CHAPTER 3

TANK TIGHTNESS TESTING PROCEDURES

3-1. General. The purpose of underground storage tank (UST) integrity tightness or tank tightness testing procedures is to determine the physical integrity of UST. The EPA, under 40 CFR 280 Subpart D, has established release detection requirements for all USTs. Tank tightness testing is used to indicate whether an UST meets the applicable release standards. Tank tightness testing should only be performed on tanks that are to be abandoned in place or tanks that are to remain active. You should choose a tank tightness test carefully to ensure that the test does not promote additional contamination of the surrounding environment. Both volumetric and nonvolumetric methods of tank tightness testing are described in this chapter. Some of these methods may be used for pipe integrity testing; however, pipe integrity testing is not the focus of this chapter.

3-2. Methods. Tank tightness testing can be performed in a variety of ways. A tank tightness test is a precision test that can be volumetric or nonvolumetric. A volumetric test measures volume changes quantitatively, while a nonvolumetric test measures changes qualitatively. Some methods require filling tanks to capacity, known as overfilling, where the fluid level reaches the fill tube. In these tests, the integrity of the entire tank and associated piping can be assessed. Other methods employ partially filled tanks, where only the integrity of the filled portion of the tank can be assessed. Tests can also be divided between constant-level and variable-level tests. In constant-level tests, product is added or removed to maintain a constant fluid level. Both overfilled and partially filled tanks can be used in constant-level tests. Variable-level tests allow the fluid level to fluctuate and are typically conducted on overfilled tanks. Tables 3-1 and 3-2 contain a summary of the various methods.

a. Volumetric. Most tank tightness test methods account for volume changes as a function of product-level changes. A constant-level volumetric test directly measures the volume added or subtracted from a tank in order to maintain a constant level. A variable-level test measures changes in the level of the product and converts these level changes to volume changes using a height-to-volume conversion factor.

TABLE 3-1
VOLUMETRIC LEAK TESTING METHODS

Method	Principle	Claimed Accuracy, gal/h	Total Downtime for Testing	Requires Empty or Full Tank for Test
Ainlay Tank Integrity Testing	Pressure measurement by a coil-type manometer to determine product-level change in a propane bubbling system.	0.02	10-12 h (filled a night before 1.5-h testing)	Full
ARCO HTC Underground Tank Detector	Level change measurement by float and light-sensing system.	0.05	4-6 h	No
Certi-Tec Testing	Monitoring of pressure changes resulting from product-level changes.	0.05	4-6 h	Full
"Ethyl" Tank Sentry	Level change magnification by a J tube manometer.	Sensitive to 0.02-in level change	Typically 10 h	No
EZY-CHEK Leak Detector	Pressure measurement to determine product-level change in an air bubbling system.	Less than 0.01	4-6 h (2 h waiting after fillup, 1-h test)	Full
Fluid-static (standpipe) Testing	Pressurizing of system by a standpipe; keeping the level constant by product addition or removal; measuring rate of volume change.	Gross	Several days	Full
Heath Petro Tite Tank and Line Testing (Kent-Moore)	Pressurizing of system by a standpipe; keeping the level constant by product addition or removal; measuring rate of volume change; product circulation by pump.	Less than 0.05	6-8 h	Full
Helium Differential Pressure Testing	Leak detection by differential pressure change in an empty tank; leak rate estimation by Bernoulli's equation.	Less than 0.05	Minimum 48 h	Empty
Mooney Tank Test Detector	Measuring level change with a dip stick.	0.02	14-16 h[1] (12 to 14 h waiting after fillup)	Full
PACE Tank Tester	Magnification of pressure change in a sealed tank by using a tube (based on manometer principle).	Less than 0.05	14 h	Full
PALD-2 Leak Detector	Pressurizing system with nitrogen at three different pressures; level measurement by an electrooptical device; estimate of leak rate based on the size of leak and pressure difference across the leak.	Less than 0.05	14 h (preferably 1 day before, 1-h fill testing, includes sealing time)	Full
Pneumatic Testing	Pressurizing system with air or other gas; leak rate measurement by change in pressure.	Gross	Several hours	No
Tank Auditor	Principle of buoyancy.	0.00001 in the fill pipe; 0.03 at the center of a 10.5-ft-diameter tank	1.5-3 h	Typically full
Two-tube Laser Interferometer System	Measuring level change by laser beam and its reflection.	Less than 0.05	4-5 h[2]	No (at existing level)

