
USACE / NAVFAC / AFCEA / NASA UFGS-33 56 13.13 (October 2005)

Preparing Activity: NAVFAC Replacing without change
UFGS-13205 (October 2005)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 19 March 2007

Latest change not indicated by CHG tags

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SECTION 33 56 13.13

STEEL TANKS WITH FIXED ROOFS 04/06

NOTE: This guide specification covers the requirements for design and installation of aboveground steel tanks with fixed cone roofs.

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).

NOTE: Tanks with fixed roofs are usually used for the storage of products having a true vapor pressure less than 10.3 kPa 0.5 psi, JP-5, diesel fuel, kerosene, and burner fuel oils. Earthwork, concrete work, piping, and other work in connection with the tanks should be included in the appropriate sections of the project specification or in a separate project specification.

NOTE: The following information shall 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, location of outlets and inlets, water drawoff connection, manholes, other tank appurtenances, 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, concrete retaining ring, and other pertinent work such as sand for sand cushion, water for testing, and furnishing and installing any tank accessories not a part of this specification.

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 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.

AMERICAN PETROLEUM INSTITUTE (API)

API RP 2009	(2002) Safe Welding, Cutting, and Hot Work Practices in the Petroleum and Petrochemical Industries
API Spec 6D	(2002; Errata 2005) Specification for Pipeline Valves
API Std 2000	(1998; Errata 1999) Venting Atmospheric and Low-Pressure Storage Tanks: Nonrefrigerated and Refrigerated
API Std 2550	(1965; R 1992) Method of Measurement and Calibration of Upright Cylindrical Tanks

API Std 650 (1998; Addendum 2005) Welded Steel Tanks for Oil Storage

ASME INTERNATIONAL (ASME)

ASME B16.11 (2005) Forged Fittings, Socket-Welding and Threaded

ASME B16.21 (2005) Nonmetallic Flat Gaskets for Pipe Flanges

ASME B16.5 (2003) Pipe Flanges and Flanged Fittings, NPS 1/2 Through NPS 24 Metric/Inch Standard

ASME B16.9 (2003) Factory-Made Wrought Buttwelding Fittings

ASTM INTERNATIONAL (ASTM)

ASTM A 182/A 182M (2006) Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service

ASTM A 193/A 193M (2006a) Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service

ASTM A 194/A 194M (2006a) Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service or Both

ASTM A 216/A 216M (2004) Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service

ASTM A 269 (2004) Seamless and Welded Austenitic Stainless Steel Tubing for General Service

ASTM A 312/A 312M (2006) Seamless and Welded Austenitic Stainless Steel Pipes

ASTM A 351/A 351M (2006) Castings, Austenitic, Austenitic, for Pressure-Containing Parts

ASTM A 403/A 403M (2006) Wrought Austenitic Stainless Steel Piping Fittings

ASTM A 492 (1995; R 2004) Stainless Steel Rope Wire

ASTM B 209 (2006) Aluminum and Aluminum-Alloy Sheet and Plate

ASTM B 209M (2006) Aluminum and Aluminum-Alloy Sheet and Plate (Metric)

ASTM C 33 (2003) Concrete Aggregates

ASTM C 88 (2005) Soundness of Aggregates by Use of

Sodium Sulfate or Magnesium Sulfate

ASTM D 2565	(1999) Xenon Arc Exposure of Plastics Intended for Outdoor Applications
ASTM D 3389	(2005) Coated Fabrics Abrasion Resistance (Rotary Platform, Double-Head Abrader)
ASTM D 3453	(2001) Flexible Cellular Materials - Urethane for Furniture and Automotive Cushioning, Bedding, and Similar Applications
ASTM D 396	(2006) Standard Specification for Fuel Oils
ASTM D 471	(2006) Rubber Property - Effect of Liquids
ASTM D 4814	(2006a) Automotive Spark-Ignition Engine Fuel
ASTM D 543	(2006) Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents
ASTM D 747	(2002) Apparent Bending Modulus of Plastics by Means of a Cantilever Beam
ASTM D 751	(2006) Coated Fabrics
ASTM E 96	(2005) Water Vapor Transmission of Materials

NACE INTERNATIONAL (NACE)

NACE RP0178	(2003) Fabrication Details, Surface Finish Requirements, and Proper Design Considerations for Tanks and Vessels to be Lined for Immersion Service
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NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 11	(2005; TIA 2006) Low-, Medium- and High-Expansion Foam Systems
NFPA 70	(2005; TIA 2005) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-DTL-38219	(Rev D) Turbine Fuel, Low Volatility, JP-7
MIL-DTL-5624	(Rev U) Turbine Fuel, Aviation, Grades JP-4 and JP-5
MIL-DTL-83133	(Rev E Turbine Fuels, Aviation, Kerosene Types, NATO F-34 (JP-8), NATO F-35 and JP-8 + 100
MIL-P-24396	(Rev A) Packing Material, Braided PTFE (Polytetrafluoroethylene)

MIL-PRF-907 (Rev F) Antiseize Thread Compound, High Temperature

MIL-R-6855 (Rev E; Notice 2; Supp 1) Rubber, Synthetic, Sheets, Strips, Molded or Extruded Shapes

MIL-R-83248 (Rev C; Notice 2) Rubber, Fluorocarbon Elastomer, High Temperature, Fluid, and Compression Set Resistant

MIL-V-12003 (Rev F; Am 1; Notice 1) Valves, Plug, Cast-Iron or Steel, Manually Operated

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS A-A-52557 (Rev A)) Fuel Oil, Diesel; for Posts, Camps and Stations

FS SS-S-1614 (Rev A; Am 1) Sealants, Joint, Jet-Fuel-Resistant, Hot-Applied, for Portland Cement and Tar Concrete Pavements

FS SS-S-200 (Rev E; Am 2) Sealant, Joint, Two-Component, Jet-Blast-Resistant, Cold-Applied, for Portland Cement Concrete Pavement

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.23 Guarding Floor and Wall Openings and Holes

29 CFR 1910.24 Fixed Industrial Stairs

29 CFR 1910.27 Fixed Ladders

U.S. NAVAL FACILITIES ENGINEERING COMMAND (NAVFAC)

NAVFAC P-355 (1992) Seismic Design for Buildings

UNDERWRITERS LABORATORIES (UL)

UL 698 (2006) Industrial Control Equipment for Hazardous (Classified) Locations

UL 886 (1994; Rev thru Nov 2005) Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations

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.] [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

Steel tank

Floating pan

Aluminum dome roof

Tracer gas detection system drawings

SD-03 Product Data

Structural steel

Pipe and fittings

Flange bolting

Gaskets

Mastic seal

Floating pan

Gage hatch

Mechanical tape level gage
Servo level gage
Plug (double block and bleed) valves
Level alarm system
High liquid level control valve
Thermometers
Sand cushion
Venting
Grating or anti-slip floor plate for stairway
Roof manholes
Shell access holes
Drain pump
Tracer gas detection system
Aluminum dome roof
Flexible membrane liner (FML)
Oil-resistant coating system

SD-04 Samples

FML Samples

SD-05 Design Data

Steel tank design calculations
Floating pan design
Aluminum dome roof design calculations

SD-06 Test Reports

Structural steel tests (including toughness test data)
FML inspections
FML tests
FML factory test
Sand cushion tests
Fire test

SD-07 Certificates

Welding procedures and procedure qualifications

Qualifications of nondestructive test examiners

Tank calibration experience

Qualifications of FML field engineer

FML Manufacturer's Representative

SD-08 Manufacturer's Instructions

Mechanical tape level gage

Servo level gage

Level alarm system

High liquid level control valve

Aluminum dome roof

Flexible membrane liner (FML)

SD-10 Operation and Maintenance Data

Mechanical tape level gage, Data Package 2[; G][; G, [____]]

Servo level gage, Data Package 2[; G][; G, [____]]

Level alarm system, Data Package 2[; G][; G, [____]]

High liquid level control valve, Data Package 2[; G][; G, [____]]

Venting, Data Package 2[; G][; G, [____]]

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

SD-11 Closeout Submittals

Tank calibration record

Weld inspection reports

Submit reports for inspection of welds, and radiographs [, to the Contracting Officer].

1.3 COPIES OF API PUBLICATIONS

Provide four copies of API RP 2009, API Std 650, API Std 2000, and API Std 2550.

