An Overview of UL Underground Storage Tank Standards: UL58, 1746 and 1316

The UL label means many things to many people when they picture an UST storing flammable and combustible liquids. Underwriters Laboratories’ Wayne Doversberger tells what it means to UL.

Underwriters Laboratories (UL) Standards have proven to be of pivotal importance in the design and use of petroleum storage tanks for U.S. manufacturers, distributors and many others in the petroleum equipment industry. And yet, relatively few people in the industry know what must be done to earn a UL Standard designation; and, for some, even UL itself is shrouded in mystery. In this article, UL’s Wayne Doversberger aims to provide the reader with a clear look at UL Standards for USTs storing flammable and combustible liquids, and a better understanding of UL. Wayne Doversberger will also explain the Standards for aboveground tanks, UL 142 and 2085, in the January issue.

setting high standards

Underwriters Laboratories tests more than 80,000 products in more than 17,000 product categories every year, including many in the petroleum equipment industry. UL is an independent, not-for-profit testing organization, founded more than a century ago.

The organization conducts investigations on products to determine their compliance with a number of nationally or internationally recognized standards, including those of UL, the National Fire Protection Association (NFPA), the American National Standards Institute (ANSI), the American Society for Testing Materials (ASTM) and the International Electrotechnical Commission (IEC).

The UL Standards for tanks that store flammable and combustible liquid are:

For underground tanks:
- UL 58, Steel Underground Tanks for Flammable and Combustible Liquids
- UL 1746, External Corrosion Protection Systems for Steel Underground Storage Tanks
- UL 1316, Glass-Fiber-Reinforced Plastic Underground Storage Tanks for Petroleum Products, Alcohols, and Alcohol-Gasoline Mixtures

For aboveground tanks:
- UL 142, Steel Aboveground Tanks for Flammable and Combustible Liquids
This article will concentrate on the UL Standards for underground tanks storing flammable and combustible liquid. They are: UL 58, UL 1746 and UL 1316. Future articles will cover API and UL Standards for above-ground tanks.

UL 58

Steel Underground Tanks for Flammable and Combustible Liquids

UL 58 covers single-wall and double-wall, bare steel underground tanks. The first edition of this standard, published in 1925, addressed leakage, buckling from external pressure and venting. The tables in the original Standard identified the minimum thickness of the steel, based on the tank diameter and length. No performance testing was required.

Steel thickness

The latest edition of UL 58, published December 13, 1996, covers the characteristics described above. It also permits manufacturers to determine the minimum steel thickness necessary, based on the Roark equation. If built according to the Roark equation, no performance testing is required.

The Roark equation is:

$$t_{min} = \left( \frac{P_1 L r^{3/2} (1-u^2)^{3/4}}{(.807E_s)} \right)^4$$

where:

- $P_1$ is the calculated external pressure (in psi) at the bottom of a tank submerged in water to depth of 5 feet, or at the maximum burial depth specified by the manufacturer.
- $E$ is the modulus of the elasticity for the steel.
- $t_s$ is the thickness of steel tank shell (in inches) with a minimum thickness of 0.123 inches (1/8”) for the primary tank and 0.093 inches (3/32”) for the secondary tank.
- $L$ is the length of the tank (in inches)
- $r$ is the radius of the tank (in inches)
- $u$ is Poisson’s Ratio, which is the ratio of the unit lateral deformation to the unit longitudinal deformation.

The Standard permits manufacturers to reduce the steel thickness up to 25%, provided the design can withstand a one-hour external pressure test. During this test, the tank is submerged in water to a depth equal to the manufacturer’s specified burial depth or 5 feet, whichever is greater. The tank is not permitted to leak, collapse, implode or buckle. Buckling is defined as deflection of 5% of the tank diameter during this test, or 4.8 inches for an 8 foot diameter tank.

Other requirements

The latest edition also added requirements for lifting lugs provided with the tank. Lifting lugs are required to (1) be able to support, for one second, a load equal to two times the empty weight of the tank without permanent deformation; and (2) not leak, when subjected to a 5 psi leakage test.
The Standard only permits certain types of welds, a 144 inch maximum diameter, a minimum length to diameter ratio of 6:1, and a specified minimum vent size. During production, each tank must be checked for leakage. The manufacturer may either pressurize the tank aerostatically to 3-5 psi and use a leak detection fluid to check for leaks, or fill the tank with water and pressurize to 5 psi and observe for water leakage before the tank is painted.