1 Including the time for tank end stabilization when testing with standpipe.
2 Including 1 to 2 h for reference tube temperature equilibrium.
Source: USEPA 1986. *Underground Storage Tank Leak Detection Methods: A State of the Art Review*. EPA/600/2-86/001.

TABLE 3-2
NONVOLUMETRIC LEAK TESTING METHODS

Method	Principle	Claimed Accuracy, gal/h	Total Downtime for Testing	Requires Empty or Full Tank for Test
Acoustical Monitoring System (AMS)	Sound detection of vibration and elastic waves generated by a leak in a nitrogen-pressurized system; triangulation techniques to detect leak location.	Does not provide leak rate; detects leaks as low as 0.01 gal/h.	1-2 h	No
Leybold-Heraeus Helium Detector, Ultratest M2	Rapid diffusivity of helium; mixing of a tracer gas with products at the bottom of the tank; helium detected by a sniffer mass spectrometer.	Does not provide leak rate; helium could leak through 0.005-in leak size.	None	No
Smith & Denison Helium Test	Rapid diffusivity of helium; differential pressure measurement; helium detection outside a tank.	Provides the maximum possible leak detection based on the size of the leak (does not provide leak rates); helium could leak through 0.05-in leak size.	Few–24 h (excludes sealing time)	Empty
TRC Rapid Leak Detector for Underground Tanks and Pipes	Rapid diffusion of tracer gas; mixing of a tracer gas with product; tracer gas detected by a sniffer mass spectrometer with a vacuum pump.	Does not provide leak rate; tracer gas could leak through 0.005-in leak size.	None	No
Ultrasonic Leak Detector (Ultrasound)	Vacuuming the system (5 lb/in^2); scanning entire tank wall by ultrasound device; noting the sound of the leak by headphones and registering it on a meter.	Does not provide leak rate; a leak as small as 0.001 gal/h of air could be detected; a leak through 0.005-in could be detected.	Few hours (includes tank preparation and 20-min test)	Empty
VacuTect (Tanknology)	Applying vacuum at higher than product static head; detecting bubbling noise by hydrophone; estimating approximate leak rate by experience.	Provides approximate leak rate.	1 h	No
Varian Leak Detector (SPY2000 or 938-41)	Similar to Smith & Denison.	Similar to Smith & Denison.	Few–24 h (excludes sealing time)	Empty

Source: EPA/600/2-86/001, "Underground Storage Tank Leak Detection Methods: A State of the Art Review."

b. Nonvolumetric.

(1) Nonvolumetric tests can be divided into vacuum tests, probe tests, and tracer tests. The vacuum test subjects the tank to a slight vacuum, enough to counteract the fluid head within the tank. When a leak is encountered, bubbles form at the leak, separate at the tank, and undergo a volume pulsation of constant frequency that can be used to determine leak size.

(2) The methods currently available for nonvolumetric tank testing use either a type of vapor monitoring or conduct the test under a vacuum. Neither method will provide an exact leak rate. However, each method will provide an analysis of the system in relation to the 0.1 gallons per minute (gpm) leak rate at a probability of detection of 0.95 and a probability of false alarm of 0.05. When selecting a nonvolumetric test method, make sure the method is approved for the entire volume of the tank and not just for the volume containing liquid on the day the tank is tested.

c. Performance. The performance of a leak-detection test method is measured by the accuracy and reliability of that test method in determining whether or not a tank is leaking. The best performance test methods are able to discriminate between the volume changes produced by a leak (signal) and other volume changes that normally occur in both nonleaking and leaking tanks (noise). This noise can often be confused with the leak by masking or mimicking the signal of the leak.

d. Results. A leak-detection test has five possible outcomes:

(1) Correctly identified leak: an accurate test result where the measured condition reflects actual conditions.

