Evaluation of the Permatank® Interstitial Monitor for Detection of Liquid Leaks

Revision Final Report

PREPARED FOR:

Steel Tank Institute
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PREFACE

This report was prepared by Ken Wilcox Associates, Inc., for the Steel Tank Institute. The evaluation procedures are based on the requirements for alternative methods as defined in the EPA protocol documents. The alternative approach was developed by Ken Wilcox Associates, Inc. specifically to meet the specialized requirements of the STI Permatank Vacuum Monitoring System. The work was conducted at the Leak Detection Test Center by Ken Wilcox of Ken Wilcox Associates, Inc. This report was revised on October 8, 2020 by Craig Wilcox, Ken Wilcox Associates Inc., in order to add additional tank sizes to the tank charts. The statistical calculations for this revision were performed by Dr. Jairus Flora, Ken Wilcox Associates, Inc. Questions should be directed to Steel Tank Institute, at (847) 438-TANK. (847-438-8265).

H. Kendall Wilcox, President

KEN WILCOX ASSOCIATES, INC.
11/22/2013

Craig Wilcox, President, KWA, Inc.
Revised 10/8/2020

Table of Contents

EXECUTIVE SUMMARY

The Permatank® Interstitial Monitor was evaluated for determining both air and liquid leaks into the interstitial space of a double-walled steel tank. Two types of leak tests are available: one based on vacuum monitoring and one based on detecting liquid accumulation in the tank interstice monitoring tube. To detect air or liquid leaks with vacuum the interstice is evacuated to 13” of Hg at the start of the test period. If the vacuum does not decrease more than 5” of Hg (i.e. to 8” Hg) over the test period specified for each tank, the tank is considered to be “tight.” Leaks are typically detected by vacuum tests in a few hours, depending on the size of the tank.

Liquid leaks are also detected in the interstice using a liquid sensor located at the bottom of the interstitial monitoring pipe. There are many options that have been approved for this type of sensor. A list of these can be obtained from the National Work Group of Leak Detection Evaluations (NWGLDE) website at nwglde.org.

Once a tank is installed, the interstice may continue to be monitored using a liquid or vapor sensor as well as a vacuum monitor for air leaks.

BACKGROUND

The Environmental Protection Agency (EPA) requires that in-tank leak detectors be tested to determine if they meet certain performance standards. In general, methods are required to detect a leak of 0.1 gal/hr with a probability of detection (PD) of at least 95% and a probability of false alarm (PFA) of 5% or less. The regulations for external monitors are much less well defined and there is no specific EPA protocol for interstitial monitors such as those developed by the Steel Tank Institute (STI).

To meet the specialized requirements for the STI Permatank® system, it has been necessary to develop alternative evaluation procedures for this system. The requirements for alternative protocols are included in the introduction to all of the EPA evaluation protocols. The procedures described in this document meet these requirements.

It should be noted that the measurements conducted for this project are based on a limited range of petroleum products. The physical characteristics of fuels vary with geographic location, climates, and brands. Physical measurements reported in this document should be taken only as indicative of general behavior and not as absolute values which might apply to specific fuels.

DESCRIPTION OF LEAK DETECTION AND OPERATIONAL PRINCIPLES

The leak detection system developed by the STI is based on either the loss of vacuum in the interstitial space formed between a steel primary containment and secondary containment vessel or detection of liquid in the interstice. The liquid could come from either the outside or inside of the double wall system. A vacuum gauge is used to monitor the vacuum, which must be at least 13" Hg when the tank leaves the factory and a minimum of 8" Hg when the tank is installed in the ground. (The initial vacuum at the factory may be has high as 29.5" Hg.) The leak detection process is based on the fact that the vacuum cannot be maintained if an air or vapor leak is present in either the primary or secondary shell. Liquid leaks result in an accumulation of liquid in the bottom of the interstice, where it may be easily detected by any of a variety of liquid sensors, including float switches, optical sensors, conductivity devices, and other methods that respond to the presence of liquids.

The Permatank® interstitial volumes are relatively small. The tanks tested in this project were constructed of an inner steel tank separated by a polymer mesh from an outer steel jacket. The earlier report was based on testing a steel tank with a fiberglass outer tank. The interstitial spacing between the inner and outer wall is 0.018 inch. The tank interstice also includes a 3" riser that extends through the inner steel wall into the interstitial space. A variety of liquid or vapor sensors may be installed in the riser as an additional means of leak detection.

