Test Procedures for Third Party Evaluation of Leak Detection Methods: Point Sensor Liquid Contact Leak Detection Systems

Point Sensors: Accuracy & Response Time
Point Sensors: Specificity
Point Sensors: Lower Detection Limit

Final Report
November 11, 1991

prepared for

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CMRI Contract 1-41224

Abstract

Presently there are no EPA approved methods or procedures for third party evaluation of liquid contact leak detection systems using point sensors. These point sensors are commonly used for detecting the presence of fuel products that collect in sumps or within the interstitial space of double-walled underground storage tanks or pipes.

These procedures were developed to satisfy the EPA criteria for third party testing of accuracy and response time, specificity, and the lower detection limit for liquid contact point sensors. The tests were designed to yield results that could be related to the performance of liquid contact point sensor leak detection systems at actual underground storage tank sites.

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Point Sensor Liquid Contact Leak Detection Systems

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Point Sensor Liquid Contact Leak Detection Systems

1.0 Introduction

These test procedures describe methods to determine the accuracy, response time, specificity, and lower detection limit for liquid hydrocarbon leak detectors that consist of a monitor and one or more point sensors. These devices are used to detect leaks of fuels or solvents that collect in sumps or within the interstitial (annular) space of double-walled pipes or tanks.

The Federal Register [1] states that a new method of detection can be used if it can detect a release rate of 0.2 gal/hour or 150 gallons within a month with a probability of detection of 95% and a probability of false alarm of 5%. Test procedures to determine if sensors can meet this criteria have been established with the March 1990, EPA manual, "Standard Test Procedures for Evaluating Leak Detection Methods: Liquid-Phase Out-of-Tank Product Detectors" [2].

The foreward of this March 1990, EPA manual (Appendix 1), contains a section titled "Alternative Test Procedures Deemed Equivalent to the EPA's". This section details guidelines for an independent lab to develop equivalent third party tests for those protocols already approved by the EPA. The design of these test procedures follows the guidelines presented in this foreward. They also go one step further in that they are designed as third party testing procedures for liquid phase product sensor/monitors for which the EPA has no approved protocols. Therefore, changes have been made to accommodate the detection mechanisms unique to liquid contact point sensors.

It should be noted that where possible, text from the EPA Standard Test Procedures has been used to provide for consistency in developing a parallel test procedure.

The procedures and the test apparatus are meant to be simple, yet flexible. The procedures use common laboratory equipment or other apparatus that can be easily fabricated. The test chamber should fit easily in a standard fume hood. It should also be possible to run several tests at the same time. The testing procedures can be

adapted to the wide variety of point sensors and monitors that are on the market. In addition, although this document is intended for point sensors that detect non-viscous hydrocarbons such as gasoline, the procedures can be easily modified for testing point sensors that detect waste oils, water, water-based solutions, etc. This will enable comparisons to be made among the many types of point sensor/monitor systems that are on the market.

The point sensor/monitor systems are tested by suspending the point sensor in a non-reactive cylindrical container, such as a glass beaker or graduated cylinder. The beaker should be just slightly larger than the diameter of the point sensor. This will minimize the amount of the test liquid that is used, an important consideration when combustible materials are being tested. The container is also fitted with a cover that will minimize the evaporation of volatile liquids.

The test liquid, commercially available, unleaded gasoline, is added to the chamber at a constant rate of flow for all of the tests, to maintain a constant increase in height of 5 mm/minute. The sensor is monitored to determine if it will activate in the presence of the test liquid. If the sensor activates, the response time is measured as well as the height of test liquid added. Finally, if the sensor can be reused, recovery time is also measured.

Four liquids were selected for use in the specificity tests. Diesel fuel and heating oil were selected because of their occurrence in documented large scale UST spills [3]. Synthetic Gasoline [4], was selected as a standard since gasoline and diesel fuels vary in chemical composition. Finally, water was selected because it has the potential of coming into contact with the point sensors.

These procedures have been developed so that test results can be used to determine how a device would perform at an underground storage tank (UST) site. As an example, a 5000 gallon UST with 3 inch interstitial spacing will be used. The UST tank's shape is rectangular for ease of modeling (Appendix 2). The model shows that a leak rate of 0.2 gal/hr will cause the level of the product to rise at a rate of 0.2 inches/hour. The test results of a given point sensor demonstrate that when 2 inches of product has accumulated in the beaker, the sensor activated. With this information, it could be determined that it would take 10 hours for the point sensor to activate for a leak of 0.2 gal/hr into the UST's interstitial space.

The calculations and manner in which the test results will be presented are again based, in general, on the March 1990, EPA manual [2]. Changes have been made to accommodate the unique properties of these point sensor leak detector systems.

A list of equations and symbols follows the sections on calculations.