1.4 RELATED REQUIREMENTS

Materials, design, fabrication, welding, erection, testing, and appurtenances shall be in accordance with API Std 650 and API Std 2000,

except as otherwise specified herein. Products to be stored in the tank are JP-5, diesel fuel, [_____] and fuel oil. Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS, applies to this section except as specified otherwise.

1.5 DESIGN REQUIREMENTS

NOTE: Insert design information for loads on tanks as given in MIL-HDBK-1002/2. General information on tanks can be obtained from DM-22. Insert the size and volume of the tank. Edit as required for project.

Tank shall be designed to resist the following loads and forces:

- a. Wind: [_____] kilometers per hour [_____] mph
- b. Seismic Zone: [_____]
- c. Roof Live Load: [_____] kPa [_____] pounds per square foot
- d. The following combinations of loads, with corresponding percentages of basic stresses to be used in design, shall be allowed:

<u>Load Combination</u>	<u>Percentage of Allowable Stress</u>
Dead load + live load	100
Dead load + live load + wind load	133
Dead load + live load + seismic load	133

- e. Determine forces and hydrodynamic effects from seismic loading in accordance with API Std 650 and NAVFAC P-355. Design tank to provide freeboard to minimize or prevent overflow and damage to the roof and upper shell that may be caused by sloshing of the liquid contents. Design columns to resist the forces caused by sloshing of the liquid contents.
- f. The usable capacity of the tank shall be not less than [_____] liters 42.0 U.S. standard gallons barrels. The tank shall be not more than [_____] m feet in diameter, and shall be approximately [_____] m feet in height plus additional height for sloshing due to seismic effects.
- g. Allowable solid bearing capacity of [_____] with minimum foundation embedment of [610] [_____] mm [24] [_____] inches. Differential settlement of up to [100] [_____] mm [4] [_____] inches under dynamic seismic loading. Bearing values may be increased on third for temporary wind and seismic loads. Allowable passive lateral soil pressure of [_____] . Coefficient of friction of [0.4] [_____] N.
- h. Specify gravity of liquid is [0.84] [_____] .
- i. Design tank and connected piping to accommodate external piping

loads in accordance with API Std 650, Appendix P.

- j. Tank interior columns, when provided, shall be of pipe or round structural tubing.

1.5.1 Corrosion Allowance

NOTE: Corrosion allowance shall not be less than
1.6 mm 1/16 inch for coated tanks. For uncoated
tanks, calculate corrosion metal loss and select
appropriate corrosion allowance.

Make allowance of [1.6] [____] mm [1/16] [____] inch in thickness of steel for corrosion loss. Corrosion allowance shall be applied to the [interior] [and] [exterior] of the shell, roof, and to surfaces of interior structural members.

1.5.2 Design Metal Temperature

NOTE: Insert design metal temperature for locations
not covered by API Std 650. Obtain low temperature
from weather data.

API Std 650 [[____] degrees C] [[____] degrees F].

1.6 TANK CALIBRATION EXPERIENCE

Perform calibration of the tank using a qualified organization that can certify to at least 2 years of prior successful and accurate experience in calibrating tanks of comparable type and size.

1.7 ELECTRICAL WORK

NOTE: Insert appropriate Section number and title
in blank below using format per UFC 1-300-02.

Electrical equipment and wiring shall be in accordance with [____]. Switches and devices necessary for controlling the electrical equipment shall be provided. Wiring, equipment, and fittings shall be explosion-proof in conformance with the applicable requirements of UL 698 and UL 886 for Class I, Division 1, Group C and D hazardous locations. Electrical installations shall conform to the requirements of the NFPA 70. Underground electrical wiring shall be enclosed in PVC coated conduit which shall be isolated from steel tanks with dielectric fittings.

1.8 QUALIFICATIONS OF FML FIELD ENGINEER

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

The Contractor shall meet the licensing requirements of the State in which

the work is to be performed. The Contractor shall provide a field engineer full time to this project. The field engineer shall have successfully completed manufacturer's training for handling and installing FML systems as well as have at least 92,950 square meter one million square feet of installation experience.

1.9 QUALITY ASSURANCE

1.9.1 Drawing Requirements

Drawings for the steel tank [,floating pan] [,and aluminum dome roof] shall be prepared by a registered structural engineer. Include erection diagrams and detail drawings of tank bottoms and foundations, roof, shell plates, wind girders, and openings and connections for fittings and appurtenances. The drawings shall include the following:

- a. Tank erection details showing dimensions, sizes, thickness, gages, materials, finishes, and erection procedures.
- b. Tank component details to include as a minimum:
 - (1) Sand cushion
 - (2) Floating pan (including details of support legs, manways, foam dams, joint attachments, anti-rotation cable, and grounding cables)
 - (3) Internal pipe and fittings
 - (4) Locations of floating pan pressure/vacuum vents, rim seals, and foam dam
 - (5) Details of AFFF fire protection system components
 - (6) Location of alarm and control switches
 - (7) Location of gages
- c. Details of the base of any component that sets on grades; complete with attachments, anchor bolt templates, and recommended clearances for maintenance and operation.
- d. Details of the electric wiring indicating applicable single line and wiring diagrams with written description of sequence of operation and the instrumentation.
- e. Details showing the location, type, and description of vibration isolation devices for all applications.
- f. Complete piping and wiring schematic diagrams.

1.9.2 Tracer Gas Detection System Drawings

Provide shop drawings for installation of the tracer gas detection system.

1.9.3 Data Requirements

Calculations for the steel tank design [,floating pan design] [,and aluminum dome roof design] shall be prepared by a registered structural engineer. Include calculations that indicate the maximum and minimum

operating pressures in accordance with API Std 650, Appendix F. [Include calculations for the buoyancy of the floating pan and the structural stability of the floating pan when resting on the support legs.]

1.9.4 Test Examiners

Submit proof of compliance of nondestructive test examiners with API Std 650. Submit certified data on tank calibration experience.

1.9.5 Qualifications of FML Field Engineer

Submit a letter providing evidence of the Contractor's and the field engineer's experience, training, and licensing. Statements of previous FML job experience shall be provided with a point of contact, a phone number, address, the type of installation, and the current status of the installation.

1.9.6 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.

PART 2 PRODUCTS

2.1 MATERIALS

Conform to the following requirements except that materials not definitely specified shall conform to API Std 650.

2.2 STRUCTURAL STEEL

API Std 650.

2.3 PIPE, FITTINGS, AND FLANGES

API Std 650, except as specified. Fittings less than 50 mm 2 inches IPS shall be flanged or threaded; sizes 50 mm 2 inches IPS and larger shall be flanged or butt-welded. Flanges shall be welding neck type in accordance with ASME B16.5. Threaded fittings shall conform to ASME B16.11, 20.7 MPa 3000 lb. Butt welding fittings shall conform to ASME B16.9.

2.3.1 Inlet and Outlet Piping, Fuel Storage Tanks

NOTE: Specify stainless steel piping for aviation
fuel operating storage tanks at naval air stations.

Stainless Steel for Inlet and Outlet of Aviation Fuel Operating Storage Tanks:

2.3.1.1 Pipe

ASTM A 312/A 312M, Schedule 40, Type 304L or 316L.

2.3.1.2 Fittings

- a. Butt welding: ASTM A 403/A 403M, Class WP, Schedule 40, Type 304L

or 316L.

- b. Threaded: ASME B16.11, Class 20.7 MPa 3000 lb, ASTM A 182/A 182M, Type 304L or 316L, forged.

2.3.1.3 Flanges

ASME B16.5, Class 150, ASTM A 182/A 182M, Type 304L or 316L.

2.3.1.4 Flange Bolting

Bolts: ASTM A 193/A 193M, Grade B7; nuts: ASTM A 194/A 194M, Grade 7.

2.4 PIPE FLANGE GASKETS

ASME B16.21, spiral-wound type.

2.5 GASKETS FOR MANHOLES, CLEANOUTS, AND COVERS

2.5.1 Flanged and Bolted Connections and Covers

Provide composition asbestos-free, fire-resistant gaskets.

2.5.2 Roof Manhole Frames and Covers

Provide rubber gaskets, MIL-R-6855, for covers which are not bolted.