(2) Correctly identified tight tank: an accurate test result where the integrity of a nonleaking tank is confirmed.

(3) A false alarm: an erroneous test result where the test mistakenly indicates a leak.

(4) A missed detection: an erroneous test result where the test mistakenly indicates that the tank is tight when it is leaking.

(5) An inconclusive test that does not provide either positive or negative evidence of a leak. Also, a positive result may or may not indicate whether the leak is in the tank or the associated piping.

3-3. Regulations. 40 CFR 280 Subpart D specifies the following general release detection requirements for all UST systems in § 280.40:

a. Release Detection. "Owners and operators of new and existing UST systems must provide a method, or combination of methods, of release detection that:

(1) Can detect a release from any portion of the tank and the connected underground piping that routinely contains product;

(2) Is installed, calibrated, operated, and maintained in accordance with the manufacturer's instructions, including routine maintenance and service checks for operability or running condition; and

(3) Meets the performance requirements in § 280.43 or 280.44, with any performance claims and their manner of determination described in writing by the equipment manufacturer or installer. In addition, methods used after December 22, 1990, except for methods permanently installed prior to that date, must be capable of detecting the leak rate or quantity specified for that method in § 280.43 (b), (c), and (d) or 280.44 (a) and (b) with a probability of detection of 0.95 and a probability of false alarm of 0.05."

b. Tank Tightness Testing. Section 280.43(c) specifies the following tank tightness testing performance requirements: "Tank tightness testing (or another test of equivalent performance) must be capable of detecting a 0.1 gallon-per-hour leak rate from any portion of the tank that routinely contains product while accounting for the effects of thermal expansion or contraction of the product, vapor pockets, tank deformation, evaporation or condensation, and the location of the water table."

3-4. Test Procedures. A summary of attributes of reliable integrity tightness testing methods has been developed by the EPA based upon research performed on over 25 commercially available methods. The testing methods are summarized in the following documents:

- *Standard Test Procedures for Evaluating Leak Detection Methods: Volumetric Tank Tightness Testing Methods*, EPA/530/UST-90/004, March 1990.

- *Standard Test Procedures for Evaluating Leak Detection Methods: Nonvolumetric Tank Tightness Testing Methods*, EPA/530/UST-90/005, March 1990.

- *Standard Test Procedures for Evaluating Leak Detection Methods: Pipeline Leak Detection Systems*, EPA/530/UST-90/101, September 1990.

- *List of Leak Detection Evaluations for Underground Storage Tank (UST) Systems,* EPA/510/B-97/004.

a. Documentation. Either the manufacturer or an independent third party can perform the demonstration tests. However, some states do not recognize results from demonstration tests performed by the equipment manufacturer. When purchasing release detection equipment or having a tank system tested, the organization providing the service or equipment must provide the owner/operator of the system with the manufacturer's documentation of equipment compliance with performance standards outlined in 40 CFR 280.40(a). This documentation must be retained at the facility to meet the record keeping requirements outlined in 40 CFR 280.34.

b. Selection. Before selecting a tank tightness test method, check with state and local agencies to make sure the proposed method was adequately evaluated and demonstrated in the performance test report. Some states have additional evaluation methods and standards. They may require third-party testing or limit the release detection method to certain size (capacity) tanks. The standards used to evaluate the release detection method will be in the performance test report. These reports will provide the following information about the test equipment: method description, test results, the product used for testing, techniques used for measuring temperature and level, how data are acquired and recorded, limitation of the test method, and certification of results. From this, a determination can be made about the following:

TABLE 3-3
MAJOR VARIABLES AFFECTING LEAK DETECTION

Variable	Impact
Temperature Change	Expansion or contraction of a tank and its contents can mask leak and/or leak rate.
Water Table	Hydrostatic head and surface tension forces caused by groundwater may mask tank leaks partially or completely.
Tank Deformation	Changes or distortions of the tank due to changes in pressure or temperature can cause an apparent volume change when none exists.
Vapor Pockets	Vapor pockets formed when the tank must be overfilled for testing can be released during a test or expand or contract from temperature and pressure changes and cause an apparent change in volume.
Product Evaporation	Product evaporation can cause a decrease in volume that must be accounted for during a test.
Piping Leaks	Leaks in piping can cause misleading results during a tank test because many test methods cannot differentiate between piping leaks and tank leaks.
Tank Geometry	Differences between the actual tank specifications and nominal manufacturer's specifications can affect the accuracy of change in liquid volume calculations.
Wind	When fill pipes or vents are left open, wind can cause an irregular fluctuation of pressure on the surface of the liquid and/or a wave on the liquid-free surface that may affect test results.
Vibration	Vibration can cause waves on the free surface of the liquid that can cause inaccurate test results.
Noise	Some nonvolumetric test methods are sound-sensitive and sound vibrations can cause waves to affect volumetric test results.
Equipment Accuracy	Equipment accuracy can change with the environment (e.g., temperature and pressure).
Operator Error	The more complicated a test method, the greater the chance for operator error, such as not adequately sealing the tanks.
Type of Liquid Stored	The physical properties of the liquid (including effects of possible contaminants) can affect the applicability or repeatability of a detection method (e.g., viscosity can affect the sound characteristics of leaks in acoustical leak-detection methods).
Power Vibration	Power vibration can affect instrument readings.
Instrumentation Limitation	Instruments must be operated within their design range or accuracy will decrease.
Atmospheric Pressure	A change in this parameter has the greatest effect when vapor pockets are in the tank, particularly for leak-rate determination.
Tank Inclination	The volume change per unit of level change is different in an inclined tank than in a level one.

Source: USEPA 1986. *Underground Storage Tank Leak Detection Methods: A State of the Art Review*. EPA/600/2-86/001.

(1) The amount of time required for the tank's contents to stabilize after a delivery of product.

(2) The required test duration for collecting data to accurately determine the condition of the tank.

(3) Limitations of the test method (such as tank capacity).

(4) The actual minimum leak rate the test method can detect to a probability of detection of 0.95 and a probability of false alarm of 0.05.

(5) Whether a third party or the equipment manufacturer conducted the performance test.

c. Performance. The performance claims for leak-detection devices produced by commercial manufacturers will not be discussed in this document. Refer to EPA/625/9-89/009 *Volumetric Tank Testing: An Overview* and EPA/510/B-97/004 *List of Leak Detection Evaluations for Underground Storage Tank (UST) Systems* and literature from individual manufacturers for additional information on the performance of specific commercially available devices.

3-5. Precautions. Table 3-3 summarizes the variables that can affect leak detection. Three of the major variables are discussed below.

a. Noise. A tank tightness or volumetric test measures the change in the volume of fluid in a tank, accounts for other sources of noise (normally occurring volume changes), and attributes the adjusted volume change (if it is above the threshold level) to a leak. Therefore, it is essential that a test method differentiate between and compensate for nonleak-related volume changes (noise) versus actual leaks. There are five common nonleak-related product-volume (or product-level) changes that are sources of ambient noise, some potentially producing larger errors than others. Precautions are incorporated in most reliable test methods to compensate for those phenomena and to minimize the probability of false alarms.

(1) Thermal expansion or contraction of the product resulting from product addition or removal during volumetric testing can be a major source of noise and, thus, error in tank tightness testing. Volume changes due to expansion and contraction of the product in a filled tank may be as large as 3.8 L (1 gallon) per

hour. Reliable test methods compensate for this phenomenon by requiring a waiting period following any tank additions prior to measurement collection.