The report ends with the Reporting Forms, summarizing the test results, which have been designed under the guidelines set forth in the "Alternative Test Procedures Deemed Equivalent to the EPA's". The Reporting Forms follow the same general format and information presented in the EPA standard results sheet.

2.0 Test Chamber

The point sensor tests should be performed using a non-reactive cylindrical container, for example, a glass beaker or graduated cylinder. It is convenient to have a transparent container so that the liquid level can be observed. The test chamber can also be constructed from stainless steel, Teflon, or any other material that is not sensitive to the test liquids (Figure 1p).

NOTE: If the test chamber is made from metal, care should be taken to ground both the chamber and the cover. The test chamber and other apparatus should be anchored securely to prevent tipping. For example, the beaker can be clamped to a ring stand. The tests should be conducted in a properly operating fume hood.

In order to minimize the amount of flammable test liquid that is used for each trial, the test chamber should have an inside diameter 1/2 to 1 inch larger than the point sensor diameter. The test chamber should be approximately twice the height of the point sensor. A height of 8 to 10 inches should accommodate most types of point sensors.

The container must have a cover to prevent the evaporation of the volatile test liquids. For example, a cover can be made from a sheet of Viton that does not react with hydrocarbons with small slits made to admit the point sensor wires, etc.

The test liquid can be added by means of a mechanical pump or by gravity flow from a separatory funnel. The separatory funnel should have a narrow stem to control the direction of the flow and a Teflon stopcock to eliminate the chance of contamination from lubricants. (For example, a Pyrex separatory funnel is available with an offset PTFE plug stopcock. A knob operates the plug against the valve seat, allowing precise control of flow.)

3.0 General Procedure

Care should be taken to minimize or eliminate conditions that would contribute to poor precision in the data. For example: The test chamber should be kept level and covered until all of the data for a particular trial are recorded. Tests should be conducted at constant, normal laboratory temperatures. All of the apparatus and test liquids should be at normal laboratory temperatures (± 2°C) before the start of testing.

Equipment such as the thermometer, data collection systems (i.e., chart recorder, lab timers, data acquisition system), and test monitor, should be calibrated before use. The dimensions of the point sensor should be measured and average readings obtained. The product delivery system should also be calibrated so that the liquid flow rate maintains the liquid rate of rise to be approximately 5 mm/min or 1 cm every 2 minutes. This would represent a leak rate of 0.12 gal/hr, assuming a point sensor with a 1 inch diameter and test chamber with a 2 inch diameter.

The cable sensor should be tested at the maximum effective range (MER) given by the manufacturer, unless it is otherwise specified in the procedures.

The point sensor should be suspended near the bottom of the test chamber in a manner similar to the way that it would be installed in the field. Consult the manufacturer's directions.

Some variations in test results can be expected because of the varying structure of a given point sensor (i.e. porous, solid, round, square, etc.). It is also important to carefully measure the product flow rate and rate of rise for each test. The average and standard deviation for each of these variables for the test procedures should be reported.

3.1 Procedure for Testing Accuracy and Response Time

The monitor/point sensor system is tested with a single test liquid: unleaded gasoline. The point sensor should be tested six times.

Before the analysis, perform a blank test by recording the monitor output for 30 minutes while the test container is empty.

The test liquid should be added near the side of the test chamber and should not flow directly over the point sensor. The flow rate should be adjusted so that the liquid level in the test chamber rises at the rate of 5 mm/min or 1 cm every 2 min. Flow should continue until the monitor is activated or until the liquid reaches 20% over the height needed for activation, as specified by the manufacturer. If the monitor has not become activated by the time that the liquid has reached this point, the flow of the liquid should be stopped, and the system allowed to stand. End the test if the monitor has not become activated after waiting an additional 2 hours.

Some sensors can only be used once and must be replaced after each test. Other sensors can recover to the original signal level when removed from the hydrocarbon and may be used again. If the sensor mechanism permits repeated usage, then the sensor should be removed from the test liquid, and the time needed to recover from the activation level should be recorded. The test should be ended after 1 hour if the signal has not recovered.

Depending on the sensor mechanism, the same point sensor may be able to be cleaned, reset and used again within a reasonable length of time. Otherwise, the point sensor must be replaced after each test run.

The following quantities should be recorded: temperature of the test liquid, rate of addition of the test liquid, volume of test liquid added, height of the test liquid at activation, response time, and recovery time.

3.2 Procedure for Testing Specificity

To test for specificity, the monitor/point sensor system is tested three times with four test liquids: heating oil, diesel fuel, synthetic gasoline (Appendix 3), and water.

Before the analysis, perform a blank test by recording the monitor output for 30 minutes while the test container is empty.