**A bending movement test is being performed on a tank fitting.**

**Courtesy of UL.**

**UL 1746**

**External Corrosion Protection Systems for Steel Underground Storage Tanks**

UL 1746 was first published in November 1989. It provides requirements for corrosion protection of steel underground tanks. There are three types of protection systems covered by the Standard: cathodically protected tanks, composite tanks and jacketed tanks. The base tank is constructed in accordance with Standard UL 58 and more corrosive protection is added.

**Part I—Pre-engineering**

Part I of UL 1746 covers pre-engineered cathodic protection systems. The tanks are provided with a galvanic anode. The material specifications are in the Standard. It also specifies requirements for the backfill around the anode, insulating bushings for electrically isolating the tank from the piping, and wire connectors for cored anodes.

The cathodic protection system shall be constructed to provide a minimum system design based on a 4,000 ohm-cm soil resistivity. The system shall consist of the following:

- Dielectric coating applied to all exposed exterior tank surfaces;
- Electrical insulating devices (gaskets and bushings) installed in each tank opening prior to shipment;
- At least two galvanic anodes per tank; and
- Test station provisions.

The Standard identifies how to determine the current requirements of the current system; the soil resistivity; the available galvanic anode current; and the galvanic anode weight.

Performance tests include:

1. **Anode pull test**—Lead wire shall withstand a direct pull of 70 pounds for a period of one minute.

2. **Anode assembly durability test**—A representative anode assembly is soaked in water for four hours, allowed to dry for at least 48 hours, then mounted on a vibration table. The sample shall be subjected to a 1/16 inch displacement from the table. The sample is to be vibrated for one hour. After this test the anode assembly shall not become inoperable nor shall the anode shift to a position closer than 0.50 inches from the container wall.
3. **Pressure wire connectors tightening torque test**—The connection between the wire and the connector shall be subjected to the tightening torque specified in the Standard for five seconds. 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.

4. **Pullout test for pressure wire connectors**—A connector wire assembly shall withstand a direct pull of 70 pounds for a period of one minute without separation or movement of parts relative to one another.

5. **Pullout test for test lead**—A test lead shall be subjected to a direct pull of 70 pounds for one minute without separation or loosening.

6. **Dielectric coating tests**—Sample coupons coated with the dielectric coating shall be subjected to impact tests both “as received” and after conditioning. The conditioning processes are air-oven aging, light and water exposure; and -29 degree C exposure. The sample shall be affected to the extent that holidays form less than one inch from the point of impact.

   • Resistance to Environmental Fluids Test. Additional coupons shall be immersed for 270 days in environmental fluids representing various soil conditions. The coatings shall not crack or flake, nor shall the coating dissolve from the surface to the extent that the base material becomes visible. The coating shall not disbond more than 1.5 square inches.
   • Flexibility Test. Sample coupons shall be placed on supports and a load applied until the deflection equals 9.7 x 10^{-2/6t}, where “t” equals sample thickness. After the load is removed, the samples shall be subjected to the holiday test in ASTM G62-87. There shall be no evidence of holidays on the sample coupons.
   • Abrasion Resistance Test. Sample coupons shall be subjected to three drops in accordance with ASTM G13-89. After the drops, the samples shall be subjected to the holiday test in ASTM G62-87. There shall be no evidence of holidays on the sample coupons.
   • Cathodic Disbondment Test. Flat sample coupons are to be subjected to Method B of ASTM G8-90. Half of the coupons are to be perforated per ASTM G8-90; the electrolyte is to be maintained at 23 +/- three degrees C; and the samples immersed for 28 days. The disbonded area of the perforated samples shall not exceed 1.5 square inches. The coating shall not disbond from the uncoated samples.

This worker is placing pea gravel under the lower quadrant of FRP jacketed tanks. Courtesy of UL.

