Preparing Activity: NAVFAC Superseding
UFGS-33 56 13.15 (August 2015)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
****

SECTION TABLE OF CONTENTS

DIVISION 33 - UTILITIES

SECTION 33 56 21.18

SINGLE WALL POL TANK UNDERTANK INTERSTITIAL SPACE

11/18

PART 1 GENERAL

1.1 REFERENCES
1.2 SUBMITTALS
1.3 RELATED REQUIREMENTS
1.4 QUALIFICATIONS
1.4.1 Qualifications of FML Field Engineer
1.5 QUALITY ASSURANCE
1.5.1 Flexible Membrane Liner Drawing Requirements
1.5.2 FML Manufacturer's Representative
1.6 Liner Manufacturer's Certification

PART 2 PRODUCTS

2.1 STEEL PIPE AND FITTINGS
2.2 LEAK DETECTION TELL-TALE PIPE
2.2.1 Fiberglass Pipe, Fittings, and Adhesive
2.2.2 Leak Detection Tell-Tale Pipe Well Screen
2.3 CP/TRACER PIPE
2.3.1 PVC Pipe, Fittings, and Adhesive
2.3.2 CP/Tracer Pipe Well Screen
2.4 FLEXIBLE MEMBRANE LINER (FML)
2.4.1 Job Lot of FML
2.4.2 FML Samples
2.4.3 FML Factory Test
2.4.4 FML Components
2.4.5 Fuels for Testing FML
2.4.5.1 Motor Gasoline (Mogas)
2.4.5.2 Diesel
2.4.5.3 No. 2 and No. 4 Fuel Oils
2.4.5.4 JP-4 and JP-5
2.4.5.5 JP-7
2.4.5.6 JP-8
2.4.5.7 ASTM Fuel B

2.5 GEOTEXTILE FABRIC
2.5.1 Geotextile
2.5.2 Manufacturing Quality Control Sampling and Testing
2.6 FILTER FABRIC
2.7 BATTEN BAR
2.8 FML RINGWALL SEALANT
2.9 SAND CUSHION

PART 3 EXECUTION

3.1 CONSTRUCTION
3.1.1 Sand Cushion
3.1.2 INSTALLATION OF FML
3.1.2.1 Field Engineer
3.1.2.2 Preparation
3.1.2.3 Surface Preparation
3.1.2.4 FML Layout and Installation
3.1.3 Cathodic Protection
3.1.4 Leak Detection Tell-Tale Pipe
3.1.5 CP/Tracer Pipe
3.1.6 Leak Simulation Probe
3.1.7 Filter Fabric Wrap
3.1.8 CP/Tracer Pipe Installation Test
3.1.9 Leak Simulation Probe[and Leak Detection Tell-Tale Pipe] Test[s]
3.2 FIELD QUALITY CONTROL
3.2.1 FML Inspections
3.2.1.1 FML Initial Visual Inspection
3.2.1.2 Sample Field Seam Inspection
3.2.2 FML Tests
3.2.2.1 FML Seam Pull Test
3.2.2.2 FML Vacuum Box Test
3.2.2.3 FML Air Lance Tests
3.2.3 FML Acceptance Inspection
3.2.4 Manufacturer's Field Service
3.2.5 Sand Cushion Tests - Prior to Delivery
3.2.6 Sand Cushion Tests - Post Delivery
3.2.7 Retesting
3.2.8 Photographic Construction Documentation of the Undertank Interstitial Space

-- End of Section Table of Contents --

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USACE / NAVFAC / AFCEC / NASA	**UFGS-33 56 21.18 (November 2018)**

Preparing Activity: NAVFAC	**Superseding**
	UFGS-33 56 13.15 (August 2015)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023

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SECTION 33 56 21.18

SINGLE WALL POL TANK UNDERTANK INTERSTITIAL SPACE
11/18

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NOTE: This guide specification is intended to be used in conjunction with Section 33 56 21.17 SINGLE WALL ABOVE GROUND FIXED ROOF STEEL POL STORAGE TANK.

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: The following information must be shown on the project drawings:

1. The extent of the work included in the project should be indicated on drawings showing the site layout and other data required for design by the Contractor.

2. If concrete foundation work is provided under a separate contract, Government work should include foundations, setting anchor bolts and other pertinent work such as piles and ringwall penetrations.