Loss of vacuum can be due to several factors. These include:

- Air leaks in either the inner or outer shell
- Product leaks in the inner shell
- Water leaks through the outer jacket if the tank is below the water table.

In all cases, the resultant loss of the integrity of either inner or outer tank will alert the owner/operator to the presence of a leak. If a leak is present, the vacuum cannot be permanently restored. In the case of a liquid leak, the interstitial space will contain liquid.

EVALUATION METHODOLOGY

Vacuum Monitoring

The data and conclusions for most of the testing conducted for the earlier project were obtained in a laboratory environment using a test cell with a volume of 5.1 gallons. This is approximately the same volume as the interstitial space of a 4,000-gallon Permatank®. This approach assumes that the behavior of the vacuum is not dependent on the shape of the interstitial space. That is, vapors and liquids will flow freely throughout the interstice and the jacket is not bonded to the inner wall. Tests for which volume was not a factor (e.g. vapor pressure measurements) were conducted in a smaller test chamber.

The loss of vacuum in the interstitial space will depend on the type of product (or air) that leaks into the interstitial space and the temperature of the interstitial environment. Air leaks from the outside of the tank or vapor leaks above the liquid in the tank will reduce the vacuum to zero relatively quickly. Test for air leaks have been described in an earlier document, ("Evaluation of the Permatank® Interstitial Vacuum Monitor for Installation Testing," Steel Tank Institute, March 25, 1993).

Table 1, below, has been abstracted from the earlier report. It shows the estimated test times for the Permatank® Interstitial Vacuum Monitor System to detect air (or vapor) leaks of 0.1 gal/hr and 0.05 gal/hr using the detection criterion of a loss of vacuum of 5 inches of Hg. Note that the test chamber actually used of 5 gallons volume is listed as the reference. Note that the earlier report was based on testing a fiberglass over steel double- walled tank. The testing in this report was based on testing close-wrapped steel tank where both the inner and outer tank are steel. This type of double-walled tank had slightly different interstitial volumes from the earlier tanks.

NOTE: These test times are only valid for tanks with a 3 inch or unknown diameter interstice riser. Tanks with a 2 inch diameter interstice riser must use the chart in the "Permatank Interstice Test Procedure 2 inch riser.pdf" KWA certification.

Table 1. Test times for vacuum leak calibrated at 0.1 and 0.05 gal/hr

				Time for Decrease of 5" Hg (hr) Leak Rate = 0.10 gal/hr			Time for Decrease of 5" Hg (hr) Leak Rate = 0.05 gal/hr		
Tank Diameter (inches)	Tank Volume (gallons)	Interstitial Volume (gallons)	Multiplier	Water	Gasoline	Diesel	Water	Gasoline	Diesel
Reference	5	5	1	12.1	1	12.5	24.2	2.1	24.9
48	550	1.504	0.59	7.2	0.6	7.4	14.3	1.2	14.7
48	1000	2.381	0.77	9.3	0.8	9.6	18.5	1.6	19.1
64	1000	2.193	0.82	10	0.8	10.3	19.9	1.7	20.5
64	1500	2.945	0.98	11.9	1	12.2	23.7	2.1	24.4
64	2000	3.677	1.12	13.5	1.1	14	27.1	2.3	27.9
64	3000	5.181	1.42	17.2	1.4	17.7	34.3	3	35.3
64	4000	6.685	1.72	20.8	1.7	21.5	41.6	3.6	42.8
84	4000	5.758	1.66	20	1.7	20.7	40.1	3.5	41.2
96	4000	5.515	1.88	22.7	1.9	23.5	45.4	3.9	46.7
72	5000	7.614	1.52	21.5	1.8	22.3	43.1	3.7	44.3
96	5000	6.518	1.89	22.9	1.9	23.6	45.7	4	47
72	6000	8.977	2.24	27.1	2.2	28	54.1	4.7	55.7
96	6000	7.520	2.08	25.1	2.1	25.9	50.2	4.4	51.7
96	8000	9.526	2.47	29.9	2.5	30.9	59.9	5.2	61.6
96	10000	19.365	2.89	34.9	2.9	36.1	69.9	6.1	71.9
72	10000	8.366	3.25	39.4	3.3	40.7	78.7	6.8	81
126	10000	10.282	2.83	34.3	2.8	35.4	68.6	6	70.6
96	12000	13.536	3.27	39.6	3.3	40.9	79.2	6.9	81.5
126	12000	11.803	2.35	28.4	2.3	29.3	56.8	4.9	58.4
126	15000	22.332	2.8	33.9	2.8	35	67.9	5.9	69.8
96	15000	10.278	3.29	39.8	3.3	41.1	79.5	6.9	81.8
126	20000	17.890	4.33	52.3	4.3	54.1	104.7	9.1	107.7
126	25000	21.838	4.37	52.8	4.4	54.6	105.7	8.7	109.2
144	30000	23.689	4.74	57.3	4.7	59.2	114.7	9.5	118.4
144	50000	37.225	7.45	90.1	7.4	93.1	180.2	14.9	186.1

