UL 1746

STANDARD FOR SAFETY

External Corrosion Protection Systems for Steel Underground Storage Tanks

UL Standard for Safety for External Corrosion Protection Systems for Steel Underground Storage Tanks, UL 1746

Third Edition, Dated January 17, 2007

Summary of Topics

These revisions to the Standard for External Corrosion Protection Systems for Steel Underground Storage Tanks, UL 1746, include the following:

1. Revisions to the scope section to clarify and update the requirements

2. Revisions to the glossary section to clarify, update, and provide consistency with other underground storage tank standards

3. Addition of a capacity and dimensions section and relocation of the requirements into this section

4. Revisions to the lift lug tests which includes the use of calculations for evaluating lift lugs

5. Deletion of abrasion test

6. Alternative to Lift Lug Test

7. Revision to indentation test for Part IV coated tanks

8. Deletion of terms Type I Tank and Type II Tank

9. Clarification of requirements for FRP matrix (resin & fibers)

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The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated November 22, 2013 and August 15, 2014.

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The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a ″SUPERSEDED REQUIREMENTS″ notice.

The following table lists the future effective dates with the corresponding reference.

Future Effective Dates	References
December 19, 2018	Paragraphs 23.1 and 33.10

JANUARY 17, 2007
(Title Page Reprinted: December 19, 2014)

1

UL 1746

Standard for External Corrosion Protection Systems For Steel Underground Storage Tanks

First Edition – November, 1989
Second Edition – July, 1993

Third Edition

January 17, 2007

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at http://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 These requirements cover pre-engineered corrosion protection systems intended to be factory installed on the exterior surface of steel underground atmospheric-type storage tanks intended for flammable and combustible liquids.

1.1 revised December 19, 2014

1.2 These requirements cover the following systems:

a) Part I for galvanic-type cathodic protection systems.

b) Part II for fiber-reinforced plastic (FRP) composite systems.

c) Part III for polyurethane (PUR), polyurea, high density polyethylene (HDPE) or fiber-reinforced plastic (FRP) jacketed systems.

d) Part IV for polyurethane (PUR) coated systems.

1.2 revised December 19, 2014

1.3 These tanks are intended for installation and use in accordance with one or more of the following: Standard for the Installation of Oil-Burning Equipment, NFPA 31; Flammable and Combustible Liquids Code, NFPA 30; Code for Motor Fuel Dispensing Facilities and Repair Garages, NFPA 30A; International Fire Code, published by the International Code Council.

1.3 revised December 19, 2014

1.4 These tanks are completely fabricated, inspected and tested for protection system defects and/or tank leakage before shipment from the factory as completely assembled vessels and are intended for burial in accordance with the manufacturers instructions.

1.4 revised December 19, 2014

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, a component of a product covered by this standard shall comply with the requirements for that component.

2.1.2 A component is not required to comply with a specific requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or

b) Is superseded by a requirement in this standard.

2.1.3 A component shall be used in accordance with its rating established for the intended conditions of use.

2.1.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

2.2 Units of measurements

2.2.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

2.3 Undated references

2.3.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

2.4 Terminology

2.4.1 In the following text, a requirement that applies only to a particular type of tank is so identified by a specific reference in that requirement to the type or types of tank involved. Absence of such specific reference or use of the term “tank” indicates that the requirement applies to all underground storage tanks unless indicated otherwise.

3 Glossary

3.1 For the purpose of this standard the following definitions apply.

3.1 revised December 19, 2014

3.1.1 ATMOSPHERIC TANK – A storage tank that has been designed to operate at pressures of negative 0.5 psig to 1.0 (negative 3.4 kPa to 6.8 kPa) psig measured at the top of the tank.

3.1.1 added December 19, 2014

3.1.2 CATHODICALLY PROTECTED TANK – A steel tank with a pre-engineered, factory installed galvanic type cathodic protection system consisting of anodes, dielectric coatings, isolated devices and accessories applied to outer tank shell which provides external corrosion protection. Cathodically protected tank requirements are found in Part I.

3.1.2 added December 19, 2014

3.1.3 COATED TANK – A steel tank with a polyurethane (PUR) layer directly bonded to the exterior of the tank which provides external corrosion protection. The polyurethane (PUR) layer does not provide an interstitial space. Coated tank requirements are found in Part IV.

3.1.3 added December 19, 2014

3.1.4 COMPOSITE TANK – A steel tank with a fiber reinforced plastic (FRP) layer or laminate directly bonded to the exterior of the tank which provides external corrosion protection. The FRP layer or laminate does not provide an interstitial space. Composite tank requirements are found in Part II.

3.1.4 added December 19, 2014

3.1.5 HOLIDAY – A small fault, crack, pin hole, or other defect in a non metallic dielectric coating, coating, covering or structural layer, that results in a spark detection when tested with high voltage apparatus as defined in this standard.

3.1.5 added December 19, 2014

3.1.6 INTERSTITIAL SPACE (aka ANNULAR SPACE, INTERSTICE) – A space between the walls of a multiple wall tank that is capable of communicating fluid from a leak in an adjacent wall to a collection point for monitoring.

3.1.6 added December 19, 2014

3.1.7 JACKETED TANK – A steel tank in a fiber reinforced plastic (FRP), high density polyethylene (HDPE), polyurea, or polyurethane (PUR) that forms an interstitial space, where the jacket provides secondary containment and external corrosion protection. Jacketed tank requirements are found in Part III.

3.1.7 added December 19, 2014

3.1.8 PRIMARY CONTAINMENT – The ability of an enclosed design or construction to directly contact and contain a liquid while in normal use.

3.1.8 added December 19, 2014

3.1.9 PRIMARY TANK – An inner wall of a tank construction that provides containment of the product being stored.

3.1.9 added December 19, 2014

3.1.10 SECONDARY CONTAINMENT – The ability of a design or construction to directly contact and contain a liquid to a minimum of 300 degrees only in abnormal use (from primary containment leakage or rupture).

3.1.10 added December 19, 2014

3.1.11 STORAGE TANK (TANK) – A vessel having a liquid capacity that exceeds 60 gallons (230 L), is intended for fixed installation, and is not used for processing.

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3.1.11 added December 19, 2014

3.1.12 UNDERGROUND TANK (aka UNDERGROUND STORAGE TANK or UST) – A storage tank that is intended for installation at least 12 inches (304.8 mm) below grade and in direct contact with backfill.

3.1.12 added December 19, 2014

3.2 *deleted December 19, 2014.*

3.3 *deleted December 19, 2014.*

3.4 *deleted December 19, 2014.*

3.5 *deleted December 19, 2014.*

3.6 *deleted December 19, 2014.*

3.7 *deleted December 19, 2014.*

CONSTRUCTION

4 General

4 effective January 17, 2009

4.1 The construction and assembly of an external corrosion protection system shall be evaluated based on its intended application on the outside of a steel tank and use in underground flammable liquid storage systems.

4.2 Only new materials and components shall be used in the fabrication of external corrosion protection systems described in the applicable parts of this Standard.

4.3 All tanks and integral accessories or components to which the external corrosion protection system is applied shall be designed and built in accordance with the Standard for Steel Underground Tanks for Flammable and Combustible Liquids, UL 58.

4.4 The overall length of a tank shall not be greater than 8 times its diameter.

4.5 *deleted December 19, 2014.*

4.6 Any opening shall not be blocked or covered by the external corrosion protection system.

4A Capacities and Dimensions

4A added December 19, 2014

4A.1 The addition of the external corrosion protection system to the tank shall not be taken into account for measuring or calculation purposes, or revised for rating or marking purposes for compliance with capacity and dimension requirements per Capacity and Dimensions, Section 4, in the Standard for Safety for Steel Underground tanks for Flammable and Combustible Liquids, UL 58.

4A.1 added December 19, 2014

5 Compartments

5 effective January 17, 2009

5.1 All tanks with compartments shall comply with Compartment Tanks, Section 13, in the Standard for Steel Underground Tanks for Flammable and Combustible Liquids, UL 58.

6 Pipe Connections

6 effective January 17, 2009

6.1 All tank pipe connections shall comply with Pipe Connections, Section 10, in the Standard for Steel Underground Tanks for Flammable and Combustible Liquids, UL 58 and shall be provided with external corrosion protection on all surfaces subject to soil exposure in expected use in accordance with one of the systems described in this Standard.

7 Manways

7 effective January 17, 2009

7.1 All tank manways shall comply with Manways, Section 11, in the Standard for Steel Underground Tanks for Flammable and Combustible Liquids, UL 58 and shall be provided with external corrosion protection on all surfaces subject to soil exposure in expected use in accordance with one of the systems described in this Standard.

8 Striker Plates

8 effective January 17, 2009

8.1 All tanks with striker plates shall comply with Striker Plates, Section 12, in the Standard for Steel Underground Tanks for Flammable and Combustible Liquids, UL 58. Any identification markings around marked striker plate openings shall be replaced with identical language after the external corrosion protection system is applied.

9 Heating Coils and Hot Wells

9 effective January 17, 2009

9.1 Heating coils or hot wells that are provided with the tank assembly that handles a fluid other than that stored in the tank, such as hot water, shall be evaluated for the identified system temperature and pressure, shall be compatible with the identified system fluids, and shall have no joints in the portion of coil or well located within the tank unless continuously seal welded or brazed.

9.2 The inlet and outlet connections of a heating coil or hot well shall be sealed through a steel manway cover by:

a) Continuous welding,

b) A threaded connection, or

c) A flanged connection.

10 Tank Accessories, Components, and Special Constructions

10 effective January 17, 2009

10.1 All tank accessories or components shall comply with Tank Accessories, Components, and Special Constructions, Section 16, in the Standard for Steel Underground Tanks for Flammable and Combustible Liquids, UL 58 and shall be provided with external corrosion protection on all surfaces subject to soil exposure in expected use in accordance with one of the systems described in this Standard.

PART I – PREENGINEERED CATHODIC PROTECTION SYSTEMS

CONSTRUCTION

11 Components

11.1 Galvanic anodes

11.1.1 A galvanic anode for use in a cathodic protection system shall be one of the following:

a) High-purity zinc anode with the composition specified in Table 11.1 and complying with ASTM B418 (Type II), Standard Specification for Cast and Wrought Galvanic Zinc Anodes, or

b) Magnesium anode with one of the compositions specified in Table 11.2.

