Alternative Test Procedures for Evaluating Leak Detection Methods: Evaluation of Vacuum Interstitial Monitoring Methods

Prepared for General Use by Ken Wilcox Associates, Inc.
September 1996

Official copies of this protocol may be obtained from the Ken Wilcox Associates, Inc. World Wide Web server at: **http://www.kwaleak.com**

Alternative Test Procedures for Evaluating Leak Detection Methods: Evaluation of Vacuum Interstitial Monitoring Methods

Prepared by:
Ken Wilcox Associates
1125 Valley Ridge Drive
Grain Valley, MO 64029

September 1996

DISCLAIMER

Some of the procedures described in this document are different than those in EPA's Standard Protocols. Users are cautioned that although this alternative protocol may have been reviewed and accepted by some regulatory agencies, this does not mean that all agencies will necessarily find it acceptable. All regulatory agencies within the geographic area of application should be contacted prior to testing to assure that the results will be acceptable. KWA, Inc. makes no statement regarding the applicability, acceptability, or quality of results that may be obtained by other users, nor do we guarantee that the results will be accepted by any individual regulator or agency.

Users should feel free to copy or modify this protocol without restriction in any way that is acceptable to the cognizant regulatory agency.

ACKNOWLEDGMENTS

This document was written by H. Kendall Wilcox, Ph.D., and J. Kendall Wilcox, M.S. for use by anyone who wishes to manufacture or evaluate vacuum interstitial monitoring methods. The effort was funded entirely by KWA.

FOREWORD[1]

The US Environmental Protection Agency recognizes three distinct ways to prove that a particular vendor or leak detection equipment meets the federal performance standards:

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

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 purpose of this document is to provide the details for an alternative evaluation procedure developed and utilized by Ken Wilcox Associates, Inc. There are several reasons why it has been necessary to develop these alternative procedures. These include the following:

1. Some leak detection systems cannot be evaluated using procedures described in the EPA Standard Methods for Evaluating Leak Detection Methods.

2. For some types of equipment (e.g., interstitial monitors) there is no EPA protocol available.

3. The costs to conduct an evaluation to the exact letter of the an existing EPA protocol may be prohibitive. Less costly approaches may be available that will meet the requirements for alternative evaluations.

Two important factors have been considered by KWA in developing alternative procedures to meet specialized test requirements: First, the EPA criteria for alternative test procedures deemed equivalent to EPA's; and second, the guidelines established by the American Society for Testing and Materials (ASTM) in their standard practice 1546E - 1993. The EPA guidelines are as follows:

---

[1] Some material has been excerpted and adapted from the Foreword that appears at the front of each of the EPA Evaluation Protocols.

Alternative Test Procedures Deemed Equivalent to EPA's

The following general criteria must be met for an alternative procedure to be considered acceptable.

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 ATG systems, for example, this will mean testing under both 0.0 gallon per hour and 0.20 gallon per hour leak rates. In the case of ground-water monitoring, this will mean testing with a 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 ATGS testing, the test should include a temperature difference between the delivered product and that already present in the tank, as well as the deformation of the tank 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.

National Consensus Code or Standard (ASTM 1526E - 1993)

This ASTM Practice provides general guidelines for performing evaluations on leak detectors designed for use on underground storage tanks. There are no specific requirements defined such as the number of tests to be conducted or specific variable such as temperature that should be included in the evaluation. None-the-less, the practice does proved a useful framework for developing alternative techniques.

Ken Wilcox Associates, Inc. Evaluation Procedures

Ken Wilcox Associates, Inc. is an independent, internationally recognized third-party evaluation laboratory. The procedures described in this document are based on operating experience, recognized scientific and engineering practices, and the guidelines provided by the EPA and ASTM. Existing procedures have been adopted when practical. Alternatives have been developed as necessary to meet the specialized requirements of leak detection systems that are not covered by the existing protocols. The complete reports include summaries of the test procedures, descriptions of the leak detection systems, and a full disclosure of the test results obtained from the testing. Questions regarding these procedures should be addressed to Ken Wilcox, President, Ken Wilcox Associates, Inc., (816) 795-7997.

