Evaluation of the Mass Technology Precision Mass Measurement System on Bulk Field-Constructed Tanks

(120,000 Gallon Vertical Tank Evaluation)

Final Report

PREPARED FOR:

Mass Technology Corporation

March 25, 1998

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PREPARED FOR:

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#7 Cox Drive
Kilgore, Texas 75662

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Preface

This report describes an independent evaluation of the Mass Technology Corporation Precision Mass Measurement System as a leak detection system for bulk field-constructed tanks. The forms contained in this report are based on data that was collected using the test protocol "Alternative Test Procedures for Evaluating Leak Detection Methods: Evaluation of Bulk Field-Constructed Tanks", Ken Wilcox Associates, Inc., February 1996. The results of the evaluation indicate that the Precision Mass Measurement System meets the requirements of the U.S. Environmental Protection Agency for leak detection systems designed to test bulk field-constructed tanks.

The work was conducted at NAS LeMoore, California. The leak simulations, data collection, data analysis, and reporting have been conducted by Ken Wilcox Associates, Inc. This report has been prepared by Mr. Jeffrey K. Wilcox.

Technical Questions regarding this evaluation should be directed to Mr. Jimmy Wolford, Mass Technology Corporation, at (903) 986-3564.

KEN WILCOX ASSOCIATES, INC.

Jeffrey K. Wilcox
Project Engineer

Approved:

H. Kendall Wilcox, Ph.D.
President

March 25, 1998

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1.0 Introduction

Mass Technology Corporation has developed the Precision Mass Measurement System for conducting leak detection testing on bulk field-constructed tanks. This report presents the results of testing conducted by Ken Wilcox Associates, Inc., on the Precision Mass Measurement System in a nominal 120,000 gallon bulk field-constructed underground storage tank. The official results of the testing have been reported in Attachment A of this report on the appropriate EPA forms, "Results of U.S. EPA Alternative Test Procedures: Bulk Field-Constructed Tank Leak Detection Methods."

The Environmental Protection Agency (EPA) requires that all tank testing equipment be tested to define the equipment's performance parameters. The minimum performance parameters for methods used on bulk tanks is not defined in the EPA test procedures. Performance parameters are determined by state and local agencies regulating particular tanks. The equipment must be capable of detecting leaks at a rate defined by the regulating agencies with a probability of detection of 95% or greater. At the same time, the method must not produce false alarms (declaring a leak when the tank is tight) more than 5% of the time.

To assure that the performance parameters of tank testing methods are defined, the EPA requires that each method be evaluated using prescribed protocols. The Precision Mass Measurement System was evaluated according to the protocol "Alternative Test Procedures for Evaluating Leak Detection Methods: Evaluation of Bulk Field-Constructed Tanks", Ken Wilcox Associates, Inc., February 1996.

The EPA protocol specifies that a minimum of 12 tests are required for a bulk field-constructed tank leak detection evaluation. The protocol specifies that leak rates should be induced equivalent to zero, 1/2 times the target threshold, 1 times the target threshold, and 2 times the target threshold. The protocol requires six product deliveries during the evaluation. The product from at least two of the six deliveries must have a different temperature from the product already in the tank.

2.0 Description of the Testing Location

The Precision Mass Measurement System was evaluated at NAS Lemoore, California. The NAS facility includes a number of bulk field-constructed tanks. Two tanks were made available from the NAS for this evaluation. The test tank was a field-constructed tank with a nominal capacity of 120,000 gallons. The tank diameter is 42 feet with a height of 12 feet. The tank is constructed of concrete, is vertical in shape, and contained JP-5 fuel.

In order to simulate product deliveries to the test tank, a second tank was made available for this evaluation. A pipeline between the test tank and the second tank made it possible to transfer product between the two tanks to simulate product deliveries. The test protocol requires temperature differences between delivered product and product already in the tank.

Openings in the tank were available for the Mass Technology equipment and for the KWA leak simulation equipment. The test tank was made available to KWA staff 24 hours a day for the duration of the evaluation. Leak simulations and product deliveries were defined by KWA staff that was present for the duration of the evaluation.

3.0 Overview of the Evaluation

Table 1 contains the test schedule, which was taken from the EPA protocol for bulk field-constructed leak detection methods.

The Precision Mass Measurement System was installed in the test tank by the manufacturer. Testing was carried out using the manufacturer's normal test routine. Leak simulations were induced through an opening in the top of the tank. The leak rate reported by the Precision Mass Measurement System was compared to the actual volume of product removed from the tank. A statistical analysis of the data was used to determine the performance characteristics of the test method.