11.1.1 effective January 17, 2009

Table 11.1
Zinc anodes

Element	Percent Composition
Aluminum	0.005 maximum
Cadmium	0.003 maximum
Iron	0.0014 maximum
Zinc	Remainder

Table 11.2
Magnesium anodes

Element	Percent composition	
	Type III[a]	MG-MN Alloy[b]
Aluminum	5.3 – 6.7	0.010 maximum
Zinc	2.5 – 3.5	0.05
Manganese	0.15 minimum	0.5 – 1.30
Copper	0.02 maximum	0.02 maximum
Silicon	0.10 maximum	0.05
Iron	0.003 maximum	0.03 maximum
Nickel	0.002 maximum	0.001 maximum
Others	0.3 maximum	0.05 each or 0.3 maximum total
Magnesium	Remainder	Remainder

[a] These anodes are commonly referred to as AZ-63 Type I, II, and III H1.
[b] High-potential anode

11.1.2 Anodes shall be packaged in a water-permeable container and the assembly shall comply with the Anode Assembly Durability Test specified in Section 13. Anodes shall be surrounded by at least 1 inch (25.4 mm) of backfill mixture complying with the requirements of 11.2.1.

11.1.3 A cored anode shall be fabricated with a galvanized steel core situated axially within the anode.

11.1.4 A cored anode shall be provided with a No. 12 AWG Type TW or larger solid conductor copper lead wire soldered or welded to the core. The anode lead wire shall comply with the gasoline- and oil-resistance requirements of the Standard for Thermoplastic-Insulated Wires and Cables, UL 83. The lead wire-anode joint shall be insulated by filling the joint recess with an electrical potting compound.

11.1.5 A weld-on anode shall be provided with an integral weldable steel core for welding directly to the tank.

11.2 Backfill materials

11.2.1 Backfill material, used in the ″bag″ around the anode, shall be a low-resistivity mixture consisting of:

a) 75 percent hydrated gypsum, 20 percent bentonite, and 5 percent anhydrous sodium sulfate by weight; or

b) An equivalent mixture that provides a backfill resistivity of 50 ohm-cm or less and which provides equivalent resistance to anode passivation.

11.3 Insulating devices (bushings and gaskets)

11.3.1 Insulating devices shall be fabricated of nonconductive materials and shall comply with Section 17, Tests for Insulating Devices (Bushings and Gaskets). These insulating devices shall electrically isolate the tank from attached piping.

11.4 Dielectric coatings test

11.4.1 Dielectric coatings shall comply with the requirements in Section 16, Dielectric Coatings.

11.5 Pressure wire connectors

11.5.1 The clamping movement of a connector shall be constructed in such a manner that it is capable of accepting a wire size of at least No. 12 AWG (3.3 mm^2).

11.5.2 Examples of clamping means include:

a) A screw with or without a pressure plate.

b) Deformation of the connector barrel (crimping) using a special tool, or

c) A nut threaded onto a split screw.

11.5.3 There shall be no sharp edges or corners on the outer edge of a connector.

11.5.4 A pressure wire connector shall comply with the Pullout Test specified in Section 14.

11.6 Test station provision

11.6.1 Each tank fitted with a preengineered cathodic protection system shall be provided with a factory installed test lead or pressure wire connector welded to the tank heads or upper 3/4 portion of the tank shell, for connection to a test station. The connector shall comply with the requirements in Section 14, Torque and Pullout Tests for Pressure Wire Connectors.

12 Cathodic Protection System Assembly

12.1 General

12.1.1 Preengineered cathodic protection system shall consist of the following components:

a) Dielectric coating

b) Electrical insulating devices (bushings and gaskets)

c) Galvanic anodes

d) Test station provision

12.1.2 Cathodic protection systems shall be constructed to provide a minimum system design based upon a 4000 ohm-cm soil resistivity.

12.2 Dielectric coatings

12.2.1 Dielectric coatings shall be applied to all exposed exterior tank surfaces, including attachments such as anode holders and attachment lugs. Crevices into which the coating does not penetrate or is not properly bonded shall be seal-welded prior to application of the coating.

12.3 Electrical isolation devices

12.3.1 All tank openings shall be supplied with electrical insulating devices (bushings or gaskets) installed prior to shipment.

12.3.2 Tank openings and insulating devices shall be closed with a wooden plug, metal cover, or equivalent to protect the threads or flange and gasket face from damage and to exclude foreign material while the tank is in storage or transit.

12.4 Galvanic anodes

12.4.1 The effective coverage radius of galvanic anodes as used in this standard shall be 17 feet (5.2 m). Therefore, tanks greater than 34 feet (10.4 m) long require both head- and shell-mounted anode assemblies.

12.4.2 A minimum of two anodes shall be installed on each tank. Anodes shall be mounted a distance of one-sixth the tank diameter from the tank bottom. Multiple head-mounted anodes shall be centered about this location.

Exception: Shell-mounted anodes shall not be mounted in other positions when required for shipping purposes unless they are mounted below the diametrical midpoint of the tank.

12.4.3 Anodes shall be located so as to distribute the anode system current uniformly about the length of the tank. When the tank length is 34 feet (10.4 m) or less, anodes shall be equally distributed on each head of the tank. When the tank length is greater than 34 feet (10.4 m), anodes shall be equally distributed on the tank heads and shell.

12.4.4 Galvanic anode requirements for each tank are to be calculated in accordance with the method specified in 12.4.5 – 12.4.8, or by a method shown to be equivalent by test or derivation.

12.4.5 The sum of the available anode current for the individual anode shall be equal to or greater than the total system current requirements. The total system current requirement is to be calculated as follows:

$$I = 0.025 \times 10^{-3} \frac{amperes}{ft^2} \times A$$

in which:

I = total system current requirement, amperes

A = total tank exterior surface area including welded-on attachments, square feet

12.4.6 The resistance of galvanic anodes in soil shall be calculated by the following equation:

$$R = \frac{250.4 \times (\ln(4 \times L/r) - 1)}{L}$$

in which:

R = anode resistance, ohms

L = anode length, inches

r = equivalent radius, inches = radius of cylindrical anodes, or square root (A/pi) for noncylindrical anodes

A = cross-sectional area of anode, square inches

12.4.7 Available galvanic anode current shall be calculated on the basis of anode-cathode driving potential and the resistance of the anode in soil as follows:

$$i = \frac{EC - EA}{R}$$

in which:

i = available anode current, amperes

EC = cathode solution potential, volts = minus 0.85 volts

EA = anode solution potential, volts as specified in Table 12.1

R = anode resistance, ohms

12.4.8 The galvanic anode weight shall be greater than the value determined by the following equation:

$$W = \frac{262{,}800 \times i}{C \times N \times U}$$

in which:

W = minimum required anode weight, pounds

i = available anode current, amperes

See Table 12.1 for definition and values of C, N, and U.

Table 12.1
Anode data

Item	Anode type		
	Zinc	Magnesium	
		AZ-63	Mg-Mn
C	372	1000	1000
N	0.9	0.50	0.50
U	0.85	0.85	0.85
EA	-1.1	-1.55	-1.73

C – Anode energy capability, ampere-hours per pound.
N – Anode efficiency.
U – Anode utilization factor.
EA – Anode solution potential, volts.

12.4.9 The lead wire of cored anodes shall be: thermite-welded; brazed or; mechanically fastened to the tank using a weldable steel pressure wire connector complying with the requirements of Section 14, Torque and Pullout Tests for Pressure Wire Connectors. Prior to connecting the lead wire or pressure connector to the tank, the weld area is to be cleaned by scraping or an equivalent method. Anodes shall be installed with a loop consisting of at least 8 inches (203 mm) of free wire to provide strain relief.

12.4.10 Cored anodes shall be secured to the tank by means of anode holder assemblies complying with Section 13, Anode Pull and Durability Test.

12.4.11 Wire connectors and any exposed bare lead wire conductor shall be covered with insulating tape complying with the requirements for weather resistant insulating tape as described in the Standard for Insulating Tape, UL 510, or equivalent means.

12.4.12 Weld-on anodes shall be seal-welded directly to the tank. Weld-on anodes shall be installed with a gap of at least 2 inches (50.8 mm) between the anode and the tank.

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13 Anode Pull and Durability Tests

13.1 Anode lead wire pull test

13.1.1 The lead wire of the anode shall withstand a direct pull of 70 pounds (311 N) for a period of 1 minute. The test is to be performed using a tension-testing machine, or equivalent, that increases the force gradually until the test force is achieved.

13.2 Anode assembly durability test

13.2.1 An anode assembly shall not become inoperable nor shall the anode shift to a position closer than 0.50 inch (12.7 mm) from the container wall after being subjected to the durability test described in 13.2.2.

13.2.2 A representative anode assembly is to be first centered, soaked in water for a period of 4 hours and then dried for a minimum period of 48 hours. The packaged anode assembly is then to be mounted onto a fixture simulating its attachment to a tank. The test fixture is to be mounted onto a vibration test machine with a platform having a horizontal surface that produces a sinusoidal vibration in the vertical linear plane. The test fixture is to be loosely restrained to limit the area of travel. The speed of the apparatus is to be adjusted so that the vibration frequency generates a 1/16 inch (1.6 mm) vertical displacement of the test fixture from the table. The sample is to be vibrated for a period of 1 hour.

14 Torque and Pullout Tests for Pressure Wire Connectors

14.1 General

14.1.1 After being subjected to the tests specified in 14.2.1 and 14.3.1, there shall be no breakage of the conductor, stripping of threads, shearing of parts, separation of the conductor from the connector, or other damage to the connector.

14.2 Tightening torque

14.2.1 The connection between the wire and the connector is to be made in accordance with Tables 14.1, 14.2, and 14.3. The specified torque is to be applied by:

a) Tightening the fastening until the specified value of torque is attained; and

b) Maintaining this value, with a static torque reading, for 5 seconds.

Table 14.1
Tightening torque for screws, pound-inches (N·m)

Wire Size		Slotted head No. 18 and larger				Hexagonal Head			
		Slot width 0.047 inch (1/2 mm) or less and slot length 0.25 inch (6.4 mm) or less		Slot width over 0.047 inch (1.2 mm) or slot length over 0.025 inch (6.4 mm)		Split bolt		Other	
AWG	(mm^2)								
12 – 10	(3.3 – 5.3)	20	(2.3)	35	(4.0)	80	(9.0)	75	(8.5)
8	(8.4)	25	(2.8)	40	(4.5)	80	(9.0)	75	(8.5)

Table 14.2
Tightening torque for screws less than No. 10

Slot length of screw,		Tightening torque, pound-inches (N·m)			
		Slot width of screw, inch (mm)			
Inch	(mm)	Smaller than 0.047 (1.2)		0.047 (1.2) and larger	
Less than 5/32	(4)	7	(0.79)	9	(1.0)
5/32	(4)	7	(0.79)	12	(1.4)
3/16	(4.8)	7	(0.79)	12	(1.4)
7/32	(5.6)	7	(0.79)	12	(1.4)
1/4	(6.4)	9	(1.0)	12	(1.4)
9/32	(7.1)			15	(1.7)
Above 9/32	(7.1)			20	(2.3)

Table 14.3
Tightening torque for socket head screws

Socket size,		Tightening torque,	
inch	(mm)	pounds-inches	(N·m)
1/8	(3.2)	45	(5.1)
5/8	(4.0)	100	(11.3)
3/16	(4.8)	120	(13.6)
7/32	(5.6)	150	(16.9)
1/4	(6.4)	200	(22.6)
5/16	(7.9)	275	(31.1)
3/8	(9.5)	375	(42.4)
1/2	(12.7)	500	(56.5)
9/16	(14.3)	600	(67.8)

14.3 Pullout test

14.3.1 A connector-wire assembly shall be subjected to a direct pull of 70 pounds (311 N) for a period of 1 minute without separation or movement of the parts relative to one another. The test is to be performed using a tension-testing machine, or equivalent, that increases the force gradually until the test force is achieved.