2.6 MASTIC SEAL

Mastic seal for sealing foundation ring wall shall be resistant to jet fuel and shall conform to FS SS-S-200 for cold applied sealant and FS SS-S-1614 for hot applied sealant.

2.7 INTERIOR PROTECTIVE COATING SYSTEM

NOTE: In order to protect product quality and to extend the life of the tank, the prescribed interior surfaces of steel petroleum storage tanks shall be coated in accordance with MIL-HDBK-1022 "Petroleum Fuel Facilities."

NOTE: Other guidance as to interior surface treatment is as follows:

1. Specify bare interior metal surfaces if coating is not required, or if the coating is to be done at a later date. Uncoated surfaces shall be cleaned of contaminants, including mill scale. Delete reference to Section 09 97 13.15 if not applicable.

2. Coating with SAE-30 weight oil should be specified when the surfaces in contact with the stored product are to be left bare, and the tank will not be placed in service immediately.

[Section 09 97 13.15 INTERIOR COATING OF WELDED STEEL PETROLEUM FUEL TANKS.] [Interior of the tank shall be bare steel. Coat interior of tank

with SAE 30 oil for temporary protection.]

2.8 EXTERIOR PROTECTIVE COATING SYSTEM

Section 09 97 13.27 EXTERIOR COATING OF STEEL STRUCTURES.

2.9 APPURTENANCES

2.9.1 Floating Pan

The floating pan shall be naturally buoyant by means of sealed honeycomb cells in aluminum sandwich panels, be suitable for operation with liquids having a specific gravity of 0.70, be internal to the tank, have full surface contact with the fuel, be equipped with a seal at each penetration, and meet the requirements of API Std 650 Appendix H. A rim shall be provided around the floating pan periphery and extend a minimum of 150 mm 6 inches above the free liquid surface. The rim shall contain turbulence and prevent fuel from splashing up onto the top surface of the floating pan.

2.9.1.1 Pan Integrity

The floating pan shall support the following loading conditions without causing damage to the pan, sinking the pan, or allowing product to spill onto the top surface of the pan in the event the pan is punctured.

- a. A uniform load of three times the weight of the pan.
- b. For tanks larger than 9144 mm 30 feet in diameter, a point load of 227 kg on a 93,000 sq mm 500 pounds on a one square foot area anywhere on the floating pan while it is floating or resting on the legs.
- c. For tanks 9144 mm 30 feet in diameter and less, a point load of 113 kg on a 93,000 sq mm 250 pounds on a one square foot area anywhere on the floating pan while it is floating or resting on the legs.

2.9.1.2 Joint Connections

Aluminum sandwich panels shall be joined together by means of a gasketed joint that transmits loads without structural failure or leakage.

2.9.1.3 Aluminum Extrusions

Extrusions shall be made from alloy 6063-T6 in accordance with ASTM B 209M ASTM B 209.

2.9.1.4 Aluminum Sandwich Panels

Panels shall be made from alloy 3003 H14, 3003 H16, 3105 H14, or 5010 H24 in accordance ASTM B 209M ASTM B 209. The skin of the panels shall have a minimum thickness of 0.356 mm 0.014 inches. The core of the panels shall be 25 mm one inch aluminum honeycomb.

2.9.1.5 Support Legs

Floating pan shall be provided with two position self-draining legs that are designed to support a uniform load of 600 Pa 12.5 pounds per square foot. The legs shall be tubular structural members at least 50 mm 2 inches in

diameter and ride with the pan when the fuel level is above the high position. The low position shall be 900 mm 36 inches and high position 1900 mm 75 inches. The exact location and number of the support legs shall be as recommended by the floating pan manufacturer. The legs shall be capable of allowing a person, standing on top of the floating pan while the tank is in service, to perform the following functions:

- a. Change from the high to the low position.
- b. Change from the low to the high position.
- c. Completely remove the legs.
- d. Adjust the legs vertically a distance equal of plus or minus 75 mm 3 inches.

2.9.1.6 Periphery Seals

Periphery seals shall be made of flexible polyurethane foam in accordance with ASTM D 3453 and be covered with a polyurethane coated polyester fabric wrap at least 0.635 mm 0.025 inch thick. The periphery seal shall fit the space between the tank shell and the outer edge of the floating pan with two flexible seals, a primary and a secondary. The seals, primary and secondary as a unit, shall accommodate a deviation between the path of the floating pan relative to the tank shell of an additional 100 mm 4 inches of compression and an additional extension of 50 mm 2 inches from its normal compressed position at any fluid level. The primary seal shall be above the liquid level and be free draining without trapping any liquid. The secondary seal shall be above the primary seal. Seals shall be capable of being replaced during tank operations, be durable in the tank's environment, be abrasion resistant, and not discolor or contaminate the liquid stored in the tank.

2.9.1.7 Penetration Seals

Penetration seals shall be made of Buna-N. Vertical appurtenances such as columns, ladders, cable, etc. that penetrate the floating pan shall have seals that permit a local deviation of plus or minus 125 mm 5 inches and have a rim that extends a minimum of 150 mm 6 inches above the free liquid to contain product turbulence and prevent the tank product from splashing up onto the top surface of the floating pan.

2.9.1.8 Manway

A manway shall be provided for each floating pan to provide access to the tank interior when the floating pan is on its supports and the tank is empty. Manway shall have an clear inside diameter of at least 760 mm 30 inches. The cover shall be bolted fuel tight to the floating pan with a Buna-N gasket. Manway shall have a rim that extends a minimum of 75 mm 3 inches above the free liquid to contain product turbulence and prevent the tank product from splashing up onto the top surface of the floating pan.

2.9.1.9 Foam Dam

NOTE: Provide foam dam for all tanks. Do not
delete for smaller tanks as done in COE
specifications.

A foam dam shall be constructed of steel plate and mounted directly to the top of the floating pan. The steel dam shall be supported by steel channels as indicated. The dam shall be constructed in accordance with NFPA 11.

2.9.1.10 Grounding Cables

Two or more 3 mm 1/8 inch diameter grounding cable made of 304 stainless steel aircraft cable conforming to ASTM A 492, with a maximum resistance of 8.5 ohms per 30.48 meters 100 feet shall be provided for each tank. The exact location and number of grounding cables shall be as recommended by the floating pan manufacturer.

2.9.1.11 Anti-Rotation Cable

One 6 mm 1/4 inch diameter anti-rotation cable made of 304 stainless steel conforming to ASTM A 492 shall be provided for each tank. Fittings for anti-rotation cables including cable clamps, pins, sockets, turnbuckles, U-bolts and nuts, etc. shall be 304 stainless steel. Cable shall be made taut by means of the turnbuckle. The exact location of the anti-rotation cable shall be as recommended by the floating pan manufacturer.

2.9.1.12 Fire Test

The floating pan design shall be fire tested by both of the following tests being applied to a test floating pan. Float the test floating pan in aviation turbine fuel or motor gasoline with a flash point of less than 120 degrees F. Successful conclusion of each fire test shows that the design is adequate if no significant damage occurs to the pan, the pan continues to float, and the fire did not spread to the whole surface of the fuel.

- a. Hole Fire: The test floating pan shall have a 300 mm 12 inch or larger diameter hole cut through it. After being lit, the fuel in the hole shall burn for a minimum of 2 hours.
- b. Rim Fire: After being lit, the fuel around the test rim section shall burn for a minimum of 2 hours.

2.9.2 Gage Hatch

Provide gage hatch and stilling well to within 75 mm 3 inches of the bottom of the tank for manual gauging. Provide a horizontal datum plate of 6 mm 1/4 inch thick stainless steel at the bottom of the stilling well with the top of the plate at the elevation at which the shell intersects the bottom.

Equip hatch with a self-closing, foot-operated, lockdown cover of nonferrous metal. Provide gasket for dissimilar metal protection. Provide a thermometer holder. Locate hatch near roof manhole, readily accessible from the top platform of the stairway.

2.9.3 Mechanical Tape Level Gage

NOTE: Delete this paragraph if Servo Level gages
are specified.