(2) Vapor pockets commonly occur in tanks and the associated piping that have been filled to capacity. Temperature fluctuations and pressure changes in the tank contents cause the expansion or contraction of vapor pockets. Volume changes of trapped vapors produce product-level changes that may be misinterpreted as leaks. Vapor pockets as small as 38 liters (10 gallons) in a 38,000 liter (10,000-gallon) tank can influence test results. In preparation for tightness testing, if vapor pockets of 40 to 80 liters (10 to 20 gallons) or more are suspected, the tank and lines should be bled as a precaution.

(3) In addition to level, temperature, and pressure changes associated with a product, the tank itself will exhibit expansion and contraction, or structural deformation. This deformation, in turn, causes the product level to change, which could be mistaken as a leak. Both instantaneous deformation and time-dependent relaxation of a tank occur. Reliable tank testing procedures introduce a waiting period between product addition and measurement collection as a precaution to allow the tank deformation effects to subside.

(4) Minor volume fluctuations may result from the evaporation of product from the fluid surface or condensation of product on tank walls. This phenomenon is more likely to occur in tanks that are not completely filled and contain air or vapor pockets. Completely filling and bleeding tanks and lines prior to test initiation are precautions that will minimize this type of “noise.”

(5) Surface or internal waves may be caused by mechanical vibrations or temperature boundary layers within a tank. These waves can produce apparent level changes that could be mistaken for volume changes or leaks. Infrequent sampling that does not detect this wave phenomenon, known as biasing, can indicate a false result. To prevent this, use reliable test methods such as frequent sampling and averaging of data during the test. Perform tests

during hours when local traffic, especially trucks, would be less prevalent so the impact on test results would be minimized.

b. Groundwater. The location of the groundwater table at the time of testing is another factor that can interfere with accurate tank tightness testing. Unlike the five factors mentioned previously, the groundwater level does not mimic a leak; however, it may have a direct effect on the apparent size of the leak. Existing site information (boring logs) should be used to estimate the depth to groundwater rather than mobilizing a rig and crew to determine the depth to groundwater. When the groundwater level is above the leak, it can restrict or prevent the flow of product out of a tank, and a leak can go undetected. As a precaution, it is important to monitor the groundwater level with respect to the bottom of the tank each time a tank tightness test is conducted. Best results are obtained when the water table is below the tank. If the tank normally is above the water table and recent precipitation has altered that situation, consider delaying the test until the water table has dropped and this potential interference is removed. If at all possible, a test should not be conducted while the water table is fluctuating. If this situation cannot be avoided, such as in a tidal area, it should be understood that the test results will be less accurate and reliable.

c. Volumetric Methods. Tank tightness testing using volumetric methods should not be conducted through the fill pipe. Volumetric test methods record temperature at various points along the diameter of the tank and require precise measurements for the test to be valid. The fill pipe would mask the true temperatures of these various points along the tank diameter.

3-6. Equipment. Each commercially available leak detection method has two components: equipment and procedures. Both the equipment (physical devices, computer hardware, and instrumentation) and procedures (operator responsibilities, computer software, theoretical and analytical approaches) can vary from one method to another. This can result in variances in method performance for different leak rates and threshold values.

a. Temperature/Volume. The majority of tank tightness test requirements include equipment that measure the temperature and volume of the product in a tank, such as thermistors and height or volume sensors.

Some methods include arrays with multiple sensors that better represent actual conditions vertically within the tank.

b. Data Measurement. The more sophisticated measurement and data analysis equipment is often used to take frequent measurements that can be statistically analyzed and provide a good representation of actual conditions within the tank. This frequent measurement rate and the resulting statistical analyses are typically facilitated by computer equipment.

c. Additional Information. The reader is directed to manufacturers' literature for details about specific test methods. EPA/625/9-89/009, *Volumetric Tank Testing: An Overview*, is also recommended as a source of information about a number of different methods that were evaluated by the EPA.