15 Pullout Test for Test Lead

15.1 A test lead is to be subjected to a direct pull of 70 pounds (311 N) for one minute without separation or loosening. The test is to be performed using a tension testing machine, or equivalent, that increases the force gradually.

16 Dielectric Coating Tests

16.1 General

16.1.1 Representative samples of the dielectric coating as specified in Table 16.1 are to be used for these tests. The steel used in the preparation of samples is to be representative of the steel for which the coating is intended, with respect to composition and surface conditions. The samples are to be prepared by the same procedures of surface cleaning, pretreatment, application of the coating system, drying or curing, and minimum dry film thickness that is used in the production procedure.

Table 16.1
Samples for dielectric coating tests

Exposure/Test	Number of test coupon	Coupon type (see below)
″As-received″ – impact	5	A
Air-oven aging	6	A
Light and water exposure	5	A
Impact and cold	2	A
Resistance to external fluids	60	B
Flexibility	5	A
Abrasion resistance	5	A
Cathodic disbondment	2	A

A – 5 by 9 inch (127 by 229 mm) coated flat No. 14 MSG (0.075 inch nominal) steel plate fabricated in accordance with the proposed production procedure of the minimum production coating thickness. The coating shall be applied to both sides of the coupon and on the edge.

B – Identical to A, except the panels have an insulated No. 12 gauge copper wire welded to the top right corner of the coupon. The wire is to be attached prior to coating the coupon.

16.2 Impact test following conditioning

16.2.1 Unconditioned samples and the samples conditioned as specified in 16.2.2 – 16.2.4 are to be subjected to the impact test specified in 16.2.5. The samples shall not be affected by the impact to the extent that holidays form further than 1 inch (25.4 mm) from the point of impact when tested in accordance with ASTM G62, Standard Test Method for Holiday Detection in Pipeline Coatings.

16.2.1 effective January 17, 2009

16.2.2 Representative sample coupons are to be conditioned in an air-circulating oven at:

a) A temperature of 70°C (158°F) for 30, 90, and 180 days; or

b) A temperature of 60°C (140°F) for 30, 90, 180, and 270 days.

16.2.3 Two groups of samples are to be subjected to 180 and 360 hours, respectively, of light and water exposure in accordance with the Standard Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials, ASTM G152 and the Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials, ASTM G153, using apparatus designated Type D or DH in ASTM G152 and ASTM G153. During each operating cycle of 120 minutes, the samples are to be exposed to light alone for 102 minutes and to light and water for 18 minutes.

16.2.3 effective January 17, 2009

16.2.4 Samples are to be conditioned for 16 hours in a cold box maintained at minus 29°C (minus 20°F).

16.2.5 Each sample is to be clamped between two steel rings having an inside diameter of 4-1/4 inches (108 mm). A 1.18 pound (536 g) steel ball is to be dropped once from a height of 6 feet (1.8 m) to strike the coating.

16.3 Resistance to external fluids tests

16.3.1 After being immersed as specified in 16.3.2 and 16.3.3 the coating shall not crack or flake, nor shall the coating dissolve from the surface to the extent that the steel becomes visible. The coating on the holiday samples shall not disbond more than 1.5 square inches (968 mm^2).

16.3.2 For external fluids, coupons are to be immersed in each of the external fluids specified in Table 20.2 for 30, 90, 180, and 270 days.

16.3.3 The coupons are to be immersed vertically in each of the fluids. The liquid level is to cover half of the test coupons. Four of the coupons are to be prepared with a 0.25 inch (6.4 mm) diameter holiday. The test fluids are to be maintained at a temperature of 38°C (100°F) during the immersion periods.

16.3.4 The current demand of the undrilled samples is to be measured (both before and after immersion) in accordance with Section 9.13 of ASTM G8, Standard Test Method for Cathodic Disbonding of Pipeline Coatings. The current demand shall not exceed 0.04 milliampere per square foot (0.43 milliampere/m^2).

16.3.4 effective January 17, 2009

16.4 Flexibility test

16.4.1 After being loaded as described in 16.4.2, the coating shall not be damaged to the extent that a holiday forms in the coating when the sample is subjected to the holiday test specified in 16.7.1.

Exception: Holidays or other damage to areas in immediate contact with the supports or loading nose shall be disregarded.

16.4.2 Samples are to be placed in a constant rate of traverse testing machine with a span of 6 inches (152.4 mm). The loading nose and supports are to be aligned such that the axes of the cylindrical surfaces are parallel and the loading nose is midway between the supports. The testing machine is to apply the load at 0.1 inches (2.5 mm) per minute until a deflection is obtained, as determined by the following equation.

$$Deflection = \frac{9.7 \times 10^{-2}}{6t} \text{ inches}^2$$

in which:

t = sample thickness (steel plus coating), inch

16.5 Abrasion resistance test

16.5.1 After being tested as specified in 16.5.2 the coating shall not be damaged to the extent that holidays form in the coating when the sample is subjected to the holiday test specified in 16.7.1.

16.5.2 Samples are to be subjected to three drops in accordance with ASTM G13-13, Test Method for Impact Resistance of Pipeline Coatings, except that flat plate specimens are to be used instead of pipe samples.

16.5.2 revised December 19, 2014

16.6 Cathodic disbondment test

16.6.1 After being subjected to the test specified in 16.6.2 the unperforated samples shall not disbond from the steel surface. The disbonded area of the perforated samples shall not exceed 1.5 square inches (968 mm^2).

16.6.2 Samples are to be subjected to Method B of ASTM G8, Standard Test Method for Cathodic Disbonding of Pipeline Coatings, except that flat panel specimens are to be used instead of pipe specimens. Half of the samples are to be perforated per ASTM G8. The temperature of the electrolyte is to be maintained at 23 ±3°C during the test. The samples are to be subjected to the test for 28 days.

16.6.2 effective January 17, 2009

16.7 Holiday test

16.7.1 Samples are to be tested in accordance with ASTM G62, Standard Test Methods for Holiday Detection in Pipeline Coatings.

16.7.1 effective January 17, 2009

17 Tests for Insulating Devices (Bushings and Gaskets)

17.1 General

17.1.1 Insulating devices for use with underground storage tank systems shall be made of nonconductive material to electrically insulate the underground tank from the piping system. Threaded bushings shall accept a standard threaded pipe in accordance with the Standard for Welded and Seamless Wrought Steel Pipe, ASME B36.10M. Insulating devices that form part of a bolted and gasketed flanged connection meet the intent of this requirement.

17.1.1 effective January 17, 2009

17.2 Leakage test

17.2.1 An insulating device shall not leak when subjected to the Leakage Test described in 17.2.2 – 17.2.5.

17.2.2 Samples are to be installed in the test fixture simulating a tank fitting as specified in the manufacturer's installation instructions. The assembly is to be partially filled with regular unleaded gasoline and sealed by installing:

a) A threaded pipe plug into a threaded bushing; or

b) A blind flange onto a flange-type connection.

17.2.3 The assembly is to be inverted so that the gasoline contacts the insulating device and subjected to the following conditioning program: 4 cycles consisting of 16 hours at minus 17.8°C (0°F) followed by 8 hours at 49°C (120°F); 72 hours at 17.8°C (0°F); 8 hours at 49°C (120°F); and 16 hours at 17.8°C (0°F).

17.2.4 The assembly is to be tested for leakage at room temperature prior to and following the conditioning program, and also following each temperature segment of the conditioning program.

17.2.5 The assembly is to be tested for leakage by aerostatically pressurizing the assembly to 5 psig (34 kPa) and brushing the device with a leak-detection solution. Continuous formation of bubbles is evidence of leakage.

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17.3 Resistance to automotive fuels test

17.3.1 An insulating device shall not exhibit a volumetric change and extraction greater than the following:

a) Volume change after test media immersion:

1) ASTM fuel C, ASTM fuel C/Methanol, ASTM fuel C/Ethanol: minus 1 to plus 40 percent

2) ASTM fuel A: minus 1 to plus 25 percent

b) Maximum extraction after test media immersion:

1) ASTM fuel C, ASTM fuel C/Methanol, ASTM fuel C/Ethanol: 10 percent

17.3.2 Samples of the insulating device material are to be immersed in the fluids specified in Table 5.4 of the Standard for Gaskets and Seals, UL 157 for the end use applications specified in Table 17.1.

Table 17.1
Resistance to automotive fuels test liquids for insulating devices

Fluid	Time and temperature
1. Gasoline	70 hours at 23 ±2°C
2. Gasoline-alcohol blends	70 hours at 23 ±2°C
3. Kerosene	70 hours at 23 ±2°C
4. Diesel fuel, fuel oil, or lubricating oil	70 hours at 23 ±2°C
5. Heated fuel oil	28 days at 121 ±1°C

17.4 Dielectric strength test

17.4.1 An insulating device shall not break down electrically when subjected to the tests specified in 17.4.2 and 17.4.3.

17.4.2 Samples are to be immersed in deionized or distilled water for 24 hours. The samples are then to be installed in a test fixture simulating a tank fitting. Threaded bushings are to be plugged with a threaded pipe plug. Flange-type bushings are to be capped with a blind flange. Test leads are to be attached to the test fixture and either the pipe plug or the blind flange. A 500 volt dc potential is then to be applied across the leads for a period of 1 minute.

17.4.3 The test is to be repeated using pipe joint sealant where specified by the manufacturer.

17.5 Aging test

17.5.1 An insulating device shall not crack when subjected to the test specified in 17.5.2.

17.5.2 Samples are to be aged in a circulating air oven for 7 days at a temperature of 87°C (188.6°F). Following aging, the samples are to be installed in a test fixture simulating a tank fitting and tested for leakage by pressurizing to 5 psig (34 kPa) with air.

17.6 Tensile strength test

17.6.1 The insulating device material shall have a tensile strength of at least 8700 psi (60,000 kPa) after conditioning for 70 hours at 23°C (73.4°F) and 50 percent relative humidity, and shall retain at least 95 percent of the original strength following a 7 day exposure in a circulating air oven at 87°C (188.6°F).

17.6.2 Samples of the insulating device material are to be tested in accordance with ASTM D638, Standard Test Method for Tensile Properties of Plastics, using Type I specimens.