The mechanical tape gage shall be complete with all necessary incidental pipe, pulleys, fittings, supports, support brackets, tension spring, and

guide wire assemblies. The gage shall automatically provide the location of the floating pan within plus or minus 1.6 mm 1/16 inch of the actual liquid level. The head shall be made of aluminum and be mounted on the exterior of the tank shell approximately 1370 mm 54 inches above the tank bottom. The head shall contain a glass covered window complete with an inside wiper. The seals shall be made of teflon. The shafts, graduated tape, and tape drum assembly shall be made of stainless steel. The tape shall be of sufficient length to measure the liquid level from the bottom to the top of the storage tank. Gage measurements shall be graduated in 1.6 mm 1/16 inch increments. The tape shall be carried over pulleys housed in elbow assemblies at each change of direction. For data transmission, the mechanical tape gage head shall be provided with a direct gear, non-contacting optical digital encoder coupled to the gage shaft. Transmitter shall provide a 4-20 MA signal to a remote digital receiver/indicator. Transmitter shall be powered from the remote receiver. Encoder/transmitter shall be UL listed and/or FM approved as intrinsically safe for use in a Class I, Division 1, Groups C and D, hazardous environment.

2.9.4 Servo Level Gage

NOTE: Delete this paragraph if Mechanical Tape gages are specified.

2.9.4.1 Construction

The materials of construction of the servo level gage, excluding "O" ring gaskets, magnetics, and electronic components, shall be constructed of either ASTM A 351/A 351M Type 316 stainless steel or cast aluminum. "O" ring gaskets shall be constructed of Buna-N. The servo level gage shall be Underwriters Laboratory (UL) or Factory Mutual (FM) labeled for Class I, Division 1, Group D hazardous areas, and shall have maximum temperature rating of "T2D" 215 degrees C 419 degrees F as defined by NFPA 70. The nameplate shall include the temperature rating. Unit shall be provided with a thermostatically controlled heater for prevention of condensation and freeze protection and an RTD and self compensating temperature converter. Unit shall receive 120 volts, single phase power and shall consume 60 VA, maximum.

2.9.4.2 Assembly

The automatic tank level gage assembly shall include a servo level gage, an ASTM A 492 Type 316 stainless steel measuring wire, an unguided 146 mm 5.7 inch diameter type 316 stainless steel displacer, an aluminum calibration chamber, local and remote level indications, and an aluminum stilling well.

The measuring wire shall be of sufficient length to measure the liquid level from the bottom to the top of the storage tank.

2.9.4.3 Gage Operation

The displacer shall indicate to the servo level gage a rise or fall in the liquid level of the tank. The servo level gage shall be capable of sensing any movement of the displacer and provide both a local and a remote liquid level indication. The servo level gage shall have a measuring accuracy of plus or minus 3 mm 0.01 feet.

2.9.4.4 Data Transmission

When the servo level gage senses a rise or fall in the tank liquid level, the internal processor shall be capable of providing serialized output capable of being transmitted over a two-wire bus to remote receiver/indicator units. The units of measurement shall be millimeters feet and measuring increments shall be 3 mm in hundredths (0.01) of a foot. Wave integration time shall be 1 to 10 seconds, adjustable.

2.9.5 Plug (Double Block and Bleed) Valves

API Spec 6D and MIL-V-12003 Type III, ANSI Class 150, nonlubricated, resilient, double seated, tapered lift, plug type capable of handling two-way shutoff; steel body, chrome-plated interior, and tapered plug of steel or ductile iron, chrome or nickel plated, supported on upper and lower trunnions, and steel or ductile iron, sealing slips, with Viton seals. Valve design shall permit sealing slips to be replaced from the bottom with the valve mounted in the piping. Valves shall operate from fully open to fully closed by rotation of the handwheel to lift and turn the plug. Valves shall have weatherproof operators with mechanical position indicators and a minimum bore size of 65 percent of nominal pipe size, unless the manufacturer can show an equivalent or greater flow rate with a lower percentage of internal cross sectional area.

2.9.5.1 Valve Operation

Rotation of the handwheel toward open shall lift the plug without wiping the seals and retract the sealing slips so that clearance is maintained between the sealing slips and the valve body. Rotation of the handwheel toward closed shall lower the plug after the sealing slips are aligned with the valve body and force the sealing slips against the valve body for positive closure. When valve is closed, the slips shall form a secondary fire-safe metal-to-metal seat on both sides of the resilient seal.

2.9.5.2 Relief Valves

ANSI Class 150, steel body. Provide plug valves with automatic thermal relief valves to relieve the pressure buildup in the internal body cavity when the plug valve is closed. Relief valves shall open at 25 psi differential pressure, and discharge to the throat of and to the upstream side of the plug valve.

2.9.5.3 Bleed Valves

ANSI Class 150, steel body valve. Provide manually operated bleed valves that can be opened to verify that plug valves are not leaking when in the closed position. Provide discharge piping so that released liquid can be contained.

2.9.6 Level Alarm System

System shall be designed and installed in such a way that the system shall be continuously and automatically self-checking without manual check. Electronic level sensors shall be thermistors or optic types, and be intrinsically safe Class I, Division 1, Group D for hazardous environments, with recognized FM, CSA or UL approval. Both high electronic level sensors shall be contained in a single multi-sensor holder/junction box. The sensor holder/junction box shall be accessible from the tank top or stairway.

2.9.6.1 Electronic Level Alarms

Level alarms shall be mechanically and electrically independent and be totally isolated from the gauging system. Two electronic high level alarms shall be provided for each tank. A High Level Alarm (HLA) shall be set at approximately 95 percent of the safe tank filling height and be arranged to actuate an audible alarm signal located at or near the normal station of the person in control of the tank filling operation. A High High Level Alarm (HHLA) shall be set at approximately 98 percent of the safe filling height. HHLA shall sound an audible and visual alarm at a control panel and close the High Liquid Level Control Valve. In addition, an electronic low level alarm shall actuate a visual and audible signal at the control panel when the tank is less than 5 percent filled.

2.9.6.2 Level Alarm Control Panel

Panel shall be located where indicated and contain one light and one relay output for each alarm point. An audible alarm shall actuate whenever any alarm point has been reached. Panel shall further contain a green (Power ON) status light and push button controls for alarm reset and test. Panel shall consist of a NEMA 4 style water-tight housing for outdoor mounting locations. Panel shall operate with 115 VAC input power. Circuitry and cables from the panel to the electronic level sensors in the tank shall be intrinsically safe.

2.9.7 High Liquid Level Control Valve

2.9.7.1 Valve

Valve shall be hydraulically operated, single-seated, normally closed, diaphragm actuated, on/off type valve. Valve shall be field adjustable. Valve shall be provided with a position indicator, float operator and assembly, pressure-operated pilot valves and accessories, solenoid-operated pilot valve, and pressure gage quick-disconnect fittings located in the valve inlet, outlet, and cover. Valve shall also operate with a special check valve feature and close rapidly when outlet pressure exceeds inlet pressure. Service and adjustments shall be possible without removing the valve from the line. Portions of the valve coming in contact with fuel shall be compatible with the fuel and be of corrosion-resistant material. Valve shall have bodies, bonnets, and covers constructed of cast steel conforming to [ASTM A 216/A 216M](#), Grade WCB internally plated with chromium, nickel, or electroless nickel. Stem and trim shall be stainless steel. Valve shall be suitable for a working pressure of [1900 kPa at 38 degrees C](#) [275 psig at 100 degrees F](#) with a weatherproof housing. Valve packing shall be Viton in accordance with [MIL-R-83248](#) or PTFE in accordance with [MIL-P-24396](#). Valve shall be provided with flanged end connections which are constructed of the same material as the valve body.

2.9.7.2 Float Operator and Assembly

Float operator and assembly shall be Grade CF3 (Type 304L) or Grade CF8M (Type 316) stainless steel conforming to [ASTM A 351/A 351M](#). Float operator shall be field adjustable. Float operator shall control the high liquid level control valve based on the indicated actuation point. The float operator and assembly shall be mounted to the storage tank's exterior where indicated. Means shall be provided to test the float operator's operation and the control system's response.

2.9.7.3 Pressure-Operated Pilot Valves and Accessories

Valves shall be the adjustable, pressure-operated type and be adjustable in the field. Valves shall be tag identified and be stainless steel conforming to **ASTM A 351/A 351M**, Grade CF3 (Type 304L) or Grade CF8M (Type 316) with stainless steel internal working parts. A 40 mesh stainless steel screen, self-cleaning strainer shall be provided in the pilot valve supply piping. Pilot system tubing shall be Type 316 stainless steel in accordance with **ASTM A 269**. Control, supply, and return connections shall be provided with isolation valves. Tubing connections shall be made with unions and not be welded or sealed with "O" rings.