The test liquid should be added near the side of the test chamber and should not flow directly over the point sensor. The flow rate should be adjusted so that the liquid level in the test chamber rises at the rate of 5 mm/min or 1 cm every 2 min. Flow should continue until the monitor is activated or until the liquid reaches 20% over the height needed for activation, as specified by the manufacturer. If the monitor has not become activated by the time that the liquid has reached this point, the flow of the liquid should be stopped, and the system allowed to stand. End the test if the monitor has not become activated after waiting an additional 2 hours.

Some sensors can only be used once and must be replaced after each test. Other sensors can recover to the original signal level when removed from the hydrocarbon and may be used again. If the sensor mechanism permits repeated usage, then the sensor should be removed from the test liquid, and the time needed to recover from the activation level should be recorded. The test should be ended after 1 hour if the signal has not recovered.

Depending on the sensor mechanism, the same point sensor may be able to be cleaned, reset and used again within a reasonable length of time. Otherwise, the point sensor must be replaced after each test run.

The following quantities should be recorded: temperature of the test liquid, rate of addition of the test liquid, volume of test liquid added, height of the test liquid at activation, response time, and recovery time.

3.3 Procedure for Testing Lower Detection Limit

The tests for lower detection limit will vary depending on the type of mechanism that activates the sensor. For point sensors which react rapidly, such as those activated by a trip switch, the lower detection limit can be calculated from the data accuracy and response time measurements for unleaded gasoline.

For point sensors which have a slower reaction time, such as those activated by a chemical process, the monitor/point sensor system is tested with a single test liquid: unleaded gasoline.

Before testing, perform a blank test by recording the monitor output for 30 minutes while the test container is empty.

The test liquid should be added near the side of the test chamber and should not flow directly over the point sensor. The sensor should be tested 6 times at 90% of the height needed for activation, as specified by the manufacturer. The system should be allowed to stand at that height until the monitor becomes activated. If the monitor has not activated after 2 hours, the test should be ended.

If all of the responses are positive at 90%, repeat the tests at 80%. If the monitor fails to activate once during the 90% height tests, the tests should be repeated at 100% of the height recommended by manufacturer. Repeat the tests at 110% and 120% if there are any negative responses.

The lower detection limit can be calculated from the data at the minimum height that activated the point sensor 6 out of 6 times for unleaded gasoline.

The following quantities should be recorded: temperature of the test liquid, rate of addition of the test liquid, volume of test liquid added, height of the test liquid at activation, response time, and recovery time.

4.0 Calculations

The calculations for these test procedures are based, in general, on the Standard Test Procedures for Evaluating Leak Detection Methods: Liquid-Phase Out-of-Tank Product Detectors [2]. Changes have been made to accommodate the unique properties of the point sensor leak detector systems. A list of equations and symbols follows the sections on calculations.

4.1 Calculations for Testing Accuracy and Response Time

Calculate and report for **unleaded gasoline** at the point ranges tested:
- **Detection Accuracy** (Equation 1)
- **Product Activation Height** as the Average Observed Value (Equation 2) with Standard Deviation (Equation 3)
- **Response Time** (Equation 4) as the Average Observed Value (Equation 2) with Standard Deviation (Equation 3)
- **Recovery Time** (Equation 5) as the Average Observed Value (Equation 2) with Standard Deviation (Equation 3)

4.2 Calculations for Testing Specificity

For heating oil, diesel fuel, synthetic gasoline, and water
Calculate and report at the point range tested:
- **Detection Accuracy** (Equation 1)
- **Product Activation Height** as the Average Observed Value (Equation 2) with Standard Deviation (Equation 3)
- **Response Time** (Equation 4) as the Average Observed Value (Equation 2) with Standard Deviation (Equation 3)
- **Recovery Time** (Equation 5) as the Average Observed Value (Equation 2) with Standard Deviation (Equation 3)
- **Specificity for Detection Accuracy** (Equation 6)
  [Use unleaded gasoline as the reference point.]

4.3 Calculations for Testing Lower Detection Limit

For point sensors which react rapidly, calculate the lower detection limit (Equation 7, 8) for the height of test liquid needed to activate the monitor. Use the data collected for unleaded gasoline at the maximum effective range for the system being tested.

For point sensors which react more slowly, calculate the lower detection limit (Equation 7, 8) from minimum product height needed to activate the sensor 6 out of 6 times.