Note: The interstitial volumes include a 3-inch (I.d.) pipe that runs the diameter of the tank. The calculation are based on an interstice thickness of 0.024 inches

Liquid Monitoring of the Interstice

Although the effects of various liquids on the vacuum are measurable, the test depends on the vapor pressure of the liquid, which, in turn, is dependent on the temperature. Instead of using this relatively complex process, liquid leaks can be monitored by placing a liquid sensor in the interstitial monitoring tube.

If a liquid sensor with a detection threshold of 1-inch of liquid is located within the riser, an alarm will occur within reasonably short times for even the largest tanks. (The maximum time is estimated at less than 14 hours for a 50,000-gallon tank.) Table 2 has the total interstitial volume as well as the volume of liquid needed to bring the liquid up to a depth of 1 inch in the interstitial monitoring tube. Table 2 also shows the time needed to detect a liquid leak at the rate of 0.1 gal/hr.

The liquid monitoring test consists of installing a liquid sensor in the interstice monitoring tube and detecting a leak when the liquid sensor detects liquid.

Table 2. Calculated Time for Permatank® to Detect a Liquid Leak of 0.1 gal/hr.

Maximum Volume (gallons)	Tank Diameter (inches)	Maximum Length (inches)	Volume of Interstice at 1 inch (gallons)	Test Time (hr)	Total Volume of Interstice (gallons)
550	48	72	0.0327	0.3274	1.504
1000	48	128	0.0329	0.3288	2.381
1000	64	73	0.0321	0.3210	2.193
1500	64	109	0.0328	0.3284	2.945
2000	64	144	0.0336	0.3356	3.677
3000	64	216	0.0350	0.3504	5.181
4000	64	288	0.0365	0.3652	6.685
4000	84	168	0.0346	0.3455	5.758
4000	96	128	0.0338	0.3382	5.515
5000	72	288	0.0369	0.3687	7.614
5000	96	160	0.0346	0.3462	6.518
6000	72	346	0.0381	0.3814	8.977
6000	96	192	0.0354	0.3543	7.520
8000	96	256	0.0370	0.3704	9.526
10000	72	570	0.0449	0.4493	19.365
10000	96	320	0.0376	0.3757	8.366
10000	126	187	0.0360	0.3599	10.282
12000	96	384	0.0403	0.4026	13.536
12000	126	224	0.0371	0.3705	11.803
15000	96	480	0.0444	0.4443	22.332
15000	126	280	0.0376	0.3764	10.278
20000	126	372	0.0413	0.4132	17.890
25000	126	468	0.0441	0.4408	21.838
30000	144	432	0.0439	0.4390	23.689
50000	144	720	0.0528	0.5277	37.225

Note: The interstitial volumes include a 3-inch (I.d.) pipe that runs the diameter of the tank.

The calculation are based on an interstice thickness of 0.024 inches

DISCUSSION AND CONCLUSIONS

The Permatank® Interstitial Monitoring System represents a sensitive method for determining leaks in double wall tanks. If vacuum is maintained above 8 inches of Hg for more than a few days, it is certain that no leak of any product greater than 0.05 gal/hr is present. This represents a worst-case condition for tanks up to 50,000 gallons.