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NOTE: For steel and stainless steel piping, pipe fittings, flanges, gaskets, and bolting, refer to Section 33 52 43.13 AVIATION FUEL PIPING or Section 33 52 40 FUEL SYSTEMS PIPING (NON-HYDRANT).

****

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.

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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.

AMERICAN PETROLEUM INSTITUTE (API)

API Std 650	(2013; Errata 1 2013; Addendum 1 2014; Errata 2 2014; Addendum 2 2016; Addendum 3 2018) Welded Tanks for Oil Storage

ASTM INTERNATIONAL (ASTM)

ASTM B221	(2021) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B221M	(2021) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)
ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C88	(2018) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C1218/C1218M	(2020c) Standard Test Method for

	Water-Soluble Chloride in Mortar and Concrete
ASTM C1580	(2015) Standard Test Method for Water-Soluble Sulfate in Soil
ASTM D396	(2021) Standard Specification for Fuel Oils
ASTM D471	(2016a) Standard Test Method for Rubber Property - Effect of Liquids
ASTM D751	(2006; R 2011) Coated Fabrics
ASTM D814	(1995; R 2020) Rubber Property - Vapor Transmission of Volatile Liquids
ASTM D2136	(2002; R 2012) Coated Fabrics - Low-Temperature Bend Test
ASTM D2665	(2014) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM D3389	(2016) Standard Test Method for Coated Fabrics Abrasion Resistance (Rotary Platform, Double-Head Abrader)
ASTM D4354	(2012; R 2020) Sampling of Geosynthetics for Testing
ASTM D4491/D4491M	(2017) Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D4533	(2011) Trapezoid Tearing Strength of Geotextiles
ASTM D4632/D4632M	(2015a) Grab Breaking Load and Elongation of Geotextiles
ASTM D4751	(2020) Standard Test Method for Determining Apparent Opening Size of a Geotextile
ASTM D4759	(2011; R 2018) Standard Practice for Determining the Specification Conformance of Geosynthetics
ASTM D4814	(2020a) Standard Specification for Automotive Spark-Ignition Engine Fuel
ASTM D4972	(2018) Standard Test Methods for pH of Soils
ASTM D5261	(2010; R 2018) Standard Test Method for Measuring Mass Per Unit Area of Geotextiles
ASTM D6241	(2014) Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm

Probe

ASTM G187 (2018) Standard Test Method for Measurement of Soil Resistivity Using the Two-Electrode Soil Box Method

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-DTL-5624 (2016; Rev W; Notice 1 2020) Turbine Fuel, Aviation, Grades JP-4 and JP-5

MIL-DTL-38219 (1998; Rev D; Notice 1 2016) Turbine Fuel, Low Volatility, JP-7

MIL-DTL-83133 (2015; Rev J) Turbine Fuels, Aviation, Kerosene Type, JP-8 (NATO F-34), NATO F-35 and JP-8 + 100 (NATO F-37)

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-52557 (2001; Rev A; Notice 1) Fuel Oil, Diesel; for Posts, Camps and Stations

UNDERWRITERS LABORATORIES (UL)

UL 971 (1995; Reprint Mar 2006) UL Standard for Safety Nonmetallic Underground Piping for Flammable Liquids

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, 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

Flexible Membrane Liner; G[, [_____]]

SD-03 Product Data

Fiberglass Pipe, Fittings, and Adhesive; G[, [_____]]

Leak Detection Tell-Tale Pipe Well Screen; G[, [_____]]

PVC Pipe, Fittings, and Adhesive; G[, [_____]]

CP/Tracer Pipe Well Screen; G[, [_____]]

Flexible Membrane Liner (FML); G[, [_____]]

Geotextile Fabric; G[, [_____]]

Filter Fabric; G[, [_____]]

Aluminum Flat Bar; G[, [_____]]

FML Ringwall Sealant; G[, [_____]]

Sand Cushion; G[, [_____]]

SD-04 Samples

FML Samples; G[, [_____]]

SD-06 Test Reports

CP/Tracer Pipe Installation Test

FML Inspections

FML Tests

Sand Cushion Tests - Prior to Delivery

Sand Cushion Tests - Post Delivery

Photographic Construction Documentation of the Undertank

Interstitial Space

SD-07 Certificates

Qualifications of FML Field Engineer

FML Manufacturer's Representative

Liner Manufacturer's Certification; G[, [_____]]

Certificate of Surface Preparation; G[, [_____]]

SD-08 Manufacturer's Instructions

Flexible Membrane Liner (FML)

SD-09 Manufacturer's Field Reports

FML Factory Test; G[, [_____]]

1.3 RELATED REQUIREMENTS

Product to be stored in the tank is [JP-5] [JP-8] [_____].