2.9.7.4 Solenoid-Operated Pilot Valve

Valve shall be used for the electronic level alarm sensor control of the high liquid level control valve. Valve shall be tag identified and be stainless steel conforming to **ASTM A 351/A 351M**, Grade CF3 (Type 304L) or Grade CF8M (Type 316) with stainless steel internal working parts. Valve shall have a manual type operator or needle valve for emergency manual bypass operation. Activation of this emergency manual bypass override, during filling operations when no electrical power is available, shall cause a visible and audible indication of override status at the Level Alarm Control Panel when electrical power is restored to the system. Solenoids shall operate on 120 volts, 60 Hz, single phase power and be housed in an UL labeled explosion-proof case for Class I, Division 1, Group D areas with maximum temperature rating of "T2D" **215 degrees C 419 degrees F**.

2.9.7.5 Control Valve Operation

The high liquid level control valve shall fully close when either the float operator or the HHLA electronic level alarm sensor are activated. Valve shall fully open when the tank's fuel is below the float operator's actuation point and the HHLA electronic level alarm sensor is not activated. Means shall be provided to test the control system's response at the activation point.

2.9.8 Thermometers

NOTE: Provide a plug for the second well if no remote temperature reading is included in the project. Provide remote temperature reading capability if authorized for the project, and delete requirement for threaded plug. Details of remote temperature reading equipment should be included in separate (electrical) section of the project specification.

NOTE: Insert appropriate Section number and title in blank below using format per UFC 1-300-02.

Provide two thermometer wells designed as indicated not more than **457 mm 18 inches** apart. In one well, provide a **127 mm 5 inch** non-mercury direct-drive Bourdon tube dial thermometer with one-degree divisions and a range of **minus 10 degrees C to plus 80 degrees C 0 degree F to plus 150 degrees F**. Construct thermometer with stainless steel case, bezel,

fittings, and stem. Seal head against dust, fumes, and moisture. [Provide a threaded plug for the second well.] [In the second well, provide a temperature-sensing bulb for remote reading temperature system. Remote temperature reading system shall conform to [____].]

2.9.9 Venting

NOTE: Use this text for vents on tanks without floating pans. Delete for tanks with floating pans. Open vents will normally be used for storage of nonvolatile products. Delete description of pressure/vacuum vents if open vents are used. Pressure/vacuum vents may be used for kerosene type jet fuel tanks where especially dirty environments exist. Delete description of open vents if pressure/vacuum vents are used.

[Provide open vent at the center or at the highest elevation of the roof. Open vent shall have a weatherhood, with galvanized steel bird screen with 6.0 mm 1/4 inch opening and a 3.43 mm 0.135 inch minimum wire diameter.] [Breather (pressure/vacuum) vents shall have hinged or guided pallets. Moving or striking parts shall be of nonferrous metal. Design shall be such that moisture cannot collect and freeze the pallet to its seat in cold weather. Provide weatherhood, with galvanized steel bird screen with 6.0 mm 1/4 inch opening and a 3.43 mm 0.135 inch minimum wire diameter for vent openings. Size pressure and vacuum relief vents in accordance with API Std 2000.]

2.9.10 Venting

NOTE: Use this text for vents on tanks with floating pans. Delete for tanks without floating pans. Include API Std 650, Appendix G, for tanks with aluminum dome roof.

2.9.10.1 Circulation Vents

Provide open circulation vents on the roof in accordance with API Std 650, Appendix H [and Appendix G]. Open vents shall have a weatherhood, with corrosion-resistant steel bird screen with 6.3 mm 1/4 inch opening and 3.43 mm 0.135 inch minimum wire diameter.

2.9.10.2 Pressure-Vacuum Vents

Breather (pressure-vacuum) vents shall have hinged or guided pallets. Moving or striking parts shall be of nonferrous metal. Design shall be such that moisture cannot collect and freeze the pallet to its seat in cold weather. Size pressure and vacuum relief vents in accordance with API Std 2000.

2.9.11 Circumferential Stairway and Platform

OSHA 29 CFR 1910.24 and 29 CFR 1910.23. Support the stairway completely on the shell of the tank with ends of the stringers clear of the ground, and at an angle of approximately 0.785 rad 45 degrees. Construct stairway

entirely of steel with treads of grating or an approved antislip floor plate. Railing shall be continuous around the platform except for access openings. At access openings, any space wider than 150 mm 6 inches between the tank and the platform shall be floored.

2.9.12 Ladders

OSHA 29 CFR 1910.27. Provide vertical interior ladders extending from the roof manholes to the tank bottom. Provide exterior ladders or catwalks as required to gain access to the second roof manhole, which is on the opposite side of the tank from the stairway platform. Provide drainage for horizontal surfaces such as stairs and floored surfaces made from steel plates.

2.9.13 Roof Manholes

NOTE: Specify additional manholes or access holes
when necessary to meet safety requirements or local
codes. Usually, larger diameter tanks (greater than
12 m 40 feet will require more manholes.

Provide [two] 610 mm 24 inch minimum square manholes for access to the interior of the tank through the roof. Locate one manhole adjacent to the platform of the stairway on one end of a diameter of the tank. Locate a second manhole at the opposite end of that diameter. [Provide other manholes as indicated.] Provide manholes with safety handrails and located directly over the interior ladders. Provide hinged and weathertight manhole covers with a formed fit.

2.9.14 Shell Access Holes

NOTE: Specify additional manholes or access holes
when necessary to meet safety requirements or local
codes. Usually, larger diameter tanks (greater than
12 m 40 feet will require more manholes.

Provide two 750 mm 30 inch diameter access holes [and flush cleanout as indicated]. Locate the access holes in the tank shell on opposite sides of the tank on a diameter approximately 1.57 rad 90 degrees from the roof manholes and at a height convenient for personnel access into the tank. Provide access holes with welded steel plate frames and covers. Secure the cover plates with corrosion-resistant bolts and nuts. Provide access holes with gaskets and smooth gasket seats.

2.9.15 Fittings and Piping

Provide fittings and piping and other miscellaneous items as necessary to permit tank operations.

2.9.15.1 Product Inlet Connections

NOTE: Design shall include means to limit fuel
inlet pipe velocity to less than one meter per second
3 feet per second until fill pipe is completely

submerged to minimize potential for static electricity generation.

Product inlet connections shall consist of an external flange, a nozzle through the tank shell, supports, and an internal expanding cone, as indicated. The flange shall be 1034 kPa 150 pound, conforming to ASME B16.5 with slip-on or welded neck.

2.9.15.2 Product Outlet Connection

NOTE: Show piping details per DM-22 on drawings.

Product outlet connection shall consist of an external flange, a nozzle through the tank shell, internal flanges, elbows, product withdrawal line assembly, and supports, as indicated.

2.9.15.3 Water Drawoff Connection

NOTE: For noncirculating tanks, provide a 25 mm one inch water drawoff connection from a point 50 mm 2 inches above the bottom of the center sump and extend through the tank shell to a filter/separator, waste tank or oil/water separator. Show piping on drawings.

Water drawoff connection shall consist of an external flange or coupling, nozzle and 25 mm one inch pipe through the tank shell, supports, and fittings to a point 50 mm 2 inches above the bottom of the center sump, as indicated. Provide a hand-operated drain pump with a maximum discharge of 0.63 to 1.26 liters per second 10 to 20 gpm on the water drawoff line.

2.9.16 Scaffold Cable Support

Provide scaffold cable support on the tank roof in accordance with API Std 650. Locate the support near the center of the tank and in a manner that supported cables will have maximum range and flexibility of operation with minimum interference with other tank fittings.

2.9.17 Tracer Gas Detection System

NOTE: The tracer gas test is optional and is not shown on any of the standard drawings. If the test is desired, include any necessary detail drawings. Include only if specifically listed in the scope of work.

