Evaluation of the Mass Technology Corporation Aboveground Storage Tank Leak Detection System

Volume 1. Test Report

Prepared for:
Mass Technology, Corporation

February 9, 1994

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Preface

The work evaluation described in this document was conducted by Ken Wilcox Associates, Inc. The evaluation is a modification of the procedures described by the protocols developed by U.S. Environmental Protection Agency for underground storage tanks. Questions should be directed to Mr. Jimmy Wolford at (903) 984-9057.

Volume 1 contains a description of the test procedures and the test results. Volume 2 contains the test data.

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Introduction

The detection of leaks from large aboveground storage tanks has presented an ongoing challenge for many years. Although the Environmental Protection Agency is currently working with ASTM, API, and other interested groups to develop leak detection methodology and standards, no official requirements have been issued.

Several companies have made efforts to develop leak detection systems for large tanks. Mass Technology Corporation has demonstrated a leak detection technique based on mass measurement. Their technology has been applied to large bulk storage tanks of several million gallons capacity. This report describes an independent evaluation of that system when applied to a large tank containing crude oil.

Since no official testing protocols are currently available, it was necessary to develop evaluation techniques independently. The techniques described in this report are based on the type of evaluations that are described in the EPA protocol for volumetrically testing underground storage tanks. ("Standard Test Procedures for Evaluating Leak Detection Methods: Volumetric Tank Tightness Testing Methods", EPA/530/UST-90/004, March 1990)

Description of Evaluation Procedures

The following procedures were used to evaluate the performance of the Mass Technology Aboveground Storage Tank Leak Detection System. The general approach was to induce a leak at a known rate into a test tank. The Mass Technology system was then used to measure the induced rate. The data from the mass technology system was compared using standard statistical techniques.

1. The leak detection equipment was installed in the tank by Mass Technology Corporation.

2. A peristaltic pump was used to induce a leak from the tank over an extended time period, typically 48 hours.

3. The volume of product removed from the tank was collected in a trailer mounted tank with a capacity of 500 gallons.

4, The volume of product removed from the test tank was determined by periodically by sticking the trailer mounted tank.

5. The induced leak rate was then calculated from the volume removed from the test tank and the leak time interval.

6. Weather data was obtained from the National Weather Service for each test period.

7. The measured leak rates were obtained from data collected and analyzed by Mass Technology Corporation.

This process was repeated over a period of several weeks until several tests were completed.

System Description

The mass measurement system measures and records the pressure generated by the mass of fluid in the tank under test. This pressure measurement is made relative to the atmospheric pressure generated by the atmosphere above the liquids in the tank. The temperature of the fluid as well as the temperature distribution within the fluid has no effect on the mass measurement so long as the tank geometry remains constant throughout the test.

The method used to measure these pressures is an adaption of a common bubbler system currently in use to measure pressures in a variety of applications. This system is unique in that it's resolution is such that very small differential pressures can be measured with a high degree of accuracy and repeatability. The system uses a gas under pressure (nitrogen) conveyed to the bottom of the tank via a hose to generate and release small bubbles at the tank bottom. The nitrogen flows from a high pressure cylinder through an accurate pressure regulator and then through a precise flow control valve. This flow control valve is used to regulate the rate at which bubbles are generated at the bottom of the tank. This rate is maintained at approximately 100 bubbles per minute. The nitrogen then flows through an insulated hose to a bubble tube which is maintained in a fixed position as near as possible to the bottom of the tank. The bubbler tube is designed such that the nitrogen bubbles are produced and released in a consistent manner. This pressure is transmitted to the systems differential pressure transducer through a second hose to remove the effects on the measurement as a result of friction in the nitrogen supply hose. The reference pressure of the atmosphere at the top of the tank is also transferred to the system via an insulted hose. The measurement system makes use of the most accurate differential pressure transducer available coupled with additional control and calibration measures to maximize accuracy and reduce the effects of environmental conditions. The measure differential pressure is processed and logged on site. Data reduction and analysis is done remotely resulting in a concrete determination of fluid mass excursions which in turn indicate the integrity of the tank's containment structures.