September 1996

Table of Contents

1.0 Background

The USEPA does not have an officially approved method for testing interstitial monitors. This procedure was prepared by Ken Wilcox Associates, Inc. and is intended to meet the criteria for alternative testing as described in the Foreword to each of the EPA Evaluation Procedures. The procedures will be submitted to the National Workgroup for Leak Detection Evaluations for approval. Some modifications may be made. Users should be aware that this protocol may not be sufficient for some regulatory agencies.

2.0 Applicability

This evaluation method applies to leak detection systems that monitor the vacuum in the interstitial space of a double-wall tank or pipeline. The procedures described in this document are used for air or vapor leaks only. Liquid leaks require different evaluation procedures. The procedure is applicable to testing tanks during installation before any fuel is added to the tank. It should not be used if the tank is below the water table or after fuel has been delivered.

3.0 Equipment

1. Calibrated orifices for the flow rates of interest - usually 0.1 gal/hr or less for a precision test

2. Vacuum gauges - accurate to within ±0.1 inch of Hg

3. Stop watch

4. Flowmeter to monitor flow rate into the tank (Optional)

5. Drill w/ 1/8 inch bit

6. Temperature measuring device accurate to 0.1 deg F

7. Vacuum pump

4.0 General Description of Leak Detector

These leak detectors operate by monitoring the vacuum in the interstice of a double-wall tank. The vacuum of the interstice is monitored at the upper limit set by the leak detector manufacturer which should not exceed the tank manufacturer’s specifications, regulatory requirements, or safety requirements. The operator monitors this vacuum regularly. As long as the vacuum does not decrease more than the amount specified by the manufacturer for a given time period, the tank is considered to be tight. A reduction of greater than this amount requires additional investigation to determine the cause.

5.0 Parameters Determined by this Test Procedure

The following parameters which have been defined below will be determined by this test protocol. The official forms in Appendix A of this protocol provide a space for the evaluator to comment on each of these parameters.

1. Open Interstice - Verification that the interstice is open to all parts of the tank. The interstice must be open to all parts of the tank to completely test the inner and outer shells of the tank..

2. Detection Time - Length of time required to detect a leak of known size.

3. Ambient Conditions - Effects of temperature and other environmental factors on the behavior of the leak detector.

6.0 Test Procedure

There are three concerns that are present for vacuum interstitial monitors: First, the interstice must be verified to be open at all points in the tank. Second, the time necessary to reduce the vacuum by the specified amount must be determined empirically. Third, the effects of temperature changes on the vacuum have been verified to show that temperature effects alone will not cause the leak detector to reach a false conclusion.

<u>Verification of Open Interstice</u>
This phase of the evaluation verifies that the interstice is open. This step is particularly important for clad tanks where the outer fiberglass wall may bond to the inner wall. This testing should be conducted by drilling through the outer wall and monitoring the vacuum changes. The procedure is as follows:

1. Locate the positions on the outer wall where holes are to be introduced. Some of these positions should be selected as far from the monitor as is practical. Holes should be located on the ends and sides of the tank and along the corners. Any locations where it would appear that local bonding might have occurred should be drilled. Locate at two positions on each tank, one on an end of the tank and one in the wall of the tank. More holes should be drilled if the evaluator has reason to believe that the interstice is not completely open.

2. Drill a small hole at one of the locations. A 1/8 inch bit or smaller may be used. The size of the hole is not critical for this phase of the testing, but it should be large enough that the orifice produced is not a severely limiting factor in reducing the vacuum. The objective is to determine if the interstice is open and secondarily, to determine approximately how long it takes to reduce the vacuum to the leak level when a large hole is present. This is of interest only if the times are longer than a few minutes.

3. After the test is completed for the first hole, seal the hole and repeat the process at the remaining locations. Temporary seals using tape are sufficient.

4. Record the locations and the results on appropriate forms.

Determination of Minimum Required Test Time

The minimum time to detect a leak is determined by introducing a known leak into the interstice. The location of the leak is not particularly important as long as the interstice has been shown to be open. The response time for a large leak should be short compared to the test time for a leak of 0.1 gal/hr. The procedure is as follows:

1. Install a port on the tank. In general, this should be as far from the monitor as is practical, but its location is not critical

2. Connect a calibrated orifice to the leak port.

3. Set the vacuum in the interstice to its normal operating range.

4. Open the orifice so that air is flowing into the interstice.

5. Record the interstitial vacuum at periodic intervals until a leak is indicated.

6. Repeat this test until a minimum of 15 tests have been completed. Different size tanks may be used or all of the tests may be conducted on one tank.