2.9.17.1 System

A tracer gas vapor collection/distribution system shall be installed in the sand below the tank bottom prior to tank construction. This shall include 20 mm 3/4 inch PVC pipe laid horizontally under the tank bottom. Pipe shall be at least 230 mm 9 inches below the tank bottom in the sand to

avoid damage during welding of the tank bottom. The number of probes shall be as indicated on the drawings and be determined by locating 6100 mm 20 foot diameter circles on the tank bottom beginning at the center of the tank. Each of these circles represents the influence of one probe. Circles shall overlap so that all areas of the tank bottom are covered. Probes shall be of sufficient length to extend from the center of each circle of influence to a termination point at the exterior of the ring wall.

2.9.17.2 Exterior Termination Points

Exterior termination points shall be 20 mm 3/4 inch female pipe threads with a 20 mm 3/4 inch plug located at the exterior of the concrete ring wall. The probe shall be connected to the coupling using a threaded adapter.

2.9.17.3 Interior Termination Points

Interior termination points (under tank bottom) shall be covered with a material designed to deter soil erosion while allowing air and water to move in and out of the open probe end. This material shall not be affected by hydrocarbons and shall be corrosion protected.

2.9.18 Aluminum Dome Roof

Provide aluminum dome roof for the [existing] tank in accordance with API Std 650, Appendix G, "Structurally Supported Aluminum Dome Roofs," and as indicated and specified. The dome fabricator/erector shall furnish all labor, materials and equipment required to design, fabricate, deliver, and erect the aluminum dome structure.

2.9.19 Material for Dome Roof

- a. Triangulated space truss: 6061-T6 aluminum struts and gussets
- b. Triangular closure panels: 16 gage 3003-H16 aluminum sheet
- c. Triangular skylight panels: (Not required)
- d. Tension ring: 6061-T6 aluminum
- e. Fasteners: 7075-T73 aluminum or series 300 stainless steel
- f. Support bearing pads if required: Teflon faced neoprene
- g. Anchor bolt: 300 series stainless steel
- h. Dormers, doors, vents, and hatches shall be 6061-T6, 5086-H34 or 3003-H16 aluminum
- i. Sealant: Heat resistant polysulfide.

2.9.19.1 Roof Design Loads

Design loads shall be specified or indicated. The dead weight of the dome structure shall not exceed 17 kilograms per square meter 3.5 pounds per square foot of surface area.

2.10 FLEXIBLE MEMBRANE LINER (FML)

NOTE: The products listed below are considered to meet this specification as of December 1991.

Petroguard 10 sold by MPC Containment Systems, Ltd.,
4834 South Oakley, Chicago IL 60609, POC Ed Reicin,
800-621-0146, 312-927-4120.

L3284NESU made by Cooley, Inc., 50 Esten Ave,
Pawtucket, RI 02860, POC Steve Seiner, 800-333-3048,
401-724-9000.

Style 1642 PTF MS-400 made by Seaman Corporation,
216-262-1111, 800-321-2615, 1000 Venture Blvd.,
Wooster Ohio 44691, POC Felon Wilson Knoxville, TN
615-691-9476.

The FML shall demonstrate the acceptable limits of the properties listed under Table 1. The FML shall be factory produced from a base fabric that is completely covered with a polymer. The base fabric shall weigh no less than 440 grams per square meter 13 ounces per square yard and be made of aramid (kevlar), polyester, or nylon. The FML shall have an overall finished weight no less than 1017 grams per square meter 30 ounces per square yard. Factory seams shall 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 shall retard the growth of mildew and be capable of containing the liquid stored, withstanding temperatures up to 82 degrees C 180 degrees F, withstanding humidity up to 99 percent relative humidity, and withstanding direct exposure to sunlight.

2.10.1 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 shall be considered a new job lot.

2.10.2 FML Samples

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

2.10.3 FML Factory Test

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

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

Property	Acceptable Limits	Test Standard	Notes
Minimum Overall Finished Thickness	0.81 mm	ASTM D 751	
Minimum Tear Strength (Fill)	178 N (ibd)	ASTM D 751 Tongue Method	(Warp & Fill)
Minimum Adhesion Strength	89 N per 25 mm	ASTM D 751	
Minimum FML (MTS) (Fill)	4448 N (ibd)	ASTM D 751 Grab Method	(Warp & Fill)
Minimum FML (MTS) (Fill)	2670 N (ibd)	ASTM D 751 Cut Strip Method	(Warp & Fill)
Minimum FML Seam Shear Strength	See Note 1	ASTM D 751 Section 53	
Minimum Abrasion Resistance	5000 cycles	ASTM D 3389	See Note 2
Minimum Withstanding of Accelerated Weathering	1000 hours	ASTM D 2565	See Note 3
Minimum Bursting Strength	10 343 kPa	ASTM D 751 Ball Tip Method	
Maximum Stiffness	206 850 kPa (ibd)	ASTM D 747	
Hydrostatic Resistance	3448 kPa	ASTM D 751	
Maximum Permeability	30.5 grams per square meter per 24 hours	ASTM E 96 Procedure BW	See Note 4
Fuel Compatibility	No Delamination, No Bubbles, No Discoloration	See Note 5	
Maximum Volume Swell (Coating Compound Only)	15 percent of original	See Note 6	
Maximum Weight Gain or Loss	10 percent of original	See Note 5	

TABLE 1. Standards and Limits for FML Properties

Property	Acceptable Limits	Test Standard	Notes
Minimum Overall Finished Thickness	32 mils	ASTM D 751	
Minimum Tear Strength (Fill)	40 pounds (ibd)	ASTM D 751 Tongue Method	(Warp &
Minimum Adhesion Strength	20 pounds per inch	ASTM D 751	
Minimum FML (MTS) (Fill)	1000 pounds (ibd)	ASTM D 751 Grab Method	(Warp &
Minimum FML (MTS) (Fill)	600 pounds (ibd)	ASTM D 751 Cut Strip Method	(Warp &
Minimum FML Seam Shear Strength	See Note 1	ASTM D 751 Section 53	
Minimum Abrasion Resistance	5,000 cycles	ASTM D 3389	See Note 2
Minimum Withstanding of Accelerated Weathering	1,000 hours	ASTM D 2565	See Note 3
Minimum Bursting Strength	1,500 pounds	ASTM D 751 Ball Tip Method	
Maximum Stiffness	30,000 pounds (ibd)	ASTM D 747	
Hydrostatic Resistance	500 pounds per square inch	ASTM D 751	
Maximum Permeability	0.10 ounces per square foot per 24 hours	ASTM E 96 Procedure BW	See Note 4
Fuel Compatibility	No Delamination, No Bubbles, No Discoloration	See Note 5	
Maximum Volume Swell (Coating Compound Only)	15 percent of original	See Note 6	
Maximum Weight Gain or Loss	10 percent of original	See Note 5	

Table Abbreviations:
 (ibd) in both direction
 (MTS) Material Tensile Strength

Notes:

1. The acceptable limit for the seam shear strength shall be 95 percent of the minimum (MTS) property using the Strip Method.
 2. Test until fabric exposure with a H-22 wheel loaded to 1,000 grams.
 3. Manufacturer's certification of the FML, instead of actual factory testing, may be considered acceptable for the Minimum Withstanding of Accelerated Weathering if the certification verifies that the acceptable limits listed were previously achieved using the test standard listed. Data from either a manufacturer's certification or an actual factory test shall verify that no visible cracking or appreciable changes resulted as a result of the testing.
 4. The test shall be performed using the Inverted Water Method with ASTM Fuel B.
 5. Testing shall be performed in accordance with [ASTM D 543](#) by immersion in ASTM Fuel B for 14 continuous days at room temperature.
 6. Testing shall be performed in accordance with [ASTM D 471](#).
- 2.10.4 FML Ring Wall Sealant

The FML ring wall sealant shall be compatible with the FML, concrete, and the fuel being stored.

2.10.5 FML Components

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

2.10.6 Fuels for Testing FML

Materials, other than the FML, shall be resistant to the fuel or fuels being stored. Fuels as required or mentioned by this specification shall be in accordance with the following:

2.10.6.1 Motor Gasoline (Mogas)

Mogas shall be in accordance with [ASTM D 4814](#).

2.10.6.2 Diesel

Diesel shall be in accordance with [FS A-A-52557](#).

2.10.6.3 No. 2 and No. 4 Fuel Oils

Oils shall be in accordance with [ASTM D 396](#).