A total of 12 tests were conducted on the Precision Mass Measurement System with product levels during testing were 77% of the tank's capacity. A total of 6 product deliveries were performed during the evaluation (including the delivery prior to the start of the first test). Leak simulations were controlled and monitored by KWA throughout the duration of the testing. Weather conditions, product levels and temperatures, and leak rates were recorded by KWA throughout the evaluation.

Leak simulations were conducted by pumping product out of the tank with a peristaltic pump from tubing that was placed in the product. Nominal leak rates of zero, 0.1 gal/h, 0.2 gal/h, and 0.4 gal/h were randomly induced during the evaluation. Leak rates were calculated from the total mass of product removed from the tank during the test time and the density of the product which was measured with an analytical balance in a laboratory. The mass of the product removed was measured by pumping product into a barrel hanging from a load cell. The uncertainty in the simulated leak rates was less than 0.01 gal/h. Leak rates were also verified by KWA staff periodically during each test by measuring the pumping rate with a graduated cylinder and a stop watch. Product levels and temperatures were monitored throughout the evaluation using a level gauge and a data acquisition software.

Table 1. Product Volume, Leak Rate, and Temperature Differential Test Schedule

Test Description**	Test No.	Pair No.	Set No.	Nominal leak rate (gallon per hour)	Nominal temperature differential* (degree F)
Empty to 50% full (if applicable)					
Refill to 90-95%	1	1	1	LR1	T1
	2	1	1	LR2	T1
Empty to 50-60%					
Refill to 90-95%	3	2	1	LR4	T2
	4	2	1	LR3	T2
Empty to 50-60%					
Refill to 90-95%	5	3	2	LR1	T3
	6	3	2	LR4	T3
Empty to 50-60%					
Refill to 90-95%	7	4	2	LR2	T4
	8	4	2	LR3	T6
Empty to 50-60%					
Refill to 90-95%	9	5	3	LR4	T5
	10	5	3	LR1	T5
Empty to 50-60%					
Refill to 90-95%	11	6	3	LR3	T6
	12	6	3	LR2	T6

* Although the temperature cannot be controlled, these temperatures should be recorded on the appropriate data sheets. The temperature differential is calculated as the temperature of the product added minus the temperature of the product in the tank.

** Two empty/fill cycles that include adding product of a different temperature are required for mass systems. Four empty/fill cycles that include adding product of a different temperature are required for volumetric measurement systems.

4.0 Description of the Precision Mass Measurement System

The official descriptions of the Precision Mass Measurement System have been provided on the appropriate EPA description forms “Description: Bulk Field-Constructed Leak Detection Method” in Attachment A of this evaluation. A brief description is given below.

The Mass Technology Precision Mass Measurement System employs the measurement of the differential pressure between one point at the bottom of the contained fluid and another point in the vapor space immediately above the fluid surface. The pressure at or near the bottom of the tank corresponds to the mass above the measuring point and independent of liquid level changes caused by the thermal expansion and contraction of the product under test.

Practical application of the system involves lowering a bubbler unit through the gauge hatch to tank bottom. A differential reference tube is placed just above the liquid surface. A low pressure inert gas is conveyed to the bubbler unit at a precisely controlled rate, an additional tube is attached which eliminates the friction and subsequent back-pressure effects on the differential pressure transducer as a result of the gas flow. The pressure required to generate a steady stream of gas bubbles at the bottom of the tank corresponds to the differential pressure as a result of the fluid mass. The pressure is measured by a micros-sensitive differential pressure transducer, recorded on a real time basis and post processed using data analysis routines to accurately calculate any changes in the mass of fluid contained within the tank to determine if there is a loss.

5.0 Test Results and Discussion

Table 2 summarizes data collected during this evaluation. The information in this table is also contained in Attachment A on the official EPA form "Reporting Form for Leak Rate Data." Table 3 summarizes the calculated test results of the Precision Mass Measurement System based on data collected during the evaluation.

A total of 12 tests were conducted on the Precision Mass Measurement System during this evaluation. The data was analyzed statistically using the procedures specified in the test protocol. The probabilities of detection (P_D) and false alarm (P_{FA}) were calculated for a leak of 0.1 gal/h using a threshold set by the vendor at 0.05 gal/h.

Leaks were induced for the duration of each test at rates defined by the test schedule in Table 1. Results were calculated based on the differences between the leak rates reported by Precision Mass Measurement System and the actual induced leak rates. A summary of the test results that follows is contained in Table 3. The official results are contained in Attachment A of this report on the forms "Results of U.S. EPA Alternative Test Procedures: Bulk Field-Constructed Tank Leak Detection Methods".

