United States Environmental Protection Agency
Office of Underground Storage Tanks

EPA

Standard Test Procedures For Evaluating Release Detection Methods: Pipeline Release Detection

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Acknowledgments

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List Of Acronyms And Abbreviations

ASTM International	American Society for Testing and Materials (ASTM) International
ATGS	automatic tank gauging system
B	bias
C	compressibility
°C	degree Celsius
CFR	Code of Federal Regulations
df	degrees of freedom
EPA	U.S. Environmental Protection Agency
°F	degree Fahrenheit
ft	foot/feet
gal	gallon
gal/hr	gallon per hour
hr	hour
in.	inch
LR	leak rate
min	minute
mL	milliliter
MSE	mean squared error
NWGLDE	National Work Group on Leak Detection Evaluations
OUST	Office of Underground Storage Tanks
%	percent
psi	pounds per square inch
P(d)	probability of detecting a leak
P(fa)	probability of false alarm
SD	standard deviation
Th	threshold
UST	underground storage tank
V	volume

Section 1: Introduction

1.1 Background

The federal underground storage tank (UST) regulation specifies performance standards for release detection methods. UST owners and operators must demonstrate the release detection method that they use meets the U.S. Environmental Protection Agency's (EPA) regulatory performance standards. This document provides test procedures for evaluating the release detection category pipeline release detection methods.

The pipeline release detection document is one of four main EPA standard test procedures for release detection methods. The test procedures present performance testing approaches to evaluate various release detection method categories according to the federal UST regulation in 40 CFR part 280, Subpart D. To provide context for the four test procedure documents, EPA developed *General Guidance Using EPA's Standard Test Procedures For Evaluating Release Detection Methods*. The general guidance provides an overview of the federal UST regulation, methods, and testing that may result in release detection methods listed as compliant with the regulatory performance standards. The general guidance is integral; it must be used with the test procedures.

The federal UST regulation specify performance standards for release detection methods used to test the integrity of the underground piping. Pipeline release detection requirements involve two types of tests:

- Catastrophic line leak detection. Pressurized underground piping must be equipped with an automatic line leak detector that will alert the operator to the presence of a 3 gallon per hour (gal/hr) at 10 pounds per square inch (psi) leak by restricting or shutting off the flow of product through the piping or by triggering an audible or visual alarm within one hour of detecting the leak.

- Periodic line leak detection – annually or monthly
    - Annual line tightness test or monthly line monitoring tests. The annual line tightness test must be capable of detecting a leak of 0.10 gal/hr (at a pressure 150 percent of the operating pressure of the line) with a probability of detection (P(d)) of 95 percent or greater and a probability of false alarm (P(fa)) of 5 percent or less.

    - Monthly line test methods are expected to detect leaks as small as 0.20 gal/hr (at the operating pressure of the line) with the same P(d) of 95 percent and P(fa) of 5 percent. The monthly monitoring requirement may also be met by one of three other qualitative methods of release detection: vapor monitoring, groundwater monitoring, or interstitial monitoring.

Note: Bulk piping associated with airport hydrant fuel distribution systems and field-constructed tanks have some alternative semiannual and annual test options, with the leak rate determined by the piping test section volume, but varying from 0.50 gal/hr to 3.0 gal/hr.

1.2 Objectives And Application

The objectives of the pipeline release detection test procedures are twofold: they provide standard test procedures for evaluating the performance of release detection methods in a consistent and objective manner, and they allow the regulated community and regulatory authorities to verify compliance with the federal UST regulation.

The methods addressed by these test procedures are associated with the piping, connections, manifolds, dispensers, etc., that make up the pipeline at an UST facility. Both pressurized and suction-piping release detection methods are included however, suction pipelines must be pressurized for the tests. The test procedures can be used to evaluate three types of pressurized pipeline leak detectors:

- Those that perform frequent tests for a large leak rate, such as hourly tests of the line and that claim to detect leak rates of 3 gal/hr defined at 10 psi with a P(d) of 0.95 and a P(fa) of 0.05

- Those that perform tests to identify low level leaks or that a system is tight, either with a monthly monitoring test with a claimed performance of 0.20 gal/hr or with a line tightness test--annually for pressurized piping or every 3 years for suction piping--with a claimed performance of 0.10 gal/hr with a P(d) of 0.95 and a P(fa) of 0.05

- Those that are designed to monitor bulk piping and claim the performance standards presented in Table 1.

Table 1. Maximum Detectable Leak Rate Per Test Section Volume

Test Section Volume* (gallons)	Semiannual Test Maximum Detectable Leak Rate** (gal/hr)	Annual Test Maximum Detectable Leak Rate** (gal/hr)
less than 50,000	1.0	0.5
≥ 50,000 to < 75,000	1.5	0.75
≥ 75,000 to < 100,000	2.0	1.0
≥ 100,000	3.0	1.5

* "Bulk piping" is greater than 50,000 gallons and associated with an airport hydrant fuel distribution systems and field-constructed tanks.

**If local regulations specify leak rates more stringent than those in the EPA regulation or the vendor desires to be evaluated under more stringent conditions, EPA-specified target rates can be substituted with different leak conditions associated with the more stringent target rate.

The test procedures evaluate whether a pipeline release detection method meets the EPA performance standards for release detection. All pipeline release detection methods will be evaluated for P(d) and P(fa) for the vendor-specified pipeline configuration. The evaluations are conducted under ambient test conditions, primarily product temperature, and at the leak rate at least as stringent as specified in the federal UST regulation. These test procedures can be used to evaluate common types of release detection methods, including those that measure pressure, volume, or flow-rate changes in the pipeline. The P(fa) will be estimated at the threshold used by the vendor, and the P(d) will be estimated at the leak rate specified in the federal UST regulations, or better.

The test procedures evaluate the performance of the hourly test, monthly monitoring test, and the annual line tightness test, under different simulated leak rates and times needed to conduct the tests. A 3-gal/hr leak is used in the evaluation of the hourly test and can be conducted in the shortest amount of time. For the monthly monitoring test, the P(d) will be estimated at a leak rate of approximately 0.20 gal/hr, while for the line tightness test the P(d) will be estimated at a leak rate of approximately 0.10 gal/hr or the appropriate bulk piping threshold. The procedures require that performance in terms of leak rate, P(d), and P(fa) be determined for the specified pipeline configuration and a wide range of product temperature conditions. In many cases, a method appropriate for the hourly test may not be appropriate for low leak rate detection associated with the other testing; these methods can be evaluated only for the hourly test against the vendor stated method capabilities. On the other hand, methods specific for low-level release detection may be evaluated for monthly monitoring and tightness testing only. However, any line leak detector that can address all applicable performance standards can be evaluated under the same range of environmental and pipeline-configuration conditions as the methods that conduct for hourly, monthly monitoring and line tightness tests. The test procedures require that the evaluator calculate and report both the P(fa) at the vendor-stated threshold and the P(d) for the appropriate leak rate specified in the federal UST regulation, or better. If it has proven performance, an automatic line leak detector used to satisfy the hourly test can also be used to satisfy the monthly monitoring test or the annual line tightness test.

Although safety is a consideration while conducting testing, these test procedures do not address the issue of safety specific to detection methods and their operating procedures, merely basic laboratory safety concerns and procedures. The vendor is responsible for conducting the testing necessary to ensure that the method is safe for operation with the type of product being tested.

Ultimately, the results of this evaluation can be used to prove that the method meets the requirements of 40 CFR Part 280, subject to the limitations listed on the EPA Standard Evaluation Form in Appendix B.

1.3 Evaluation And Approach Summary

Evaluators can use these test procedures to evaluate the performance of release detection methods used for testing pipelines associated with USTs for releases. The test procedures apply to release detection methods that are physically attached to the pipeline and that can relate the measured output quantity to a leak rate associated with the loss of product through a hole in a pipeline under pressure. Two release detection scenarios are addressed in these test procedures: the ability to detect a large release that occurs over a short time, and the ability to test for a small release over a long period.

In general, the test procedures call for using the pipeline release detection method on a tank system known to be tight and estimating the leak rate, both under the no leak condition and under induced leak conditions. The leak rate measured by the pipeline release detection method is compared to the induced leak rate for each test. To estimate the performance of the method, the differences are summarized and used with the normal probability model for the measurement errors. The results are applicable to release detection methods for both pressurized and suction piping.

These test procedures provide two approaches for generating the data necessary to evaluate pipeline release detection methods capabilities. The first approach is to conduct the evaluation at an instrumented test facility specifically designed to evaluate pipeline release detection methods, and the second is to perform it at one or more operational UST facilities that are specially instrumented to conduct the evaluation. Both options require that the data be collected under a specific set of product temperature differentials, which are measured as part of the test procedures, on a pipeline system that has defined characteristics. For small pipelines, up to 50,000-gallon capacity, the following temperature differentials will be tested: -10-degree Fahrenheit (°F), 0°F, and 10°F. For larger pipelines, greater than 50,000 gallons, the temperatures will be recorded as is, but will not require the temperature ranges specified for small pipes.

1.4 Organization Of This Document

The evaluation approach is presented in detail in the following sections of this document.

- Section 2 presents a brief discussion of safety issues.
- Section 3 describes the apparatus and materials needed to conduct the tests
- Section 4 presents step-by-step procedures
- Section 5 describes the data analysis and provides some interpretation of the results.
- Section 6 describes how the results are to be reported.
- Appendix A includes definitions for some technical terms
- Appendix B contains the forms for the data collection and reporting
  - Standard reporting forms for the evaluation results
  - Standard forms for describing the detection method, data reporting forms, and individual test logs.

Section 2: Safety

The vendor should test the pipeline release detection method equipment, determine the equipment is safe for the products it is designed for, and provide a safety protocol as part of its standard operating procedure. The protocol should specify requirements for safe installation and use of the method. In addition, all facilities hosting an evaluation of a pipeline release detection method should supply its safety policy and procedures to evaluating personnel on site. All safety requirements should be followed to ensure the safety of those performing the evaluation and those near the evaluation.

At a minimum, the following safety equipment should be available at the site:

- Two class ABC fire extinguishers;
- One eyewash portable station;
- Adequate quantity of spill absorbent; and
- Appropriate Safety signage such as "No Smoking" "Authorized Personnel Only" and "Keep Out".

Personnel working at the UST facility should wear safety glasses when working with product and wear steel-toed shoes when handling heavy pipes or covers. After the safety equipment has been placed at the site and before any work can begin, the area should be secured with appropriate signage.

All safety procedures appropriate for the product in the tanks should be followed, as well as, any safety procedures required for a test equipment.

These test procedures only address the issue of the method's ability to detect leaks. It does not address testing the release detection method for safety hazards. The vendor should arrange for testing for construction standards to ensure that key safety hazards such as intrinsic safety, product compatibility, fire, and shock are addressed. The evaluator should ensure that safety testing has been completed before the equipment is used for performance testing to ensure that the test operation will be as safe as possible.

Section 3: Apparatus And Materials

3.1 Pipeline Release Detection Method

The vendor will supply the equipment for each pipeline release detection method. In general, other than automatic line leak detectors, a pipeline release detection method will consist of some system to: monitor product volume; compensate for temperature; and measure the pressure, volume, or flow-rate changes in the pipeline. It will also typically include instrumentation for collecting and recording the data, as well as procedures for using the data to calculate a leak rate and interpret the results as pass or fail for the piping system.

When pipeline release detection methods are installed permanently and left for the UST owner and operator to operate, the evaluator should receive specialized training and demonstrate understanding of its proper operation. When the methods are not permanent, it is acceptable for the vendor or a vendor representative to operate the equipment during testing.

3.2 Pipelines

Pipelines constructed at special instrumented test facilities for testing should simulate the important features of the type of pipeline systems found at UST facilities. The test procedures assume that the release detection method to be evaluated may be used on an underground piping system with one or more USTs, where the diameter of the piping is at least 2 inches (in.) or be comprised of varying diameters, and the length is at least 200 feet (ft). Whether the evaluation is conducted at a special instrumented testing facility or at operational UST facility, the minimum requirements are as follows:

- The pipeline, constructed of commercially available materials, such as fiberglass, steel, flex piping and/or semi-rigid piping, must have a diameter of, or comprised of varying diameters, at least 2 in. ± 0.5 in.
- The pipeline must be at least 200 ft long.
- The pipeline system must have a known compressibility (C).
- A mechanical line leak detector must be present within the line if the release detection method being evaluated normally conducts tests with this device in place.
- There must be a way to pressurize the pipeline system.
- There must be a tank or storage container to hold product withdrawn from the line during a test.
- There must be a pump to circulate product from the storage container through the pipeline. At most test facilities, this container may be an UST using a submersible pump to pressurize the pipeline and circulate the product.
- The pipeline must have valves that can be used to isolate the piping from other system components, such as the UST and the dispenser. These valves must be checked for tightness under the maximum operating pressure of the pipeline system.
- The pipeline must contain a petroleum product during the evaluation.
- There must be a unit to heat or cool the product in the storage container when an evaluation is conducted at a special test facility.

The performance of some of the methods evaluated with these test procedures may decrease as the diameter or length of the pipeline increases. This is particularly true for volumetric measurement methods that are directly affected by thermal expansion or contraction of the product in the pipeline. The performance estimate generated by these test procedures is considered valid for systems with no less than half of the ratio of the C to the volume of the product (V) in the pipeline during the evaluation (C/V). This is an arbitrary limitation; it does not consider the type of system, the method of temperature compensation, or the performance of the method. It allows flexibility in the application of the method. Thus, in selecting the length of the pipeline to be used in the evaluation, the evaluator and vendor should consider how the method will be used operationally. The test procedures also allow the vendor to present a separate written justification indicating why pipelines with capacities larger than this limitation of the evaluation pipeline should be permitted. The evaluator must concur with this justification. The evaluation report must contain both the written justification and evaluator's concurrence.

3.3 Product

The most common products in USTs today are motor fuels, particularly non-alcohol blended gasoline, alcohol-blended gasoline, diesel, and biodiesel fuels. These test procedures are designed primarily to evaluate these currently widely marketed products.

Any commercial petroleum product of grade number 2 or lighter may be used for testing, depending on the availability and restrictions of the test tanks. The vendor decides which product used during testing assures that it is capable of being used with the method equipment. Evaluating the method with a specific product verifies its performance with that product. Products with similar physical and chemical characteristics may be used and results may, in some instances, be inferred to represent typical responses. The evaluator must justify the extent of applicability of results to other products. However, alcohol-based fuels and bio-blended fuels are appreciably dissimilar to petroleum-based fuels and the evaluation must specifically test petroleum-based fuels, in addition to using a representative alcohol-based or bio-blended fuel product, under reasonable conditions likely encountered in the field.

It may not be possible to find a fully representative alcohol-based or bio-blended fuel product. Ethanol-based fuels, for example, are available in varying concentrations of ethanol content, ranging from about 10 percent to 85 percent. Each concentration might affect functionality of a release detection method differently. The evaluator will need to decide whether testing of several blends of an alcohol-based or bio-blended fuel is needed in order to verify full performance by a method.