17.6.2 effective January 17, 2009

18 Cathodically Protected Tank Assembly Tests

18.1 General

18.1.1 The following tests pertain to all cathodically protected tanks:

a) Strength of Pipe Fittings Test – Torque

b) Strength of Pipe Fittings Test – Bending Moment

c) Strength of Lift Fittings Test

d) Leakage Test

18.2 Strength of pipe fittings test – torque

18.2.1 Each fitting design shall be subjected to this test. The fitting shall not crack or split, the threads shall not strip, and no damage to the tank, fitting, or coating shall occur as a result of this test.

18.2.2 A length of pipe is to be threaded into a fitting for pipe connection and is to be tightened to the torque specified in Table 22.1.

18.2.3 Following this test, the tank is to be subjected to the leakage tests specified in 18.5.1 and 18.5.2.

18.3 Strength of pipe fittings test – bending moment

18.3.1 Each fitting design is to be subjected to the test described in 18.3.2. The fittings shall not crack or split, and no damage to the tank fitting or coating shall occur as a result of this test.

18.3.2 A 4 foot (1.2 m) length of Schedule 40 steel pipe is to be threaded into the fitting. A force is then to be applied to the top of the pipe. For a cylindrical tank, the force is first to be applied parallel to the longitudinal axis of the tank and then transverse to the longitudinal axis of the tank. For a spherical tank, the force is first to be applied in any one direction and then perpendicular to the direction in which the force was first applied. The applied force is to increase so that the bending moment is increased from 0 to 2000 pound-feet (2712 N·m) in 250 pound-feet (339 N·m) increments. When the Schedule 40 pipe bends before the required bending moment is reached, the test is to be stopped and the fitting examined for compliance with the requirements in 18.3.1.

18.3.3 Following this test, the tank is to be subjected to the leakage tests specified in 18.5.1 and 18.5.2.

18.4 Lift lug test

18.4 revised December 19, 2014

18.4.1 Following this test, the tank shall not leak when tested per the production leakage test. The lift lugs, their connection to the tank, and the tank shall not show evidence of damage, as defined by cracking or tearing of the metal lug itself, of the tank wall itself, or of any metal weld attachment.

18.4.1 revised December 19, 2014

18.4.2 Lifting lugs intended to be used to lift and move a tank are to be subjected for not less than 1 minute to a load equal to twice the weight of the empty tank. Single or multiple lugs may be tested to establish a load rating for each lug. A lug or lugs are to be tested in a manner which simulates the manufacturer's worst case lifting configuration for which each lug's load rating will be determined.

18.4.2 added December 19, 2014

18.4.3 Tank corrosion protection systems surrounding the lift lug shall not sustain damage that results in breakdown when subjected to the Holiday Test, applicable for the system type.

Exception: Damage is acceptable if a field repair kit evaluated to this standard is demonstrated to successfully repair the damage and pass the Holiday Test and the manufacturer requires the repair kit to be used.

18.4.3 added December 19, 2014

18.4.4 For lift lugs or lifting fittings that have passed testing without damage to the corrosion protection system, the lugs or fittings can be changed if calculations show equal or less deformation around the lug or fitting than the design that previously passed testing.

18.4.4 added December 19, 2014

18.5 Leakage test

18.5.1 There shall be no leakage when a complete cathodic tank assembly, including fittings and manways, is tested as described in 18.5.2.

18.5.2 The tank is to be pressurized with air to 5 psig (34 kPa) and brushed or sprayed with a leak-detection solution. Formation of sustained bubbles is evidence of leakage.

18.6 External pressure test

18.6.1 Tanks constructed in accordance with 5.1.4 in the Standard for Steel Underground Tanks for Flammable and Combustible Liquids, UL 58 shall be subjected to this test.

18.6.1 effective January 17, 2009

18.6.2 The tank shall not leak, collapse, implode or buckle (defined as deflection of 5% of the tank diameter) when subjected to the External Pressure test described in 18.6.3.

18.6.3 An empty tank is to be installed in a test fixture that facilitates submerging the tank in water. The support structure for the test tank shall not add additional tensile or compressive stresses to the bottom of the test tank. Clean water is then added to the test fixture until the tank is submerged 5 feet (1.52 m) or to a depth equal to the manufacturer's specified maximum burial depth, whichever is greater. The tank is to remain submerged for 1 hour and the pressure inside the tank is to be maintained at atmospheric pressure for the duration of the test.

PART II – COMPOSITE TANKS

CONSTRUCTION

19 Components

19.1 General

19.1.1 Composite tank corrosion protection systems shall consist of a steel tank with a nonmetallic external coating and nonmetallic caps to cover external attachments (such as lift lugs) and unused tank openings.

19.1.2 Nonmetallic external coatings shall be fabricated using material at least 0.100 inch (2.54 mm) thick.

PERFORMANCE

20 Physical Properties of Materials Tests

20.1 General

20.1.1 Representative samples of the composite tank coating system as specified in Table 20.1 shall be used for these tests.

Table 20.1
Samples for physical properties of materials and corrosion evaluation tests

Exposure/test	Number of test coupons	Coupons type (see below)
″As-received″	10	A
Air-oven aging	20	A
Light and water exposure	10	A
″As-received″	10	B
Resistance to external fluids	40	B
Impact and cold	10	C
Corrosion evaluation	50	C
Permeation/coating dissolution	20	D

COUPON TYPE

A – 7.5 by 9 inch (178 by 229 mm) coating coupons fabricated per the proposed production procedure of the minimum production coating thickness. Each coupon is then to be cut to provide one 2.5 by 9 inch (64 by 229 mm) sample and one 5 by 9 inch (127 by 229 mm) sample and both samples marked for identification. The 5 by 9 inch sample shall be edge-sealed with the resin used to manufacture the coupons.

B – Identical to Type A, or manufactured at twice the minimum production coating thickness (as an alternative to the single-sided exposure samples). Note: Twice thickness samples are not applicable when total sample thickness exceeds 0.50 inch (12.7 mm) based on Izod Impact Test requirements.

C – 6 by 9 inch (152 by 229 mm) coupons with coating of the minimum production coating thickness fabricated per the proposed production procedure on one side of a flat No. 14 MSG (0.075 inch nominal) steel plate.

D – 6 by 6 inch (152 by 152 mm) flat coating coupons fabricated per the proposed production procedure of the minimum production coating thickness.

20.1.2 In cases where alternate glass fibers (rovings or mattes) are requested to be used within a FRP matrix that has previously been evaluated in accordance with all applicable requirements in this standard, the following steps in 20.1.3 to 20.1.6 for a comparative analysis shall be used to determine equivalency and/or the need for additional testing.

20.1.2 added December 19, 2014

20.1.3 Basic material information (generic type and class, physical properties, dimensions, etc.) shall be obtained from the manufacturer on the original and alternate component fiber for comparison. If the fiber materials are in the same generic family with similar properties and dimensions, continue to 20.1.4, otherwise, full testing per Section 20 for short and long term material properties is required.

20.1.3 added December 19, 2014

20.1.4 Separate production samples, fabricated laminate samples, or glass/resin rods of the glass and resin FRP matrix using the same resin, but with original and alternate glass fibers, shall be evaluated for glass content comparison per the UL 746A Section 43, Ash Content Test. If the glass content of the alternate FRP is within ± 5 percent of the original FRP, continue to 20.1.5, otherwise, full testing per Section 20 for short and long term material properties is required.

20.1.4 added December 19, 2014

20.1.5 Separate production samples of the FRP matrix using the same resin, but with original and alternate glass fibers, shall be evaluated for flexural strength comparison per paragraph 20.3.1, Physical Properties Tests for ASTM D790 Flexural Strength, except 10 samples for each set of materials being compared shall be tested in the as-received and after boiling (in DI water for 24 hrs) conditions.

20.1.5 added December 19, 2014

20.1.6 If the flexural modulus strength results comparing the original and alternate(s) of both before and after retention value averages are statistically similar (using a “difference of means” calculation with a 0.10 alpha significance level), the alternate glass fiber is accepted as an equivalent without additional testing, otherwise, full testing per Section 20 for short and long term material properties is required.

20.1.6 added December 19, 2014

20.1.7 If analytical or other applicable test data is available from the original glass evaluation, the alternate glass test results may be compared to that data in lieu of making new original samples, provided the new candidate glass FRP matrix is identical to the original sample FRP matrix, except for glass fiber deviations.

20.1.7 added December 19, 2014

20.2 Air-oven aging

20.2.1 Representative sample coupons are to be conditioned in an air-circulating oven at a temperature of 70°C (158°F) for 30, 90, and 180 days, respectively.

20.3 Coating materials

20.3.1 Following the conditioning, the samples are to be prepared and tested to determine flexural strength as well as izod impact strength. The flexural strength test is to be conducted in accordance with ASTM D790, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials using a crosshead speed of 0.1 inch per minute (2.54 mm/minute). The Izod Impact Tests are to be conducted in accordance with ASTM D256, Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics.

20.3.1 effective January 17, 2009

20.3.2 The izod impact, and flexural strength of each sample that has been conditioned in the air-circulating oven shall be at least 80 percent of the as-received sample.

20.4 Resistance to external fluids test

20.4.1 Coupons are to be immersed in the external fluids noted in Table 20.2. The test fluids are to be maintained at a temperature of 38°C (100°F) during the immersion periods.

Table 20.2
Immersion test – liquids

Table 20.2 effective January 17, 2009

External fluids	
Type A	**Type B**
Sulfuric acid (pH 3)	Distilled water[a,b]
Saturated sodium chloride solution	Hydrochloric acid (1 percent)[c]
	Nitric acid (1 percent)[c]
	Sodium carbonate – sodium bicarbonate solution (pH 10)[d]
	Sodium hydroxide solution (pH 12)

[a] Distilled water having a maximum total matter of 2.0 ppm and a maximum electrical conductivity of 5.0 micromhos/cm at 25°C (77°F) as described for Type IV grade reagent water in the Standard Specification for Reagent Water, ASTM D1193.

[b] Deionized water having a maximum electrical conductivity of 5.0 micromhos/cm at 25°C (77°F) as described for Type IV grade reagent water in the Standard Specification for Reagent Water, ASTM D1193.

[c] Percentage by weight.

[d] A pH of 10 is obtained by mixing 10.6 g/L of sodium carbonate and 8.4 g/L of sodium bicarbonate. A pH meter is to be used and the ratio of sodium bicarbonate adjusted as required. The pH is to be checked several times during the test.

20.4.2 For external fluid, coupons are to be immersed in the Type A fluids noted in Table 20.2 for 30, 90, 180, and 270 days or the coupons are to be immersed in the Type B fluids noted in Table 20.2 for 30, 90, and 180 days.

20.4.3 Following the immersions, the representative samples are to be removed from the test solutions then prepared and tested per 20.3.1.