The detection of leaks of the order 0.1 gal/hr is relatively fast. In every case, liquid (or air) leaks will reduce the vacuum to near zero within a few hours or days. In such cases, an operator who checks his tanks daily or weekly will certainly detect the leak within a few days of its occurrence. It is very unlikely that any product would reach the environment.

In addition to monitoring the vacuum of the interstice, a liquid sensor may be located in the interstice monitoring tube. Several liquid sensors have been evaluated. The NWGLDE web site lists the liquid sensors that have been evaluated along with their thresholds. (For illustrative purposes, a threshold of 1 inch has been assumed and used in this report, but the owner/operator should review the threshold of the particular sensor to be used in a specific application.) When the liquid in the monitoring tube reaches the threshold of the sensor, it will also produce an alarm. For low volatility liquids such as water and diesel fuel, this will occur well before the vacuum level has dropped by 5 inches of Hg.

TEST PROCEDURE

1. The vacuum shall be a minimum of 13” Hg at the start.
2. The test period for each tank shall be that stated in Table 1 for vacuum monitoring or Table 2 for liquid sensing.
3. Vacuum decreases of less than 5” of Hg during the test period indicate that the tank is tight. Record vacuum change, if any, in the space provided on the installation checklist.
4. A vacuum decrease of more than 5” of Hg during the test period requires further investigation.
5. For liquid leaks, follow the instructions of the liquid sensor manufacturer. In every case, the sensor will alarm within 14 hours if water or fuel reaches a height of 1” or more within the interstitial space.
6. If further investigation is required, the tank manufacturer shall be contacted. After investigation is complete, this test shall be repeated.
7. This test procedure meets the EPA requirements for tightness testing of operating underground storage tanks containing product.

APPENDIX—ALTERNATIVE EPA EVALUATION FORMS
Results of the 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 also includes a report describing the method and 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 federal regulations. Tank owners should check with State and Local Agencies to make sure this form satisfies their requirements.

Method Description

Name: Permatank® Interstitial Monitor

Version: Liquid Leaks

Vendor: Steel Tank Institute
944 Donata Court
Lake Zurich, IL 60047
847-438-8265 (847-438-TANK)
(phone number)

Detector output type (X) Quantitative ( ) Qualitative
Detector Operating Principle: loss of vacuum over time (air); liquid detection Detector Sampling Frequency: ( ) Intermittent (X) Continuous

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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:
Accuracy—Ability of the detector to respond to small leaks
Detection time—Length of time required to detect a leak of known size Lower Detection Limit—smallest leak which could be readily detected
Ambient Conditions—Effects of temperature and product type on behavior of the leak detector.

Criteria for Declaring Leaks
The tank is declared to be tight when the vacuum decreases less than 5" of Hg over the test times specified in Table 1. The vacuum prior to the test must be a minimum of 13" of Hg.

Interstitial Tightness Testing Method Permatank Interstitial Monitor

Interstitial Monitor Version: Liquid leaks

Complied Evaluation Results

Tank sizes range from 500 gallons to 20,000 gallons. Total interstitial volumes range from 1.8 gallons to 18.2 gallons. Test times to detect 0.05 and 0.1 gal/hr liquid leaks are shown in Table 1 for water, gasoline and diesel fuel.

Accuracy—System has a probability of detection of 100% for leaks of 0.1 gal/hr or greater when all the testing criteria are met. The false alarm rate for a tight tank is <5%. It is impossible to maintain a steady vacuum if a leak is present.

Specificity—The liquid sensor test procedure is intended to detect liquid product or water leaks. The vacuum test will detect liquid or vapor leaks.

Lower Detection Limit—Estimated to be 0.1 gal/hr with a test time as indicated in Table 1 of the text for vacuum and Table 2 of the text for liquid sensors.

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

Certification of Results

I certify that the interstitial monitor was installed and operated according to the vendor's instructions. I also certify that the evaluation was performed using methods which meet the requirements of the Alternative EPA test procedures as they are applied to interstitial monitors and that the results presented above are those obtained during the evaluation.

H. Kendall Wilcox, President — Ken Wilcox Associates, Inc.

H. Kendall Wilcox

(Print Name) — (Organization performing evaluation)

Independence Mo 64055

(Signature) — (City, State, Zip)

February 24, 1994, Rev. November 22, 2013 — (816)-443-2492

(Date) — (Phone Number)