Given the variability of the proportion of bio-components in fuels, the true proportion of ethanol or biodiesel to fuel should be determined analytically during performance testing of a method and reported with the test results. This characterization of the product is very important so that users of the evaluation results know with certainty what levels of bio-component were present during testing. The ASTM International standard methods presented below, or another national voluntary consensus code, will be used to analyze an aliquot of the fuel for the biofuel content. Table 2 specifies the methods that may be used for bio-component analysis by fuel.

Table 2. Analytical Methods for Bio-Component Determination

Method Designation	Method Title	Fuel Product
ASTM D7371	Determination of Biodiesel (Fatty Acid Methyl Esters) Content in Diesel Fuel Oil Using Near Infrared Spectroscopy	Biodiesel
ASTM D4815	Standard Test Method for Determination of MTBE, ETBE, TAME, DIPE, tertiary-Amyl Alcohol and C1 to C4 Alcohols in Gasoline by Gas Chromatography	Alcohol blend up to 20%
ASTM D5501	Standard Test Method for Determination of Ethanol and Methanol Content in Fuels Containing Greater than 20% Ethanol by Gas Chromatography	Alcohol blend over 20%

3.4 Equipment For Generating Test Conditions

During an evaluation of a pipeline leak detection method, the following conditions must be generated: line pressure, which influences the leak rate; the leak itself; the compressibility of the line; the temperature of the product in the line; and the amount of vapor trapped in the line. One or more of the following pieces of equipment may be required to produce the test conditions: a pressure sensor; a leak simulator; a mechanical device to modify the compressibility of the pipeline system; product and ground temperature sensors; and an apparatus to trap vapor in the pipeline system. The following measurements are required:

- Measure line pressure during the test with a precision of 0.5 psi and an accuracy of 1 psi or better;
- Measure the flow rate due to a leak in the line at a specified pressure with an accuracy of 0.01 gal/h;
- Measure the C of the pipeline system with a precision and accuracy such that C/V_o is known within 0.025 psi/gal, where V_o is the volume of the product in the pipeline;
- Measure the difference in temperature between the ground and the product at the bottom of the tank (which is brought into the pipeline to produce a temperature condition) with an accuracy of 0.2°F; and
- Measure the total volume of product in the line to within 1 gallon.

No specific brand name equipment is required. The test procedures require only that the measurements be made within the specified range of precision and accuracy, and under the specified range of conditions.

3.4.1 Line Pressure

A pressure sensor is necessary to determine the pressure in the line during each test and to set a leak rate. A mechanical gauge or an electromechanical transducer and automatic data acquisition system can be used to measure pressure. A calibrated mechanical gauge is acceptable.

To measure pressure, any mechanical pressure gauge that can be read manually to the nearest 0.5 psi and has an accuracy of 1 psi can be used. To measure pressure automatically, a pressure transducer that has a precision and accuracy of 0.5 and 1 psi, respectively, can be used. Even if pressure is automatically recorded, it is recommended that a mechanical pressure gauge be inserted in the line to help conduct and control the experimental measurements. The pressure sensor can be attached at any point on the pipeline.

These pressure sensors should be calibrated before the evaluation, or more frequently, if required. Calibration can be done by applying a known pressure to the system and recording the output of the sensor. A mercury manometer can be used for this purpose. Obtain calibration data in increments of 5 psi or less; at least five points are required. A calibration curve is generated by fitting a regression line to the pressure measured by the sensor being calibrated (y-axis) and the known pressure from the reference source (x-axis). The precision of the sensor is estimated from the standard deviation of the ordinate (y coordinate). The accuracy is determined from the y-intercept of the curve of the leak rate. Convert the output of the sensor to pressure units (for example, volts to psi) using the calibration curve; if the sensor output is already in units of pressure, the calibration curve will correct any measurement errors that the sensor may have developed since its original calibration by the vendor.

If pressure measurements are recorded digitally by a computer, it is important that the instrument clocks be synchronized to the nearest second, and the start and end times of all required pressure measurements be recorded. If the pressure measurements are made with a mechanical or electrical gauge, the tester should read pressures and record the time of the reading.

3.4.2 Leak Simulation

The leak simulation equipment must be capable of being used with the release detection method being tested. The equipment must allow for the removal of product from the pipe, measuring the amount of product removed and the time of collection, then calculating the resulting induced leak rate. The nominal leak rates to be induced are presented in Tables 1 and Table 3.

Since the pipeline is under pressure, a port and valve must be present to let the product flow out under its own pressure. The flow is directed through a rotameter to set the initial flow at the desired rate, then to simulate leak behavior, the initial rate can drop as the pressure drops on the piping.

A leak can be generated at any location in the line. It is easier to withdraw product at either end of the line, either near the submersible pump and mechanical line leak detector or at the shear valve near the dispenser. However, the shear valve near the dispenser tends to be the easiest location to generate and measure the leak. The standard pressure for defining a leak rate for all pipeline release detection methods is 20 psi, except for hourly testing methods, in which the federal UST regulation established a specific pressure of 10 psi, or, 3 gal/hr, as the standard for defining the leak to be detected. Therefore, all values of leak rate will be established at 10 psi for the hourly testing methods designed to meet the 3 gal/hr EPA standard and at 20 psi for all other methods designed to meet the 0.20 gal/hr monthly monitoring or 1.5 times operating pressure for 0.10 gal/hr line tightness testing standards or bulk methods. For suction lines, the minimum pressure for the evaluation must be 15 psi. When using a leak simulator, the evaluator sets a leak rate by adjusting the size of an orifice, usually by means of an adjustable valve. Once the rate of the leak through the valve or orifice has been set at 10, 15, or 20 psi, depending on whether the method uses an hourly test, any other pressure can be used during the evaluation if the size of the orifice does not change. The vendor stipulates an initial test pressure for any method being evaluated. The leak rate should be measured at this initial pressure in addition to the minimum pressure.

A mathematical relationship can be used to find the appropriate leak rate for the given pressure if it is not possible to establish the leak rate at 10 or 20 psi. This mathematical relationship can determine the equivalent leak rate at the test pressure so that the EPA-specified leak rate is properly defined at 10 or 20 psi. If it is possible to test the line release detection method at the relevant pressure, 10 psi for 3 gal/hr; operating pressure for 0.20 gal/hr; 1.5 times operating pressure for 0.10 gal/hr or bulk method thresholds, this testing should be done directly.

The mathematical relationship required to convert a leak rate generated at the test pressure to 20 psi depends on whether the flow is laminar or turbulent, which in turn depends on the density and viscosity of the product, the diameter of the hole, and the length and roughness characteristics of the leak simulator itself. The relationship describing the flow through a hole in an in-situ pipeline is even more complicated because the surrounding backfill and any residual sediment in the product will also affect the flow rate. For laminar flow, where product moves smoothly, the flow rate for free flow through an orifice is proportional to the pressure at the orifice; for turbulent flow, where product flow undergoes irregular fluctuations in movement, the flow rate is proportional to the square root of pressure. Prior to testing, the evaluator should measure the flow to determine if it is laminar or turbulent. The equations below present relationships that can be used to convert the leak rate at the test pressure to the leak rate at 20 psi for turbulent and laminar flow. These equations can be used to convert leak rate (LR) measured in psi at one pressure to a leak rate, $LR_{20\ psi}$, at a pressure of 20 psi. These two equations should set the end points of the actual relationship for the pipeline, leak simulator and product.

$$LR_{20psi} = LR\,(20/P)^{0.5} \text{ for turbulent flow}$$

$$LR_{20psi} = LR\,(20/P) \text{ for laminar flow}$$

This mathematical relationship must be developed empirically for the pipeline, product, and the leak simulator used in the evaluation. This can be done by setting the preferred leak rate at 10 or 20 psi and then measuring the flow rate through the same orifice at the test pressure; these procedures should be repeated three times to obtain a mean value. Once completed, the leak rate measured at the test pressure can be used during the evaluation. It is important to note that this leak rate will be different from, but equivalent to, the leak rate measured at 10, 15, or 20 psi.

To generate the leak described above, the following equipment should be used: a leak simulator that allows a constant flow of product from a pipeline, graduated cylinders, a stopwatch, a pressure sensor, and a one-gallon storage container that can safely handle petroleum fuels. Figure 1 illustrates the important features of an apparatus that can generate a leak. A mechanical system must have three valves and able to be attached and detached from the line. Valve A, located between the line and the metered valve, is used to open and close the line. Valve B is a metered valve used to set the leak rate and release product from the line. This valve should have a dial mechanism to adjust and maintain a constant flow rate. Valve C is used to release a larger volume of product from the line. A leak can be generated at a given line pressure by first pressurizing the line, then opening valve A and adjusting valve B until the desired leak rate is obtained.

While the rate leak is being measured, the line must be kept at a constant pressure. Typically, this would be the operating pressure of the pipeline during dispensing of product. Once the initial flow rate is set to simulate leak behavior, the initial rate can drop as the pressure drops on the piping.

Making this measurement requires several graduated cylinders, preferably 10 milliliters (mL), 25 mL, 100 mL, and 250 mL in size. At least one graduated cylinder of each size should be available. For safety reasons, graduated cylinders should not be used to store product; a proper storage container should be used to hold product removed from the pipeline during the tests. The procedures for generating a leak are as follows:

- Bring the line to the pressure required for testing.
- Open valve A and adjust valve B until the desired leak rate is obtained. Then close valve A until it is time to generate a leak in the line. Open valve A to generate the leak.
- Using a graduated cylinder and a stopwatch, measure the volume of product released from the line until valve A is closed.
- Repeat the leak rate measurement twice and use the mean of the three leak rate estimates if the difference between the minimum and maximum values is less than 0.0 2 gal/h.
- Make additional measurements if the difference between the minimum and maximum values exceed 0.02 gal/h, and use only the last three consecutive measurements to make the calculation.
- Keep the pressure constant to within ±1 psi during the measurements.

Each time valve B, is adjusted, the leak rate should be measured. If testing is done over a period of one hour or longer at one set leak rate, then the leak rate should be checked. When the test exceeds one hour, leak rate measurements should be made at the beginning and end of the test period and that the average leak rate be reported.

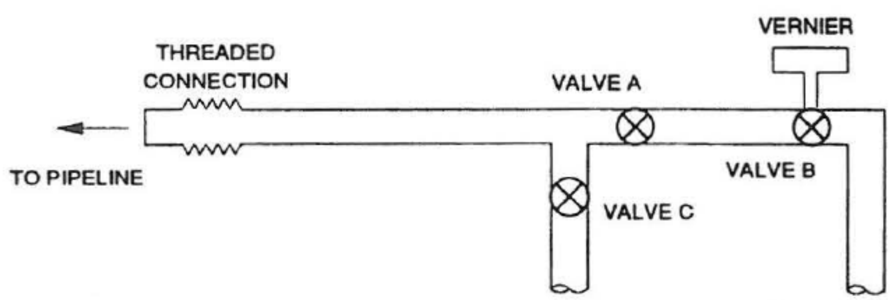


Figure 1. Schematic Diagram Of An Apparatus To Generate Small And Large Leaks In The Pipeline

3.4.3 Pipeline Compressibility

Pipeline compressibility (C) is a characteristic that varies widely among systems and does not need to be controlled for during testing; however, it is important to know under what conditions testing takes place. Therefore, the compressibility characteristics of the pipeline system used in the evaluation must be determined and reported. C is characterized by the compressibility of the pipeline system, which is estimated with a simple measurement procedure using a pressure sensor, either mechanical or electrical; a leak simulator; a stopwatch; and a graduated cylinder.

The device shown in Figure 2 consists of a liquid-tight piston installed in a cylinder. Liquid from the pipeline enters the chamber in front of the piston. When placed under pressure, the liquid in the pipeline will apply a force on the face of the piston; the springs attached to the back of the piston resist this force. This device will affect the compressibility of the pipeline system. The magnitude of its effect depends on the spring constant.

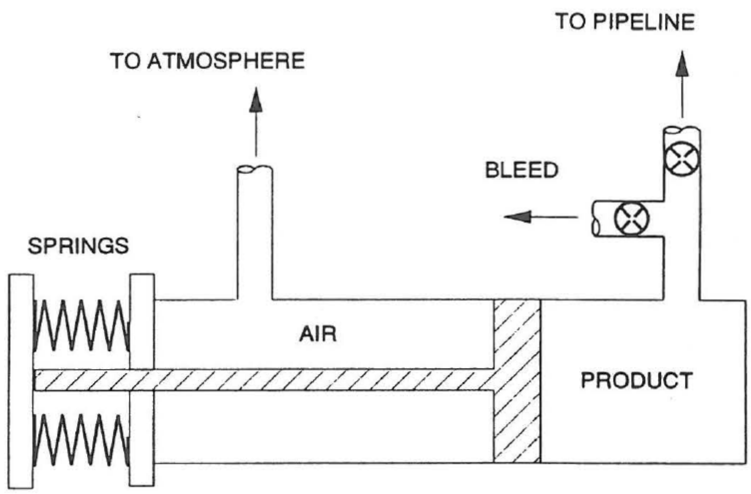


Figure 2. Mechanical Device To Modify The Compressibility Characteristics Of The Pipeline System

To measure the pipeline C, drain the product from a line initially raised to operating pressure, and then measure simultaneously the cumulative volume of product released from the line and the pressure in the line at the time of the volume measurement. The procedure includes the compressibility effects of any vapor trapped in the line. If no vapor is trapped in the pipeline, the pressure y-axis, should be linearly related to the volume of product in the line (V_o) (x-axis). The slope of a regression line fit to these data gives an estimate of C/V_o; C can be estimated directly from the volume of the product in the line.

The value of C will depend on when and how the test pressure in the line is established. If the pressure is raised or lowered suddenly, as typically happens when the submersible pump is turned on, the pressure changes in the line will be adiabatic. If a test is conducted immediately after the pressure has been raised suddenly and if the duration of the test is short, less than 5 min, C will be nearly adiabatic. If the test is long, about 1 hour, or if the pressure is kept constant for 15 min before beginning a test, C will not be adiabatic and will have a different value.

Mechanical pressure gauges are best used to measure pressure, since they eliminate the time registration problems that are encountered if volume measurements are made manually and if pressure measurements are made with an electrical pressure transducer and a digital acquisition system. For a given thermodynamic regime, the value of C or C/V_o should not change as a function of leak rate, so any convenient leak rate can be used in performing the calibration. C can vary with temperature, so until the temperature changes in the pipeline are less than 0.01°C, these measurements should not be made. In general, an 8- to 12-hour waiting period will ensure that the temperature changes are small. The selected leak rate should be as large as possible while still allowing pressure measurements to be made to within 1 psi and volume measurements to be made to within 1 mL. In most pipelines, the total volume of product that will be drained as the pressure drops from 20 psi to near 0 psi ranges from 20 to 200 mL.