20.4.4 The samples shall show no evidence of blistering, softening, crazing, or other damage that impairs the performance of the coating.

20.4.5 The izod impact and flexural strength of each sample that has been immersed in a Type B solution shall be at least 30 percent of the as-received sample.

20.4.6 The izod impact and flexural strength of each sample that has been immersed in a Type A solution shall be at least 50 percent of the as-received sample. In addition, the results from the immersion in each of the Type A external fluids are to be extrapolated (using a regression analysis technique which results in a correlation coefficient of 0.9 or greater) to obtain 270-day retention values. The extrapolated values shall not be less than 50 percent of the as-received values. When the correlation coefficient is less than 0.9 or the extrapolated value is less than 50 percent for a particular solution, an additional coupon is to be immersed in, that solution for a total of 270 days. The samples are then to be tested per 20.4.3 and 20.4.4. The izod and flexural strength of the 270-day samples shall not be less than 50 percent of the as-received samples.

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20.5 Light and water exposure test

20.5.1 Representative sample coupons are to be conditioned as described in 20.5.2 then prepared and tested per 20.3.1. The izod impact and flexural strength of each sample that has been subjected to the light and water exposure shall be at least 80 percent of the as-received sample.

20.5.2 The samples are to be subjected to 180 and 360 hours of light and water exposure in accordance with the Standard Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials, ASTM G152 and the Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials, ASTM G153, using apparatus designated Type D or DH. During each operating cycle of 20 minutes, the coupons are to be exposed to light alone for 17 minutes and to light and water for 3 minutes.

20.5.2 effective January 17, 2009

20.6 Impact and cold exposure test

20.6.1 Coating steel samples are to be conditioned for 16 hours in a cold box maintained at minus 29°C (minus 20°F). These samples and additional unconditioned samples are to be clamped, one at a time, between two steel rings having an inside diameter of 4-1/4 inches (108 mm). A 1.18 pound (0.536 kg) steel ball is to be dropped once from a height of 6 feet (1.8 m) to strike the coated surface of the sample.

20.6.2 The samples shall not crack, nor show rupture of the coating, and the coating shall not separate or uplift from the steel.

21 Corrosion Evaluation Tests

21.1 General

21.1.1 Representative samples of the composite tank coating system as detailed in Table 20.1 shall be used for these tests.

21.2 Corrosion evaluation test

21.2.1 Following the exposures described in 21.2.2, the representative samples are to be removed from the chamber. The coating shall show no evidence of blistering, softening, crazing, or other damage that impairs the performance of the coating. The coating is to be removed from the steel and the steel examined for corrosion. There shall be no corrosion of the steel.

21.2.2 Nonmetallic cylinders measuring 5 inches (127 mm) in diameter by 10 inches (254 mm) long are to be fitted to the coating side of the samples and secured with an adhesive. The cylinders are then to be filled with the test solutions noted in Table 21.1 (capped to prevent evaporation) and placed in a chamber maintained at a temperature of 38°C (100°F) for 30, 90, and 180 days.

21.2.3 When corrosion has not occurred following the 180 day exposures and there is less than 1 percent weight loss indicated by the Permeation/Coating Dissolution Test, 21.3.1 – 21.3.3 the corrosion evaluation test is to be discontinued. When permeation is greater than 1 percent, the corrosion evaluation test is to be continued to 270 days.

21.3 Permeation/coating dissolution test

21.3.1 The thickness of the coating samples used for this test are to be measured at five locations and the values recorded for comparison to production samples.

21.3.2 The coating samples are to be sealed with an adhesive to glass dishes containing the solutions specified in Table 21.1. After the sealing material has cured, the assemblies are to be weighed on an analytical balance. The assemblies are then to be inverted so that the solutions contact the coating samples, and placed in a chamber at a temperature of 38°C (100°F).

Table 21.1
Corrosion evaluation and permeation/coating dissolution test solutions

Saturated sodium chloride solution
Sodium carbonate-sodium bicarbonate solution (pH10)
Potassium biphthalate buffer solution (pH4)
Distilled water
Sodium hydroxide (pH12)

21.3.3 The assemblies are to be reweighed monthly for a period of 180 days. At the conclusion of the test, the samples are to be remeasured and any loss due to dissolution or permeation are to be recorded.

22 Composite Tank Assembly Tests

22.1 General

22.1.1 The following tests pertain to all composite tanks:

a) Strength of pipe fittings test – torque (22.2)

b) Strength of pipe fittings test – bending moment (22.3)

c) Strength of lift fittings test (22.4)

d) Tank impact test (22.5)

e) Leakage test (22.6)

f) Tank examination and holiday test (22.7)

22.2 Strength of pipe fittings test – torque

22.2.1 Each fitting design shall be subjected to this test. The fitting shall not crack or split, the threads shall not strip, and no damage to the tank, fitting, or coating shall occur as a result of this test.

22.2.2 A length of pipe is to be threaded into a fitting for pipe connection and is to be tightened to the torque specified in Table 22.1.

Table 22.1
Torques on pipe fittings

Table 22.1 effective January 17, 2009

Nominal pipe size, inches[a]	Torque, pound-inches	(N·m)
3/4	2000	(226)
1	2400	(271)
1-1/4	2900	(328)
1-1/2	3100	(350)
2	3300	(373)
2-1/2	3500	(395)
3	3600	(407)
3-1/2	3700	(418)
4	3800	(429)
6	4200	(475)
8	4600	(520)

[a] Nominal pipe size specifications are in accordance with the Standard for Welded and Seamless Wrought Steel Pipe, ASME B36.10M.

22.2.3 Following this test, the tank is to be subjected to the holiday and leakage tests specified in 22.6.1 – 22.7.2.

22.3 Strength of pipe fittings test – bending moment

22.3.1 Each fitting design is to be subjected to this test. The fittings shall not crack or split, and no damage to the tank fitting or coating shall occur as a result of this test.

22.3.2 A 4 foot (1.2 m) length of Schedule 40 steel pipe is to be threaded into the fitting. A force is then to be applied to the top of the pipe. For a cylindrical tank, the force is first to be applied parallel to the longitudinal axis of the tank and then transverse to the longitudinal axis of the tank. For a spherical tank, the force is first to be applied in any one direction and then perpendicular to the direction in which the force was first applied. The applied force is to increase so that the bending moment is increased from 0 to 2000 pound-feet (2712 N·m) in 250 pound-feet (339 N·m) increments. When the Schedule 40 pipe bends before the required bending moment is reached, the test is to be stopped and the fitting examined for compliance with the requirements in 22.3.1.

22.3.3 Following this test, the tank is to be subjected to the leakage test and the holiday test specified in 22.6.1 – 22.7.2.

22.4 Lift lug test

22.4 revised December 19, 2014

22.4.1 Following this test, the tank shall not leak when tested per the production leakage test. The lift lugs, their connection to the tank, and the tank shall not show evidence of damage, as defined by cracking or tearing of the metal lug itself, of the tank wall itself, or of any metal weld attachment.

22.4.1 revised December 19, 2014

22.4.2 Lifting lugs intended to be used to lift and move a tank are to be subjected for not less than 1 minute to a load equal to twice the weight of the empty tank. Single or multiple lugs may be tested to establish a load rating for each lug. A lug or lugs are to be tested in a manner which simulates the manufacturer's worst case lifting configuration for which each lug's load rating will be determined.

22.4.2 revised December 19, 2014

22.4.3 Tank corrosion protection systems surrounding the lift lug shall not sustain damage that results in breakdown when subjected to the Holiday Test, applicable for the system type.

Exception: Damage is acceptable if a field repair kit evaluated to this standard is demonstrated to successfully repair the damage and pass the Holiday Test and the manufacturer requires the repair kit to be used.

22.4.3 added December 19, 2014

22.4.4 For lift lugs or lifting fittings that have passed testing without damage to the corrosion protection system, the lugs or fittings can be changed if calculations show equal or less deformation around the lug or fitting than the design that previously passed testing.

22.4.4 added December 19, 2014

22.5 Tank impact test

22.5.1 There shall be no damage to the tank as indicated by a crack, debonding, delamination visible from the outside, or detection of holidays (per 22.7.1 and 22.7.2) at impact heights of 40 inches (1016 mm) or less. There shall be no breaking of pieces, separation of coating, uplift of coating, or puncture with impact heights greater than 40 inches (1016 mm) and less than 72 inches (1829 mm). Holidays shall not occur unless they are a result of an impact at a height greater than 40 inches (1016 mm) and less than 72 inches (1829 mm).

22.5.2 A representative sample tank is to be subjected to blows from a 12 pound (5.4 kg) steel ball swung on a 6 foot (1.8 m) tether. The tether is to be fixed at a point directly above the impact point and the ball moved backward and up away from the tank to the indicated distance measured vertically above the point of impact and then swung freely to the tank. The vertical height above the impact point is to be varied from 10 to 72 inches (254 to 1829 mm) with no two impacts on the same point. The head and shell are to be tested.

22.5.3 Following this test, the tank is to be subjected to the leakage test and the holiday test specified in 22.6.1 – 22.7.2.

22.6 Leakage test

22.6.1 There shall be no leakage when a complete composite tank assembly, including fittings and manways, is pressurized with air to 5 psig (34 kPa) and brushed or sprayed with a leak-detection solution.

22.6.2 Formulation of sustained bubbles is evidence of leakage.

22.7 Tank examination and holiday test

22.7.1 Following each of the tests specified in this section the complete tank assembly is to be physically examined for damage.

22.7.2 A complete tank assembly is to be subjected to a holiday test using a high voltage holiday detector set at 15,000 volts or the minimum voltage in accordance with the Standard Recommended Practice for Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates, NACE International RP0188, whichever is greater.

22.7.2 effective January 17, 2009

22.8 External pressure test

22.8.1 Tanks constructed in accordance with 5.1.4 in the Standard for Steel Underground Tanks for Flammable and Combustible Liquids, UL 58 shall be subjected to this test.

22.8.1 effective January 17, 2009

22.8.2 The tank shall not leak, collapse, implode or buckle (defined as deflection of 5% of the tank diameter) when subjected to the External Pressure test described in 22.8.3.

22.8.3 An empty tank is to be installed in a test fixture that facilitates the tank to be submerged in water. The support structure for the test tank shall not add additional tensile or compressive stresses to the bottom of the test tank. Clean water is then added to the test fixture until the tank is submerged 5 feet (1.52 m) or to a depth equal to the manufacturer's specified maximum burial depth, whichever is greater. The tank is to remain submerged for 1 hour and the pressure inside the tank is to be maintained at atmospheric pressure for the duration of the test.

PART III – JACKETED TANKS

CONSTRUCTION

23 Components

23.1 Jacketed tank corrosion protection systems shall consist of a steel tank with a nonmetallic external FRP, polyurethane, polyurea or thermoplastic jacket and caps to cover external attachments (such as lift lugs) and unused tank openings. The tank and jacket are separated by an interstitial space with the jacket acting as a barrier to provide a minimum of 300 degrees of secondary containment centered at the tank bottom and the heads shall be 100 percent contained.