1.4 QUALIFICATIONS

1.4.1 Qualifications of FML Field Engineer

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

The Contractor must meet the licensing requirements of the State in which the work is to be performed. The Contractor must provide a field engineer full time to this project during FML installation and testing. The field engineer must have successfully completed manufacturer's training for handling and installing FML systems, as well as have at least 100,000 square meter one-million square feet of installation experience. Submit a letter providing evidence of the Contractor's and the field engineer's experience, training, and licensing. Statements of previous FML job experience must be provided with a point of contact, a phone number, address, the type of installation, and the current status of the installation.

1.5 QUALITY ASSURANCE

1.5.1 Flexible Membrane Liner Drawing Requirements

Submit drawings of the FML installation indicating the locations of field seams, penetrations, contours, and transitions and details of penetrations, boots, and miscellaneous components.

1.5.2 FML Manufacturer's Representative

Submit a letter, prior to placing the FML, from the FML manufacturer naming their authorized representative complete with their address, phone number, and a point of contact.

1.6 Liner Manufacturer's Certification

Following the successful installation and testing of the liner, submit a letter signed by the liner manufacturer's authorized representative 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.

PART 2 PRODUCTS

2.1 STEEL PIPE AND FITTINGS

Steel and stainless steel pipe and fittings must be provided in accordance with Section 33 52 43.13 AVIATION FUEL PIPING or Section 33 52 40 FUEL SYSTEMS PIPING (NON-HYDRANT) and API Std 650.

2.2 LEAK DETECTION TELL-TALE PIPE

****

NOTE: Since a leak in the undertank tell-tale pipe could result in contamination of ground water and PVC manufacturers have been unable to certify that PVC adhesive is suitable for use in jet fuel, PVC is not an acceptable material for the undertank drain tell-tale pipe.

****

2.2.1 Fiberglass Pipe, Fittings, and Adhesive

Fiberglass pipe and fittings must be fiber reinforced plastic pipe per UL 971 Standard for Safety Nonmetallic Underground Piping for Flammable Liquids. Fiberglass adhesives must be as recommended by the manufacturer for use with jet fuel and water.

2.2.2 Leak Detection Tell-Tale Pipe Well Screen

Well screen must be fiberglass pipe as specified above. The 100 mm 4-inch well screen must have four rows of 0.25 mm 0.010-inch wide slots with a net open area of at least 102 square centimeters/meter 4.8 square inches/foot.

2.3 CP/TRACER PIPE

2.3.1 PVC Pipe, Fittings, and Adhesive

CP/tracer pipe and leak simulation probe pipe, fittings, and well screen must be ASTM D2665 SCH 40 PVC Pipe. PVC adhesives must be as recommended by the manufacturer.

2.3.2 CP/Tracer Pipe Well Screen

CP/Tracer Gas Detection well screen must be PVC pipe as specified above and must have three rows of 0.25 mm 0.010-inch wide slots. CP/Tracer Gas Detection piping must be slotted, starting at 600 mm 2 feet within the ringwall on one side of the tank and continuing under the tank bottom to within 600 mm 2 feet of the foundation ringwall on the other side of the tank.

2.4 FLEXIBLE MEMBRANE LINER (FML)

The secondary containment (under-tank-bottom) FML must demonstrate the acceptable limits of the properties listed under Table 1. The FML must be factory produced from a base fabric that is completely covered with a polymer. The base fabric must be made of aramid (kevlar), polyester, or nylon. Factory seams must be made with a 50 mm 2-inch overlap, plus or minus 6 mm 1/4-inch, by an automatic thermal high-pressure welding process. The FML must retard the growth of mildew and be capable of containing the liquid stored, withstanding temperatures up to 71 degrees C 160 degrees F, and withstanding humidity up to 100 percent relative humidity.