The pressure-volume measurements can be difficult to make from an operational standpoint if the leak rate is too large. In general, it takes two people to measure if pressure measurements are made with a mechanical gauge and the cumulative volume of released product is read in a graduated cylinder. The best way to make this measurement is to read the pressure in predetermined intervals of 5 or 10 mL as the graduated cylinder is filling up with product that is draining from the line. For most pipelines, accurate measurements are possible if the leak-making apparatus is set to allow a flow rate of between 0.20 and 0.50 gal/hr at the test pressure; the exact flow rate of the leak is unimportant and does not need to be measured. The data collection should take less than 2 minutes; if the test is completed in less than 2 minutes, the value of C should be nearly equal to the value of C for an adiabatic process. At least 5 pairs of pressure-volume data points should be collected so that the slope of the line can be accurately determined. Three measurements of C/V_o should be made and the mean value should be reported. The differences between the mean value and the minimum and maximum values should be less than 10 percent.

To estimate the volume of the product in the pipeline, the diameter and length of the pipe and fittings need to be known. The volume of the product in the pipeline should be known to within 1 gallon, or the amount of product contained in a 6-ft length of 2-in. diameter pipe, or 10 percent of the total volume in the line.

3.4.4 Product Temperature

Measuring the rate of change of temperature of the product inside a pipeline is difficult, since it requires an array of temperature sensors capable of measuring the rate of change of temperature to 0.2°F. Two to three uniformly spaced sensors are required for each 10 gal of product in the line, a 100 ft, 2 in. diameter line would require approximately six temperature sensors. Even if such an array measured the product temperature accurately, there is no guarantee of standardized evaluation conditions. The temperature of the product in the pipeline changes exponentially over time and the rate of change depends on the heat transfer properties of the pipeline and the backfill and soil, the temperature of the product in the pipeline, and the temperature distribution in the backfill and soil at the start of the test. As product is dispensed through the pipeline, the temperature distribution in the surrounding backfill and soil changes. The temperature of the backfill and soil immediately surrounding the pipeline may be very different from the temperature of the soil some distance away. The degree of difference depends on how often product was dispensed prior to the test and how long it has been since the last dispensing of product through the pipeline. Therefore, the actual rate of change of temperature of product in the pipeline during two release detection tests can be different, even though the temperature difference between the product in the tank and the temperature of the backfill or soil located far away from the pipeline is the same.

A release detection method whose protocol includes a waiting period between the last dispensing of product and the beginning of a test will always experience more benign temperature conditions than a method whose protocol does not require a waiting period. Simply comparing the temperature difference between product at the bottom of the tank and product in the pipeline, or the ground temperature at the same depth as the pipeline but not adjacent to it, is not sufficient, because this difference does not accurately account for the distribution of temperature in the backfill and soil.

When there is no dispensing of product through the line, the initial rate of change of temperature is great, but the temperature of the product in the pipeline approaches the temperature of the ground more quickly. This, however, is not typical of what occurs at an operational facility. Calculations with a mathematical model show that the rate of change of the product's temperature is similar regardless of whether product is through the line for 1 hour or for 16 hours. However, when product has been flowing through the line for only several minutes, the rate of change is quite different.

It is important to ensure that all evaluations of pipeline release detection methods are conducted under similar conditions, particularly temperature. Four temperature sensors with a precision and a relative accuracy of 0.2°F are required. The relative accuracy can be determined by calibrating all four temperature sensors together in the same temperature bath so that each is referenced to the same temperature. You should be able to measure and account for differences in sensor readings.

As shown in Figure 3, position the three sensors in the ground somewhere near the midpoint of a 2 in. diameter pipeline and located 2, 4, and 12 inches away from the outside edge of the pipeline. The most distant temperature sensor is intended to measure the ground temperature at a location that is not significantly influenced by the product in the pipeline. If the temperature sensors are too close to the dispensing end of the pipeline, their readings could be influenced by ambient air temperature or convective mixing from product in the vertical extension of the pipe leading into the dispenser. Therefore, the sensor array should be located at least 5 feet into the line from either the dispenser or the tank. This may not be possible at an operational UST facility. If there are multiple pipes in the backfill, it is preferable to use only the outer pipe. The fourth sensor should be in the tank, approximately 4 inches from the bottom, or in whatever container is used to store the product pumped into the pipeline during a test. This provides an estimate of the temperature of the product that is pumped from the tank into the pipeline.

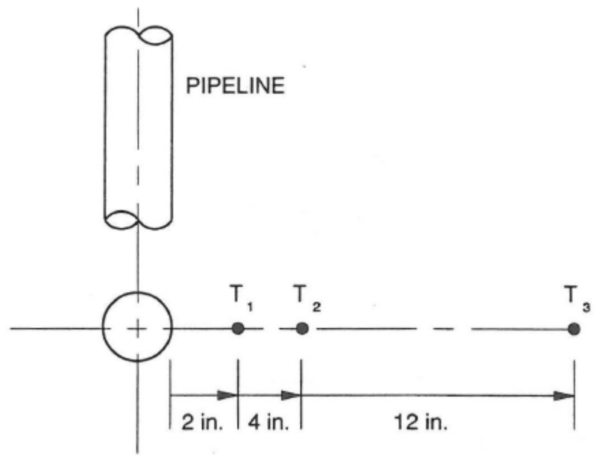


Figure 3. Geometry Of The Temperature Measurements To Be Made In The Backfill And Soil Surrounding An Underground Pipeline

The temperature sensors should be calibrated before the evaluation, or more frequently, if required by the evaluator. Calibrate the sensors by inserting the temperature sensors in a water bath that is continuously mixed and simultaneously recording the output of these sensors and a reference sensor. The precision of the reference sensor should be 0.02°F. The accuracy of the reference sensor need only be good to the nearest 1°F. Measure calibration data in increments of 5 to 10°F or less over the range of ground and product temperatures expected during the evaluation; a calibration starting at 35°F and ending at 90°F is sufficient. At least five points are required to complete the calibration. A calibration curve is generated by fitting a regression line to the temperature measured by each sensor being calibrated, the y-axis, and the temperature of the water bath from the reference sensor, the x-axis. The precision of each temperature sensor is estimated from the standard deviation of the ordinate, the y-coordinate). Estimate the accuracy of each temperature sensor from the intercept of the curve, or the y-intercept. It is not essential to know the absolute accuracy of each sensor, but rather that each temperature sensor measure the same value. The relative accuracy is determined from the standard deviation of the intercepts of each calibration curve or from the standard deviation of a given temperature calculated from each calibration curve.

During a test, it is necessary to characterize the temperature conditions in the pipeline. The procedure used to characterize the temperature conditions varies slightly depending on the testing environment, which could be either a specialized test facility or one or more operational UST facilities. Temperature is controlled on systems with less than 50,000 gallons volume, but due to technical difficulties, may not be controlled when testing bulk piping at or greater than 50,000 gallons. When temperature conditions are generated at a test facility, product is taken from the bottom of the tank, pumped into the line, and circulated continuously through the pipeline until twice the volume of the pipe has been circulated. This serves three purposes:

- Produces a difference in temperature between the product in the pipeline and the surrounding backfill and soil
- Produces a temperature distribution in the surrounding backfill and soil that is similar to that produced by dispensing product at operational UST facilities

- Produces repetitive temperature conditions from test to test

The end of the circulation marks the start of a release detection test or an initial waiting period.

At an operational UST facility, a release detection test should be initiated at the end of the day, immediately after dispensing operations have ceased. Before a test begins, the entire contents of the line must be flushed for 5 minutes with product from the bottom of the tank to produce the temperature condition. The end of the flushing marks the start of a release detection test or an initial waiting period.

Model calculations suggest that the rate of change in temperature of the product in the pipeline depends on the temperature distribution of the backfill and soil immediately around the pipeline even though the difference in temperature between the product in the pipeline and the soil that is thermally undisturbed by the pipeline is the same. A temperature condition could be produced by circulating product through the pipeline for 5 minutes, and then start the test; however, to ensure repetitive conditions, you should wait 8 hours after the test before producing another temperature condition.

The temperature condition for a particular test is calculated from the following equation

$$\Delta T = T_{TB} - T_G$$

where

ΔT	=	difference between the temperature of the product at the bottom of the tank and a weighted average of the temperature of the ground surrounding the pipeline
T_{TB}	=	temperature of the product 4 inches from the bottom of the tank or the temperature of the product to be circulated through the pipeline
T_G	=	$[((T_1/3) + (2T_2/3))/3] + [2T_3/3]$ = weighted average of the temperature of the ground surrounding the pipeline
T_1, T_2, T_3	=	temperature of the backfill or soil measured 2, 4, and 12 inches from the outer wall of the pipeline

This equation accounts for the insulating effect of the ground around the pipeline and the effect of the temperature of the undisturbed ground.

Again, for bulk piping methods (greater than 50,000 gallons volume), temperature variations do not need to be tested.

3.4.5 Trapped Vapor

The pipeline used in the evaluation should be free of any trapped vapor. The sensitivity of the release detection method to vapor is assessed by trapping a known volume of vapor in the pipeline and conducting one or more release detection tests.

Figure 4 shows how a vapor pocket apparatus is used to trap vapor in a pipeline. This apparatus can be constructed from commercially available materials and contains a tube that has a volume of approximately 500 mL. The tube is capped at the top and bottom and has two valves that open and close manually. The volume of vapor to be trapped in the line nominally depends on the length of the tube and the apparatus must be airtight. If no bubbles are observed before use, when the apparatus is under pressure and sprayed with a soapy water solution at all joints, it is considered airtight.

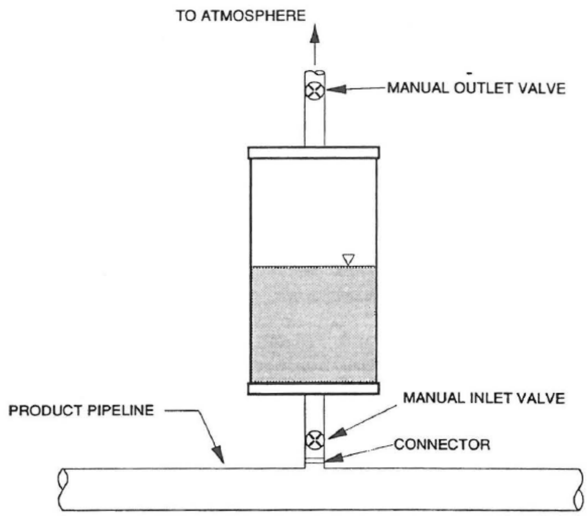


Figure 4. Vapor Pocket Apparatus For Trapping Vapor In A Pipeline System

To measure the volume of the vapor pocket apparatus, submerge the apparatus, fill it with water, and then close both valves. After removing any excess water from the inlet or outlet tubes, measure the volume of the water in the apparatus by emptying it into a graduated cylinder and taking a reading of the level to the nearest 1 mL.

The insulated vapor pocket apparatus can be attached to any part of the pipeline while both the inlet and outlet valves are closed. Once the apparatus is attached to the line, open the outlet valve to release any residual air that may have been trapped. The outlet valve is then closed and the inlet valve is opened to allow product from the pipeline to enter the container and pressurize it. When the inlet valve is open, a known volume of vapor is trapped in the line. The volume of trapped vapor will depend on line pressure.

The presence of trapped vapor in a pipeline can be identified from the pressure-volume data collected for estimating the compressibility of the pipeline system. Curvature of the regression line suggests the presence of trapped vapor. Since the volume at zero pressure is known, if the pressure-volume relationship for vapor is known, the volume of the trapped vapor in the apparatus can be estimated. The volume of vapor trapped in the apparatus can be estimated from the following equation of state for a gas:

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

where P_1 and V_1 are the absolute pressure and volume of the vapor in the line at one temperature (T_1), P_2 and V_2 are the absolute pressure and volume of the vapor in the line at a second temperature (T_2). Note that the temperature values in this equation must be on an absolute scale (in Kelvin).

This relationship cannot be easily used if a mechanical line leak detector is present in the line because of the discontinuity in the pressure-volume curve exhibited in the absence of any vapor.

3.5 Miscellaneous Equipment

In addition to the equipment mentioned above, containers will be necessary to hold the product collected from the induced leaks. A variety of tools are needed to make the necessary equipment connections.

The test procedures require cycling of product under pressure through the pipelines at different temperatures. One or more submersible turbine pumps of large capacity will be required to accomplish this in a reasonable amount of time.

Section 4: Test Procedure

The overall performance of a pipeline release detection method is estimated by a comparison of the method's results to actual induced leaks. Some release detection methods measure an output quantity and compare it to a predetermined threshold to assess whether the pipeline is leaking. The pipeline is declared tight if the measured quantity is less than the threshold. Otherwise, the pipeline is either declared leaking or another test is conducted to confirm or refute the first result. Other methods use a preset threshold switch that activates only if the changes in the line are large enough and no quantity is reported. The test procedures for evaluating both quantitative and qualitative methods are described in Section 4.1. The differences in estimating and interpreting the performance of these two types of methods in terms of P(d) and P(fa) are presented in Section 5.

4.1 Pipeline Release Detection Method Evaluation

Before performing evaluation tests with a leak detection method, it is necessary to ensure that the method is correctly installed and properly calibrated according to the vendor's procedures. These procedures may be conducted under two main testing environments:

- A specialized test facility
- One or more operational retail UST facilities.

These procedures are most easily implemented at a test facility where the integrity of the pipeline system is known and a range of environmental conditions can be generated and monitored quantitatively. The other environment for testing is at one or more operational UST facilities where the systems are known to be tight, though some monitoring instrumentation will need to be installed. The data for these two options are to be collected on the respective forms as presented in Appendix B.

The test setup can be determined following the detailed steps below.

Step 1: **Setup.** Install the pipeline release detection method following the vendor's instructions. Assemble and install the required equipment and diagnostic instrumentation including: the leak simulator, pressure sensor, a minimum of four temperature sensors, a pipeline compressibility device, the vapor pocket apparatus, graduated cylinders, and a stopwatch.

Step 2: **Trial run.** The pipeline system used in the evaluation must be tight. Before the evaluation begins, the line should be tested with a release detection method that has a known performance. If operational UST facilities are used, the integrity of the lines must be verified before each test.

Step 3: **Measure the pipeline compressibility characteristics.** Measurements for calculating C/V_o should be made when the temperature changes are small, less than 0.02°F over the duration of the measurement period. The release detection method should not be physically present in the line if it affects the magnitude of

C/V_o. Unless temperature sensors such as thermistors are used to measure temperature in the line, measurements for C/V_o cannot be made until the pressure in the line stays within 1 psi over a period equal to the average duration of a C/V_o measurement, or approximately 2 min. Three estimates of C/V_o must be made and the mean value reported.

Step 4: **Select leak rates, temperature, and pressure conditions according to types of tests the method performed: hourly tests, monthly monitoring testing or line tightness testing.** Following a trial run in the tight piping, perform a minimum of 24 tests using one fuel product according to the type of testing evaluated as presented in Tables 1 and 3, see pages 2 and 21, respectively. Four nominal leak rates will be induced during the testing and will be assigned randomly to the four leak rates LR_1 to LR_4. It is also possible to run three additional tests as a performance demonstration with vapor trapped in the line. If this option is chosen, the minimum number of release detection tests is 27.