Revised 23.1 effective December 19, 2018

23.2 Nonmetallic external FRP, polyurethane, polyurea or thermoplastic jackets shall be fabricated using material at least 0.100 inch (2.5 mm) thick.

23.3 These tanks shall have provisions for monitoring the annular space for leakage.

PERFORMANCE

24 Physical Properties of Materials Tests

24.1 General

24.1.1 Samples representative of the manufacturing process are to be used for these tests. Sample requirements for fiber reinforced plastic polyurethane, polyurea jacketed tank systems are specified in Table 24.1. Sample requirements for thermoplastic material are specified in Table 24.2.

Table 24.1
Sample requirements for fiber reinforced plastic (frp) polyurethane, polyurea jacket systems

Exposure/test	Number of test coupons	Coupons type (see below)
″As-received″	10	A
Air-oven aging	20	A
Light and water exposure	10	A
″As-received″	10	B
Resistance to external and internal fluids	60	B
Impact and cold	10	C
Corrosion evaluation	50	C
Permeation/jacket dissolution	20	D

COUPON TYPE

A – 7.5 by 9 inch (178 by 229 mm) jacket coupons fabricated per the proposed production procedure of the minimum production coating thickness. Each coupon is then to be cut to provide one 2.5 by 9 inch (64 by 229 mm) sample and one 5 by 9 inch (127 by 229 mm) sample and both samples marked for identification. The 5 by 9 inch sample is to be edge-sealed with the resin used to manufacture the coupons.

B – Identical to Type A, or manufactured at twice the minimum production coating thickness (as an alternative to the single-sided exposure samples). Note: Twice thickness samples are not applicable when total sample thickness exceeds 0.50 inch (12.7 mm) based on izod Impact test requirements.

C – 6 by 9 inch (152 by 229 mm) coupons with jacket of the minimum production coating thickness fabricated per the proposed production procedure on one side of a flat No. 14 MSG (0.075 inch nominal) steel plate.

D – 6 by 6 inch (152 by 152 mm) flat jacket coupons fabricated per the proposed production procedure of the minimum production coating thickness.

Table 24.2
Sample requirements for a thermoplastic jacket system

Exposure/test	Number of samples	Sample type
Fluid resistance, Air-oven aging, Ultraviolet	1	A,B
Corrosion	55	C
Permeation/jacket dissolution	20	D
Impact	10	E
Cold exposure	20	D

SAMPLE TYPE

A – 50 square feet (4.64 m^2) jacket material at production thickness in sheet form.

B – One 4 foot (1.2 m) sheet of each type of jacket joint, and jacket to head joint with the joint running longitudinal and 6 inches (152 mm) of jacket on each side of the joint.

C – 6 by 9 inch (152 by 229 mm) flat No. 14 MSG (0.075 inch nominal) steel coupon and complete jacket support system sealed in an envelope of representative jacket material.

D – 6 by 9 inch (152 by 229 mm) sealed envelopes of jacket material with threaded plug in one side for the addition of fluids. The side of the envelope around the plug is to be reinforced with the jacket material to a distance no greater than 3/8 inch (9.6 mm) from the edge of the fill hole.

E – 6 by 9 inch (152 by 229 mm) coupons with a representative jacket system production thickness attached to one side of a flat No 14 MSG steel plate.

24.1.2 In cases where alternate glass fibers (rovings or mattes) are requested to be used within a FRP matrix that has previously been evaluated in accordance with all applicable requirements in this standard, the following steps in 24.1.3 to 24.1.6 for a comparative analysis shall be used to determine equivalency and/or the need for additional testing.

24.1.2 added December 19, 2014

24.1.3 Basic material information (generic type and class, physical properties, dimensions, etc.) shall be obtained from the manufacturer on the original and alternate component fiber for comparison. If the fiber materials are in the same generic family with similar properties and dimensions, continue to 24.1.4, otherwise, full testing per Section 24 for short and long term material properties is required.

24.1.3 added December 19, 2014

24.1.4 Separate production samples, fabricated laminate samples, or glass/resin rods of the glass and resin FRP matrix using the same resin, but with original and alternate glass fibers, shall be evaluated for glass content comparison per the UL 746A Section 43 Ash Content Test. If the glass content of the alternate FRP is within ± 5 percent of the original FRP, continue to 24.1.5, otherwise, full testing Section 24 for short and long term material properties is required.

24.1.4 added December 19, 2014

24.1.5 Separate production samples of the FRP matrix using the same resin, but with original and alternate glass fibers, shall be evaluated for flexural strength comparison per paragraph 24.2.3, Physical Properties Tests for ASTM D790 Flexural Strength, except 10 samples for each set of materials being compared shall be tested in the as-received and after boiling (in DI water for 24 hrs) conditions.

24.1.5 added December 19, 2014

24.1.6 If the flexural modulus strength results comparing the original and alternate(s) of both before and after retention value averages are statistically similar (using a “difference of means” calculation with a 0.10 alpha significance level), the alternate glass fiber is accepted as an equivalent without additional testing, otherwise, full testing Section 24 for short and long term material properties is required.

24.1.6 added December 19, 2014

24.1.7 If analytical or other applicable test data is available from the original glass evaluate, the alternate glass test results may be compared to that data in lieu of making new original samples, provided the new candidate glass FRP matrix is identical to the original sample FRP matrix, except for glass fiber deviations.

24.1.7 added December 19, 2014

24.2 Air-oven aging

24.2.1 Representative sample are to be conditioned as described in 24.2.2 and then prepared and tested in accordance with 24.2.3 or 24.2.4, as applicable. The measured physical property of the samples, after conditioning, shall be at least 80 percent of that for a sample in the as-received condition.

24.2.2 Representative sample coupons are to be conditioned in an air-circulating oven at a temperature of 70°C (158°F) for 30, 90, and 180 days.

24.2.3 Following the conditioning, FRP or polyurethane, polyurea samples are to be prepared and tested to determine flexural strength as well as Izod Impact strength. The flexural strength test is to be conducted in accordance with ASTM D790, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials using a crosshead speed of 0.1 inch (2.54 mm) per minute. The Izod Impact Tests are to be conducted in accordance with ASTM D256, Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics.

24.2.3 effective January 17, 2009

24.2.4 Following the conditioning, thermoplastic samples are to be prepared and tested to determine tensile strength and tensile impact energy. The tensile properties tests are to be conducted in accordance with ASTM D638, Standard Test Method for Tensile Properties of Plastics. The tensile impact energy properties tests are to be conducted in accordance with ASTM D1822, Standard Test Method for Tensile-Impact Energy to Break Plastics and Electrical Insulating Materials.

24.2.4 effective January 17, 2009

24.3 Resistance to external and internal fluids test

24.3.1 Representative samples are to be immersed in the external fluids noted in Table 24.3. They are to be immersed in the Type A solutions for 30, 90, 180, and 270 days. They are to be immersed in the Type B solutions for 30, 90, and 180 days. The test liquids are to be maintained at a temperature of 38°C (100°F) during the immersion periods.

Table 24.3
Immersion test – liquids

Table 24.3 effective January 17, 2009

Internal fluids		External fluids	
Type A[e]	**Type B**	**Type A**	**Type B**
Premium leaded gasoline[a]	Toluene	Sulfuric acid (pH 3)[a]	Distilled water[b,c]
Regular unleaded gasoline[a]		Saturated sodium chloride[a]	Hydrochloric acid (1 percent)[d,a]
No. 2 fuel oil[a]			
ASTM Reference Fuel C			Nitric acid (1 percent)[d,a]
No. 6 fuel oil[g,a]			
Methanol (100%)			Sodium carbonate – sodium bicarbonate solution (pH 10)[a,f]
Ethanol (100%)			
50% Methanol/50% Ref. Fuel C			
50% Ethanol/50% Ref. Fuel C			Sodium hydroxide solution (pH 12)[a]
15% Methanol/85% Ref. Fuel C			
15% Ethanol/85% Ref. Fuel C			
10% Ethanol/90% Ref. Fuel C			
30% Ethanol/70% Ref. Fuel C			

[a] FRP, polyurethane, polyurea specimens are only to be subjected to the flexural strength test specified in 24.2.3.

[b] Distilled water having a maximum total matter of 2.0 ppm and a maximum electrical conductivity of 5.0 micromhos/cm at 25°C (77°F) as described for Type IV grade reagent water in the Standard Specification for Reagent Water, ASTM D1193.

[c] Deionized water having a maximum electrical conductivity of 5.0 micromhos/cm at 25°C (77°F) as described for Type IV grade reagent water in the Standard Specification for Reagent Water, ASTM D1193.

[d] Percentage by weight.

[e] Reference Fuel C is to be as described in the Standard Test Method for Rubber Property – Effect of Liquids, ASTM D471.

[f] A pH of 10 is obtained by mixing 10.6 g/L of sodium carbonate and 8.4 g/L of sodium bicarbonate. A pH meter is to be used and the ratio of sodium bicarbonate adjusted as required. The pH is to be checked several times during the test.

[g] Not required, to be used only at the request of and at the temperature specified by the manufacturer.

24.3.2 Representative samples are to be immersed in the internal fluids in Table 24.3 for 30 days. The test liquids are to be maintained at a temperature of 38°C (100°F) during the immersion periods with the exception of No. 6 fuel oil which is maintained at the maximum rated temperature specified by the manufacturer.

24.3.3 Representative samples of polyurethane and polyurea materials are to be immersed in the internal fluids noted in Table 24.3. They are to be immersed in the Type A solutions for 30, 90, 180, and 270 days. They are to be immersed in the Type B solutions for 30, 90, and 180 days. The test liquids are to be maintained at a temperature of 38 °C (100 °F) during the immersion periods.

24.3.4 An immersion test liquid is classed as either a Type A or Type B as follows:

a) Type A liquids represent either a product to be stored or an outside soil condition.

b) Type B liquids are more severe than expected conditions.

24.3.5 Following the immersions, the representative samples are to be removed from the test solutions then prepared and tested in accordance with 24.2.3 or 24.2.4, as applicable. The samples shall show no evidence of blistering, softening, crazing, or other damage that impairs the performance of the jacket.

24.3.6 The measured physical property of each sample, after conditioning in a Type A solution, for 30 days for internal fluids and 270 days for external fluids, shall be at least 50 percent of the as-received samples. When the results from the immersion of samples in each external fluid for 30, 90, and 180 day periods are reliably extrapolated to 270 days, the resistance to fluids tests are discontinued. The samples measured physical property, after conditioning in Type B solution, for 30 days for internal fluids and 180 days for external fluid, shall be at least 30 percent of that for a sample in the as-received condition.