Calculation of P_D and P_{FA}

When the threshold for declaring a leak is set at 0.05 gal/h, the probability of detection (P_D) of a 0.1 gal/h leak was calculated to be 97.9%. The corresponding probability of a false alarm (P_{FA}) on a tight tank was determined to be 2.1%.

Test Times

Test times during the evaluation ranged from 20 to 41 hours and with an average of 25 hours. The vendor specifies a test time of 24 hours and the results of this evaluation indicate that 24 hours is sufficient for conducting a leak detection test.

Product Levels

For this evaluation, testing was conducted with tank product levels 77% full. This was the maximum level that the tank operators could fill the test tank for this evaluation. The results of this evaluation indicate that tank product levels of 90% full or greater are adequate for conducting leak detection tests.

Size of Tank

The performance of a leak detection system can be affected by the size and geometry of the tank. Parameters that affect the relationship between the volumetric noise for a leak detection system and the tank size/geometry are a function of the technology and the specific implementation of the technology under evaluation. This relationship is not quantitatively understood for each technology and for each implementation of that technology. For most volumetric technologies, performance is related to tank volume,

Table 2. Test Data and Results of the Leak Detection Tests

Test No.	Date at Completion of Last Fill d/m/y	Time at Completion of Last Fill (hh:mm)	Stablization Time (dd:hh:mm)	Date Test Began d/m/y	Time Test Began (hh:mm)	Date Test Ended d/m/y	Time Test Ended (hh:mm)	Total Test Time (dd:hh:mm)	Product Temperature Differential (deg F)	Nominal Leak Rate (gal/h)	Induced Leak Rate (gal/h)	Measured Leak Rate (gal/h)	Meas.-Ind. Leak Rate (gal/h)
1	N/A	N/A	N/A	12/09/97	14:00	12/11/97	07:46	01:17:46	N/A	0	0	-0.01	-0.010
2	N/A	N/A	N/A	12/11/97	08:35	12/12/97	08:00	00:23:25	N/A	0.4	-0.384	-0.38	0.004
3	12/15/97	13:28	00:03:32	12/15/97	17:00	12/16/97	17:00	01:00:00	-1.4	0.1	-0.089	-0.094	-0.005
4	N/A	N/A	N/A	12/17/97	07:52	12/18/97	07:52	01:00:00	N/A	0.4	-0.328	-0.31	0.018
5	01/21/98	9:00	01:07:00	01/22/98	16:00	01/23/98	16:05	01:00:05	N/A - 0	0	0	0.001	0.001
6	N/A	N/A	N/A	01/24/98	07:40	01/25/98	07:40	01:00:00	N/A	0.2	-0.18	-0.19	-0.010
7	01/26/98	11:38	00:06:22	01/26/98	18:00	01/27/98	17:30	00:23:30	-2.44	0.1	-0.078	-0.08	-0.002
8	N/A	N/A	N/A	01/28/98	08:25	01/29/98	08:25	01:00:00	N/A	0.2	-0.211	-0.2	0.011
9	01/29/98	11:38	00:01:02	01/29/98	12:40	01/30/98	08:30	00:19:50	-1.6	0.4	-0.358	-0.42	-0.062
10	N/A	N/A	N/A	01/30/98	08:45	01/31/98	10:30	01:01:45	N/A	0	0	0	0.000
11	02/20/98	9:00	00:09:00	02/20/98	18:00	02/21/98	17:30	00:23:30	-2.2	0.2	-0.217	-0.25	-0.033
12	N/A	N/A	N/A	02/21/98	17:35	02/22/98	18:10	01:00:35	N/A	0.1	-0.103	-0.082	0.021

Table 3. Summary of the Test Results for the Precision Mass Measurement System

Required Test Time	24 Hours
Required Product Level in Tank	90% full
Maximum Size of Tank	60 ft diameter
Maximum Temperature Difference (between product delivered and product in the tank)	±0.75 deg F
Required Stabilization Time After Delivery or Fueling Operations	None - (provided a minimum of 24 hours of data is collected and analyzed)
Standard Deviation of the Test Data	0.022 gal/h
Threshold	0.05 gal/h
Probability of False Alarm (P_{FA}) using a Threshold of 0.05 gal/h	2.1%
Probability of Detection of a 0.1 gal/h leak	97.9%
Minimum Threshold for a 5% P_{FA}	0.039 gal/h
Minimum Detectable Leak Rate for 95% P_D (when the minimum threshold is used)	0.078 gal/h

and for most mass-based technologies, performance is related to the surface area of the fuel in the tank (but not the depth of the tank); for some systems, performance is a function of both volume and surface area.