Leak Rates. Table 1 presents the leak rates for bulk piping. Table 3 presents the nominal leak rates that may be induced depending on the type of test. More stringent target leak rates may be used if local regulatory authorities specify it or if a vendor would like to be evaluated using lower leak rates.

Temperature Differentials. Use three nominal temperature differentials between the temperature of added product and the temperature of the product in the system during each test. These three temperature differentials are -10°, 0°, and +10°F (-5.6°, 0°, and +5.6°C). The product should cycle through the length of the piping twice before beginning the next test. The duration of this cycle is dependent on the volume of the piping and the rate of pumping. This is not required for bulk piping method evaluations.

Step 5: **Randomize the test conditions.** For quantitative methods, perform a base of 24 tests by inducing the 12 combinations of the four leak rates, LR_1, LR_2, LR_3, and LR_4, and the three temperature differentials, T_1, T_2, and T_3, replicated twice as outlined in Table 4. For qualitative methods, perform 42 tests by inducing the four chosen leak rates, where three rates could be all equal, and the three temperature differentials as outlined in Table 5. The 42 tests are arranged in 21 sets of two tests each. Table 5 shows a possible ordering of the 21 sets. The evaluator should randomly rearrange the order of the sets so that the leak rates are blind to the vendor.

Table 3. Nominal Leak Rates For The Type Of Testing Being Evaluated

Type of Test (EPA Target Rate*)	Leak Conditions	Pipeline Pressure (psi)**	Nominal Leak Rates in English units (gal/hr)	Nominal Leak Rates in Metric units (mL/minute)
Hourly Test (3 gal/hr)	No leak Target leak rate	10 psi	0.00 3.0***	0.00 189.00
Monthly Testing (0.2 gal/hr)	No leak Half of target rate Target leak rate Double target rate	20 psi	0.00 0.10 0.20 0.40	0.00 6.30 12.6 25.2
Tightness Testing (0.1 gal/hr)	No leak Half of target rate Target leak rate Double target rate	1.5 times the operating psi	0.00 0.05 0.10 0.20	0.00 3.20 6.30 12.6

* If local regulations specify leak rates more stringent than those in the EPA regulation or the vendor desires to be evaluated under more stringent conditions, EPA-specified target rates can be substituted with different leak conditions associated with the more stringent target rate.

** When testing a suction system, minimum pressure must be at 15 psi.

***The second, third, and fourth leak rates may all be equal or may follow leak conditions for the other tests.

The randomization of the tests is achieved by randomly assigning the nominal leak rates in Tables 1 and 3 gal/hr to LR_1, LR_2, LR_3, and LR_4 and by randomly assigning the nominal temperature differentials of 0°, -10°, and +10°F to T_1, T_2, and T_3, following the sequence of tests as shown in Tables 4 and 5 for quantitative and qualitative methods, respectively. The evaluator is responsible for randomly assigning the four leak rates to LR_1, LR_2, LR_3, and LR_4 and the three temperature conditions to T_1, T_2, and T_3. In addition, the evaluator will randomly assign the groups to a set number, without disturbing the order of the tests within a set. The randomization balances any unusual conditions and ensures that the vendor does not have prior knowledge of the sequence of leak rates and conditions to be used.

Notational Conventions. The nominal leak rates from Tables 1 and 3, after randomizing the order, are denoted by LR_1, LR_2, LR_3, and LR_4. These leak rates cannot be achieved exactly in the field; rather, these numbers are targets that should be achieved within ±30 percent.

The leak rates induced for each of the tests will be measured during each test. They will be denoted by S_1, S_2, ... S_n. The leak rates obtained by the pipeline release detection method will be compared against these leak rates.
The leak rates measured by the release detection method during each of the tests will be denoted by L_1, L_2, …, L_{24} and correspond to the induced leak rates S_1, S_2,., S_{24}.
The subscripts 1, 24, or 27 correspond to the order in which the tests are performed. For example, S_5 and L_5 correspond to the test results from the fifth test in the test sequence.

Step 6: **Conduct release detection method testing.** Perform the testing of the release detection method by following the test matrices in either Tables 4 or 5, depending on the output of the method. During the compressibility measurements the pipeline leak detector may have been disconnected from the line. If so, it should be reconnected so you can conduct the release detection testing. Perform a release detection test according to both vendor's test procedures and the test design. The result of each test should be recorded in terms of the output of the method. The three tests in which trapped vapor are present in the pipeline are also part of the test design and should be included in the overall data collection effort. At a test facility, a temperature condition is created by circulating product through the pipeline twice; the temperature of this product must be different from the temperature of the backfill and the ground around the pipeline. At an operating facility, flush the line for 5 minutes. All dispensing through a pipeline should cease during a release detection test on that line. In addition, dispensing through other pipelines buried in the same backfill and within 12 inches of the pipeline being tested should also be halted.

The equipment and the procedures for generating a leak in the line are described in Section 3. If possible, generate all leaks at a line pressure equal to the pressures specified in Table 3. If this cannot be done, the leak can be generated at another pressure, for example, the operating pressure of the line, if it is equivalent to leak rates defined earlier. The leak rate established in each test should be measured and reported. Once the leak has been generated, the line pressure can be readjusted, if this is required by the method's test procedures, to the appropriate pressure for the test. The result of each test must be recorded in terms of the output of the method.

Trapped Vapor Tests. Three trapped vapor tests are included at the end of Table 4. These tests should be included in the overall data collection effort. During an evaluation, the three trapped vapor tests should be randomly distributed in the test design. Tests should be done under the same nominal temperature condition. If the method is being evaluated as a line tightness test or a monthly monitoring test, the three tests will be conducted with leaks of 0.0, 0.10, and 0.20 gal/hr with vapor trapped in the pipeline. If the method is being evaluated as an hourly test, the leaks generated for the three tests should be 0.0, 2.75, and 3.25 gal/hr, respectively. The results of the tests on lines with trapped vapor should be tabulated and reported on the standard form included as Attachment 6 in Appendix B.

Table 4. Quantitative Release Detection Method Test Design

Test No.	Set No.	Nominal Leak Rate (gal/hr)	Nominal Temperature Differential (°F)
Trial Run	-	0	0
1	1	LR_1	T_2
2	1	LR_2	T_2
3	1	LR_4	T_2
4	1	LR_3	T_2
5	2	LR_1	T_1
6	2	LR_4	T_1
7	2	LR_2	T_1
8	2	LR_3	T_1
9	3	LR_4	T_3
10	3	LR_1	T_3
11	3	LR_3	T_3
12	3	LR_2	T_3
13	4	LR_3	T_2
14	4	LR_4	T_2
15	4	LR_2	T_2
16	4	LR_1	T_2
17	5	LR_2	T_1
18	5	LR_3	T_1
19	5	LR_4	T_1
20	5	LR_1	T_1
21	6	LR_3	T_3
22	6	LR_2	T_3
23	6	LR_4	T_3
24	6	LR_1	T_3
Optional for Trapped Vapor Tests			
25	7	LR_1	T_1
26	7	LR_2	T_1
27	7	LR_3	T_1

Table 5. Qualitative Release Detection Method Test Design

	Test No.	Set No.	Nominal Leak Rate (gal/hr)	Nominal Temperature Differential (°F)
	Trial run		0.0	0.0
Replace 2 times pipeline volume				
	1	1	LR_2	T_3
	2	1	LR_1	T_3
Replace 2 times pipeline volume				
	3	2	LR_1	T_2
	4	2	LR_1	T_2
Replace 2 times pipeline volume				
	5	3	LR_1	T_1
	6	3	LR_3	T_1
Replace 2 times pipeline volume				
	7	4	LR_3	T_3
	8	4	LR_1	T_3
Replace 2 times pipeline volume				
	9	5	LR_4	T_1
	10	5	LR_1	T_1
Replace 2 times pipeline volume				
	11	6	LR_2	T_2
	12	6	LR_3	T_2
Replace 2 times pipeline volume				
	13	7	LR_4	T_1
	14	7	LR_1	T_1
Replace 2 times pipeline volume				
	15	8	LR_3	T_3
	16	8	LR_1	T_3
Replace 2 times pipeline volume				
	17	9	LR_4	T_3
	18	9	LR_1	T_3
Replace 2 times pipeline volume				
	19	10	LR_1	T_2
	20	10	LR_3	T_2
Replace 2 times pipeline volume				
	21	11	LR_3	T_1
	22	11	LR_1	T_1
Replace 2 times pipeline volume				
	23	12	LR_1	T_3
	24	12	LR_2	T_3
Replace 2 times pipeline volume				
	25	13	LR_2	T_2
	26	13	LR_4	T_2
Replace 2 times pipeline volume				
	27	14	LR_3	T_3
	28	14	LR_1	T_3
Replace 2 times pipeline volume				
	29	15	LR_1	T_1
	30	15	LR_2	T_1
Replace 2 times pipeline volume				
	31	16	LR_1	T_2
	32	16	LR_1	T_2

Table 5. Qualitative Release Detection Method Test Design (Continued)

	Test No.	Set No.	Nominal Leak Rate (gal/hr)	Nominal Temperature Differential (°F)
Replace 2 times pipeline volume				
	33	17	LR_1	T_3
	34	17	LR_4	T_3
Replace 2 times pipeline volume				
	35	18	LR_1	T_2
	36	18	LR_4	T_2
Replace 2 times pipeline volume				
	37	19	LR_2	T_1
	38	19	LR_1	T_1
Replace 2 times pipeline volume				
	39	20	LR_1	T_2
	40	20	LR_2	T_2
Replace 2 times pipeline volume				
	41	21	LR_1	T_1
	42	21	LR_4	T_1

4.2 Evaluation Procedures

In these test procedures, it is assumed that the evaluation is being performed to obtain the P(d) and P(fa) at the leak rate specified in the federal UST regulation for example, 0.10 gal/hr for a line tightness test, 0.20 gal/hr for a monthly monitoring test, or 3 gal/hr for an hourly test or appropriate bulk piping leak rates. Thus, the procedures described can be tailored for the leak rate of greatest regulatory interest for a line tightness test: a monthly monitoring test, an hourly test, and bulk piping method. If local regulations specify leak rates more stringent than those in the federal UST regulation, than the local standard can be substituted for the EPA-specified leak rates.

Unlike release detection methods that quantitatively measure and report the output of the method, the only output from a preset-threshold method is a simple pass or fail* -- that is, did the method respond to the leak or the temperature condition. Therefore, this is the only performance estimate that can be derived from the evaluation. An advantage of preset-threshold methods is that the analysis used to estimate P(fa) and the P(d) for the EPA-specified leak rate is simpler than it is for the methods that quantitatively measure the output; however, the latter can be analyzed the same way as the preset-threshold methods.

Some methods that use a preset-threshold switch and are intended to meet the 3-gal/hr hourly test requirements are designed to do a quick test of the pipeline system. Normally, the duration of a test ranges from a few seconds to less than a minute because the method is designed to test the line at least once per hour between occurrences of product dispensing. Whereas most other methods have a test duration equal to the data collection time, the methods in question have a test duration equal to the difference between the time a method is activated and the time it responds to a leak. Since the method does not control the response time, the test duration may not be specifically defined in these methods. To avoid misleading or ambiguous results with these

* Pass means that the threshold was not exceeded and that lines are tight and fail means that the threshold was exceeded and that a leak was detected.

methods, the evaluator should ensure that the vendor clearly defines the test duration in the test procedures and specifies it in the evaluation. The test duration should be consistent with the normal operational practice and the vendor's intended use of the method. If it is not, the evaluator should indicate this in the report, as the method being evaluated should be the same as the commercially available method.

Section 5: Calculations

A series of calculations will be performed to evaluate the method's performance using the results obtained after all testing is completed.

The calculations compare the method's measured leak rate with the induced leak rate under a variety of experimental conditions. The P(d) and the P(fa) are estimated using the difference between these two numbers. If the overall performance of the pipeline release detection is satisfactory, analysis and reporting of results could end at this point.

In these test procedures, leaks are characterized as product lost from the system or pipeline per unit of time. They are typically, but not always, represented by positive numbers; a large leak represents a greater product loss. Some vendors report volume changes per unit time with the negative sign indicating product is lost from the system or pipeline, or a positive sign representing product coming into the system or pipeline. In these test procedures, leaks refer to the direction out of the system or pipeline and the rate to the magnitude of the flow.

5.1 Quantitative Pipeline Release Detection Methods

After all tests are performed according to the test matrices outlined above in Table 4 for quantitative methods, a total of at least n = 24 pairs, or 4 leak rates x 3 temperature differentials x 2 replications, of measured leak rates and induced leak rates will be available. These data form the basis for the performance evaluation of the method. The measured leak rates are denoted by $L_1,\ldots, L_{24}$ and the associated induced leak rates by $S_1,\ldots, S_{24}$. These leak rates are numbered in chronological order. Table 6 summarizes the notation used throughout these test procedures, using the example test design of Table 4.

5.1.1 Basic Statistics

The n = 24 or 27 data points are used to calculate the mean squared error (MSE) the bias (B), and the variance of the method as follows.

Mean Squared Error, MSE

$$MSE = \sum_{i=1}^{n}(L_i - S_i)^2/n$$

where L_i is the measured leak rate obtained from the ith test at the corresponding induced leak rate, S_i, with i =1, …, n.

Table 6. Notation Summary

Test No.	Set No.	Nominal Temperature Differential (°F)	Nominal Leak Rate (gal/hr)	Induced Leak Rate (gal/hr)	Measured Leak Rate (gal/hr)	Absolute Leak Rate Difference |L - S| (gal/hr)
1	1	T_2	LR_1	S_1	L_1	d_1
2	1	T_2	LR_2	S_2	L_2	d_2
3	1	T_2	LR_4	S_3	L_3	d_3
4	1	T_2	LR_3	S_4	L_4	d_4
5	2	T_1	LR_1	S_5	L_5	d_5
6	2	T_1	LR_4	S_6	L_6	d_6
7	2	T_1	LR_2	S_7	L_7	d_7
8	2	T_1	LR_3	S_8	L_8	d_8
9	3	T_3	LR_4	S_9	L_9	d_9
10	3	T_3	LR_1	S_{10}	L_{10}	d_{10}
11	3	T_3	LR_3	S_{11}	L_{11}	d_{11}
12	3	T_3	LR_2	S_{12}	L_{12}	d_{12}
13	4	T_2	LR_3	S_{13}	L_{13}	d_{13}
14	4	T_2	LR_4	S_{14}	L_{14}	d_{14}
15	4	T_2	LR_2	S_{15}	L_{15}	d_{15}
16	4	T_2	LR_1	S_{16}	L_{16}	d_{16}
17	5	T_1	LR_2	S_{17}	L_{17}	d_{17}
18	5	T_1	LR_3	S_{18}	L_{18}	d_{18}
19	5	T_1	LR_4	S_{19}	L_{19}	d_{19}
20	5	T_1	LR_1	S_{20}	L_{20}	d_{20}
21	6	T_3	LR_3	S_{21}	L_{21}	d_{21}
22	6	T_3	LR_2	S_{22}	L_{22}	d_{22}
23	6	T_3	LR_4	S_{23}	L_{23}	d_{23}
24	6	T_3	LR_1	S_{24}	L_{24}	d_{24}

Bias, B

$$B = \sum_{i=1}^{n} (L_i - S_i)/n$$

The B is the average difference between measured and induced leak rates over the number of tests. It is a measure of the accuracy of the method and can be either positive or negative.