3-7. Materials. Once a tank tightness test method has been selected, the operator will provide the necessary equipment, handling/transferring procedures, and training on material safety data sheets (MSDS) for the liquids to be used. The only material that is typically necessary is additional product to fill the tank.

To ensure an accurate test, use product identical in formulation to that which is already in the tank. The added product should also be approximately the same temperature as the product already in the tank to minimize volume expansion or contraction due to temperature variations. If temperatures are not identical, the required settling time prior to testing should be sufficient to allow the temperatures to equalize.

It should be noted that topping off tanks with product may be difficult. The Defense Fuel Supply Center that contracts for most of the Army's fuel has stated they will not contract to have the tanks topped off. Individuals responsible for performing the integrity testing will provide added fuel to top off the tanks to be tested.

3-8. Operations, Procedures, and Instructions. There are three steps involved in all tank tightness testing: preparation, testing, and analysis. Although operations, procedures, and instructions will vary for each commercial test method selected, the common elements of the methods are described. The procedures for a particular test must be strictly followed to assure the performance cited.

a. Preparation.

(1) The tank is first filled to the level required for testing with the same product at the same temperature as the tank contents. A waiting period follows to allow temperature variations, wave actions, and structural deformations to subside. If necessary, the tank is bled to reduce vapor pockets.

(2) The sensor instrumentation is inserted into the tank. In the case of overfilled tests, the tank is topped off by adding or removing small amounts of product to bring the product to the test level. A second waiting period is observed.

(3) Values are taken to determine the coefficient of thermal expansion and/or the height-to-volume conversion. The water-table level is also measured if it is in the vicinity of the tank and if there is a monitoring well.

b. Testing. The sensors inserted into the tank measure the temperature and the level (or volume) of the product in the tank over time. Often these two measurements are collected at the same rate. The instrument readings are recorded either electronically or manually. The test ends based on the data results. Often this is a function of time, but sometimes the decision to end the test is controlled by other measurements.

c. Analysis.

(1) Convert the level data to volume data and compensate for temperature changes using procedures defined by the manufacturer. Use these data to calculate a volumetric flow rate of leakage from the tank.

(2) Compare this calculated volumetric flow rate to the predetermined detection criterion for the test. If the calculated volumetric flow rate exceeds the detection criterion, a leak is suspected. If not, it is assumed that no leak is present.

3-9. Waste Disposal. Typically, no wastes are generated during integrity tightness testing. If any product is spilled as a result of the testing, it should be handled consistently with procedures outlined in Chapter 6.

3-10. Reporting and Documentation.

a. Reporting. Owners and operators of UST systems must report suspected releases based upon tank tightness test results to the implementing agency within 24 hours, or another reasonable time period specified by the implementing agency. This requirement is mandatory unless the monitoring device is found to be defective and is immediately repaired, recalibrated, or replaced, and subsequent monitoring does not confirm the initial result.

b. Documentation.

(1) All UST system owners and operators must maintain records demonstrating compliance with applicable regulations.

(2) The records must include the following:

(a) All written performance claims pertaining to any release detection system used, including the manner in which these claims have been justified or tested by the equipment manufacturer or installer. Claims must be maintained for 5 years, or for another reasonable period of time determined by the implementing agency, from the date of installation.

(b) The results of any sampling, testing, or monitoring must be maintained for at least 1 year, or for another reasonable period of time determined by the implementing agency. The results of tank tightness testing must be retained until the next test is conducted.

(c) Written documentation of all calibration, maintenance, and repair of release detection equipment permanently located onsite must be maintained for at least 1 year after the servicing work is completed, or for another reasonable time period determined by the implementing agency. Retain schedules of required calibration and maintenance provided by the release detection equipment manufacturer for 5 years from the date of installation.

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