5.0 Equations

$$\text{detection accuracy, \%} = \frac{r_p}{n} \times 100 \tag{1}$$

$$\text{average observed value } (\overline{V_o}) = \frac{1}{n} \sum_{i=1}^{n} V_i \tag{2}$$

$$\text{standard deviation of n values (s)} = \sqrt{\frac{\sum_{i=1}^{n} V_i^2 - n\left(\overline{V_o}\right)^2}{n-1}} \tag{3}$$

$$\text{response time} = T_{activation} - T_{initial} \tag{4}$$

$$\text{recovery time} = T_{recovery} - T_{activation} \tag{5}$$

$$\text{specificity, \%} = \frac{\overline{V_o}}{V_r} \times 100 \tag{6}$$

$$\text{absolute bias, B} = \left| \overline{V_o} - V_r \right| \tag{7}$$

$$\text{lower detection limit} = 2(K \times s) + B \tag{8}$$

6.0 Symbols

B = absolute bias

K = one-sided tolerance limit factor for a 5% beta error
at a 95% confidence level [3.707 for n=6] (Table 1)

n = number of tests in the data set

r_p = number of positive responses

s = standard deviation of n values (n-1 degrees of freedom)

$T_{activation}$ = time when monitor becomes activated

$T_{initial}$ = time when liquid is first added to the test container

$T_{recovery}$ = time when monitor recovers to unactivated state

V_i = the individual response to the test product

$\overline{V_o}$ = the average observed value

V_r = the reference or theoretical value

Disclaimers

These procedures involve hazardous materials, operations, and equipment. This document does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use. There is no intent to endorse any commercial products that may be mentioned in these procedures.

TABLE 1. One-Sided Tolerance Limit Factors for a 5% Beta Error at a 95% Confidence Level

n	Tolerance Limit Factor (K)
3	7.655
4	5.145
5	4.202
6	3.707
7	3.399
8	3.188

Experimental Statistics, M. G. Natrella, National Bureau of Standards Handbook 91, US Department of Standards, Stock Number 003-003-00135-0, 1963, Reprinted 1966.
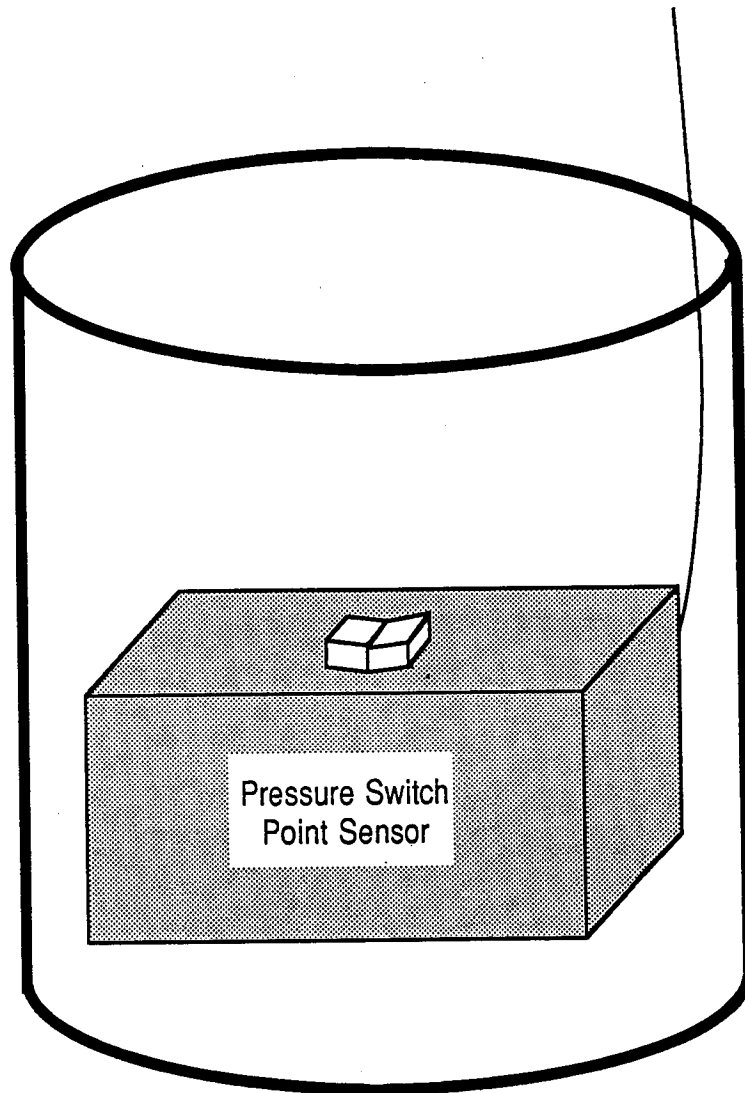
FIGURE 1p: TEST CHAMBER FOR POINT SENSORS

(not to scale)

Appendix 1 -- EPA Documents: Foreword

Standard Test Procedures for Evaluating Leak Detection Methods:
Liquid-Phase Out-of-Tank Product Detectors, EPA/530/UST-90/009
March 1990

Foreword

How to Demonstrate that Leak Detection Methods Meet EPA's Performance Standards

The Environmental Protection Agency's (EPA'S) regulations for underground storage tanks require owners and operators to check for leaks on a routine basis using a number of detection methods (40 CFR Part 280, Subpart D). In order to ensure the effectiveness of these methods, EPA set minimum performance standards for equipment used to comply with the regulations. For example, after December 22, 1990, all tank tightness testing methods must be capable of detecting a 0.10 gal/hr leak rate with a probability of detection of at least 95% and a probability of false alarm of no more that 5%. It is up to tank owners and operators to select a method of leak detection that has been shown to meet the relevant performance standard.