Variance And Standard Deviation

The variance is obtained as follows:

$$Variance = \sum_{i=1}^{n} [(L_i - S_i) - B]^2/df$$

Standard deviation (SD) is the square root of the variance.

Note: The differences between the measured and induced leak rates should be plotted against the time or the order in which they were performed. They can also be plotted against the temperature condition and by the size of the induced leak rate. This would allow one to detect any patterns that might exist, indicating potentially larger differences in the results from the first test of each set of tests or among the three temperature differentials.

Test For Zero Bias

To test whether the method is accurate – that is, the bias is zero – the following test on the bias calculated above is performed.

Compute the t-statistic:

$$t_B = \sqrt{n}B/SD$$

From the t-table in Appendix A, obtain the critical value corresponding to a t with (24 - 1) = 23 degrees of freedom (df) and a two-sided 5 percent significance level. This value is 2.07. Note: If more than 24 tests are done, replace 24 with the number of tests, n, throughout. A larger number will change the t-value.

Compare the absolute value of t_B, abs(t_B), to 2.07, or to the appropriate t-value if more than 24 tests were performed. If abs(t_B) is less than 2.07, conclude the bias is not statistically different from 0, that is, the bias is negligible. Otherwise, conclude the bias is statistically significant.

5.1.2 False Alarm Rate, P(fa)

The normal probability model is assumed for the errors in the measured leak rates. Using this model, together with the statistics estimated above, allows for the calculation of the P(fa) and P(d) of 3.0 gal/hr.

The vendor will supply the threshold for interpreting the results of the pipeline release detection test function. Typically, the leak rate measured by the method is compared to that threshold and the results interpreted as indicating a leak if the measured leak rate exceeds the threshold (Th). The P(fa) is the probability the measured leak rate exceeds the Th when the pipeline is tight. Note that by convention, all leak rates representing volume losses from the tank are treated as positive.

P(fa) is calculated by one of two methods, depending on whether the bias is statistically significantly different from 0.

False Alarm Rate With Negligible Bias

In the case of a nonsignificant bias, discussed in Section 5.1.1, compute the t-statistic

$$t_1 = Th/SD$$

where SD is the SD calculated above and Th is the method's threshold. Using the notational convention for leak rates, Th is positive, P(fa) is then obtained from the t-table, using 23 df. P(fa) is the area under the curve to the **right** of the calculated value t_1.
In general, t-tables are constructed to give a percentile, t_a, corresponding to a given number of df, and a preassigned area, alpha (α), under the curve, to the right of t_a, shown in Figure 5 below and

in Table A-1 in Appendix A. For example, with 23 df and $\alpha = 0.05$ (equivalent to a P(fa) of 5%), $t_a = 1.714$.

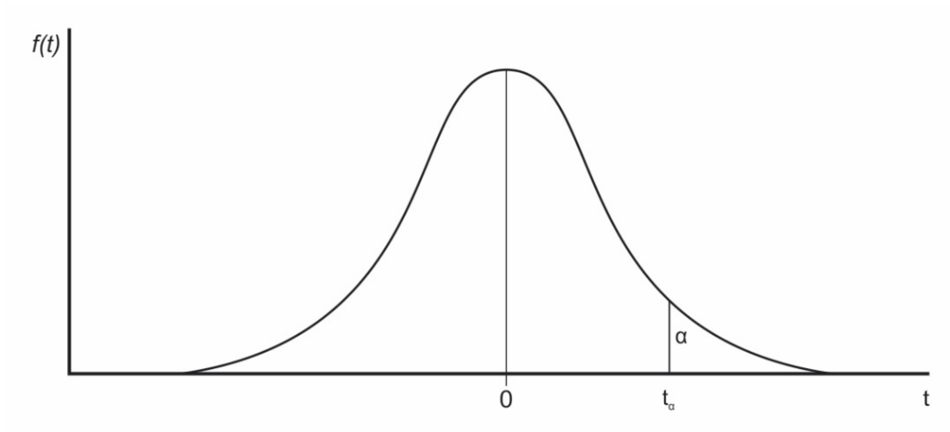


Figure 5. Student's t-Distribution Function

In this case, however, determine the area under the curve to the right of the calculated percentile, t_l, with a given number of df. This is done by interpolating between the two areas corresponding to the two percentiles in Table A-1 on either side of the calculated statistic, t_l. The approach is illustrated below.

Suppose that the calculated $t_l = 1.85$ and has 23 df. From Table A-1, obtain the following percentiles at df = 23:

t_a	α (alpha)
1.714	0.05
1.85	X to be determined
2.069	0.025

Calculate X by linearly interpolating between 1.714 and 2.069 corresponding to 0.05 and 0.025, respectively.

$$X = 0.05 - \frac{(0.05 - 0.025)}{(1.714 - 2.069)} \times (1.714 - 1.85) = 0.040$$

Thus, the P(fa) corresponding to a t_l of 1.85 would be 4%. L This achieves the EPA requirement that P(fa) be ≤ 5 percent.

A more accurate approach would be to use a statistical software package, like SAS or SYSTAT, to calculate the probability.

False Alarm Rate With Significant Bias

The computations are similar to those in the case of a nonsignificant bias with the exception that B is included in the calculations, as shown next. Compute the t-statistic:

$$t_2 = (\mathrm{Th} - \mathrm{B})/\mathrm{SD}$$

P(fa) is then obtained by interpolating from the t-table, using 23 df. P(fa) is the area under the curve to the **right** of the calculated value t_2. Th is positive, but the bias could be either positive or negative.

5.1.3 Probability Of Detecting A Leak Rate Of 3.0 gal/hr, P(d)

The probability of detecting LR, P(d), is the probability the measured leak rate exceeds Th when the true mean leak rate is 3.0 gal/hr. As for P(fa), one of two methods is used in the computation of P(d), depending on whether the bias is statistically significantly different from 0.

P(d) With Negligible Bias

In the case of a nonsignificant B, the bias is 0 – compute the t-statistic

$$t_3 = (\mathrm{Th} - \mathrm{LR})/\mathrm{SD}$$

Next, using the t-table at the appropriate number of df, determine the area under the curve to the **right** of t_3. The resulting number will be P(d).

P(d) With Significant Bias

The procedure is similar to the one just described, except that B is introduced in the calculations as shown below. Compute the t-statistic.

$$t_4 = \frac{\mathrm{Th} - \mathrm{B} - \mathrm{LR}}{\mathrm{SD}}$$

Next, using the t-table at the appropriate number of df, determine the area under the curve to the right of t_4. The resulting number will be P(d).

5.2 Qualitative Pipeline Release Detection Methods

After all tests are performed according to the schedule outlined in Section 4, in Table 5, a total of at least 42 test results will be available. Of these, 21 will have been obtained under tight tank conditions, and 21 under induced leak conditions. The P(fa) and P(d) are calculated next.

5.2.1 Probability Of False Alarm, P(fa)

The results obtained from the tests performed under tight tank conditions will be used to calculate P(fa). Let N_1 denote the number of these tests, normally 21. This number must be at least 21 but could be larger if more tests are called for in the experimental plan setup at the beginning of the testing. Let TL_1 denote the number of cases where the method indicated a leak. If the test results, L_j, are coded as 0 when no leak is indicated and 1 when a leak is indicated, then

$$TL_1 = \sum_{i=1}^{N_i} L_i$$

where the sum is taken over the N_1 tests at zero leak rate. The P(fa) is estimated by the ratio

$$P(fa) = TL_1/N_1$$

For the method to meet the performance standards, the estimated P(fa) must be less than or equal to 5 percent. Thus, in order for the method to meet the performance standards, TL_1 must be no more than 1 if the standard 21 tests are performed.

If the method did not identify the tank to be leaking when it was tight and, $TL_1 = 0$, then the proportion of false alarms becomes 0 percent. However, this does not mean that the method is perfect. The observed P(fa) of 0 percent is an estimate of the false alarm rate based on the evaluation test results and the given test conditions.

One can calculate an upper confidence limit for P(fa) in the case of no mistakes. Let N_1 be the number of tests performed under the tight tank condition. Choose a confidence coefficient, (1 - α), for example, 95 or 90 percent. Then the upper confidence limit, UL, for P(fa) is calculated as:

$$\text{UL for } P(fa) = 1 - \alpha^{1/N_1}$$

In the case of 0 false alarms out of 21 tests, the upper limit to P(fa) becomes 0.133 or 13.3 percent with a 95 percent confidence coefficient. That is, P(fa) is estimated at 0 percent, and with a confidence of 95 percent, P(fa) is less than or equal to 13.3 percent. In general, the confidence interval for P(fa) can be calculated from the binomial distribution with N_1 trials. The 95 percent confidence interval must be calculated and reported on the results form, located in Appendix B.

5.2.2 Probability Of Detecting A Leak, P(d)

The probability of detection, P(d), is calculated for a specific size of leak. The size of leak that can be detected with this probability is reported. Normally this will be 3.0 gal/hr, as required by the performance standards. The results obtained from the tests performed under induced leak conditions will be used to calculate P(d). Let N_2 be the number of such tests. Typically, N_2 will also be 21, but could be larger if the evaluation was initially set up to include more tests. Let TL_2 be the number of cases where the method indicated a leak. As before, the test results, L_i, are coded as 0 when the tank is declared to be tight and 1 when the tank is declared to be leaking. Thus, TL_2 is calculated as

$$TL_2 = \sum_{i=1}^{N_2} L_i$$

where the sum is taken over the N_2 tests with induced leaks. The P(d) is then estimated by the ratio

$$P(d) = TL_2/N_2$$

The estimated P(d) must be at least 95 percent for the method to meet the performance standards. Thus, TL_2 must be either 20 or 21 (out of 21 tests) for the estimated probability of detection to be at least 95 percent.

If the method identified the tank to be leaking in all tests where a leak was simulated, then the proportion detected becomes 100 percent. However, this does not mean that the method is perfect. The P(d) of 100 percent is an estimate of the probability of detection, based on the evaluation test results and the given test conditions.

One can calculate a lower confidence limit for P(d) in the case of no mistakes. Let N_2 be the number of tests performed under the induced leak conditions. Choose a confidence coefficient, (1- α), for example, 95 or 90 percent. Then the lower confidence limit, LL, for P(d) is calculated as:

$$\text{LL for P(d)} = \alpha^{1/N_2}$$

In the case of 21 tests performed under leak conditions, the lower limit to P(d) becomes 0.867 or 86.7 percent with a 95 percent confidence coefficient. In this example, P(d) is estimated at 100 percent, and with a confidence of 95 percent, P(d) is greater than or equal to 86.7 percent. The 95 percent confidence interval for P(d) must be calculated based on the binomial distribution with N_2 trials and reported on the results form in Appendix B.

5.3 Release Detection Tests With Trapped Vapor In The Pipeline

The evaluator must consider whether a special set of three tests must be conducted with a small volume of vapor trapped in the pipeline. These tests may be needed to determine the sensitivity of the release detection method to any residual vapor that might be trapped in a line during a test. The results of these three tests should be tabulated and reported but should not be included in the main analysis used to estimate the performance of the method. Trapped vapor tests are typically not required when evaluations are performed at operational facilities because evaluations require many tests; as a result, it is likely that trapped vapor will be present during some of the tests and that it will thus be included in the actual performance estimates.

If the method is being evaluated as a line tightness test or a monthly monitoring test, then the three tests should be conducted with leaks of 0.0, 0.10, and 0.20 gal/hr, and with > 500 mL ± 20 mL vapor trapped in the pipeline. These tests should be done under the same nominal temperature condition. If the method is being evaluated as an hourly test, the leaks generated for the three tests should be 0.0, 2.75, and 3.25 gal/hr, respectively. If these are blind tests, the leaks should be in random order.

The vapor pocket apparatus shown in Figure 4 is used to trap vapor in the pipeline. By opening or closing an inlet valve, trapped vapor enters the line; the apparatus, and how it generates a vapor pocket, is described in section 3. The results of these three tests are reported in Attachment 6 in Appendix B.

Section 6: Reporting Of Results

Appendix B is designed to be the framework for a standard evaluation report, including the U.S. EPA Standard Evaluation form and six attachments.

Results of U.S. EPA Standard Evaluation is an executive summary of the findings and given to each tank owner or operator that uses this method of release detection. The report should be succinct so that the form can be widely distributed.

Six attachments provide additional details about the method and the evaluation which can be independently reviewed and verified. The attachments include:

- Attachment 1 - Description of the Method Evaluated
- Attachment 2 - Summary of the Performance of the Method Evaluated
- Attachment 3 - Summary of the Configuration of the Pipeline System(s) Used in the Evaluation
- Attachment 4 – Summary of the Product Temperature Conditions Used in the Evaluation
- Attachment 5 – Summary of the Test Results and the Leak Rates Used in the Evaluation
- Attachment 6 – Summary of the Test Results and the Trapped Vapor Tests

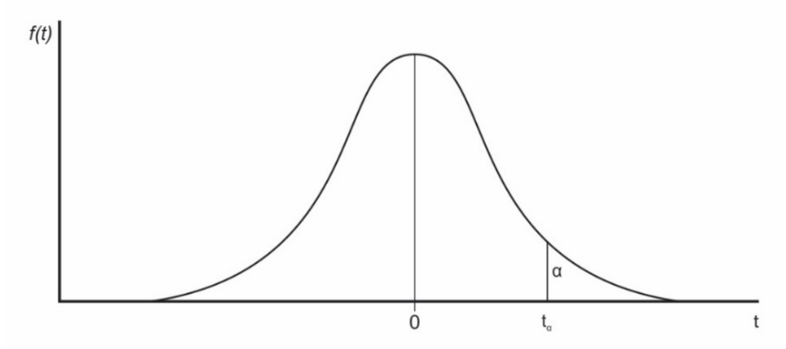
Appendix A

Definitions And Student's t Distribution

Definitions of terms used throughout the test procedures and the Student's t distribution table (Table A-1) are presented here. For more information on the statistical approach and relationships between the statistics calculated in these test procedures see the *General Guidance For Using EPA's Standard Test Procedures For Evaluating Release Detection Methods*.