Site Description

The system was mobilized on October 18th, 1993 to run a series of tests on a 117 foot diameter, aboveground, crude oil storage tank outside of Kilgore, Texas. The tank top was closed via a fixed roof with a floating internal roof as well. The tank inlet and discharge valves were blanked during the testing to preclude any valve leaks that might have compormised the testing.

A series of sixteen tests were performed under a variety of weather conditions and controlled leak rates. The leak rates were under the direct control of the third party evaluator and not made available to the test team. The purpose of the test in total was to determined the leak detection accuracy and threshold of the system in real world conditions.

The storage tank, referred to as SPC1016, contained East Texas crude with an API gravity of 49.1. This in turn is equal to a specific gravity of 0.7835. The cross sectional area of the tank was calculated to be 10,764 sq. ft. The volume per inch of fluid height in the tank was thereby calculated to be 6,710 U.S. gallons. The equivalent volume of crude oil required to produce a hydrostatic pressure equal to one inch of water column was calculated to be 8,564 gallons or 8.564 gallons of crude oil per 0.001 inches of water column.

Test Results

The results of the testing are summarized in Table 1. The raw test data for each run has been provided in Attachment 1 as well as the weather data. A statistical analysis of the data for a threshold of 1.00 gal/hr provides the performance parameters shown in Table 2. Table 3 provides a summary of the probabilities of detection and false alarm for different thresholds.

Tests 1 and 2 were aborted due to problems with the leak simulation equipment. Test 5 was aborted because the tank operator needed the temporary use of the tank. Tests 8 and 13 were conducted during transfer of fuel from the storage reservoir back to the test tank. Because the equipment was not designed to track this type of activity, the results were not included in the data analysis.

Discussion

The mass measurement system demonstrated by Mass Technology Corporation is capable of detecting leaks as small as 0.88 gal/hr with a probability of 95%. The test times must be a minimum of 36 hrs duration (two nights and the day between) to obtain adequate data. In some instances, rapidly changing weather conditions during the test could make it necessary to extend the test time.

Testing of the system under a variety of situations has shown that tank geometry is indeed a variable under the effects of external temperature changes. Floating roofs also add a variable to the tank geometry as well as the measured mass. Experience has shown that variations of internal temperature are generally insignificant over the duration of the test. External temperature changes make it necessary to gather data over a period of at least two nights in order to take advantage of the smaller temperature changes, by comparison to daytime temperature changes, during these night time periods. Experience has shown that without any temperature compensation, leak detection thresholds of an amount less than one gallon per hour can routinely be achieved in tanks of 100 foot diameter and larger. Additionally with minimal temperature compensation it is possible to attain thresholds of an even lower level.

Table 1. Test Data for Mass Technology Corporation

Test No.	Induced Rate (gal/hr)	Measured Rate (gal/hr)	Difference (Measured - Induced) (gal/hr)
1	No Test*		
2	No Test*		
3	0	0	0
4	8.2	7.9	-0.3
5	No Test*		0
6	5.9	5.3	-0.6
7	3.4	3.6	0.2
8	-120**	-210	**
9	2	1.8	-0.2
10	1.4	2.2	0.8
11	1.04	1.6	0.56
12	0.41	1.2	0.79
13	-195**	-291	**
14	0	0	0
15	0.36	0	-0.36
16	0.5	1.1	0.6

* No test on 1 and 2 due to equipment adjustments. No test on 5 due to terminal operator required shutdown.

** Transfer of fuel from reservoir back to test tank.

Table 2. Summary of Performance Parameters for Mass Technology Leak Detector

Parameter	Value
Variance	0.2395 gal^2/hr^2
Standard Deviation	0.489 gal/hr
Threshold	1.00 gal/hr
Probability of Detection	96.4 %
Probability of False Alarm	3.6 %
Minimum Threshold for P(FA) of 5%	0.88 gal/hr
Minimum Detectable Leak for P(D) of 95%	1.76 gal/hr
Test Time	36 hrs (typical)

Table 3. Performance as a Function of Threshold

Threshold (gal/hr)	Probability of Detection (%)	Probability of False Alarm (%)
0.88	95.0	5.0
1.00	96.5	3.6
1.35	99.0	1.0