2.4.1 Job Lot of FML

A job lot of FML is defined by this specification as the amount of FML product that can be produced from a singular mixture of chemicals. Any FML material created from a new or altered mixture of chemicals must be considered a new job lot.

2.4.2 FML Samples

Twenty four samples must be cut from every job lot of FML. Each sample must be approximately 216 by 280 mm 8-1/2 by 11 inches in size. Eight of the samples must be cut across factory seams.

2.4.3 FML Factory Test

Each manufacturer's job lot of FML must have each of the FML properties verified by the factory test procedures and methods listed below. No substitute methods are allowed for verification of any property. Each separate verification of a property must be made on a separate sample. The FML must demonstrate through factory testing the acceptable limits of the following properties listed in Table 1. The properties must be verified by each of the test standards listed.

****

NOTE: Include testing for permeability using the liquid stored in addition to Fuel B.

****

TABLE 1. Standards and Limits for FML Properties (Metric)

Property	Minimum Acceptable Value
Base Fabric Weight (nominal)	441 g/m^2
Finished Coated Weight ASTM D751	1085 g/m^2 plus 70 g/m^2
Thickness ASTM D751	0.86 mm

TABLE 1. Standards and Limits for FML Properties (Metric)	
Property	Minimum Acceptable Value
Grab Tensile ASTM D751	3338 N
Strip Tensile ASTM D751 Procedure B	490 daN/5cm
Adhesion ASTM D751 Dielectric Weld	18 daN/5cm
Hydrostatic Resistance ASTM D751 Procedure A	5.52 MPa
Bursting Strength ASTM D751 Ball Tip	5340 N
Low Temperature ASTM D2136 3 mm mandrel, 4 hour	Pass minus 46 degrees C
Abrasion Resistance ASTM D3389 H22 wheel/1000 g load	10,000 cycles (min) before fabric exposure
Permeability ASTM D814 Fuel B and [_____]	19.1 $mL/m^2/24$ hr

TABLE 1. Standards and Limits for FML Properties (English)	
Property	Minimum Acceptable Value
Base Fabric Weight (minimum)	13.0 oz/yd^2
Finished Coated Weight ASTM D751	30 oz/yd^2
Thickness ASTM D751	0.034 inches
Grab Tensile ASTM D751	750 lb_f/in
Strip Tensile ASTM D751 Procedure B	550 lb_f/in
Adhesion ASTM D751 Dielectric Weld	20 lb_f/in
Hydrostatic Resistance ASTM D751 Procedure A	800psi
Bursting Strength ASTM D751 Ball Tip	1200 lb_f

TABLE 1. Standards and Limits for FML Properties (English)	
Property	Minimum Acceptable Value
Low Temperature ASTM D2136 1/8 inch mandrel, 4 hour	Pass minus 50 degrees F
Abrasion Resistance ASTM D3389 H22 wheel/1000 g load	10,000 cycles (min) before fabric exposure
Permeability ASTM D814 Fuel B and [_____]	0.05 fl. oz/ft^2/24 hr

2.4.4 FML Components

Components, such as sleeves, boots, must be factory prefabricated from the FML material and have the same fabrication characteristics.

2.4.5 Fuels for Testing FML

Other materials, in addition to the FML, must be resistant to the fuel or fuels being stored. Fuels, as required or mentioned by this specification, must be in accordance with the following:

2.4.5.1 Motor Gasoline (Mogas)

Mogas must be in accordance with ASTM D4814 REV B.

2.4.5.2 Diesel

Diesel must be in accordance with CID A-A-52557.

2.4.5.3 No. 2 and No. 4 Fuel Oils

Oils must be in accordance with ASTM D396.

2.4.5.4 JP-4 and JP-5

Fuels must be in accordance with MIL-DTL-5624.

2.4.5.5 JP-7

Fuel must be in accordance with MIL-DTL-38219.

2.4.5.6 JP-8

Fuel must be in accordance with MIL-DTL-83133.

2.4.5.7 ASTM Fuel B

ASTM Fuel B as referenced in this section must be in accordance with ASTM D471.