Deciding whether a method meets the standard has not been easy, however. Until recently, manufacturers of leak detection methods have tested their equipment using a wide variety of approaches, some more rigorous than others. Tank owners and operators have been generally unable to sort through the conflicting sales claims that are made based on the results of these evaluations. To help protect consumers, some state agencies have developed mechanisms for approving leak detection methods. These approval procedures vary from state to state, making it their method nationwide. The purpose of this policy is to describe the ways that owners and operators can check that the leak detection equipment or service they purchase meets the federal regulatory requirements. States may have additional requirements for approving the use of leak detection methods.

EPA will not test, certify or approve specific brands of commercial leak detection equipment. The large number of commercially available leak detection methods makes it impossible for the Agency to test all the equipment or review all the

performance claims. Instead, the Agency is describing how equipment should be tested to prove that it meets the standards. Conducting this testing is left up to equipment manufacturers in conjunction with third-party testing organizations. The manufacturers will then provide a copy of the report showing that the method meets EPA's performance standards. This information should be provided to customers or regulators as requested. Tank owners and operators should keep the evaluation results on file to satisfy EPA's record keeping requirements.

EPA recognizes three distinct ways to prove that a particular brand of leak detection equipment meets the federal performance standards:

1. Evaluate the method using the EPA's standard test procedures for leak detection equipment;

2. Evaluate the method using a national voluntary consensus code or standard developed by a nationally recognized association or independent third-party testing laboratory; or,

3. Evaluate the method using a procedure deemed equivalent to an EPA procedure by a nationally recognized association or independent third-party testing laboratory.

The manufacturer of the leak detection method should prove that the method meets the regulatory performance standards using one of these three approaches. For regulatory enforcement purposes, each of the approaches is equally satisfactory. The following sections describe the ways to prove the performance in more detail.

EPA Standard Test Procedures

EPA has developed a series of standard test procedures that cover most of the methods commonly used for underground storage tank leak detection. These include:

1. "Standard Test Procedures for Evaluating Leak Detection Methods: Volumetric Tank Tightness Testing Methods"
2. "Standard Test Procedures for Evaluating Leak Detection Methods: Non-Volumetric Tank Tightness Testing Methods"
3. "Standard Test Procedures for Evaluating Leak Detection Methods: Automatic Tank Gauging Systems"
4. "Standard Test Procedures for Evaluating Leak Detection Methods: Statistical Inventory Reconciliation Methods"
5. "Standard Test Procedures for Evaluating Leak Detection Methods: Vapor-Phase Out-of-Tank Product Detectors"
6. "Standard Test Procedures for Evaluating Leak Detection Methods: Liquid-Phase Out-of-Tank Product Detectors"
7. "Standard Test Procedures for Evaluating Leak Detection Methods: Pipeline Leak Detection Systems"

Each test procedure provides an explanation of how to conduct the test, how to perform the required calculations, and how to report the results. The results from each standard test procedure provide the information needed by tank owners and operators to determine if the method meets the regulatory requirements.

The EPA standard test procedures may be conducted directly by equipment manufacturers or may be conducted by an independent third party under contract to the manufacturer. However, both state agencies and tank owners typically prefer that the evaluation be carried out by an independent third party in order to prove compliance with the regulations. Independent third parties may include consulting firms, test laboratories, not-for-profit research organizations, or educational institutions with no organizational conflict of interest. In general, EPA believes that evaluations are more likely to be fair and objective the greater the independence of the evaluating organization.

National Consensus Code or Standard

A second way for a manufacturer to prove the performance of leak detection equipment is to evaluate the system following a national voluntary consensus code or standard developed by a nationally recognized association (e.g. ASTM, ASME, ANSI, etc.). Throughout the technical regulations for underground storage tanks, EPA has relied on national voluntary consensus codes to help tank owners decide which brands of equipment are acceptable. Although no such code presently exists for evaluating leak detection equipment, one is under consideration by the ASTM D-34 subcommittee. The Agency will accept the results of evaluations conducted following this or similar codes as soon as they have been adopted. Guidelines for developing these standards may be found in the U.S. Department of Commerce "Procedures for the Development of Voluntary Product Standards" (FR, Vol. 51, No.118, June 20, 1986) and OMB Circular No. A-119.

