geotextile in direct contact with the existing subgrade to be covered. Install the geotextile in strict accordance with manufacturer's recommendations. Install geotextile to closely fit around projections (for example, pipe penetrations, concrete foundations/pads, conduit penetrations, etc.).] Submit a signed letter from the field engineer, prior to placing any geotextile or liner, that states the subgrade was adequately prepared per the liner manufacturer's recommendations.

3.1.3 Liner Installation

Place the liner over the prepared surface in accordance with the [liner manufacturer's installation instructions](#). Place the liner in such a manner as to assure minimum handling and field seams. Use sand bags (or other manufacturer approved means) to hold the lining down in position during installation especially in areas where wind is prevalent. Do not drag or slide materials, equipment or other items across the surface of the liner at anytime. Personnel walking or working on the lining material shall wear soft-sole shoes. Laying out and welding liner shall only be performed when the ambient temperature and the temperature of the liner is [-4 degrees C](#) [25 degrees F](#) or higher.

3.1.3.1 Field Seams

Provide a [50 mm](#) [2 inch](#) overlap plus or minus [6 mm](#) [1/4-inch](#) for field seams. Clean and prepare overlapped areas according to manufacturer's recommendations. Prior to performing field seam welds between liner panels/sheets, completely unroll and layout each liner panel/sheet.

3.1.3.2 Liner Projections

Install lining sheets to closely fit around liner projections (for example, pipe penetrations, concrete foundations/pads, conduit penetrations, etc.). Install and center manufacturer supplied sleeves/boots around liner projections in strict accordance with manufacturer's recommendations. Compress the end of pipe sleeves to a pipe with a stainless steel band clamp assembly. For liner anchorage to concrete, install a stainless steel mounting strip around the liner edge and mount with concrete anchor bolts. Apply outdoor sealant to the perimeter edge of exposed liner to include the edge of sleeves/boots.

3.2 FIELD QUALITY CONTROL

3.2.1 Visual Inspection of Field Seams

Visually inspect each field seam to confirm that the seams are tightly bonded. Perform the inspection of a seam within 30 hours after the

manufacturer's suggested application, curing, and cooling time. Repair and re-inspect seams found to be defective in accordance with manufacturer's recommendations.

3.2.2 Liner Vacuum Box Test

After successful completion of the visual inspection of field seams, perform a vacuum box test in accordance with ASTM D 5641 on each field seam, the area around the seams, and each liner surface showing injury due to scuffing, penetration by foreign objects, or distress from rough subgrade. If the vacuum box test indicates a continuous stream of bubbles on repeated testing at the same location, then the area being tested shall be considered damaged and shall be repaired and retested. Perform repairs in accordance with manufacturer's recommendations.

3.2.3 Liner Air Lance Test

After successful completion of the liner vacuum box test, perform an air lance test on seams not testable with a vacuum box test (for example, small seams around penetrations, oddball types of patches, etc.) to detect an unbonded area. Perform the test using a minimum 345 kPa (50 psig) 50 psig jet of air regulated and directed through a 4.8 mm (3/16-inch) 3/16-inch diameter nozzle. Apply the jet of air to the lip of a seam in a near perpendicular direction to the length of the seam. Hold the nozzle a maximum of 100 mm 4 inches from the seam and travel at a rate of not to exceed 12 mpm 40 fpm. Inflation of any section of the seam by the impinging air stream shall be indicative of an unbonded area. Unbonded areas shall be repaired and retested. Perform repairs in accordance with manufacturer's recommendations.

-- End of Section --