2.5 GEOTEXTILE FABRIC

Provide geotextile fabric between sand and underside of flexible membrane liner under the tank bottom with the following properties:

PROPERTY	TEST VALUE	TEST METHOD
Unit Weight g/sq. meter (oz/yd^2)	335 min. (10)	ASTM D5261
Elongation at Break, Percent	50	ASTM D4632/D4632M
Apparent Opening, mm (mil)	0.15 max. (6)	ASTM D4751
Permittivity, sec-1	1.2 max.	ASTM D4491/D4491M
Puncture, N (lbs)	710 min. (160)	ASTM D6241
Grab Tensile, N (lbs)	1110 min. (250)	ASTM D4632/D4632M
Trapezoidal Tear, N (lbs)	445 min. (100)	ASTM D4533

2.5.1 Geotextile

Geotextile must be a woven or nonwoven (as noted) pervious sheet of polymeric material and must consist of long-chain synthetic polymers composed of at least 95 percent by weight polyolefins, polyesters, or polyamides. The use of woven, slit-film geotextiles (i.e. geotextiles made from yarns of a flat, tape-like character) will not be allowed. Stabilizers [and][or] inhibitors must be added to the base polymer, as needed, to make the filaments resistant to deterioration by ultraviolet light, oxidation, and heat exposure. Regrind material, which consists of edge trimmings and other scraps that have never reached the consumer, may be used to produce the geotextile. Post-consumer recycled material may also be used. Geotextile must be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including the selvages. Geotextiles and factory seams must meet the requirements specified in Table 1. Where applicable, Table 1 property values represent minimum average roll values (MARV) in the weakest principal direction.

2.5.2 Manufacturing Quality Control Sampling and Testing

Manufacturing quality control sampling and testing must be performed in accordance with the manufacturer's approved quality control manual. As a minimum, geotextiles must be randomly sampled for testing in accordance with ASTM D4354 Procedure A. Acceptance of geotextile must be in accordance with ASTM D4759. Tests not meeting the specified requirements must result in the rejection of applicable rolls.

2.6 FILTER FABRIC

Wrap Leak Detection Tell-Tale and CP/Tracer Pipe well screen, with filter fabric. Filter fabric must be needle-punched, non-woven geotextile with a typical weight of 200 g/square meter 6 oz/square yard with the following qualities:

PROPERTY	TEST VALUE	TEST METHOD
Elongation at Break, Percent	50	ASTM D4632/D4632M
Apparent Opening, mm (U.S. Sieve)	0.212 max. (70)	ASTM D4751
Permittivity, sec-1	2.1 max.	ASTM D4491/D4491M
Puncture, N (lbs)	240 min. (55)	ASTM D6241
Grab Tensile, N (lbs)	400 min. (90)	ASTM D4632/D4632M
Trapezoidal Tear, N (lbs)	175 min. (40)	ASTM D4533

2.7 BATTEN BAR

The FML must be installed using a batten bar bolted to the concrete ringwall as indicated. Batten bar must be ASTM B221M ASTM B221 aluminum flat bar rolled to the inside diameter of the ringwall foundation. Anchor bolt, nut, and washer must be galvanized steel. Neoprene mounting pad must be rated with a Shore A hardness of not more than 40.

2.8 FML RINGWALL SEALANT

The FML-to-ringwall sealant must be fuel and water resistant and as recommended by the FML manufacturer.

2.9 SAND CUSHION

Sand must be fine sand aggregate in accordance with ASTM C33/C33M, except maximum allowable percentage passing a 150 micron sieve and a 300 micron sieve must be reduced to 5 and 15 percent, respectively. Cushion must contain no more than 300 parts per million (ppm) chlorides in accordance with ASTM C1218/C1218M, no more than 150 ppm sulfates in accordance with ASTM C1580, and have a pH greater than 7 in accordance with ASTM D4972. Cushion must have a minimum electrical resistivity of 35,000 ohm-cm 13,780 ohm-inch in accordance with ASTM G187. Magnesium sulfate must be used in the ASTM C88 soundness test.

PART 3 EXECUTION

3.1 CONSTRUCTION

3.1.1 Sand Cushion

Provide compacted clean sand above and below the FML as indicated. Thoroughly compact the sand cushion below each of the interstitial space components (i.e. liner, CP anodes, leak detection tell-tale pipe, CP/tracer pipe). Grade sand to match slope of the tank bottom and protect from contamination and disturbance until after the tank bottom is installed. Provide self-draining protective covering over the top of any sand placed on top of FML and keep sand dry at all times during construction.