Alternative Test Procedures Deemed Equivalent to EPA's

In some cases, a specific leak detection method may not be adequately covered by EPA standard test procedures or a national voluntary consensus code, or the manufacturer may have access to data that makes it easier to evaluate the system another way. Manufacturers who wish to have their equipment tested according to a different plan (or who have already done so) must have that plan developed or reviewed by a nationally recognized association or independent third-party testing laboratory (e.g. Factory Mutual, National Sanitation Foundation, Underwriters Laboratory, etc.). The results should include an accreditation by the association or laboratory that the conditions under which the test was conducted were at least as rigorous as the EPA standard test procedure. In general, this will require the following:

1. The evaluation tests the system both under the no-leak condition and an induced-leak condition with an induced leak rate as close as possible to (or smaller than) the performance standard. In the case of tank testing, for example, this will mean testing under both 0.0 gallon per hour and 0.10 gallon per hour leak rates. In the case of ground water monitoring, this will mean testing with 0.0 and 0.125 inch of free product.

2. The evaluation should test the system under at least as many different environmental conditions as the corresponding EPA test procedure.

3. The conditions under which the system is evaluated should be at least as rigorous as the conditions specified in the corresponding EPA test procedure. For example, in the case of volumetric tank tightness testing, the test should include a temperature difference between the delivered product and that already present in the tank, as well as the deformation caused by filling the tank prior to testing.

4. The evaluation results must contain the same information and should be reported following the same general format as the EPA standard results sheet.

5. The evaluation of the leak detection method must include physical testing of a full-sized version of the leak detection equipment, and a full disclosure must be made of the experimental conditions under which (1) the evaluation was performed, and (2) the method was recommended for use. An evaluation based solely on theory or calculation is not sufficient.

APPENDIX 2:
Example Calculations Relating Product Leak Rate to Product Rate of Rise in an UST Interstitial Space.

Conversion Factors
1 ft^3 = 7.481 gal
1 in^3 = 0.00433 gal
1 gallon = 0.1337 ft^3
1 gallon = 231 in^3
1 ft^3 = 1728 in^3

Specifications
Tank Capacity = 5000 gal = 668 ft^3
Interstitial Spacing = 3 in
Leak Rate = 0.2 gal/hr = 46.2 in^3/hr

Assume: Double-walled UST with a capacity of 5000 gal or 668 ft^3 and an interstitial spacing of 3 inches. The point sensor hangs vertically in the interstitial space on one end of the UST.

Assumed dimensions
  Internal tank: 70 in. (width) X 236 in. (length) X 70 in. (height).
  External tank: 76 in. (width) X 242 in. (length) X 76 in. (height).
  Interstitial area (A) where the leaking product will accumulate:
    76 in. X 3 in. or 228 in^2.

The UST is tilted so that all of the fluid accumulates in area A. If the product leak rate is 0.2 gal/hr or 46.2 in^3/hr, equation 1, then the product will rise at the rate of 0.2 in/hr, equation 2.

$$\text{Product Leak Rate: 0.2 gal/hr} \times 231 \text{ in}^3/\text{gal} = 46.2 \text{ in}^3/\text{hr} \tag{1}$$

$$\text{Rate of Product Rise} = \frac{\text{Product Leak Rate}}{\text{Interstitial Area}} = \frac{46.2 \text{ in}^3/\text{hr}}{228 \text{ in}^2} = 0.203 \text{ in/hr} \tag{2}$$

If the Product Activation Height for a given point sensor is 2 in., then it will take at least 10 hrs. for enough product to accumulate to cause the sensor to activate and sound an alarm, equation 3.

$$\text{System Response Time} = \frac{\text{Product Activation Height}}{\text{Rate of Product Rise}} = \frac{2 \text{ in}}{0.203 \text{ in/hr}} = 10 \text{ hrs} \tag{3}$$

Appendix 3

Excerpts from EPA Documents: Preparation of Synthetic Gasoline

Standard Test Procedures for Evaluating Leak Detection Methods:
Liquid-Phase Out-of-Tank Product Detectors, EPA/530/UST-90/009
March 1990

X0004: Standard Practice for Preparation of Synthetic Gasoline

1. Scope

1.1 This practice covers preparation of a standard hydrocarbon mixture to be used for testing out-of-tank petroleum detectors. The mixture is intended to approximate commercially available automotive gasoline.

2. Summary of Test Method

2.1 An eleven-component mixture consisting of chemicals representing classes of chemicals found in automotive gasoline is mixed in standard proportions.

3. Significance of Use

3.1 The synthetic gasoline mixture is used as a standard for determining the performance of out-of-tank petroleum detectors. This mixture is provided because commercial gasoline compositions vary geographically, seasonally, and by manufacturer.