2.10.6.4 JP-4 and JP-5

Fuels shall be in accordance with [MIL-DTL-5624](#).

2.10.6.5 JP-7

Fuel shall be in accordance with [MIL-DTL-38219](#).

2.10.6.6 JP-8

Fuel shall be in accordance with [MIL-DTL-83133](#).

2.10.6.7 ASTM Fuel B

ASTM Fuel B as referenced in this section shall be in accordance with

ASTM D 471.

2.11 ANTISEIZE COMPOUND

Provide antiseize compound for fasteners on tank exterior flanges and bolted connections and covers. Provide MIL-PRF-907 compound on steel fasteners. Provide an approved antiseize compound for stainless steel fasteners. Do not use MIL-PRF-907 compound on stainless steel. On tank interior fasteners, use oil only.

2.12 SAND CUSHION

Cushion shall be located on top of the flexible membrane liner (FML) and beneath the tank bottom plates. Cushion shall be a minimum of 8 inches thick and be fine sand aggregate in accordance with ASTM C 33. Cushion shall contain no more than 25 parts per million (ppm) chlorides, no more than 30 ppm sulfates, and have a pH greater than 7. Magnesium sulfate shall be used in the ASTM C 88 soundness test.

PART 3 EXECUTION

3.1 SAFETY PRECAUTIONS

API RP 2009 for fire and explosion hazard areas.

3.2 CONSTRUCTION

3.2.1 Tank

NOTE: Provide a reinforced concrete ring wall for all tanks, regardless of size, as shown in Figure 4 of DM-22.

Provide tank of welded construction, and support tank on a concrete ring wall. Slope the tank bottom down to the center sump approximately 150 mm 6 inches for each 3.00 m 10 feet of tank radius. Butt-weld or lap-weld bottom plates with the outer plates on top. Slope the roof down from the center to the periphery. Reinforce openings larger than 50 mm 2 inches in diameter through plating of the tank shell and roof. Provide structural stiffening, consisting of rings, thicker plates, or other approved means to maintain roundness when the tank is subjected to wind or seismic loads.

3.2.1.1 Prohibition of Protective Coatings on Surfaces to be Welded

Remove protective coatings on surfaces to be welded and on surfaces not less than 25 mm one inch from weld preparation. "Weld-through" inorganic zinc coatings and similar coatings will not be permitted.

3.2.1.2 Welding of Column Base

When columns are provided in the tank, weld the column base to the tank bottom. Welds shall be continuous and shall provide a seal against the entry of water or other liquids into the space between the column base and the tank bottom.

3.2.2 Area Beneath Tank

Cover the area beneath the tank with a fuel resistant plastic membrane of FML in accordance with paragraph entitled "Installation of FML." Lay the plastic over a thoroughly compacted select subgrade free from rocks that could puncture the plastic. Provide a minimum 100 mm 4 inches of compacted clean sand or similar material over the plastic. Securely attach and cement the plastic membrane to the inside of the concrete foundation ring wall beneath the tank shell. Provide a drain pipe or pipes through the concrete foundation ring wall so that water beneath the tank can escape by gravity. The drain pipe shall also serve as a telltale for tank bottom leaks. Provide FML between the tank and berm where indicated.

3.2.3 Mastic Seal

Seal the outer edge of the joint between the concrete tank foundation ring and the tank floor plate by caulking with mastic seal.

3.2.4 Nozzles

Nozzles less than 50 mm 2 inches in size shall be flanged or screwed type. Sizes 50 mm 2 inches in size or larger shall be flanged and shall have reinforcing plate. Nozzles for pipe connections inside the tank shall be flanged inside and outside of tank. Reinforcing plates for shell nozzles shall be rolled to the curvature of the shell.

3.2.5 Drain Sump

NOTE: For sites where gravity draining of water is not possible or practical, the project specification should include a drain pump for the stripping line to the sump. Such a pump should be hand-operated, with a maximum discharge of 0.63 to 1.26 liters per second 10 to 20 gpm, to avoid vortexing the stored product and drawing it down the drain line. Show design details on project drawings.

Weld drain sump to the lowest point of the tank bottom. Construct drain sump of extra strong steel butt welding pipe cap installed below the tank bottom, and provide with a stripping line as indicated.

3.2.6 Installation of Level Controls

Install level alarm system and high liquid level control valve in accordance with the manufacturers' instructions. Bleed air from control valve pilot system tubing in accordance with the manufacturer's written instructions. Valve will malfunction with air in the tubing.

3.2.7 Fire Protection

NOTE: Provide a foam extinguishing system for tanks of 378,500 or more liters 100,000 or more gallons capacity per DM-22. Consult the Fire Protection Branch at the appropriate EFD for guidance. Delete paragraph if not applicable.

Provide foam extinguishing system in accordance with Section 21 13 21.00 20
FOAM FIRE EXTINGUISHING FOR FUEL TANK PROTECTION.

3.2.8 Cathodic Protection

NOTE: Provide cathodic protection if required to
comply with local regulations. Delete paragraph if
not applicable.

NOTE: Insert appropriate Section number and title
in blank below using format per UFC 1-300-02.

Provide cathodic protection in accordance with [____].

3.3 INSTALLATION OF FML

3.3.1 Field Engineer

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

3.3.2 Preparation

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

3.3.3 Surface Preparation

The surfaces to be covered shall be free of vegetation, rocks, debris, etc., graded true, compacted, and be smooth with no abrupt projections of any kind.

3.3.3.1 Surface Finishing

Finish tank interior surfaces in accordance with Section 4 of NACE RP0178, and accompanying Visual Comparator, to the condition described and shown for NACE Weld Designation "C" welds. Finish tank exterior surfaces in accordance with Section 4 of NACE RP0178, and accompanying Visual Comparator, to condition described and shown for NACE Weld Designation "D" welds.

3.3.4 FML Layout and Installation

After successful completion of the FML visual inspection, the FML shall be laid out. Laying out and welding FML shall 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 shall have a 50 mm 2 inch overlap plus or minus 6 mm 1/4 inch, and be made by the FML manufacturer's authorized representative. Panels or sheets of FML to be seam welded together shall be laid out prior to welding field seams. The overlapped areas shall be cleaned and prepared according to the installation instructions and procedures. Welds shall be tightly bonded.

3.4 FIELD QUALITY CONTROL

NOTE: Availability of utilities services and charges are established by the station and should be stated in Division 1 of the contract specifications. Use alternate test methods for testing shell if water supply is inadequate for filling the tank.

The Contracting Officer will conduct field inspections and witness field tests and trial operations specified in this section. The Contractor shall perform all trial operations and field tests and provide all labor, equipment and incidentals required for testing. The Government will provide water required for field tests, when available.

3.4.1 FML Tests

3.4.2 FML Vacuum Box Test

After successful completion of the FML visual inspection, a vacuum box test shall be performed on all field seams, the area around the seams, and all FML surfaces showing injury due to scuffing, penetration by foreign objects, or distress from rough subgrade. A glass topped vacuum box which has a neoprene sealing gasket shall be used. The vacuum box test shall be performed as follows:

- a. A commercial bubble forming solution shall be applied to the area to be tested.
- b. The vacuum box shall 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 shall be considered damaged and shall be repaired and retested.
- d. If the vacuum box test do not indicate a leak, then the vacuum shall be slowly increased until a maximum differential pressure of 14 kPa plus 0.0 or minus 2 kPa 2 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 shall be considered damaged and shall 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 shall be considered damaged and shall be replaced and retested.

3.4.2.1 FML Air Lance Tests

After successful completion of the FML vacuum box test, an air lance test shall be performed on all seams not accessible with a vacuum box test (i.e. small seams around penetrations, oddball types of patches, etc.). 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 shall be indicative of an unbonded area. Unbonded areas shall be repaired and retested.

3.4.3 FML Inspections

3.4.3.1 Sample Field Seam Inspection

- a. Visual Inspection - Sample field seams shall be subjected to a visual inspection performed within 30 hours after the seam has been made, cured, and cooled.
- b. Vacuum Box Inspection - After successful completion of the visual inspection, a vacuum box inspection shall be performed. A glass topped vacuum box which has a neoprene sealing gasket shall be used. The vacuum box test shall be performed as follows:
 - (1) A commercial bubble forming solution shall be applied to the area to be tested.
 - (2) The vacuum box shall 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.
 - (3) 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.
 - (4) If the vacuum box test do not indicate a leak, then the vacuum shall be slowly increased until a maximum differential pressure of 14 kPa plus 0.0 or minus 2 kPa 2 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 shall be considered damaged and shall 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 shall be considered damaged and shall be replaced and retested.