Accuracy:	The degree to which the calculated leak rate agrees with the induced leak rate on the average. If a method is accurate, it has a very small or zero bias.
Calculated Leak Rate, R:	A positive number, in gallons per hour (gal/hr), estimated by the pipeline method and indicating the amount of product leaking out of the tank. A negative leak rate could result from water leaking into the tank, miscalibration, or other causes.
False Alarm:	Declaring that a tank is leaking when in fact it is tight.
Induced Leak Rate, S:	The actual leak rate, in gal/hr, introduced in the evaluation data sets, against which the results from a given method will be compared.
Mean Squared Error, MSE:	An estimate of the overall performance of a test method.
Method Bias, B:	The average difference between calculated and induced leak rates. It is an indication of whether the pipeline method consistently overestimates, called a positive bias, or underestimates, called a negative bias, the actual leak rate.
Precision:	A measure of the test method's ability in producing similar results, or results that are in close agreement, under identical conditions. Statistically, the precision is expressed as the standard deviation of these measurements.
Probability of Detection, P(d):	The probability of detecting a leak rate of a given size, R gal/hr. In statistical terms, it is the power of the test method and is calculated as one minus beta (β), where beta is the probability of not detecting (missing) a leak rate R. Commonly the power of a test is expressed as a percentage, say, 95%.
Probability of False Alarm, P(fa):	The probability of declaring a tank leaking when it is tight. In statistical terms, this is also called the Type I error, and is denoted by alpha (α). It is usually expressed as a percentage, say, 5%.
Root Mean Squared Error, RMSE:	The positive square root of the mean squared error.
Threshold, Th:	The leak rate above which a method represents a leak. It is also called the threshold of the method.
Variance:	A measure of the variability of measurements. It is the square of the standard deviation.

Table A-1. Percentage Points Of Student's t Distribution



df	α = .10	α = .05	α = .025	α = .010	α = .005
1	3.078	6.314	12.706	31.821	63.657
2	1.886	2.920	4.303	6.965	9.925
3	1.638	2.353	3.182	4.541	5.841
4	1.333	2.132	2.776	3.747	4.604
5	1.476	2.015	2.571	3.365	4.032
6	1.440	1.943	2.447	3.143	3.707
7	1.415	1.895	2.365	2.998	3.499
8	1.397	1.860	2.306	2.896	3.355
9	1.383	1.833	2.262	2.821	3.250
10	1.372	1.812	2.228	2.764	3.169
11	1.363	1.796	2.201	2.718	3.106
12	1.356	1.782	2.179	2.681	3.055
13	1.350	1.771	2.160	2.650	3.012
14	1.345	1.761	2.145	2.624	2.977
15	1.341	1.753	2.131	2.602	2.947
16	1.337	1.746	2.120	2.583	2.921
17	1.333	1.740	2.110	2.567	2.898
18	1.330	1.734	2.101	2.552	2.878
19	1.328	1.729	2.093	2.539	2.861
20	1.325	1.725	2.086	2.528	2.845
21	1.323	1.721	2.080	2.518	2.831
22	1.321	1.717	2.074	2.508	2.819
23	1.319	1.714	2.069	2.500	2.807
24	1.318	1.711	2.064	2.492	2.797
25	1.316	1.708	2.060	2.485	2.787
26	1.315	1.706	2.056	2.479	2.779
27	1.314	1.703	2.052	2.473	2.771
28	1.313	1.701	2.048	2.467	2.763
29	1.311	1.699	2.045	2.462	2.756
30	1.310	1.697	2.042	2.457	2.750
40	1.303	1.684	2.021	2.423	2.704
60	1.296	1.671	2.000	2.390	2.660
120	1.289	1.658	1.980	2.358	2.617
inf.	1.282	1.645	1.960	2.326	2.576

Appendix B

Reporting Forms

Reporting Forms

The results of a pipeline release detection method evaluation conducted according to the EPA test procedures are available in three variant forms. The form depends on whether the release detection method is used as a line tightness test, a monthly monitoring test, or an hourly test. Use the form that is appropriate for the method evaluated. If the method was evaluated as all three or any combination of these, fill out each form that is applicable.

At the end of the evaluation, the evaluator fills out the appropriate forms, including attachments. All items are to be filled out and the appropriate boxes checked. If a question is not applicable to the method, write "NA" in the appropriate space.

Results Of U.S. EPA Standard Evaluation
Pipeline Release Detection Method

Line Tightness Test

This form summarizes the results of an evaluation to determine whether the pipeline release detection method named below and described in Attachment 1 complies with the federal UST regulation for conducting a line tightness test. The evaluation was conducted according to the U.S. EPA's evaluation procedures, specified in *Standard Test Procedures for Evaluating Release Detection Methods: Pipeline Release Detection*. The full evaluation report includes six attachments.

UST system owners and operators who use this pipeline release detection method should keep this form on file to show compliance with the federal UST regulation. UST system owners and operators should check with state and local regulatory authorities to make sure this form satisfies their release detection requirements.

Method Evaluated

Method Name: ______________________________

Version of Method: ______________________________

Vendor Name: ______________________________

____
(street address)

____
(city, state, zip code)

____
(telephone number)

Evaluation Results

1. The performance of this method
   ☐ meets or exceeds
   ☐ does not meet the federal standards established by the EPA regulation for line tightness tests.

   The EPA regulation for a line tightness test requires that the method be capable of detecting a leak as small as 0.10 gal/hr with a probability of detection (P(d)) of 95% and a probability of false alarm (P(fa)) of 5%.

2. The estimated P(fa) in this evaluation is _____% and the estimated P(d) against a leak rate of 0.10 gal/hr defined at a pipeline pressure of 20 psi in this evaluation is _________%.

Threshold for Declaring a Leak

3. This method
   - ☐ uses a preset threshold
   - ☐ measures and reports the output quantity and compares it to a predetermined threshold to determine whether the pipeline is leaking.

4. This method
   - ☐ uses a single test
   - ☐ uses a multiple-test sequence consisting of ________ tests (specify number of tests required) separated by ____________ hours (hr) (specify the time interval between tests) to determine whether the pipeline is leaking.

5. This method declares a leak if the output of the measurement system exceeds a threshold of _______(specify flow rate in gal/hr) in ________ out of ________ tests (specify, for example, 1 out of 2, 2 out of 3). Please give additional details, if necessary, in the space provided.

Evaluation Approach

6. A total of____________tests were conducted on nonleaking tank(s) between ___________ (date) and___________ (date). A description of the pipeline configuration used in the evaluation is given in Attachment 3.

7. The pipeline used in the evaluation was _______ in. in diameter, ______________ ft long and constructed of ________ (fiberglass, steel, or other).

8. A mechanical line leak detector
   - ☐ was
   - ☐ was not present in the pipeline system.

9. The evaluation was conducted on ____________ (how many) pipeline systems ranging in diameter from ________ in. to ________ in., ranging in length from ___________ ft to _________ ft, and constructed of ______________________________ (specify materials).

10. Specify how much time elapsed between the delivery of product and the start of the data collection:
    - ☐ 0 to 6 hr
    - ☐ 6 to 12 hr
    - ☐ 12 to 24 hr
    - ☐ 24 hr or more

Data Used to Make Performance Estimates

11. The induced leak rate and the test results used to estimate the performance of this method are summarized in Attachment 5. Were any test runs removed from the data set?
    - ☐ no
    - ☐ yes

    If yes, specify the reason and include with Attachment 5. (If more than one test was removed, specify each reason separately.)

12. ☐ According to the vendor, this method can be used even if trapped vapor is present in the pipeline during a test.
☐ According to the vendor, this method *should not be used* if trapped vapor is present in the pipeline.

13. The sensitivity of this method to trapped vapor is indicated by the test results summarized in Table 1. These tests were conducted at ________ psi with ______mL of vapor trapped in the line at a pressure of 0 psi. The data and test conditions are reported in Attachment 6.

Table 1. Summary Of The Results Of Trapped Vapor Tests

Test No.	ΔT (°F)	Induced Leak Rate (gal/hr)	Measured Leak Rate (gal/hr)
1			
2			
3			

Application of the Method

14. This release detection method is intended to test pipeline systems that are associated with underground storage tank facilities, that contain petroleum or other chemical products, that are typically constructed of fiberglass, steel, or other, and that typically measure 2 in. in diameter and 200 ft or less in length. The performance estimates are valid when:

- the method that was evaluated has not been substantially changed by subsequent modifications
- the vendor's instructions for using the method are followed
- a mechanical line leak detector
  ☐ is present in
  ☐ has been removed from the pipeline (check both if appropriate)
- the waiting time between the last delivery of product to the underground storage tank and the start of data collection for the test is ______________ hr
- the waiting time between the last dispensing of product through the pipeline system and the start of data collection for the test is _______ hr
- the total data collection time for the test is_____________ hr
- the volume of the product in the pipeline system is less than twice the volume of the product in the pipeline system used in the evaluation, unless a separate written justification for testing larger pipeline systems is presented by the vendor, concurred with by the evaluator, and included with this evaluation as an additional attachment.
- give any other limitations specified by the vendor or determined during the evaluation: __
  ____
  ____

Attachments

Attachment 1 - Description of the Method Evaluated
Attachment 2 - Summary of the Performance of the Method Evaluated
Attachment 3 - Summary of the Configuration of the Pipeline System(s) Used in the Evaluation
Attachment 4 - Data Sheet Summarizing Product Temperature Conditions Used in the Evaluation
Attachment 5 - Data Sheet Summarizing the Test Results and the Leak Rates Used in the Evaluation
Attachment 6 - Data Sheet Summarizing the Test Results and the Trapped Vapor Tests

Certification of Results

I certify that the pipeline release detection method was operated according to the vendor's instructions. I also certify that the evaluation was performed according to the procedures specified by EPA and that the results presented above are those obtained during the evaluation.

____
Name of person performing evaluation

____
Signature

____
Date

____
Telephone number

____
Organization performing evaluation

____
Street address

____
City, state, zip

Results of U.S. EPA Standard Evaluation
Pipeline Release Detection Method

Monthly Monitoring Test

This form summarizes the results of an evaluation to determine whether the pipeline release detection method named below and described in Attachment 1 complies with the federal UST regulation for conducting a monthly monitoring test. The evaluation was conducted according to the U.S. EPA's evaluation procedures, specified in *Standard Test Procedures for Evaluating Release Detection Methods: Pipeline Release Detection*. The full evaluation report includes six attachments.

UST system owners and operators who use this pipeline release detection method should keep this form on file to show compliance with the federal UST regulation. UST system owners and operators should check with state and local regulatory authorities to make sure this form satisfies the requirements of their agencies.

Method Evaluated

Method Name: ____

Version of Method: ____

Vendor Name: ____

____
(street address)

____
(city, state, zip code)

____
(telephone number)

Evaluation Results

1. The performance of this method
   - ☐ meets or exceeds
   - ☐ does not meet the federal standards established by the EPA regulation for monthly monitoring tests.

   The EPA regulation for a monthly monitoring test requires that the method be capable of detecting a leak as small as 0.2 gal/hr with a probability of detection (P(d)) of 95% and a probability of false alarm (P(fa)) of 5%.

2. The estimated P(fa) in this evaluation is _______% and the estimated P(d) against a leak rate of 0.20 gal/hr defined at a pipeline pressure of 20 psi in this evaluation is _____________ %.

Criterion for Declaring a Leak

3. This method
☐ uses a preset threshold
☐ measures and reports the output quantity and compares it to a predetermined threshold to determine whether the pipeline is leaking.

4. This method
☐ uses a single test
☐ uses a multiple-test sequence consisting of ________ tests (specify number of tests required) separated by _____________ hours (specify the time interval between tests) to determine whether the pipeline is leaking.

5. This method declares a leak if the output of the measurement method exceeds a threshold of _____________ (specify flow rate in gal/hr) in _____________ out of ________ tests (specify, for example, 1 out of 2, 2 out of 3). Please give additional details, if necessary, in the space provided.
____
____

Evaluation Approach

6. A total of ____________ tests were conducted on nonleaking lines(s) between _________ (date) _______ and __________ (date). A description of the pipeline configuration used in the evaluation is given in Attachment 3.

7. The pipeline used in the evaluation was _______ in. in diameter, _____________ ft long and constructed of ________________________________ (fiberglass, steel, or other).

8. A mechanical line leak detector
☐ was
☐ was not present in the pipeline system.

9. The evaluation was conducted on ____________ (how many) pipeline systems ranging in diameter from _ _______ in. to ________ in., ranging in length from ___________ ft to _________ ft, and constructed of __ ____ (specify materials).

10. Please specify how much time elapsed between the delivery of product and the start of the data collection:
☐ 0 to 6 hr
☐ 6 to 12 hr
☐ 12 to 24 hr
☐ 24 hr or more

Data Used to Make Performance Estimates

11. The induced leak rate and the test results used to estimate the performance of this method are summarized in Attachment 5. Were any test runs removed from the data set?
☐ no
☐ yes
If yes, please specify the reason and include with Attachment 5. (If more than one test was removed, specify each reason separately.)

Sensitivity to Trapped Vapor

12. ☐ According to the vendor, this method can be used even if trapped vapor is present in the pipeline during a test.
☐ According to the vendor, this method should not be used if trapped vapor is present in the pipeline.

13. The sensitivity of this method to trapped vapor is indicated by the test results summarized in Table 1. These tests were conducted at _________ psi with _____________mL of vapor trapped in the line at a pressure of 0 psi. The data and test conditions are reported in Attachment 6.

Table 1. Summary Of The Results Of Trapped Vapor Tests

Test No.	ΔT (°F)	Induced Leak Rate (gal/hr)	Measured Leak Rate (gal/hr)
1			
2			
3			

Application of the Method

14. This release detection method is intended to test pipeline systems that are associated with underground storage tank facilities, that contain petroleum or other chemical products, that are typically constructed of fiberglass, steel, or other, and that typically measure 2 in. in diameter and 200 ft or less in length. The performance estimates are valid when:

- the method that was evaluated has not been substantially changed by subsequent modifications
- the vendor's instructions for using the method are followed
- a mechanical line leak detector
  ☐ is present in
  ☐ has been removed from the pipeline (check both if appropriate)
- the waiting time between the last delivery of product to the underground storage tank and the start of data collection for the test is ______________ hr
- the waiting time between the last dispensing of product through the pipeline system and the start of data collection for the test is________ hr
- the total data collection time for the test is_____________ hr
- the volume of the product in the pipeline system is less than twice the volume of the product in the pipeline system used in the evaluation, unless a separate written justification for testing larger pipeline systems is presented by the vendor, concurred with by the evaluator, and included with this evaluation as an additional attachment.
- give any other limitations specified by the vendor or determined during the evaluation: _________
  ____
  ____

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Attachment 3 - Summary of the Configuration of the Pipeline System(s) Used in the Evaluation
Attachment 4 - Data Sheet Summarizing Product Temperature Conditions Used in the Evaluation
Attachment 5 - Data Sheet Summarizing the Test Results and the Leak Rates Used in the Evaluation
Attachment 6 - Data Sheet Summarizing the Test Results and the Trapped Vapor Tests

Certification of Results

I certify that the pipeline release detection method was operated according to the vendor's instructions. I also certify that the evaluation was performed according to the procedures specified by EPA and that the results presented above are those obtained during the evaluation.