****

NOTE: Include the first bracketed paragraph for self anchored tanks. Include the second bracket

paragraph for anchored tanks.
****

[For anchored tanks, build up the sloped sand pad so that the tank bottom will rest on the sand and the foundation ringwall shims.] [For unanchored tanks, build up the sand so that the tank bottom will rest on the sand and the foundation ringwall gasket.] Do not use or place fiberboard on top of the foundation ringwall or on top of the sand.

3.1.2 INSTALLATION OF FML

3.1.2.1 Field Engineer

The field engineer must supervise the complete installation of the FML and perform each FML inspection and test.

3.1.2.2 Preparation

Prior to laying out the FML, three sample field seams must be performed. Each seam must be 1500 mm 5 feet in length. Seams must be made only when the ambient temperature and the temperature of the FML are both minus 4 degrees C 25 degrees F or higher.

3.1.2.3 Surface Preparation

The surfaces to be covered must be concrete or clean sand, as specified in the paragraph SAND CUSHION, free of rocks, debris, and smooth with no abrupt projections of any kind. Submit a certificate of surface preparation signed by the field engineer, prior to placing any geotextile or liner, stating the subgrade was adequately prepared per the specification and the liner manufacturer's recommendations. Prior to laying the FML, cover prepared surfaces with geotextile fabric as indicated.

3.1.2.4 FML Layout and Installation

After successful completion of the FML visual inspection, the FML must be laid out. Install FML over geotextile fabric. Laying out and welding of FML must only be done when the ambient temperature and the temperature of the FML are both minus 4 degrees C 25 degrees F or higher. Field seams must have a 50 mm 2-inch overlap, plus or minus 6 mm 1/4-inch. Panels or sheets of FML to be seam welded together must be laid out prior to welding field seams. The overlapped areas must be cleaned and prepared according to the installation instructions and procedures. Welds must be tightly bonded. Seal the FML around the penetrations using preformed boots. Use fuel resistant adhesive sealant between the boot and the penetration. Clamp the boots to the penetrations using stainless steel hose clamps as indicated. Prepare and weld the boots to the FML using the same preparation and welding methods used to weld the FML seams.

3.1.3 Cathodic Protection

Provide the underside of the tank bottom with impressed current cathodic protection. Install the cathodic protection anodes, slotted PVC tube for portable reference cell, and portable reference cell in the sand between the FML and the tank bottom in accordance with Section 26 42 17 IMPRESSED CURRENT CATHODIC PROTECTION (ICCP) SYSTEM.

3.1.4 Leak Detection Tell-Tale Pipe

****

NOTE: Include verbiage in the coating specification and on the drawing to provide, on the lower 300 mm one foot of the shell, 50 mm 2-inch high black stencil lettering with an arrow, pointing down, over the "Leak Detection Tell-Tale", the "Leak Simulation Probe", and the CP/Tracer Pipe. Identify the later as "Tracer Gas/CP Slider Tube" and identify the CP/Tracer pipe by its unique number. Refer to paragraph CP/TRACER PIPE INSTALLATION for additional information on CP/Tracer Pipe identification.

****

Prior to steel tank construction, install leak detection tell-tale pipe through the ringwall and in the sand below the planned location of the tank bottom as indicated. System piping must slope evenly downward (gravity draining) from the interior termination point at the tank bottom FML sump to the exterior termination point as indicated. Interior termination point must be fiberglass well screen as indicated and covered with two wraps of filter fabric held in place with nylon ties or straps. Exterior termination point must be as indicated.

3.1.5 CP/Tracer Pipe

****

NOTE: Locate the CP/Tracer gas detection well screens, with one well screen at 600 mm 2 feet off from tank center, no greater than 13411 mm 44 feet apart and with all areas of the tank bottom within 6700 mm 22 feet of at least one well screen.

****

Prior to steel tank construction, install the CP/tracer pipe and well screen piping through the ringwall and in the sand below the tank bottom as indicated. Cover with two wraps of filter fabric held in place with nylon ties or straps. The material, number, and lengths of the well screens and pipe must be as indicated.