3.4.3.2 FML Initial Inspection

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

3.4.3.3 FML Seam Inspection

Field seams shall be subjected to a visual inspection performed within 30 hours after the seam has been made, cured, and cooled. Any seams visually found to be defective shall be repaired and reinspected.

3.4.3.4 Acceptance Inspection

As soon as practicable after successful completion of the FML vacuum box

test and the air lance tests, an acceptance inspection shall be performed. If the inspection reveals any defects in the work, such defects shall be repaired or the unsatisfactory work replaced before acceptance. The cost of such repairs and replacements shall be borne by the Contractor. The Contractor shall provide materials, facilities, and equipment necessary to permit adequate inspection by the Contracting Officer or his representative.

3.4.4 Manufacturers Field Service

If any problems are noticed in any inspection of a seam, the Contracting Officer shall be notified immediately. The FML manufacturer's point of contact shall also be contacted by telephone and informed that the installation of their product can not be adequately completed. After a solution has been formed, jointly between the FML manufacturer and their authorized representative, as to why the problems were encountered, another set of sample field seams shall be made and reinspected.

3.4.5 Sand Cushion Tests

Test the sand prior to installing any storage tank bottom to verify the amount of chlorides (ppm) and sulfates (ppm) and to determine the pH value of the sand. Test result shall conform to paragraph entitled "Sand Cushion."

3.4.6 Tank Calibration

NOTE: Delete paragraph if it is in the best interest of the Government to enter into a separate contract for tank calibration. If the paragraph is used, the method of calibration and gage tables required for "critical measurement" should be specified if tank will be used for the custody transfer of petroleum products. Method of calibration and gage tables required for "operating control" should be specified if tank will be used for other than custody transfer of products.

After installation of the tank is complete, prepare a calibration table for the tank showing the volume of fuel in barrels of 158.76 liters 42 gallons in the tank to any height of liquid in m feet, inches, and mm eighths of an inch when measured by a steel tape lowered through the roof. Calibrate the tank in accordance with API Std 2550 for [critical measurement] [operating control]. Correct the data obtained for use with the product to be stored.

3.4.7 Weld Inspection

Perform inspection of welds in accordance with API Std 650. Inspect butt welds requiring complete penetration and complete fusion by the radiographic method.

3.4.8 Tightness Tests and Welding Repairs

NOTE: Availability of utilities services and charges are established by the activity and should be stated in Division 1 of the contract specifications. Use alternate test methods for

testing shell if water supply is inadequate for
filling the tank.

Perform tightness tests and repairs in accordance with API Std 650, except as modified herein, prior to blast cleaning and application of the protective coating.

3.4.8.1 Test of Tank Bottom

Test tank bottom immediately after completion and prior to installing any columns. Test seams in bottom of tank by applying a commercial soap film and subjecting the seam to a vacuum. Use a glass top vacuum box with hypalon or neoprene sealing gasket. Apply a commercial bubble forming solution to the weld or area to be tested; position the vacuum box over the area and slowly pull a partial vacuum. Observe the solution film for bubble formation between 0-14 kPa 0-2 psi differential pressure. Continue to open the valve until a differential pressure of 34.5 kPa 5 psi or 3.50 m 11.5 feet of water or 259 mm 10.2 inches of mercury is achieved and hold for at least 20 seconds while continuing to observe the solution for bubbles.

3.4.8.2 Tank Shell to Bottom Inside Corner Welds

Inspect tank shell to bottom inside corner welds using the oil test. After the inside fillet weld is made, apply oil to the outside corner crevice before the outside weld is made. After 4 hours, inspect the inside fillet weld for oil penetration through defects, and correct defects. Remove oil completely prior to finishing weld joint. Then complete the remainder shell to bottom weld joint.

3.4.8.3 Tank Shell

Test the shell by filling tank with water and maintaining it full for a period of not less than 24 hours, then inspect shell for leaks. The appearance of damp spots shall be considered evidence of leakage. Minimize water retention time to limit rusting of tank interior. If water supply is insufficient for filling tank, perform alternate testing of shell in accordance with API Std 650. Repair leaks disclosed by the tests by drilling, chipping, or gas gouging and rewelding, or by other methods, then retest the tank and prove the tank tight.

3.4.8.4 Stripping Line

Test stripping line from sump, product inlet line, and product outlet line with water at 345 kPa 50 psi.

3.4.8.5 Tracer Gas Test

**Note: If the "Tracer Gas Detection System"
paragraphs in Part 2 were deleted, then delete the
following paragraphs.**

The tracer gas test shall be performed preceding the vacuum box test and be in accordance with the following:

- a. The test shall be conducted using an analytical method which can detect vapor movement through any void in the tank bottom.
- b. The testing company shall locate the leaks to within 75 mm 3 inches of actual leak location by attempting to force or draw a detectable gas through the tank bottom.
- c. The gas used shall be an non-explosive, non-toxic, and shall not be damaging to the ozone layer.
- d. The instrumentation shall be able to detect the leak as being used at the accuracy described below.
- e. The test shall be conducted before application of any coating.
- f. A leak is characterized by the detection of 1 tenth (0.10) part per billion in air of the detectable gas on the opposite side from its point of injection.
- g. The tracer gas will be introduced to the underside of the tank using the monitoring well leak system piping. Gas release shall be pressure-regulated to prevent uplift and damage to the tank bottom.

3.4.9 Floating Pan Tests

NOTE: Delete paragraph if floating pan is not used.

Following the installation of a floating pan, the deck penetrations and rim area shall be subjected to a visual inspection for seal tightness. Leaks or seal deformations shall be corrected according to manufacturer's recommendations. Following the seal inspection, the floating pan shall be subjected to a flotation test. The tank shall be filled with to 25 percent of the total capacity with fuel. While filling the tank, the top of the floating pan shall be visually inspected for fuel leakage. The appearance of damp spots on the top of the floating pan shall be considered evidence of leakage, the Contracting Officer shall be notified and the fuel removed immediately. Leaks shall be repaired and the flotation test performed again.

3.4.10 Fill Test

If the tightness test and welding repairs above are completed without a hydrostatic test of the tank using water, fill test the tank using fuel. Tank piping and appurtenances shall be ready for service. The Government will provide the necessary fuel and labor to fill the tank with fuel. Advise the Contracting Officer, in writing, at least 10 days in advance of the need for this service. Fill tank half full and check that drain valves are closed and check tank for leaks. Keep tank half full the first 12 hours of test, then fill tank to full capacity and check that drain valves are closed and check tank for leaks. Monitor tank level hourly during the first 24 hours of the fill test and notify the Contracting Officer immediately of any leaks detected. Padlock drain valves closed for the duration of the test and provide one set of keys to the Contracting Officer. After the temperature of the fuel has become stabilized, take daily readings of the fuel level for a period of 10 days. If there is no measurable drop in the fuel level during this period, the tank will be

accepted. If leakage becomes apparent during the filling or the test period, immediately notify the Contracting Officer and Government personnel will pump the fuel from the tank. Free the tank of vapor, clean it, and then carefully inspect the tank for evidence of failures at the Contractor's expense. Repair defects found and repeat fill tests.

3.4.11 Testing High Level Controls

3.4.11.1 Tank High Level Alarm

After flushing is completed, the Government will furnish fuel to fill the tank. Check the operation of the high level and high level alarms. Verify operation of the alarm horn and light.

3.4.11.2 Tank High Level Shutoff Valve

Check the operation of the high level shutoff valve on the inlet to the tank to assure that the valve closes fully at high tank level. Check closing by the float valve and the solenoid pilot valve separately. Before the tank high level is reached, verify operation of the valve by the manual operation of the float and solenoid pilot. Check for proper operation when the tank is filled with appropriate safety measures.

3.4.12 Retesting

Deficiencies found shall be rectified and work effected by such deficiencies shall be completely retested at the Contractor's expense.

-- End of Section --