The protocol also specifies that the threshold for declaring a leak must be adjusted when testing tanks that are larger than the tank used in the evaluation. For volumetric systems, the threshold for different tank sizes is obtained by multiplying the standard deviation of the method measured in the evaluation by the ratio of the volume of the tank being tested and the tank used in the evaluation. For a mass-based system, the threshold is obtained from the ratio of the surface area of the tank being tested and the surface area of the tank used in the evaluation.

The Precision Mass Measurement System is a mass-based system. In this protocol, the maximum tank size to which a mass-based method may be applied is determined by the surface area of the tank and is limited to twice the surface area of the tank used in the evaluation. Since the surface area of the 40-ft diameter, 120,000 gallon tank used in this evaluation is 1,257 ft^2, the Precision Mass Measurement System can be used to test tanks with diameters up to 60 ft. The maximum tank size (in terms of volume) that can be tested with the Precision Mass Measurement System will depend on (but is not limited by) the height of the tank. The applicable threshold to use when testing larger tanks than used in the evaluation will be a function of the ratio of the surface area tank being tested and the surface area of the evaluated tank.

Temperature Differences

The temperature of the product which was delivered to the test tank during the evaluation ranged from -2.4 deg F to -1.4 deg F with a standard deviation of 0.5 deg F. The EPA protocol specifies that testing may be conducted with a maximum temperature difference between product delivered and product in the tank of 1.5 times the standard deviation, or ±0.75 deg F.

Waiting Time After Product Deliveries or Fueling Operations

The vendor specifies that testing may be initiated immediately following a delivery provided that a minimum of 24 hours of quality data are collected and analyzed. Stabilization times during the evaluation ranges from 62 minutes to 31 hours with a median time of one 6 hours 22 minutes.

Detection of Water Leaks into the Tank

The Precision Mass Measurement System is a mass-based systems which will detect increases and decreases in mass in the tank. Water leaks into or out of the tank are detected as changes in mass and the tank operator is alerted if a problem exists.

Minimum Threshold

The minimum thresholds for specific false alarm and detection levels can be calculated. The minimum threshold for a 5% false alarm rate is 0.039 gal/h. If a threshold of less than the minimum threshold is used to declare a leak, the false alarm rate will be higher than the 5% maximum level specified by the regulations.

Minimum Detectable Leak Rate

The minimum detectable leak rate is 0.078 gal/h when the threshold is set at 0.039 gal/h. Leak rates smaller than the minimum detectable leak rate value will be detected with a probability of less than 95%.

6.0 Conclusions

The following conclusions and recommendations are based on the results of the testing described in this report.

1. For the Precision Mass Measurement System, the Probability of Detection (P_D) of a 0.1 gal/h leak is 97.9% when the threshold is set at 0.05 gal/h. The corresponding Probability of False Alarm (P_{FA}) is 2.1%.

2. The minimum test time for a leak detection test to be valid is 24 hours.

3. The tank should be 90% full before conducting a leak detection test.

4. The results of this evaluation are valid for tanks with diameters up to 60 feet, provided that the threshold is adjusted by the ratio of the surface area of the larger tank being tested and the surface area of the tank used in the evaluation.

5. Leak detection tests should not be conducted immediately following a delivery if the temperature difference between the delivered product and the product in the tank is greater than ±0.75 deg F.

7. Leak detection tests may be initiated immediately following a product delivery provided a minimum of 24 hours of quality data are collected and analyzed.

Attachment A

EPA Forms for the Mass Technology Precision Mass Measurement System

(120,000 Gallon Vertical Tank Evaluation)

Results of U.S. EPA Alternative Test Procedures
Bulk Field-Constructed Tank
Leak Detection Method

This form describes the performance of the leak detection method described below. The evaluation was conducted by the equipment manufacturer or a consultant to the manufacturer according to a modification of the U.S. EPA's "Standard Test Procedure for Evaluating Leak Detection Methods: Automatic Tank Gauging Systems." The full evaluation report also includes a form describing the method and a form summarizing the test data.

Tank owners using this leak detection system should keep this form on file to provide compliance with the federal regulations. Tank owners should check with State and local agencies to make sure this form satisfies their requirements.