3.1.6 Leak Simulation Probe

****

NOTE: Locate the end of the leak simulation probe under the tank approximately 3000 mm 10 feet from the ringwall foundation and as far from a CP/Tracer gas well screen as practical.

****

Prior to steel tank construction, install the leak simulation probe through the ringwall and in the sand below the tank bottom as indicated. Interior termination point (under tank bottom) must be an open ended coupling with two wraps of filter fabric held in place with nylon ties or straps.

3.1.7 Filter Fabric Wrap

Prior to steel tank construction, cover all of the well screen pipe segments with two wraps of filter fabric held in place with nylon ties or

straps placed 300 mm one foot on center.

3.1.8 CP/Tracer Pipe Installation Test

After installation of the CP/tracer pipe and well screen is complete, prove that each of the CP/tracer pipes is clear (without obstructions or bends) in the presence of the contracting officer using a continuous length (including couplings) of 25 mm one-inch PVC pipe at least as long as the pipe being tested plus 1 meter 3 feet. The test must be performed by passing the 25 mm one-inch PVC pipe through each of the 50 mm 2-inch CP/tracer pipes and removing the 25 mm one-inch PVC pipe from the opposite end of the 50 mm 2-inch pipe on the other side of the ringwall. Notify the contracting officer at least 24 hours prior to the test.

3.1.9 Leak Simulation Probe[and Leak Detection Tell-Tale Pipe] Test[s]

Repeat the "CP/Tracer Pipe Installation Test" for the Leak Simulation Probe; exercise care not to damage the filter fabric wrap at the end.[For elevated foundation type tanks, repeat the "CP/Tracer Pipe Installation Test" for the Leak Detection Tell-Tale Pipe but use a 65 mm 2-1/2 inch PVC pipe. Exercise care not to damage the end.]

3.2 FIELD QUALITY CONTROL

The Contractor must perform all trial operations and field tests and provide all labor, equipment, and incidentals required for testing. The FML manufacturer authorized representative must be present for all FML tests. The representative must supervise and approve all FML tests. The representative must provide detailed test results. Notify and provide the Contracting Officer with the opportunity to witness all field tests at least 24 hours in advance of their performance.

3.2.1 FML Inspections

3.2.1.1 FML Initial Visual Inspection

The visual inspection must verify the finished surface to be covered with the FML is properly graded and compacted. A visual inspection of the FML must be performed on each FML panel or sheet as it is unrolled. The Contracting Officer must be notified of any damage detected.

3.2.1.2 Sample Field Seam Inspection

Field seam samples must be subjected to a visual inspection performed within 30 hours after the seam has been made, cured, and cooled.

3.2.2 FML Tests

3.2.2.1 FML Seam Pull Test

Just prior to vacuum box testing the FML field seams, perform manual pull testing of the FML field seams at ten locations selected by the Contracting Officer. The test must be performed by applying at least 222 N 50 pounds of force across the selected seams and maintaining for at least 60 seconds.

3.2.2.2 FML Vacuum Box Test

After successful completion of the FML visual inspection, a vacuum box

test must be performed on all field seams, the area around the seams, and all FML surfaces showing scuffing, penetration by foreign objects, or distress from rough subgrade. A glass topped vacuum box, which has a neoprene sealing gasket, must be used. The vacuum box test must be performed as follows:

a. A commercial bubble forming solution must be applied to the area to be tested.

b. The vacuum box must be positioned over the area and a vacuum slowly applied until a differential pressure of 7 kPa one psi is achieved and held for at least 5 seconds while observing the solution for bubble formation.

c. If the vacuum box test indicates a continuous stream of bubbles on repeated testing at the same location, then the area being tested must be considered damaged and must be repaired and retested.

d. If the vacuum box test does not indicate a leak, then the vacuum must be slowly increased until a maximum differential pressure of 14 kPa plus 0.0 or minus 2 kPa 2 psi plus 0.0 or minus 0.25 psi is achieved and held for at least 20 seconds. If the test indicates a continuous stream of bubbles on repeated testing at the same location, then the area being tested must be considered damaged and must be repaired and retested. Care must be taken to limit the vacuum to no more than the maximum differential pressure because, if it is exceeded by more than 2 kPa 0.25 psi, the FML must be considered damaged and must be replaced and retested.