7. **Insulated bushings test**—Samples of the insulating bushing are to be installed in a test fixture simulating a tank fitting. The assembly is to be partially filled with regular unleaded gasoline and sealed. The assembly is to be inverted and subjected to four temperature cycles of 16 hours at minus 0 degrees F, followed by eight hours at 120 degrees F; 72 hours at 0 degrees F; and 16 hours at 0 degrees F. After conditioning, the samples are to be checked for leakage by aerostatically pressurizing to 5 psi.
8. Resistance to automotive fluids—The insulating device shall be exposed to fluids representing automotive fluids. The volume change and extraction shall be determined after the exposure. The maximum volume change is minus one to plus 40% for fluids with ASTM Fuel C mixtures and minus one to plus 25% for samples exposed to ASTM Fuel A. The maximum extraction permitted is 10%.

9. Dielectric strength test—Insulating devices shall not break down electrically when subjected to a 500 volt dc (direct current) potential. Samples are to be conditioned for 24 hours in distilled water prior to applying the test potential.

10. Aging test—Insulating devices shall not crack when subjected to seven day air-oven aging at 87 degrees C. Following the conditioning, the samples are to be installed on a test fixture and subjected to a 5 psi aerostatic pressure test.

11. Tensile strength test—Insulating device material shall have a tensile strength of at least 8,700 psi “as received” and retain at least 95% after seven days of air-oven aging at 87 degrees C.

12. The tank assembly shall be subjected to the following tests: strength of pipe fitting tests, including torque and bending moment; strength of lift fittings test; and the leakage tests noted below under UL 1316 tests.

Part II—Composite Tanks

Part II of UL 1746 covers composite tanks. These are steel tanks complying with UL 58 that are coated with a nonmetallic coating at least 0.100 inches thick. The steel thickness of the tank may be reduced if the earth load test, water load test and external pressure test are conducted on a sample tank. These tests are noted below under UL 1316 tests.

Samples of the composite tank-cladding system are subjected to the air-oven conditioning and to environmental fluids immersion for 30, 90 and 180 days. The samples shall retain 80% of the “as received” flexural strength value after aging; 50% after Type A fluid immersion and 30% after Type B fluid immersions. Additional samples shall be subjected to the light and water exposure test and the impact and cold exposure test noted below under UL 1316.

The coating shall also be evaluated with respect to corrosion protection when exposed to fluids representing group oil conditions. There shall be no evidence of blistering, softening, crazing or other damage that could impair the performance of the cladding after 270-day exposure to the test fluids at 38 degrees C.

The composite tank assembly shall be subjected to the following tests: Strength of pipe fittings tests, including tests for torque and bending moment; and strength of lift fittings test noted below under UL 1316; and the external pressure test noted above under UL 58.

In addition, the tank assembly shall be subjected to the leakage test, tank impact test and holiday
test. The tank shall be subjected to a 5 psi aerostatic leakage test and checked for leakage using a leak detection solution. The tank impact test consists of impacting the tank with a 12 pound steel ball. The complete tank assembly is subjected to a holiday test using a 35,000 volt holiday tester. There shall be no evidence of holidays after the above tests.

These FRP doublewall tanks are subjected to a rigorous series of 16 tests under UL 1316. Courtesy of Fluid Containment.

Part III—Jacketed Tanks

Part III of UL 1746 covers jacketed tanks. These tanks consist of a steel tank complying with UL 58 with a nonmetallic external FRP or thermoplastic jacket. The tank and jacket are separated by an interstitial space with the jacket acting as a secondary containment barrier. The jacket shall be fabricated using a material at least 0.100 inches thick.

The tank assembly shall be subjected to the strength of pipe fitting test; the bending moment, and strength of lift fittings test; the tank impact test; the leakage test; the holiday test; and the annulus proof pressure tests noted below.

In addition, a jacketed tank shall also be subjected to an interstitial communication test. During the communication test, a sample is installed underground and filled to capacity with water. At the farther point from the interstitial monitoring point, water, and vacuum-created pressure shall be added to the interstitial space. There shall be measurable communication to the monitoring point within 24 hours.

If a jacketed tank is constructed with reduced steel thickness, the water load test, the earth load test and the external pressure test (noted below) shall be conducted on a sample tank assembly.

Part IV—Urethane-Coated Tanks

Part IV of UL 1746 is currently being developed and will cover urethane-coated tanks. As part of normal production, each tank shall be subjected to the leak-age test. Each cathodically protected tank is subjected to the anode continuity test to verify that there is continuity between the anode lead wire and the tank connection. Each composite tank and areas of FRP jacketed tanks where the FRP is bonded to the steel tank shall be subjected to the holiday test.