Leak Detection Method Description

Name Mass Technology Precision Mass Measurement System

Version number 120,000 Gallon Vertical Tank Evaluation

Vendor(s) Mass Technology Corporation

#7 Cox Drive	Kilgore,	Texas	75662	(903) 986 3564
(street address)	(city)	(state)	(zip)	(phone)

Evaluation Results

This Leak Detection Method which declares tank to be leaking when the measured leak rate exceeds the threshold of 0.05 gallon per hour, has a probability of false alarms [P_{FA}] of 2.1 % for tests conducted on tanks with diameters of 60 ft. or less.

The corresponding probability of detection [P_D] of a 0.100 gallon per hour leak is 97.9 %.

The standard deviation of the test data results was 0.022 gal/h.

The minimum water level (threshold) in the tank that the method can detect is N/A inches.

The minimum change in water level that can be detected by the method is N/A inches (provided that the water level is above the threshold).

Test Conditions During Evaluation

The evaluation testing was conducted in a nominal 120,000 gallon
( ) steel ( ) fiberglass (**X**) concrete tank that was ( ) horizontal (**X**) vertical
and was 40 feet in diameter and 13 feet ( ) long (**X**) tall.

The tests were conducted with the tank product level 90-95% % full.

The product used in the evaluation was JP-5 .

Method Name and Version: Mass Technology Precision Mass Measurement System
Date of Certification: March 25, 1998 (120,000 Gallon Vertical Tank Evaluation)

Limitations on the Results

The performance estimates above are only valid when:

- # The method has not been substantially changed.
- # The vendor's instructions for installing and operating the Leak Detection Method are followed.
- # The tank contains a product identified on the method description form.
- # The diameter of the tank is no larger than 60 ft.
- # The threshold for declaring a leak in a tank larger than the one being tested is adjusted by multiplying the ratio of the surface area of the tank being tested and the surface area of the tank used in this evaluation, which is 1,257 ft.
- # The tank is at least 90% percent full.
- # The waiting time after adding any substantial amount of product to the tank is 0 hours.
- # The temperature of the added product does not differ more than ±0.7 degrees Fahrenheit from that already in the tank.
- # The total data collection time for the test is at least 24 hours.
- # Other limitations specified by the vendor of determined during testing:

  None

Procedural Information

State the procedures used to compensate for the presence of a water table above the bottom of the tank.

None

State the procedures used to determine when the tank is stable.

None

State the procedures used to account for fuels of different volatility.

None

Method Name and Version: Mass Technology Precision Mass Measurement System
Date of Certification: March 25, 1998 (120,000 Gallon Vertical Tank Evaluation)

Other Information

Summary of Test Procedure Modifications

Temperature Variations were achieved by: (describe briefly)

Product was transferred from a nearby bulk tank using the local fuel farm bulk pipeline.

Other Modifications: (describe briefly)

None .

Have other evaluations been conducted on this method? ( ) Yes (X) No

If so, please summarize the results or attach a copy of the EPA Results Forms to this document.

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

Certification of Results

I certify that the Leak Detection Method was installed and operated according to the vendor's instructions and that the results presented on this form are those obtained during the evaluation.

H. Kendall Wilcox, Ph.D. President (printed name)	Ken Wilcox Associates, Inc. (organization performing evaluation)
_____ (signature)	Grain Valley, Missouri 64029 (city, state, zip)
March 25, 1998 (date)	(816) 443-2494 (phone number)

Reporting Form for Leak Rate Data

Bulk Field-Constructed Tank Leak Detection Method

Name and Version of Method: Masstech Precision Mass Measurement System (120,000 Gallon Vertical Tank Evaluation)

Evaluation Period: from 11/25/1997 to 2/17/1998 (Dates)