7. Procedure

7.1 Prepare 1-L of synthetic gasoline by mixing the identified volumes of hydrocarbon liquids listed in Table 1 in a glass container. The mixture should be prepared using glass graduated cylinders or burets, and the resulting mixture should be stored in a tightly sealed container as soon after preparation as possible to avoid loss of volatile components.

Table 1. Synthetic Gasoline Component Proportions and Volumes

Component	Proportion, wt%	Volume Per Liter, mL
2-methlybutane	10	119
n-pentane	10	118
n-hexane	5	56
2-methyl-2-butene	5	56
2,2,4-trimethylpentane	5	52
n-octane	20	211
cyclohexane	5	48
toluene	20	171
1,2,4-trimethylbenzene	8	68
benzene	2	17
xylene(s)	10	84

Appendix 4 -- Definitions

Activated -- refers to the state of a qualitative detector's response when indicating the presence of hydrocarbons.

Bias -- systematic error inherent in a method. It may be positive or negative.

Detection -- refers to the activation of a leak monitor, indicating the presence of hydrocarbons.

Detection Accuracy -- accuracy measurements provide a means for estimating the reliability of a point sensor/monitor system. Accuracy is a measure of how well the monitor responds after the sensor has been exposed to a given height of test liquid for a given length of time.

Jumper cable -- a non-sensing cable which serves to connect other parts of a leak detection system.

Non-activated -- refers to the state of a qualitative detector's response when indicating that no hydrocarbons are present. .

Point sensor -- a component of a leak detection system which functions as a discrete location sensor. It must come into contact with the hydrocarbon before a leak is detected.

Precision -- the degree of agreement of repeated measurements of the same parameter. It reflects random error and is not affected by bias. Precision is the percent coefficient of variation.

Product activation height -- the height of fuel product required to activate the sensor/monitor

Qualitative detector -- type of detector which responds only to the presence or absence of hydrocarbons without determining the distance to hydrocarbon leak.

Recovery time -- the elapsed time from a detector's activated response until it reaches an unactivated state.

Response -- detector's indication of the presence of petroleum hydrocarbons.

Response time -- the elapsed time from a detector's first contact with the test product until it produces an activated response.

Sensitivity -- a measure of the intensity of the monitor response with respect to the amount of sensor cable wetted. Sensitivity varies with the range of the leak detecting network.

Specificity -- the ability of a sensor to respond to various test liquids. It is measured by the percent difference between the average value for a series of tests and a reference value.

Test product -- commercial or synthetic gasoline used to characterize detector performance.

Other definitions relating to statistical calculations can be found in ASTM E456 -- Standard Terminology Relating to Statistics.

Appendix 5 -- Referenced Documents

1. **Rules and Regulations**, Federal Register, Vol. 53, No. 185, Sept. 23, 1988, 37164-5

2. **Standard Test Procedures for Evaluating Leak Detection Methods: Liquid-Phase Out-of-Tank Product Detectors**, EPA/530/UST-90/009, March 1990.

3. **Leak Prevention and Corrective Action Technology for Underground Storage Tanks**, Gangadharan, et al., Noyes Data Corporation, Park Ridge, NJ (1988), pg 21.

4. **Standard Test Procedures for Evaluating Leak Detection Methods: Liquid-Phase Out-of-Tank Product Detectors**, EPA/530/UST-90/009, including Method X0004 -- "Standard Practice for Preparation of Synthetic Gasoline."

5. **CRC Mathematical Tables**, 28th. edn., CRC Press, Inc., Boca Raton, FL (1987).

6. **Experimental Statistics**, M. G. Natrella, National Bureau of Standards Handbook 91, US Department of Standards, Stock Number 003-003-00135-0 (1963, Reprinted 1966).

7. **Handbook of Statistical Methods for Engineers and Scientists**, ed. H. M. Wadsworth, Jr., McGraw-Hill, New York (1990).

8. **ASTM D1125** -- Standard Test Methods for Electrical Conductivity and Resistivity of Water.

9. **ASTM E456** -- Standard Terminology Relating to Statistics.

Appendix 6 -- Reagents

Unleaded gasoline -- regular unleaded gasoline purchased at a retail outlet. The gasoline should contain less than 2% water-miscible substances.

Synthetic gasoline -- an eleven component mixture representative of automotive gasoline. It is prepared according to Method X0004, see Appendix 5.

Heating oil -- Fuel oil No. 2 purchased at a retail outlet. The fuel should contain less than 2% water-miscible substances.

Diesel fuel -- Automotive diesel fuel, grade 2, purchased at a retail outlet. The fuel should contain less than 2% water-miscible substances.

Water -- drinking water or other relatively pure water with an electrical conductivity of at least 50 μmho/cm. See ASTM D1125 -- Standard Test Methods for Electrical Conductivity and Resistivity of Water.