UL 1316

Glass-Fiber-Reinforced Plastic Underground Storage Tanks for Petroleum Products, Alcohols, and Alcohol-Gasoline Mixtures

First published in July 1983, UL 1316 covers both single- and double-wall FRP tanks. It addresses safety issues regarding protection from leakage; buckling due to external pressure; the ability of the tank to withstand internal pressures that may develop in the tank during testing; and the compatibility of the materials with the intended fluids and ground soil conditions.
The Standard requirements include the location of openings and minimum vent size. The test program includes the following:

1. **Leakage test**—The tank is pressurized and checked for leaks.

2. **Strength-of-pipe fittings tests**
   - Torque—A length of pipe is threaded into fittings for pipe connections and a torque is applied based on the thread size. The fitting shall not crack or split, and the threads shall not strip.
   - Bending Moment—A length of schedule 40 steel pipe is threaded into the fitting and a force is applied perpendicularly to the pipe axis. The fitting and the tank shall not be damaged.
   - Leakage—After each of the above tests, the tank and fittings shall not leak when subjected to the leakage test.

3. **Strength-of-lifting fittings test**—A lift fitting shall be subjected to a load equal to twice the weight of the empty tank. Neither the fitting nor the tank shall be damaged. The tank is subjected to the leakage test after this test is conducted.

4. **Water-load test**—The tank shall be placed in a sand bed so that one-eighth of the tank is buried and then filled with water. The tank shall not be damaged.

5. **External pressure test**—The tank is placed in a pit and back-filled according to the manufacturer's instructions. The pit is then filled with water so that the tank is submerged to its maximum burial depth. The tank is to remain submerged for 24 hours. Then, while still submerged, the tank is subjected to an internal vacuum. The tank shall not be damaged or implode.

6. **Internal pressure test**—A tank shall withstand without rupture an internal pressure test for one minute. The test pressure is 25 psi for tanks with diameter of 10 feet or less and 15 psi for tanks greater than ten feet in diameter.

7. **Physical properties of materials tests**—Coupons cut from the tank shall be subjected to air oven aging, immersion in liquids representing the actual product, and immersion in liquids representing outside soil. A coupon is a sample cut from the nonmetallic tank that is as flat as possible. Coupons are used for conducting physical tests on the materials both before and after conditioning (again, fluid immersions and light and water exposure). The physical tests include tensile strength, Izod impact, cold impact and flexural strength tests. Physical tests conducted after the conditioning will be compared to results of tests conducted on “as received” coupons.
   - Impact and cold exposures—Coupons are subjected to impact from a steel ball dropped from a height of six feet at both room temperature and at -29 degrees C. The coupons shall not crack or rupture, but surface crazing is permitted.
   - Light and water exposure—Coupons shall maintain at least 80% of their “as received” properties after 180 and 360 hours of light and water exposure. The test is conducted according to ASTM G23-90.
8. **Earth-load test**—The tank shall not implode or be otherwise damaged during this test. The tank is installed in a pit and backfilled according to the manufacturer’s installation instructions. The tank is to be covered so that it is 3 feet below the surface of the fill, and the tank shall remain buried for one hour. After this test, the tank is subjected to the leakage test.

9. **Annulus proof-pressure test**—The annulus of a double-wall tank is to be subjected to its maximum rated pressure or vacuum for 24 hours. For a positive pressure tank, the annulus pressure is then increased to twice the rated value for one minute. For a negative pressure tank, the annulus vacuum is then increased by 5.3 inches of mercury and held for one minute. There shall be no rupture of the tank.

As part of normal production, each tank shall be subjected to the leakage test, an internal vacuum test and a surface cure test. The surface cure test verifies that the hardness of the laminate is within the resin manufacturer’s specified tolerances.

**Conclusion**

It is important to note UL’s standard development process gives interested parties the chance to comment before a new or revised standard becomes final. Interested parties include manufacturers and trade associations, such as the Steel Tank Institute, the Petroleum Equipment Institute, the Fiberglass Tank & Pipe Institute, NFPA and building code officials, just to name a few.

Working with these interested parties helps UL to develop standards that are practical for manufacturers, compatible with other standards and installation codes and effective in addressing public safety issues. UL also works with standards writing and certification organizations in other counties to harmonize requirements.

Wayne Doversberger is a licensed Professional Engineer and a Group Leader at Underwriters Laboratories.