3.2.2.3 FML Air Lance Tests

After successful completion of the FML vacuum box test, an air lance test must be performed on all seams not accessible with a vacuum box test (i.e. small seams around penetrations, irregular patches). The air lance test will be performed using a 345 kPa 50 psig jet of air regulated and directed through a 5 mm 3/16-inch diameter nozzle, applied to the upper edge of an overlapped seam or repaired area to detect an unbonded area. Inflation of any section of the seam by the impinging air stream must be indicative of an unbonded area. Unbonded areas must be repaired and retested.

3.2.3 FML Acceptance Inspection

As soon as practicable after successful completion of the FML vacuum box test and the air lance tests, an acceptance inspection must be performed. If the inspection reveals any defects in the work, such defects must be repaired or the unsatisfactory work replaced before acceptance. The cost of such repairs and replacements must be borne by the Contractor. The Contractor must notify the Contracting Officer at least 48 hours in advance of the acceptance inspection.

3.2.4 Manufacturer's Field Service

If any problems are noticed in any inspection of an FML seam, the Contracting Officer must be notified immediately. The FML manufacturer's point of contact must also be contacted by telephone and e-mail and informed that the installation of their product cannot be adequately completed. After the FML manufacturer and their authorized representative have identified the problem and developed and exercised a solution,

another set of sample field seams must be made and reinspected.

3.2.5 Sand Cushion Tests - Prior to Delivery

Sample and test the sand prior to delivery and demonstrate that the sand meets the requirements of ASTM C33/C33M as well as for other properties described under the paragraph SAND CUSHION.

For each sample, along with the requirements of ASTM C33/C33M, verify the amount of chlorides (ppm) and sulfates (ppm) and determine the pH value of the sand and the resistivity.

3.2.6 Sand Cushion Tests - Post Delivery

Sample and test the sand after delivery and demonstrate that the sand meets the requirements of ASTM C33/C33M as well as for other properties described under the paragraph SAND CUSHION.

During delivery, stockpile the sand for each individual storage tank bottom into separate stockpiles.

Take one sample from each tank bottom stockpile, and test. The Contractor must notify the Contracting Officer at least 48 hours in advance of the sand delivery for each tank in order to allow the Contracting Officer the opportunity to witness the sampling. The sand cushion(s) may be placed before the results of the past delivery testing have been submitted.

For each sample, along with the requirements of ASTM C33/C33M, verify the amount of chlorides (ppm) and sulfates (ppm) and determine the pH value of the sand and the resistivity.

Deliveries and stockpiles of sand found not to conform to the requirements specified in the paragraph SAND CUSHION must not be used to construct the sand cushion, but must be promptly removed from the site. This must be the case even if the stockpiled sand has been placed and the tank is partially or completely constructed.

3.2.7 Retesting

Deficiencies found must be rectified and work effected by such deficiencies must be completely retested.

3.2.8 Photographic Construction Documentation of the Undertank Interstitial Space

Provide photographic documentation of the construction of the undertank interstitial space and the installation of the FML liner. Mark-up a plan view of the liner ringwall penetrations identifying each penetration by a unique number starting clockwise of the fill nozzle and proceeding clockwise. Identify the FML penetration in each photograph by the same number shown for that penetration on the marked-up drawing specified above. Submit the marked-up plan review of the penetrations and all photographs to the Contracting Officer in digital form at high resolution (1MB per picture, minimum) on the media type chosen by the Contracting Officer. As Basis of Bid, provide them on compact disc(s) in JPEG format. Take the photographs prior to placement of the sand cushion. Include photographs of the installation of all ringwall penetrations by undertank piping, [including foundation drains,] and cathodic protection. Particular attention must be paid to the way the FML is sealed to the pipe

and conduit penetrations. Number all ringwall penetrations clockwise from tank fill line nozzle and document all penetrations using the penetration number. Each penetration must have at least three photographs: left side, right side, and close-up from the open end of the boot seal, showing the caulk and clamp arrangement.

Particular attention must also be paid to the way the FML is sealed to the interior tank ringwall [and to the tank column base]; photograph the completed FML/batten bar installation at 1 meter 3 foot intervals.

-- End of Section --