24.3.7 Additionally for polyurethane and polyurea materials, the measured physical property of each sample, after conditioning in a Type A solution, for 270 days for internal fluids, shall be at least 50 percent of the as-received samples. When the results from the immersion of samples in each internal fluid for 30, 90, and 180 day periods are reliably extrapolated to 270 days, the resistance to fluids tests are discontinued. The samples measured physical property, after conditioning in Type B solution, for 180 days for internal fluid, shall be at least 30 percent of that for a sample in the as-received condition.

24.4 Light and water exposure test

24.4.1 The measured physical property, after conditioning as described in 24.4.2 and 24.4.3 shall be at least 80 percent of that for a sample in the as-received condition.

24.4.2 The samples are to be subjected to 180 and 360 hours of light and water exposure in accordance with the Standard Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials, ASTM G152 and the Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials, ASTM G153, using apparatus designated Type D or DH. During each operating cycle of 20 minutes, the coupons are to be exposed to light alone for 17 minutes and to light and water for 3 minutes.

24.4.2 effective January 17, 2009

24.4.3 After conditioning as described in 24.4.2 the representative samples are to be then prepared and tested in accordance with 24.2.3 or 24.2.4 as applicable.

24.5 Impact and cold exposure test

24.5.1 Jacket/tank system samples detailed in Table 24.1 or 24.2 are to be conditioned for 16 hours in a cold box maintained at minus 29°C (minus 20°F). Immediately following removal from the cold box, these samples and additional unconditioned samples are to be clamped, one at a time, between two steel rings having an inside diameter of 4-1/2 inches (108 mm). A 1.18 pound (536 g) steel ball is to be dropped once from a height of 6 feet (1.8 m) to strike the jacket surface of the sample.

24.5.2 The samples shall not crack, nor show rupture of the jacket.

25 Corrosion Evaluation Tests

25.1 General

25.1.1 Representative samples as detailed in Table 24.1 or 24.2 are to be used for these tests.

25.2 Corrosion evaluation test

25.2.1 Following the exposures described in 25.2.2, the representative samples are to be removed from the chamber. The jacket is to be removed from the steel and the steel examined for corrosion. There shall be no corrosion of the steel. The jacket shall show no evidence of blistering, softening, crazing, or other damage that impairs the performance of the jacket.

25.2.2 One end of a nonmetallic cylinder measuring 5 inches (127 mm) in diameter by 10 inches (254 mm) long is to be fitted to the jacket side of the samples and secured with an adhesive. The cylinders are then to be filled with the test solutions noted in Table 25.1, capped to prevent evaporation, and placed in a chamber maintained at a temperature of 38°C (100°F) for 30, 90, and 180 days.

Table 25.1
Corrosion evaluation and permeation/jacket dissolution test solutions

Saturated Sodium Chloride Solution
Sodium Carbonate-Sodium Bicarbonate Solution (pH10)
Potassium Biphthalate Buffer Solution (pH4)
Distilled Water
Sodium Hydroxide (pH12)

25.2.3 When corrosion has not occurred following the 180 day exposures and there is less than 1 percent weight loss indicated by the Permeation/Jacket Dissolution Test, 25.3.1 – 25.3.2, the corrosion evaluation test is discontinued. When permeation is greater than 1 percent, the corrosion evaluation test is to be continued to 270 days.

25.3 Permeation/jacket dissolution test

25.3.1 The thickness of the FRP or polyurethane, polyurea jacket samples used for this test are to be measured at five locations and the values recorded for comparison to production samples. A glass dish, into which the test solution is to be sealed with the permeation samples, is to be weighed alone. The dish is then to be reweighed with the solution. The weight of the solution is then determined. The samples are to be sealed with an adhesive and cured. After curing, the assemblies are to be reweighed. The assemblies are then to be inverted so that the solutions contact the jacket samples and placed in a chamber at a temperature of 38°C (100°F).

25.3.2 The thermoplastic jacket permeation sample envelopes are to be weighed, filled with the solutions specified in Table 25.1, sealed and reweighed. The samples are to be placed in a chamber at a temperature of 38°C (100°F). The assemblies are to be reweighed monthly for a period of 180 days. The percent solution weight loss is to be calculated and recorded. At the conclusion of the test, the samples are to be measured. Any loss due to dissolution or permeation is to be recorded.

26 Jacketed Tank Assembly Tests

26.1 General

26.1.1 The following tests pertain to jacketed tanks:

a) Strength of Pipe Fittings Test – Torque

b) Strength of Pipe Fittings Test – Bending Moment

c) Strength of Lift Fittings Test

d) Tank Impact Test

e) Leakage Test

f) Tank Examination and Holiday (FRP polyurethane, polyurea only) Tests

g) Annulus Proof Pressure Test

h) Interstitial Communication Test

26.2 Strength of pipe fittings test – torque

26.2.1 Each fitting design is to be subjected to this test. The fitting shall not crack nor split, the threads shall not strip, and no damage to the tank, fitting, or jacket shall occur as a result of this test.

26.2.2 A length of pipe is to be threaded into the fitting for pipe connection and is to be tightened to the torque specified in Table 22.1.

26.2.3 Following this test, the tank is to be subjected to the tests specified in 26.6.1 – 26.7.1 for FRP polyurethane, polyurea jackets and 26.6.1 – 26.6.3 for thermoplastic jackets.

26.3 Strength of pipe fittings test – bending moment

26.3.1 Each fitting design is to be subjected to this test. The fitting shall not crack or split, and no damage to the tank fitting or jacket shall occur as a result of this test.

26.3.2 A 4 foot (1.2 m) length of Schedule 40 steel pipe is to be threaded into the fitting. A force is then to be applied to the top of the pipe. For a cylindrical tank, the force is first to be applied parallel to the longitudinal axis of the tank and then transverse to the longitudinal axis of the tank. For a spherical tank, the force is first to be applied in any one direction and then perpendicular to the direction in which the force was first applied. The applied force is to increase so that the bending moment is increased from 0 to 2000 lb-ft (2172 N·m) in 250 lb-ft (339 N·m) increments. When the Schedule 40 pipe bends before the required bending moment is reached, the test is to be stopped and the fitting examined for compliance with the requirements in 26.3.1.

26.3.3 Following this test, the tank is to be subjected to the tests specified in 26.6.1 – 26.7.1 for FRP polyurethane, polyurea jackets and 26.6.1 – 26.6.3 for thermoplastic jackets.

26.4 Lift lug test

26.4 revised December 19, 2014

26.4.1 Following this test, the tank shall not leak when tested per the production leakage test. The lift lugs, their connection to the tank, and the tank shall not show evidence of damage, as defined by cracking or tearing of the metal lug itself, of the tank wall itself, or of any metal weld attachment.

26.4.1 revised December 19, 2014

26.4.2 Lifting lugs intended to be used to lift and move a tank are to be subjected for not less than 1 minute to a load equal to twice the weight of the empty tank. Single or multiple lugs may be tested to establish a load rating for each lug. A lug or lugs are to be tested in a manner which simulates the manufacturer's worst case lifting configuration for which each lug's load rating will be determined.

26.4.2 revised December 19, 2014

26.4.3 Tank corrosion protection systems surrounding the lift lug shall not sustain damage that results in breakdown when subjected to the Holiday Test, applicable for the system type.

Exception: Damage is acceptable if a field repair kit evaluated to this standard is demonstrated to successfully repair the damage and pass the Holiday Test and the manufacturer requires the repair kit to be used.

26.4.3 added December 19, 2014

26.4.4 For lift lugs or lifting fittings that have passed testing without damage to the corrosion protection system, the lugs or fittings can be changed if calculations show equal or less deformation around the lug or fitting than the design that previously passed testing.

26.4.4 added December 19, 2014

26.5 Tank impact test

26.5.1 There shall be no damage to the tank as indicated by a crack, disbonding, delamination visible from the outside, or detection of holidays at impact heights of 40 inches (1016 mm) or less. There shall be no breaking of pieces or puncture with impact heights greater than 40 inches and less than 72 inches (1829 mm). Holidays that are apparent by visual inspection are permissible at impact heights greater than 40 inches.

26.5.2 A representative sample tank is to be subjected to blows from a 12 pound (5.4 kg) steel ball swung on a 6 foot (1.8 m) tether. The tether is to be fixed at a point directly above the impact point and the ball moved backward and up away from the tank to the indicated distance measured vertically above the point of impact and then swung freely to the tank. The vertical height above the impact point is to be varied from 10 to 72 inches (254 to 1829 mm) with no two impacts on the same point. Head, shell and knuckle are to be tested.

26.5.3 Following this test, the tank is to be subjected to the tests specified in 26.6.1 – 26.7.1 for FRP polyurethane, polyurea jackets and 26.6.1 – 26.6.3 for thermoplastic jackets.

26.6 Leakage test

26.6.1 There shall be no leakage when a complete jacketed tank assembly, including fittings and man ways, is aerostatically tested.

26.6.2 Tanks that are marked for testing the annular space with positive pressure are to be tested by manifolding the annular space to the primary tank and pressurize the entire system to twice rated pressure [maximum 5 psig (34.5 kPa)]. The outer jacket is to be checked for leakage by using soap suds or equivalent leak detection solution.

26.6.3 Tanks that are marked for testing of the annular space with a vacuum are to be tested by subjecting the annular space to a partial vacuum of at least maximum rated vacuum, and not less than 13 inches of mercury (43.9 kPa). This is to be held for at least 24 hours. Deviation in the pressure greater than ±2 inches mercury (±6.75 kPa) indicated by the gauge is evidence of leakage.

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26.7 Tank examination and holiday tests

26.7.1 A complete FRP polyurethane, polyurea tank jacket assembly is to be subjected to a holiday test using a high voltage holiday detector set at 15,000 volts or the minimum voltage in accordance with the Standard Recommended Practice for Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates, NACE International RP0188, whichever is greater. There shall be no holidays.

26.7.1 effective January 17, 2009

26.8 Annulus proof-pressure test

26.8.1 The annular space of tanks that are marked for testing with a positive pressure shall withstand without rupture for 1 minute an internal pressure of 5 psig (34.5 kPa) or five times rated pressure, whichever is greater.

Exception: The annular space is not required to withstand an air pressure of five times rated pressure when the jacket relieves pressure in a manner that does not present a potential risk of injury.

26.9 Interstitial communication test

26.9.1 A representative tank is to be installed underground as intended. The primary tank is to filled to capacity with water. At a point farthest from the interstitial monitoring point water, rated vacuum, or rated pressure is to be added to the interstitial space.

26.9.2 The communication of the water, vacuum, or pressure to the monitoring point is to be monitored and timed. There shall be measurable communication in less than 24 hours.

26.10 External pressure test

26.10.1 Tanks constructed in accordance with 5.1.4 in the Standard for Steel Underground Tanks for Flammable and Combustible Liquids, UL 58, shall be subjected to this test.