____________________ Name of person performing evaluation	____________________ Organization performing evaluation
____________________ Signature	____________________ Street address
____________________ Date	____________________ City, state, zip
____________________ Telephone number	

Results Of U.S. EPA Standard Evaluation
Pipeline Release Detection Method

Hourly Test

This form summarizes the results of an evaluation to determine whether the pipeline release detection method named below and described in Attachment 1 complies with the federal UST regulation for conducting an hourly test. The evaluation was conducted according to the U.S. EPA's evaluation procedures, specified in *Standard Test Procedures for Evaluating Release Detection Methods: Pipeline Release Detection*. The full evaluation report includes six attachments.

UST system owners and operators who use this pipeline release detection method should keep this form on file to show compliance with the federal UST regulation. UST system owners and operators should check with state and local regulatory authorities to make sure this form satisfies the requirements of their agencies.

Method Evaluated

Method Name: ______________________________

Version of Method: ______________________________

Vendor Name: ______________________________

____
(street address)

____
(city, state, zip code)

____
(telephone number)

Evaluation Results

1. The performance of this method
   - ☐ meets or exceeds
   - ☐ does not meet the federal standards established by the EPA regulation for hourly tests.

   The EPA regulation for an hourly test requires that the method be capable of detecting a leak as small as 3.0 gal/hr with a probability of detection (P(d)) of 95% and a probability of false alarm (P(fa)) of 5%.

2. The estimated P(fa) in this evaluation is _______ % and the estimated P(d) against a leak rate of 3.0 gal/hr defined at a pipeline pressure of 20 psi in this evaluation is ___________ %.

Criterion for Declaring a Leak

3. This method
   ☐ uses a preset threshold
   ☐ measures and reports the output quantity and compares it to a predetermined threshold to determine whether the pipeline is leaking.

4. This method
   ☐ uses a single test
   ☐ uses a multiple-test sequence consisting of ________ tests (specify number of tests required) separated by ____________ hours (specify the time interval between tests) to determine whether the pipeline is leaking.

5. This method declares a leak if the output of the measurement method exceeds a threshold of _____________ (specify flow rate in gal/hr) in _____________ out of _______ tests (specify, for example, 1 out of 2, 2 out of 3). Please give additional details, if necessary, in the space provided.

   ____

   ____

Evaluation Approach

6. A total of ___________ tests were conducted on non-leaking tank(s) between _________ (date) and ___________ (date). A description of the pipeline configuration used in the evaluation is given in Attachment 3.

7. The pipeline used in the evaluation was _______ in. in diameter, _____________ ft long and constructed of ______________________________ (fiberglass, steel, or other).

8. A mechanical line leak detector
   ☐ was
   ☐ was not present in the pipeline system.

9. The evaluation was conducted on ____________ (how many) pipeline systems ranging in diameter from ________ in. to ______________ in., ranging in length from ___________ ft to _________ ft, and constructed of ____ (specify materials).

10. Please specify how much time elapsed between the delivery of product and the start of the data collection:
    ☐ 0 to 6 hr
    ☐ 6 to 12 hr
    ☐ 12 to 24 hr
    ☐ 24 hr or more

Data Used to Make Performance Estimates

11. The induced leak rate and the test results used to estimate the performance of this method are summarized in Attachment 5. Were any test runs removed from the data set?
    ☐ no
    ☐ yes
    If yes, please specify the reason and include with Attachment 5. (If more than one test was removed, specify each reason separately.)

Sensitivity to Trapped Vapor

12. ☐ According to the vendor, this method can be used even if trapped vapor is present in the pipeline during a test.
☐ According to the vendor, this method *should not be used* if trapped vapor is present in the pipeline.

13. The sensitivity of this method to trapped vapor is indicated by the test results summarized in Table 1. These tests were conducted at ________ psi with ____________mL of vapor trapped in the line at a pressure of 0 psi. The data and test conditions are reported in Attachment 6.

Table 1. Summary of the Results of Trapped Vapor Tests

Test No.	ΔT (°F)	Induced Leak Rate (gal/hr)	Measured Leak Rate (gal/hr)
1			
2			
3			

Application of the Method

16. This release detection method is intended to test pipeline systems that are associated with underground storage tank facilities, that contain petroleum or other chemical products, that are typically constructed of fiberglass, steel, or other and that typically measure 2 in. in diameter and 150 ft or less in length. The performance estimates are valid when:

- the method that was evaluated has not been substantially changed by subsequent modifications
- the vendor's instructions for using the method are followed
- a mechanical line leak detector
  ☐ is present in
  ☐ has been removed from the pipeline (check both if appropriate)
- the waiting time between the last delivery of product to the underground storage tank and the start of data collection for the test is _____________ hr
- the waiting time between the last dispensing of product through the pipeline system and the start of data collection for the test is________ hr
- the total data collection time for the test is____________ hr
- the volume of the product in the pipeline system is less than twice the volume of the product in the pipeline system used in the evaluation, unless a separate written justification for testing larger pipeline systems is presented by the vendor, concurred with by the evaluator, and included with this evaluation as an additional attachment.
- give any other limitations specified by the vendor or determined during the evaluation: ________
  ____
  ____

Attachments

Attachment 1 - Description of the Method Evaluated
Attachment 2 - Summary of the Performance of the Method Evaluated
Attachment 3 - Summary of the Configuration of the Pipeline System(s) Used in the Evaluation
Attachment 4 - Data Sheet Summarizing Product Temperature Conditions Used in the Evaluation
Attachment 5 - Data Sheet Summarizing the Test Results and the Leak Rates Used in the Evaluation
Attachment 6 - Data Sheet Summarizing the Test Results and the Trapped Vapor Tests

Certification of Results

I certify that the pipeline release detection method was operated according to the vendor's instructions. I also certify that the evaluation was performed according to the procedures specified by EPA and that the results presented above are those obtained during the evaluation.

Name of person performing evaluation	Organization performing evaluation
Signature	Street address
Date	City, state, zip
Telephone number	

Attachment 1
Description

Pipeline Release Detection Method

The evaluator, with help from the vendor, fills out this form prior to the start of the evaluation. This form provides a description of the method and how it works. It should be filled out completely – check all appropriate boxes for each question. If *other* is checked, provide a description. For those answers dependent on site conditions, give answers that apply in typical conditions. This form is to be filled out by the evaluator with assistance from the vendor before the start of the evaluation. Describe the important features of the method as indicated below. A detailed description is not required, nor is it necessary to reveal proprietary features of the system.

Method Name and Version: ______________________________

Date: ______________________________

Applicability of the Method

1. With what products can this method be used? (Check all applicable responses.)

☐ gasoline
☐ diesel
☐ aviation fuel
☐ fuel oil #4
☐ fuel oil #6
☐ solvent
☐ waste oil
☐ other (specify) ______________________________

2. What types of pipelines can be tested? (Check all applicable responses.)
☐ fiberglass
☐ steel
☐ other (specify) ______________________________

3. Can this release detection method be used to test double-wall pipeline systems?
☐ yes ☐ no

4. What is the nominal diameter of a pipeline that can be tested with this method?
☐ 1 in. or less
☐ between 1 and 3 in.
☐ between 3 and 6 in.
☐ between 6 and 10 in.
☐ other ______________________________

5. The method can be used on pipelines pressurized to ____ psi.

The safe maximum operating pressure for this method is _______ psi.

6. Does the method conduct a test while a mechanical line leak detector is in place in the pipeline?
☐ yes ☐ no

General Features of the Method

7. What type of test is the method conducting? (Check all applicable responses.)
☐ 0.10 gal/hr Line Tightness Test
☐ 0.20 gal/hr Monthly Monitoring Test
☐ 3 gal/hr Hourly Test

8. Is the method permanently installed on the pipeline?
☐ yes ☐ no

Does the method test the line automatically?
☐ yes ☐ no

If a leak is declared, what does the method do? (Check all applicable responses.)
☐ displays or prints a message
☐ triggers an alarm
☐ alerts the evaluator
☐ shuts down the dispensing system

9. What quantity or quantities are measured by the method? (Please list.)
____
____
____

10. Does the method use a preset threshold that is automatically activated or that automatically turns on an alarm?

☐ yes (If yes, skip question 11.)
☐ no (If no, answer question 11.)

11. Does the method measure and report the quantity
☐ yes ☐ no

If so, is the output quantity converted to flow rate in gallons per hour?
☐ yes ☐ no

12. What is the specified line pressure during a test?
☐ operating pressure of line
☐ 150% of operating pressure
☐ a specific test pressure of _________ psi

Test Protocol

13. What is the minimum waiting period required between a delivery of product to an underground storage tank and the start of the data collection for a pipeline release detection test?
☐ no waiting period
☐ less than 15 min
☐ 15 min to 1 hr
☐ 1 to 5 hr
☐ 6 to 12 hr
☐ 12 to 24 hr
☐ greater than 24 hr
☐ variable (Briefly explain.) ____

14. What is the minimum waiting period required between the last dispensing of product through the pipeline and the start of the data collection for a pipeline release detection test?

☐ no waiting period
☐ less than 15 min
☐ 15 min to 1 hr
☐ 1 to 4 hr
☐ 4 to 8 hr
☐ greater than 8 hr
☐ variable (Briefly explain.) ____

15. What is the minimum amount of time necessary to set up equipment and complete a release detection test? (Include setup time, waiting time and data collection time. If a multiple-test sequence is used, give the amount of time necessary to complete the first test as well as the total amount of time necessary to complete the entire sequence.)
_____ hr (single test)
_____ hr (multiple test)

16. Does the method compensate for those pressure or volume changes of the product in the pipeline that are due to temperature changes?
☐ yes ☐ no

17. Is there a special test to check the pipeline for trapped vapor?
☐ yes ☐ no

18. Can a test be performed with trapped vapor in the pipeline?
☐ yes ☐ no

19. If trapped vapor is found in the pipeline, is it removed before a test is performed?
☐ yes ☐ no

20. Are deviations from this protocol acceptable?
☐ yes ☐ no

If yes, briefly specify: ____
____
____

21. Are elements of the test procedures determined by on-site testing personnel?
☐ yes ☐ no

If yes, which ones? (Check all applicable responses.)
☐ waiting period between filling the tank and the beginning of data collection for the test
☐ length of test
☐ determination of the presence of vapor pockets
☐ determination of "outlier" (or anomalous) data that may be discarded
☐ other (Describe briefly.) ____

Data Acquisition

22. How are the test data acquired and recorded?
☐ manually
☐ by strip chart
☐ by computer
☐ by microprocessor

23. Certain calculations are necessary to reduce and analyze the data. How are these calculations done?
- ☐ manual calculations by the evaluator on site
- ☐ interactive computer program used by the evaluator
- ☐ automatically done with a computer program
- ☐ automatically done with a microprocessor

Detection Criterion

24. What threshold is used to determine whether the pipeline is leaking?
___________________________ (in the units used by the measurement system)
___________________________ (in gal/hr)

25. Is a multiple-test sequence used to determine whether the pipeline is leaking?
- ☐ yes (If yes, answer the three questions below)
- ☐ no (If no, skip the three questions below)

How many tests are conducted? ____
How many tests are required before a leak can be declared? ___________________________________
What is the time between tests? ____
(Enter 0 if the tests are conducted one after the other.)

Calibration

26. How frequently are the sensor systems calibrated?
- ☐ never
- ☐ before each test
- ☐ weekly
- ☐ monthly
- ☐ semi-annually
- ☐ yearly or less frequently

Attachment 2
Summary Of Performance Estimates

Pipeline Release Detection Method
Line Tightness Test

Complete this page if the pipeline release detection method has been evaluated as a line tightness test. Complete the first table. The last three tables present the performance of the method for different combinations of thresholds, probabilities of false alarm, and probabilities of detection. They are useful for comparing the performance of this method to that of other methods. However, completion of the last three tables is optional.

Performance Of The Pipeline Release Detection Method As Evaluated

Description	Leak Rate (gal/hr)	P(d)	P(fa)	Threshold (gal/hr)
Evaluated Method	0.10			
EPA Standard	0.10	0.95	0.05	N/A

P(fa) As A Function Of Threshold

Threshold (gal/hr)	P(fa)
	0.10
	0.075
	0.05
	0.05

P(d) As A Function Of Threshold For A Leak Rate Of 0.10 gal/hr

Threshold (gal/hr)	P(d)
	0.95
	0.90
	0.80
	0.50

Smallest Leak Rate That Can Be Detected With The Specified P(d) and P(fa)

Leak Rate (gal/hr)	P(d)	P(fa)
	0.95	0.10
	0.95	0.075
	0.95	0.05
	0.90	0.05
	0.80	0.05
	0.50	0.05

Attachment 2
Summary Of Performance Estimates

Pipeline Release Detection Method
Line Tightness Test
First Test Of A Multiple-Test Sequence

Complete these tables only if the method being evaluated requires, as part of its test procedures, more than one complete test to determine whether the pipeline is leaking. Method performance based on the first test alone must be reported on this form. Complete the first table. The last three tables present the performance of the method for different combinations of thresholds, probabilities of false alarm, and probabilities of detection. They are useful for comparing the performance of this method to that of other methods. However, completion of the last three tables is optional.

Performance Of The Pipeline Release Detection Method As Evaluated

Description	Leak Rate (gal/hr)	P(d)	P(fa)	Threshold (gal/hr)
Evaluated Method	0.10			
EPA Standard	0.10	0.95	0.05	N/A

P(fa) As A Function Of Threshold

Threshold (gal/hr)	P(fa)
	0.10
	0.075
	0.05
	0.05

P(d) As A Function Of Threshold For A Leak Rate Of 0.10 gal/hr

Threshold (gal/hr)	P(d)
	0.95
	0.90
	0.80
	0.50

Smallest Leak Rate That Can Be Detected With The Specified P(d) and P(fa)

Leak Rate (gal/hr)	P(d)	P(fa)
	0.95	0.10
	0.95	0.075
	0.95	0.05
	0.90	0.05
	0.80	0.05
	0.50	0.05

Attachment 2
Summary Of Performance Estimates

Pipeline Release Detection Method
Monthly Monitoring Test

Complete this page if the pipeline release detection method has been evaluated as a monthly monitoring test. Complete the first table. The last three tables present the performance of the method for different combinations of thresholds, probabilities of false alarm, and probabilities of detection. They are useful for comparing the performance of this method to that of other methods. However, completion of the last three tables is optional.

Performance Of The Pipeline Release Detection Method As Evaluated

Description	Leak Rate (gal/hr)	P(d)	P(fa)	Threshold (gal/hr)
Evaluated Method	0.20			
EPA Standard	0.20	0.95	0.05	N/A

P(fa) As A Function Of Threshold

Threshold (gal/hr)	P(fa)
	0.10
	0.075
	0.05
	0.05

Probability Of Detection As A Function Of Threshold For A Leak Rate Of 0.20 gal/hr

Threshold (gal/hr)	P(d)
	0.95
	0.90
	0.80
	0.50

Smallest Leak Rate That Can Be Detected With The Specified P(d) and P(fa)

Leak Rate (gal/hr)	P(d)	P(fa)
	0.95	0.10
	0.95	0.075
	0.95	0.05
	0.90	0.05
	0.80	0.05
	0.50	0.05

Attachment 2
Summary of Performance Estimates

Pipeline Release Detection Method
Monthly Monitoring Test
First Test Of A Multiple-Test Sequence

Complete these tables only if the method being evaluated requires, as part of its test procedures, more than one complete test to determine whether the pipeline is leaking. Method performance based on the first test alone must be reported on this form. Complete the first table. The last three tables present the performance of the method for different combinations of thresholds, probabilities of false alarm, and probabilities of detection. They are useful for comparing the performance of this method to that of other methods. However, completion of the last three tables is optional.