Appendix 7

EPA Document Review Letter

OCT 3 1 1991

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OFFICE OF
SOLID WASTE AND EMERGENCY RESPONSE

Dear Mr. Portnoff:

This letter is in response to your request for documentation of our earlier conversations. Your draft reports entitled "Test Procedures for Third Party Evaluation of Leak Detection Methods: Cable Sensor Liquid Contact Leak Detection Systems" and "Test Procedures for Third Party Evaluation of Leak Detection Methods: Point Sensor Liquid Contact Leak Detection Systems" were reviewed by Joe Womack of EPA's Region VI and myself. These test procedures were developed for evaluation of certain leak detection systems for which there are presently no EPA methods or procedures.

Our review was done from the point of view of trying to determine whether or not EPA's intent for evaluation is achieved in these procedures. It does appear that the procedures were developed in a manner that will allow test results to be compared to EPA standards. Therefore, systems evaluated by these procedures would likely be acceptable both to industry and to state and local implementing agencies. We assume that appropriate data and reporting forms will be developed for inclusion in the final procedure.

Of course, I must note that EPA will neither test, certify, or approve specific brands of leak detection equipment, nor deem evaluation procedures equivalent to EPA's. I thank you for consulting EPA and keeping us informed, and I apologize for not responding in writing earlier. Please call me at (703)308-8877 if you have any questions.

Yours,

David R. Wiley
Office of Underground Storage Tanks

cc: Dave O'Brien
     Joe Womack, Region VI

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Appendix 8

Qualitative Liquid Contact Point Sensor Results Form

Results of Third Party Standard Evaluation
Point Sensor Liquid Contact Product Detectors

This form documents the performance of the cable sensor liquid contact leak detection system described below. The evaluation was conducted by the equipment manufacturer or a consultant to the manufacturer according to the Third Party Procedures developed according to the U.S. EPA's "Standard Test Procedure for Evaluating Leak Detection Methods: Liquid-Phase Out-of-Tank Product Detectors."[1]

Tank owners using this leak detection system should keep this form on file to prove compliance with the federal regulations. Tank owners should check with state and local agencies to verify that this form satisfies their requirements.

Method Description

Name _____

Version_____

Vendor_____

_____
                    (street address)

_____
          (city)   (state)   (zip)   (phone)

Detector output type: ____Qualitative

Detector operating principle: ____Electrical Conductivity ____Capacitance Change

___Interface Probe ___Product Permeable ___Product Soluble ___Thermal Conductivity

___Pressure Switch ___Magnetic Switch ___Other _____

Detector sampling frequency: ___Intermittent ___Continuous _____

Evaluation Results

The detector described above was tested for its ability to detect test liquids in contact with the cable sensor. The following parameters were determined:

- Detection Accuracy - The measure of sensor response to the presence of liquids.

- Response Time - Amount of time the detector must be exposed to liquid before it responds.

- Recovery Time - Amount of time that passes before the detector returns to its baseline reading after the test liquid is removed.

- Lower Detection Limit - The smallest liquid concentration that the detector can reliably detect.

- Product Activation Height - The height of liquid to cause sensor activation.

- Specificity - Indicates the level of response, of the detector, to several different liquids.

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[1] Carnegie Mellon Research Institute. Test Procedures for Third Party Evaluation of Leak Detection Methods: Point Sensor Liquid Contact Leak Detection Systems: Final Report - November 11, 1991.

Liquid Contact Product Detector_____

Version_____

Evaluation Results (continued)

> Compiled Test Results for Qualitative Detector   (Test Product Flow Rate:)

	Detection Accuracy	Product Activation Height	Response Time at a Flow Rate of	Recovery Time
Accuracy and Response Time Regular Unleaded Commercial Gasoline (6 tests)				
Specificity Synthetic Fuel (3 tests)				
Diesel Fuel (3 tests)				
Home Heating Oil #2 (3 tests)				
Water (3 tests)				

* Specificity Reference: Regular Unleaded Commercial Gasoline

Calculated Lower Detection Limit for 95% / 5% Condition	Product Activation Height
Regular Unleaded Commercial Gasoline	

> **Safety disclaimer:** This test procedure only addresses the issue of the method's ability to detect the presence of liquid product. It does not test the equipment for safety hazards.

Certification of Results

I certify that the point sensor liquid contact product detector was operated according to the vendor's instructions and that the evaluation was performed according to the Third Party Procedures developed according to the U.S. EPA's "Standard Test Procedure for Evaluating Leak Detection Methods: Liquid-Phase Out-of-Tank Product Detectors."[1] I also certify that the results presented above are those obtained during the evaluation.

_____
(printed name)

_____
(signature)

_____
(date)

_____
(organization performing evaluation)

_____
(city, state, zip)

_____
(phone number)