Determination of Temperature Effects on a Vacuum

Temperature variations in underground tanks are relatively tiny. These very small changes will not affect the vacuum level measurably with the types of gauges used for monitoring. Calculations show that the temperature change would need to be greater than 50 deg F to produce a vacuum change of 2 in of Hg. Changes of 50 deg F obviously will not occur under any reasonable circumstances.

However, if the evaluator has reason to believe that temperature effects may cause the leak detector to reach a false conclusion, additional consideration should be given to temperature effects and this should be noted in the certification. In extreme cases where the leak detector's result may be affected by temperature changes, the evaluator may require the leak detection method to monitor the temperature of the interstitial space with a temperature measuring device to assure that a false conclusion is not reached due to temperature changes. Leak detection methods which use very small changes in vacuum pressure (5 inches of Hg or less) to determine a result may be required to monitor the temperature of the interstitial space during testing. This should be noted on the certification forms.

Construction of Orifices

The orifices used to produce the simulated leaks must be carefully calibrated prior to their use. The reference that has been used is to calibrate the orifice against a four foot diesel head. Another reference could be used, but the evaluator should carefully describe how the calibration process was accomplished. The leak rate, response time, and other relevant factors should be expressed as a range based on other possible head pressures that may be expected to be present during test conditions.

One approach to constructing an orifice is to drill a small hole through a metal plug or disk using a #80 size drill bit. This hole will allow a flow of diesel fuel of approximately 0.4 gal/hr with a 4 foot head. The orifice size can then be reduced using a center punch to peen the hole until the desired rate is obtained. (This process can be difficult and frustrating but is necessary). A needle valve may also be used, but the calibration is more difficult and a flowmeter must be used to verify the proper setting before each test. One method for calibrating the flowmeter is to use a series of orifices prepared as describe above.

7.0 Calculations

Determination of Open Interstice

There are no calculations for this process. The data should be recorded on the data sheet provided and the times noted for each leak location. The evaluator should be able to conclude that the interstice is open before further testing is conducted. The time for the vacuum to be reduced below the minimum set by the manufacturer should be short when compared to a leak of 0.1 gal/hr. If it is not, the test time is set by the rate of diffusion of air through the interstice rather than through the test orifice.

Determination of Minimum Test Time

The minimum test time for at least one tank must be experimental measured. If the interstice is not completely open, it may be necessary to test each tank size and type individually. Calculations are based on the assumption that the interstice is open and that the leak detector responds to large hole within a few minutes or less.

Once the leak time has been experimentally determined for one tank with a known interstitial volume, the results can be used to calculate test times for other size tanks with known interstitial volumes. The evaluator should verify these volumes when possible from the manufacturers construction dimensions. This may not be exact, but it should be approximately correct.

The calculation of test times for tanks of different sizes is based on a direct linear scaling of the time based on interstitial volume. This process will be reasonably accurate if the interstice is truly open. The calculation for test times for tanks of different sizes as follows:

New Test Time = (Reference Time) x (New Tank Volume/Reference Volume)

The test times should be tabulated for each tank model number and included in the test report.

Alternatively, the evaluator can conduct the testing on the largest size tank produced by the manufacturer. The required test time for the largest tank can then be used as a standard for all of the tanks produced by the manufacturer which have a volume equal to or less than that of the test tank.

Temperature Effects on a Vacuum

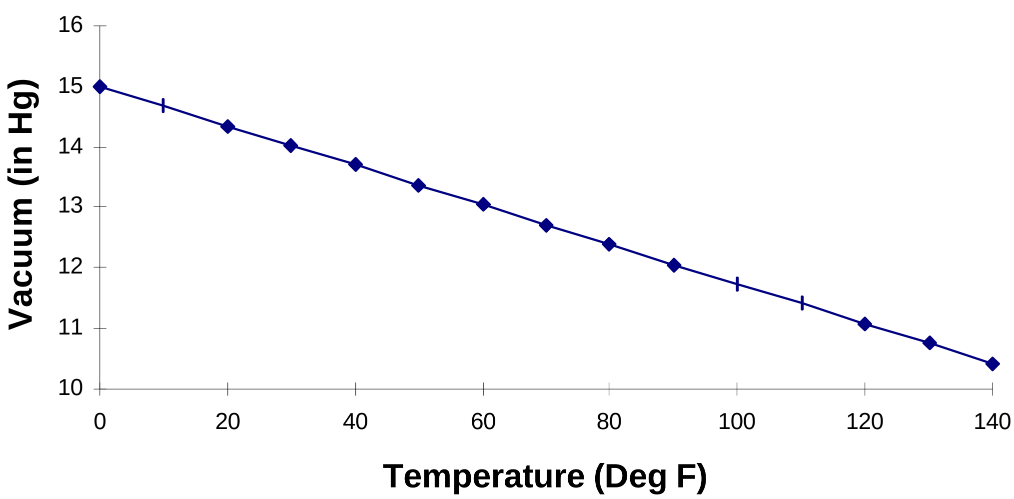
The theoretical effects of temperature on an interstitial space can be calculated using the combined gas law:

$$\frac{P_1 V_1}{T1} = \frac{P_2 V_2}{T2}$$

where P_1 is the initial pressure, P_2 is the final pressure, T_1 and T_2 are the initial and final temperatures, and V is the volume of the interstitial volume. Since the volume is fixed for each tank, the temperature effect is independent of interstitial volume. These effects are shown in Figure 1 and can easily be seen to be insignificant for the range of temperature changes expected for buried tanks.

However, if the evaluator has reason to believe that temperature effects may cause the leak detector to reach a false conclusion, additional consideration should be given to temperature effects and this should be noted in the certification. In extreme cases where the leak detector's result may be affected by temperature changes, the evaluator may require the leak detection method to monitor the temperature of the interstitial space with a temperature measuring device to assure that a false conclusion is not reached due to temperature changes. Leak detection methods which use very small changes in vacuum pressure (5 inches of Hg or less) to determine a result may be required to monitor the temperature of the interstitial space during testing.

Figure 1. Vacuum vs. Temperature (Air)



8.0 REPORTING OF RESULTS

The reporting forms in Appendix A should be filled out at the conclusion of the testing. Because of the nature of this type of leak detection, any false alarms or missed leak detections should be investigated when they occur and the testing repeated with an explanation of the problem.

APPENDIX A

REPORTING FORMS
FOR EPA TEST PROCEDURES

Results of U.S. EPA Alternative Evaluation

Interstitial Monitoring Method

This form documents the performance of the interstitial monitor described below. The evaluation was conducted by the equipment manufacturer or a consultant to the manufacturer according to the U.S. EPA's requirements for alternative protocols. The full evaluation report also includes a report describing the method, a description of the evaluation procedures, and a summary of the test data. The results forms were modified from the Vapor-Phase Out-of-Tank Product Detectors. The evaluation procedures are included in Attachment A of this report.

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 make sure this form satisfies their requirements.

Method Description

Name ____

Version ____

Vendor ____
(Name of Manufacturer)

____
(Address)

____
(City) (State) (Zip Code) (Phone)

Detector Output Type: ( ) Quantitative ( ) Qualitative

Detector Operating Principle: ____________________________

Detector Sampling Frequency: ( ) Intermittent ( ) Continuous

Evaluation Results

The detector described above was tested for its ability to detect losses in vacuum over a period of time. The following parameters were determined:

<u>Applicability</u> - Types of tanks and circumstances that the method may be used on.

<u>Open Interstice</u> - Verification that the interstice is open to all parts of the tank. The interstice must be open to all parts of the tank to completely test the inner and outer shells of the tank.

<u>Detection Time</u> - Length of time required to detect a leak of known size.

<u>Ambient Conditions</u> - Effects of temperature and product type on behavior of the leak detector.

Criteria for Declaring a Leak

____
____
____

Name ____
Version ____

Compiled Evaluation Results

Applicability - ____

Open Interstice - ____

Detection Time - ____

Ambient Conditions - ____

Additional Limitations or Considerations - ______________________________

> Safety Disclaimer: This test procedure only addresses the issue of the methods ability to detect leaks. It does not test the equipment for safety hazards.

Certification of Results

I certify that the interstitial monitor was tested under conditions according to the vendor's operating instructions. I also certify that the evaluation was performed using methods described in the attached Alternative EPA Test Procedures for Interstitial Monitors, and that the results presented above are those obtained during the evaluation.

(printed name)	(organization performing evaluation)
(signature)	(city, state, zip)
(date)	(phone number)