26.10.1 effective January 17, 2009

26.10.2 The tank shall not leak, collapse, implode or buckle (defined as deflection of 5% of the tank diameter) when subjected to the External Pressure Test described in 26.10.3.

26.10.3 An empty tank is to be installed in a test fixture that facilitates submerging the tank in water. The support structure for the test tank shall not add additional tensile or compressive stresses to the bottom of the test tank. Clean water is then added to the test fixture until the tank is submerged 5 feet (1.52 m) or to a depth equal to the manufacturer's specified maximum burial depth, whichever is greater. The tank is to remain submerged for 1 hour and the pressure inside the tank is to be maintained at atmospheric pressure for the duration of the test.

PART IV – COATED TANKS

CONSTRUCTION

27 Components

27.1 General

27.1.1 Coated tank corrosion protection systems shall consist of a steel tank with a nonmetallic external coating and nonmetallic caps to cover external attachments (such as lift lugs) and unused tank openings.

27.1.2 Nonmetallic external coatings shall be fabricated using material at least 0.070 inch (1.8 mm) thick.

27.1.3 Coated tanks shall be provided with a coating repair kit and appropriate instructions.

27.1.4 Coated tanks shall be provided with measures to protect the coating in areas subject to damage during storage, shipment, installation, and use.

PERFORMANCE

28 Physical Properties of Materials and Corrosion Evaluation Tests

28.1 General

28.1.1 Representative coupons of the coated tank corrosion protection system as specified in Table 28.1 shall be used for these tests.

28.1.2 The coated tank repair kit material shall be evaluated as specified in Table 28.1. The Air-oven aging, Abrasion resistance, Resistance to external fluids, Light and water exposure, Impact and cold, and Corrosion tests are to be performed.

Exception: When the repair kit material is the same as the coating material on the tank, only the Abrasion resistance, Impact and cold, and Corrosion evaluation tests shall be performed.

Table 28.1
Samples for physical properties of materials and corrosion evaluation tests

Exposure/test	Number of test coupons	Coupon type(s)
"As-received"	5, 12, 5	A, F, G
Air-oven aging	20, 18, 20	A, F, G
Abrasion resistance	5, 5	E, D
Resistance to external fluids	40, 100, 40	A, F, G
Light and water exposure	10, 12, 10	A, F, G
Impact and cold	10, 10	B, D
Corrosion evaluation	50, 50	B, D
Permeation/coating dissolution	20	C
COUPON TYPE A – 7.5 by 9 inch (191 by 229 mm) coupons fabricated per the proposed production procedure of the minimum production coating thickness. Each coupon is then to be cut to provide one 2.5 by 9 inch (64 by 229 mm) sample and one 5 by 9 inch (127 by 229 mm) sample and both samples marked for identification. The 5 by 9 inch (127 by 229 mm) sample shall be edge-sealed as required with the coating used to manufacture the coupons. B – 6 by 9 inch (152 by 229 mm) coupons with the minimum production coating thickness and fabricated per the proposed production procedure on one side of a flat No. 14 MSG (0.075 inch nominal) steel plate.		

Table 28.1 Continued on Next Page

Table 28.1 Continued

Exposure/test	Number of test coupons	Coupon type(s)
C – 6 by 6 inch (152 by 152 mm) flat coating coupons fabricated per the proposed production procedure of the minimum production coating thickness. D – Same as coupon B except with a 2 inch (50.8 mm) diameter holiday in the coating to bare metal and repaired with the coating repair kit in accordance with the manufacturer's instructions. E – 5 by 9 inch (127 mm by 229 mm) coated flat No. 14 MSG (0.075 inch nominal) steel plate fabricated in accordance with the proposed production procedure of the minimum production coating thickness. The coating shall be applied to both sides of the coupon and the edges. F – 1 by 4 inch (25.4 by 101.6 mm) samples fabricated per the proposed production procedure of the minimum production coating thickness. The samples (in sets of two) shall be bonded together using the coating repair kit in accordance with the manufacturer's instructions. The bonded samples shall become a 1 by 7.5 inch (25.4 by 190.5 mm) coupon. The bonded samples are to be edge-sealed as required with the coating used to manufacture the samples. G – Same coupon requirements as coupon type A except manufactured from the repair kit material. NOTES – 1 When the material in the repair kit is the same as the coating material, the Air-oven aging, Light and water exposure and Resistance to external fluids exposures are not required for coupon types F and G. 2 The number of test coupons requested is often more than the number of coupons required for the test. Additional sample amounts are requested due to breakage that occurs when the coupons are milled into the specimen geometries for the Tensile impact energy or tensile strength tests.		

28.2 Tensile properties test methods

28.2.1 The Tensile strength test is to be conducted in accordance with ASTM D638, Standard Test Method for Tensile Properties of Plastics. The Type 4 Tensile strength specimen shall be used. The Tensile impact energy tests are to be conducted in accordance with ASTM D1822, Standard Test Method for Tensile-Impact Energy to Break Plastics and Electrical Insulating Materials. The Type S tension impact specimen geometry shall be used. Five tensile strength and five tensile impact specimens shall be tested.

28.2.1 effective January 17, 2009

28.3 Shear strength test method

28.3.1 The Shear strength test is to be conducted in accordance with ASTM D3164, Standard Test Method for Determining Strength of Adhesively Bonded Plastic Lap-Shear Sandwich Joints in Shear by Tension Loading. Each test coupon is to consist of two 4 inch by 1 inch by the minimum production thickness of the coating. The samples are to be joined together using the repair kit material with a 1/2 inch overlap. After assembly, the test coupon is to be 7-1/2 inches long by 1 inch wide. Five coupons (type F) are to be tested.

28.4 As received tensile properties tests

28.4.1 The specimens are to be tested to determine tensile strength and tensile impact energy for the coupons in the as received condition. The specimens are to be tested in accordance with the methods indicated in 28.2.1 except ten tensile strength and ten tensile impact specimens shall be tested. See Table 28.1 for the requested amount of coupons and the type.

28.5 As received shear strength tests

28.5.1 The test coupons are to be tested to determine the shear strength of the coupons in the as-received condition. The coupons are to be tested in accordance with the methods indicated in 28.3.1, shear strength test method; except ten coupons are to be tested. See Table 28.1 for the requested amount of coupons and type.

28.6 Air-oven aging tensile properties shear strength tests

28.6.1 The tensile impact and tensile strength of each test specimen that has been conditioned in the air-circulating oven shall be at least 80 percent of the as-received test specimen. The shear strength of each coupon that has been conditioned in the air-circulating oven shall be at least 80 percent of the as-received coupons.

28.6.2 Representative coupons and specimens are to be conditioned in an air-circulating oven at a temperature of 70°C (158°F) for 30, 90, and 180 days. The coupons and specimens, after each time period, are to be tested in accordance with the methods indicated in 28.2.1, Tensile properties test methods; and 28.3.1, Shear strength test method. See Table 28.1 for the requested amount of coupons and type.

28.7 Abrasion resistance test

28.7.1 The coating shall not be damaged to the extent that holidays form in the coating when the coupon is subjected to the Holiday test specified in 29.7.

28.7.2 Five coupons are to be subjected to three drops in accordance with ASTM G13-13, Standard Test Method for Impact Resistance of Pipeline Coatings (Limestone Drop Test) (1996) e1, except coupons are to be used instead of pipes. See Table 28.1 for the requested amount of coupons and the type.

28.7.2 revised December 19, 2014

28.7.3 Following the test described in 28.7.2 the coupons are to be subjected to the Holiday test specified in 29.7.

28.8 Resistance to external fluids test

28.8.1 The coupons shall show no evidence of blistering, softening, crazing, or other damage that impairs the performance of the coating.

28.8.2 The tensile impact and tensile strength of each specimen that has been immersed in a Type A solution shall be at least 50 percent of the as-received specimens. The shear strength of each coupon that has been immersed in a Type A solution shall be at least 50 percent of the as-received coupons. In addition, the results from the immersion in each of the Type A external solutions are to be extrapolated (using a regression analysis technique which results in a correlation coefficient of 0.9 or greater) to obtain 270-day retention values. The extrapolated values shall not be less than 50 percent of the as-received values. When the correlation coefficient is less than 0.9 or the extrapolated value is less than 50 percent for a particular solution, additional coupons are to be immersed in that solution for a total of 270 days as described in 28.8.4. The coupons are then to be tested per 28.2.1, Tensile properties test methods; and 28.3.1, Shear strength test method. The tensile impact and tensile strength of the 270-day specimens shall not be less than 50 percent of the as-received specimens. The shear strength of the 270-day coupon shall not be less than 50 percent of the as-received coupons.

28.8.3 The tensile impact and tensile strength of each specimen that has been immersed in a Type B solution shall be at least 30 percent of the as-received specimen. The shear strength of each coupon that has been immersed in a Type B solution shall be at least 30 percent of the as-received coupons.

28.8.4 Coupons are to be immersed in the internal and external fluids noted in Table 28.2. The test fluids are to be maintained at a temperature of 38°C (100°F) during the immersion periods.

28.8.5 For external fluids, coupons are to be immersed in the Type A fluids noted in Table 28.2 for 30, 90, 180, and 270 days or the coupons are to be immersed in the Type B fluids noted in Table 28.2 for 30, 90, and 180 days.

Table 28.2
Immersion test – liquids

Table 28.2 effective January 17, 2009

External fluids	
Type A[a,b]	**Type B[b]**
Sulfuric acid (pH 3)	Distilled water[c] or deionized[d]
Saturated sodium chloride solution	Hydrochloric acid (1 percent)[e]
Hydrochloric acid (1 percent)[e]	Sodium carbonate-sodium bicarbonate solution (pH 10)[f]
	Nitric acid (1 percent)[e]
	Sodium Hydroxide (pH 12)

[a] Type A liquids represent either a product to be stored or an outside soil condition.

[b] Type B liquids are more severe than expected conditions.

[c] Distilled water having a maximum total matter of 2.0 ppm and a maximum electrical conductivity of 5.0 micromhos/cm at 25°C (77°F) as described for Type IV grade reagent water in the Standard Specification for Reagent Water (Federal Test Method Standard No. 7916), ASTM D1193.

[d] Deionized water having a maximum electrical conductivity of 5.0 micromhos/cm at 25°C (77°F) as described for Type IV grade reagent water in the Standard Specification for Reagent Water (Federal Test Method Standard No. 7916), ASTM D1193.

[e] Percentage by weight.

[f] A pH of 10 is obtained by mixing 10.6 g/L of sodium carbonate and 8.4 g/L of sodium bicarbonate. A pH meter is to be used and the ratio of sodium bicarbonate adjusted as required. The pH is to be checked several times during the test.

28.8.6 Following each immersion period, coupons from each external fluid shall be removed and tested per 28.2.1, Tensile properties test methods; and 28.3.1, Shear strength test method.