Performance Of The Pipeline Release Detection Method As Evaluated

Description	Leak Rate (gal/hr)	P(d)	P(fa)	Threshold (gal/hr)
Evaluated Method	0.20			
EPA Standard	0.20	0.95	0.05	N/A

P(fa) As A Function of Threshold

Threshold (gal/hr)	P(fa)
	0.10
	0.075
	0.05
	0.05

P(d) As A Function Of Threshold For A Leak Rate Of 0.20 gal/hr

Threshold (gal/hr)	P(d)
	0.95
	0.90
	0.80
	0.50

Smallest Leak Rate That Can Be Detected With The Specified P(d) and P(fa)

Leak Rate (gal/hr)	P(d)	P(fa)
	0.95	0.10
	0.95	0.075
	0.95	0.05
	0.90	0.05
	0.80	0.05
	0.50	0.05

Attachment 2
Summary Of Performance Estimates

Pipeline Release Detection Method
Hourly Test

Complete this page if the pipeline release detection method has been evaluated as an hourly test. Complete the first table. The last three tables present the performance of the method for different combinations of thresholds, probabilities of false alarm, and probabilities of detection. They are useful for comparing the performance of this method to that of other methods. However, completion of the last three tables is optional.

Performance Of The Pipeline Release Detection Method As Evaluated

Description	Leak Rate (gal/hr)	P(d)	P(fa)	Threshold (gal/hr)
Evaluated Method	3.0			
EPA Standard	3.0	0.95	0.05	N/A

P(fa) As A Function Of Threshold

Threshold (gal/hr)	P(fa)
	0.10
	0.075
	0.05
	0.05

P(d) As A Function Of Threshold For A Leak Rate Of 3.0 gal/hr

Threshold (gal/hr)	P(d)
	0.95
	0.90
	0.80
	0.50

Smallest Leak Rate That Can Be Detected With The Specified P(d) And P(fa)

Leak Rate (gal/hr)	P(d)	P(fa)
	0.95	0.10
	0.95	0.075
	0.95	0.05
	0.90	0.05
	0.80	0.05
	0.50	0.05

Attachment 2
Summary Of Performance Estimates

Pipeline Release Detection Method
Hourly Test
First Test Of A Multiple-Test Sequence

Complete this page only if the method being evaluated requires, as part of its test procedures, more than one complete test to determine whether the pipeline is leaking. Method performance based on the first test alone must be reported on this form. Complete the first table. The last three tables present the performance of the method for different combinations of thresholds, probabilities of false alarm, and probabilities of detection. They are useful for comparing the performance of this method to that of other methods. However, completion of the last three tables is optional.

Performance Of The Pipeline Release Detection Method As Evaluated

Description	Leak Rate (gal/hr)	P(d)	P(fa)	Threshold (gal/hr)
Evaluated Method	3.0			
EPA Standard	3.0	0.95	0.05	N/A

P(fa) As A Function Of Threshold

Threshold (gal/hr)	P(fa)
	0.10
	0.075
	0.05
	0.05

P(d) As A Function Of Threshold For A Leak Rate Of 3.0 gal/hr

Threshold (gal/hr)	P(d)
	0.95
	0.90
	0.80
	0.50

Smallest Leak Rate That Can Be Detected With The Specified P(d) and P(fa)

Leak Rate (gal/hr)	P(d)	P(fa)
	0.95	0.10
	0.95	0.075
	0.95	0.05
	0.90	0.05
	0.80	0.05
	0.50	0.05

Attachment 3
Summary Of The Configuration Of The Pipeline System(s)

Complete these tables to identify the configuration of the pipeline system.

Pipeline Release Detection Method *At Test Facility Or Retail Station*

Specialized Test Facility Or Operational UST Facility	
lnside diameter of pipeline (in.)	
Length of pipeline (tank to dispenser) (ft)	
Volume of product in line during testing (gal)	
Type of material (fiberglass, steel, other[1])	
Type of product in tank and pipeline (gasoline, diesel, other[2])	
Was a mechanical line leak detector present? (yes or no)	
Was trapped vapor present? (yes or no)	
Compressibility (C) (psi)	
C/V_o (psi/gal)	
Storage tank capacity (gal)	

[1] Specify type of construction material.
[2] Specify type of product for each tank.

Attachment 3
Summary Of The Configuration Of The Pipeline System(s)

Pipeline Release Detection Method *At Retail Facility*

Operational Tank System	**1**	**2**	**3**	**4**	**5**
lnside diameter of pipeline (in.)					
Length of pipeline (tank to dispenser) (ft)					
Volume of product in line during testing (gal)					
Type of material (fiberglass, steel, other[1])					
Type of product in tank and pipeline (gasoline, diesel, other[2])					
Was a mechanical line leak detector present? (yes or no)					
Was trapped vapor present? (yes or no)					
Compressibility (C) (psi)					
C/V_o (psi/gal)					
Storage tank capacity (gal)					

[1] Specify type of construction material.
[2] Specify type of product for each tank.

Operational Tank System	**6**	**7**	**8**	**9**	**10**
lnside diameter of pipeline (in.)					
Length of pipeline (tank to dispenser) (ft)					
Volume of product in line during testing (gal)					
Type of material (fiberglass, steel, other[1])					
Type of product in tank and pipeline (gasoline, diesel, other[2])					
Was a mechanical line leak detector present? (yes or no)					
Was trapped vapor present? lye's or no)					
Compressibility (C) (psi)					
C/V_o (psi/gal)					
Storage tank capacity (gal)					

[1] Specify type of construction material.
[2] Specify type of product for each tank.

Attachment 3
Summary Of The Configuration Of The Pipeline System(s)

Pipeline Release Detection Method *At Retail Facility*

Operational Tank System	**11**	**12**	**13**	**14**	**15**
lnside diameter of pipeline (in.)					
Length of pipeline (tank to dispenser) (ft)					
Volume of product in line during testing (gal)					
Type of material (fiberglass, steel, other[1])					
Type of product in tank and pipeline (gasoline, diesel, other[2])					
Was a mechanical line leak detector present? (yes or no)					
Was trapped vapor present? (yes or no)					
Compressibility (C) (psi)					
C/V_o (psi/gal)					
Storage tank capacity (gal)					

[1] Specify type of construction material.
[2] Specify type of product for each tank.

Operational Tank System	**16**	**17**	**18**	**19**	**20**
lnside diameter of pipeline (in.)					
Length of pipeline (tank to dispenser) (ft)					
Volume of product in line during testing (gal)					
Type of material (fiberglass, steel, other[1])					
Type of product in tank and pipeline (gasoline, diesel, other[2])					
Was a mechanical line leak detector present? (yes or no)					
Was trapped vapor present? lye's or no)					
Compressibility (C) (psi)					
C/V_o (psi/gal)					
Storage tank capacity (gal)					

[1] Specify type of construction material.
[2] Specify type of product for each tank.

Attachment 4
Data Sheet Summarizing Product Temperature Conditions

Pipeline Release Detection Method *At Test Facility*

Test No. (Based on Temperature Condition)	Date Test Began	Nominal Product Temperature Before Circulation Was Started	Two Times Replacement Of Volume In Piping	Duration Of Circulation	Time Of Temperature Measurements	T_{TB}	T_1	T_2	T_3	T_G	$T_{TB} - T_G$	Temperature Differential
	(D-M-Y)	(°F)	(gal)	(hr-min)	(local military)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)
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2												
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Attachment 4
Data Sheet Summarizing Product Temperature Conditions

Pipeline Release Detection Method *At Test Facility*

Test No.	Date Test Began	Nominal Product Temperature Before Circulation Was Started	Two Times Replacement Of Volume In piping	Duration of Circulation	Time Of Temperature Measurements	T_{TB}	T_1	T_2	T_3	T_G	T_{TB} - T_G	Temperature Differential
	(D-M-Y)	(°F)	(gal)	(hr-min)	(local military)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)
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24*												
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39												
40												
41												
42**												

***Minimum number of tests for quantitative test methods.**

****Minimum number of tests for qualitative test methods.**

Attachment 4
Data Sheet Summarizing Product Temperature Conditions

Pipeline Release Detection Method *At Retail Facility*

Test No.	Date Test Began	Date of Last Product Delivery	Time of Last Product Delivery	Time Between Product Delivery And Data Collection For Test	Time of Last Dispensing	Time Between Last Dispensing And Start Of Data Collection For Test	Time of Temperature Measurements	T_{TB}	T_1	T_2	T_3	T_G	$T_{TB}-T_G$	Temperature Differential
	(D-M-Y)	(D-M-Y)	(local military)	(hr-min)	(local military)	(hr-min)	(local military)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)
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Attachment 4
Data Sheet Summarizing Product Temperature Conditions

Pipeline Release Detection Method *At Retail Facility*

Test No.	Date Test Began	Date of Last Product Delivery	Time of Last Product Delivery	Time Between Product Delivery And Data Collection For Test	Time Of Last Dispensing	Time Between Last Dispensing And Start Of Data Collection For Test	Time Of Temperature Measurements	T_{TB}	T_1	T_2	T_3	T_G	$T_{TB} - T_G$	Temperature Differential
	(D-M-Y)	(D-M-Y)	(local military)	(hr-min)	(local military)	(hr-min)	(local military)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)
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24*														
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41														
42**														

***Minimum number of tests for quantitative test method evaluation. **Minimum number of tests for qualitative test method evaluation.**

Attachment 5
Data Sheet Summarizing Test Results And Leak Rates

Pipeline Release Detection Method *At Test Facility*

Test No.	Date Test Began	Induced Leak Rate	Time Between End Of Circulation And Start Of Data Collection For Test	Time Data Collection Began	Time Data Collection Ended	Measured Test Result (quantitative)	Was Threshold Exceeded? (qualitative)
	(D-M-Y)	(gal/hr)	(hr-min)	(local military)	(local military)	(gal/hr)	(yes or no)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24*							
25							
26							
27							
28							
29							
30							
31							
32							
33							

Attachment 5
Data Sheet Summarizing Test Results And Leak Rates

Pipeline Release Detection Method *At Test Facility*

Test No.	Date Test Began	Induced Leak Rate	Time Between End Of Circulation And Start Of Data Collection For Test	Time Data Collection Began	Time Data Collection Ended	Measured Test Result (quantitative)	Was Threshold Exceeded? (qualitative)
	(D-M-Y)	(gal/hr)	(hr-min)	(local military)	(local military)	(gal/hr)	(yes or no)
34							
35							
36							
37							
38							
39							
40							
41							
42**							

***Minimum number of tests for quantitative test method evaluation.**
****Minimum number of tests for qualitative test method evaluation.**

Attachment 5
Data Sheet Summarizing Test Results And Leak Rates

Pipeline Release Detection Method *At A Retail Facility*

Test No.	Date Test Began	Date of Last Product Delivery	Time of Last Product Delivery	Time Between Product Delivery And Start of Data Collection For Test	Time Of Last Dispensing	Time Between Last Dispensing And Start Of Data Collection For Test	Time Data Collection Began	Time Data Collection Ended	Measured Test Result (quantitative)	Was Threshold Exceeded? (qualitative)
	(D-M-Y)	(D-M-Y)	(local military)	(hr-min)	(local military)	(hr-min)	(local military)	(local military)	(gal/hr)	(yes or no)
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
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16										
17										
18										
19										
20										
21										

Attachment 5
Data Sheet Summarizing Test Results And Leak Rates

Pipeline Release Detection Method *At A Retail Facility*

Test No.	Date Test Began	Date of Last Product Delivery	Time of Last Product Delivery	Time Between Product Delivery And Start Of Data Collection For Test	Time Of Last Dispensing	Time Between Last Dispensing And Start Of Data Collection For Test	Time Data Collection Began	Time Data Collection Ended	Measured Test Result (quantitative)	Was Threshold Exceeded? (qualitative)
	(D-M-Y)	(D-M-Y)	(local military)	(hr-min)	(local military)	(hr-min)	(local military)	(local military)	(gal/hr)	(yes or no)
22										
23										
24*										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										
35										
36										
37										
38										
39										
40										
41										
42**										

***Minimum number of tests for quantitative test method evaluation.** ****Minimum number of tests for qualitative test method evaluation.**

Attachment 6
Data Sheet Summarizing Test Results And Trapped Vapor Tests

Pipeline Release Detection Method *At Test Facility*
Summary of Temperature Conditions

Test No.	Date Test Began	Nominal Product Temperature Before Circulation Was Started	Time Circulation Started	Time Circulation Ended	Duration Of Circulation	Time of Temperature Measurements	T_{TB}	T_1	T_2	T_3	T_G	T_{TB} - T_G	Temperature Test Matrix Category
	(D-M-Y)	(°F)	(local military)	(local military)	(hr-min)	(local military)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)	(Table 2)
1													
2													
3													

Summary of Leak Rates

Test No.	Date Test Began	Pipeline Pressure	Induced Leak Rate	Time Between End Of Circulation And Start Of Data Collection For Test	Time Data Collection Began	Time Data Collection Ended	Measured Test Result (quantitative)	Was Threshold Exceeded? (qualitative)
	(D-M-Y)	(psi)	(gal/hr)	(hr-min)	(local military)	(local military	(gal/hr)	(yes or no)
1								
2								
3								

Attachment 6
Data Sheet Summarizing Test Results And Trapped Vapor Tests

Pipeline Release Detection Method *At A Retail Facility*
Summary Of Temperature Conditions

Test No.	Date Test Began	Date of Last Product Delivery	Time of Last Product Delivery	Time between Product Delivery And Start Of Data Collection For Test	Time Of Last Dispensing	Time between Start of Data Collection for Test and Last Dispensing	Time Of Temperature Measurements	T_{TB}	T_1	T_2	T_3	T_G	$T_{TB} - T_G$	Temperature Test Matrix Category
	(D-M-Y)	(D-M-Y)	(local military)	(hr-min)	(local military)	(hr-min)	(local military)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)	(Table 2)
1														
2														
3														

Summary of Leak Rates

Test No.	Date Test Began	Pipeline Pressure	Induced Leak Rate	Time between Product Delivery And Start Of Data Collection For Test	Time Between Start Of Data Collection For Test And Last Dispensing	Time Data Collection Began	Time Data Collection Ended	Measured Test Result (quantitative)	Was Threshold Exceeded? (qualitative)
	(D-M-Y)	(psi)	(gal/hr)	(hr-min)	(hr-min)	(local military)	(local military)	(gal/hr)	(yes or no)
1									
2									
3									

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Environmental	Emergency Management	May 2019
Protection Agency	5401R	www.epa.gov/ust