Test No.	Date at Completion of Last Fill d/m/y	Time at Completion of Last Fill (hh:mm)	Stablization Time (dd:hh:mm)	Date Test Began d/m/y	Time Test Began (hh:mm)	Date Test Ended d/m/y	Time Test Ended (hh:mm)	Total Test Time (dd:hh:mm)	Product Temperature Differential (deg F)	Nominal Leak Rate (gal/h)	Induced Leak Rate (gal/h)	Measured Leak Rate (gal/h)	Meas.-Ind. Leak Rate (gal/h)
1	N/A	N/A	N/A	12/09/97	14:00	12/11/97	07:46	01:17:46	N/A	0	0	-0.01	-0.010
2	N/A	N/A	N/A	12/11/97	08:35	12/12/97	08:00	00:23:25	N/A	0.4	-0.384	-0.38	0.004
3	12/15/97	13:28	00:03:32	12/15/97	17:00	12/16/97	17:00	01:00:00	-1.4	0.1	-0.089	-0.094	-0.005
4	N/A	N/A	N/A	12/17/97	07:52	12/18/97	07:52	01:00:00	N/A	0.4	-0.328	-0.31	0.018
5	01/21/98	9:00	01:07:00	01/22/98	16:00	01/23/98	16:05	01:00:05	N/A - 0	0	0	0.001	0.001
6	N/A	N/A	N/A	01/24/98	07:40	01/25/98	07:40	01:00:00	N/A	0.2	-0.18	-0.19	-0.010
7	01/26/98	11:38	00:06:22	01/26/98	18:00	01/27/98	17:30	00:23:30	-2.44	0.1	-0.078	-0.08	-0.002
8	N/A	N/A	N/A	01/28/98	08:25	01/29/98	08:25	01:00:00	N/A	0.2	-0.211	-0.2	0.011
9	01/29/98	11:38	00:01:02	01/29/98	12:40	01/30/98	08:30	00:19:50	-1.6	0.4	-0.358	-0.42	-0.062
10	N/A	N/A	N/A	01/30/98	08:45	01/31/98	10:30	01:01:45	N/A	0	0	0	0.000
11	02/20/98	9:00	00:09:00	02/20/98	18:00	02/21/98	17:30	00:23:30	-2.2	0.2	-0.217	-0.25	-0.033
12	N/A	N/A	N/A	02/21/98	17:35	02/22/98	18:10	01:00:35	N/A	0.1	-0.103	-0.082	0.021

Description
Bulk Field-Constructed Tank
Leak Detection Method

This section describes briefly the important aspects of the bulk tank leak detection method. It is not intended to provide a thorough description of the principles behind the system or how the equipment works.

Method Name and Version

Mass Technology Precision Mass Measurement System

Product

> Product type

For what products can this Method be used? (check all applicable)

(X) gasoline

(X) diesel

(X) aviation fuel

(X) fuel oil #4

(X) solvents

(X) other (list) Any liquid

> Product level

What product level is required to conduct a test?

( ) greater than 90% full

( ) greater than 50% full

(X) other (specify) Method is not sensitive to product level.

Does the Method measure inflow of water as well as loss of product (gallon per hour)?

(X) yes

( ) no

Does the Method detect the presence of water in the bottom of the tank?

( ) yes

(X) no

Method Name and Version: Mass Technology Precision Mass Measurement System
Date of Certification: March 25, 1998 (120,000 Gallon Vertical Tank Evaluation)

Principle of Operation

What technique is used to detect leaks in the tank system?

( ) directly measure the volume of product change

(X) changes in head pressure

( ) changes in buoyancy of a probe

( ) mechanical level measure (e.g., ruler, dipstick)

( ) changes in capacitance

( ) ultrasonic

( ) change in level of float (specify principle, e.g., capacitance, magnetostrictive, load cell, etc.) _____

( ) acoustical signal characteristics of a leak

( ) identification of a tracer chemical outside the tank system

( ) other (describe briefly) _____

Temperature Measurement

How many temperature sensors are used to measure the product temperature?

(X) Product temperature not measured

( ) One sensor

( ) Two sensors

( ) Three sensors

( ) Four sensors

( ) Five sensors

( ) Other (describe briefly) _____

What type of temperature sensor is used?

(X) Product temperature not measured

( ) resistance temperature detector (RTD)

( ) bimetallic strip

( ) quartz crystal

( ) thermistor

( ) other (describe briefly) _____

If product temperature is not measured during a test, why not?

(X) the factor measured for change in level/volume is independent of temperature (e.g., mass)

(X) the factor measured for change in level/volume self-compensates for changes in temperature

( ) other (explain briefly) _____

Data Acquisition

How are the test data acquired and recorded?

( ) manually

( ) by strip chart

(X) by computer

Procedure information

> Waiting times

What is the required waiting period between adding a large volume of product (i.e., a delivery) and the beginning of a test (e.g., filling from 50% to 90-95% capacity)?

__0__ Hours __0__ Minutes

Additional Comments: _____

_____

_____

> Test duration

What is the required time for collecting data?

__24__ Hours __0__ Minutes

Additional Comments: _____

_____

_____

What is the sampling frequency for the level and temperature measurements?

( ) more than once per second

( ) at least once per minute

(X) every 1-15 minutes

( ) every 16-30 minutes

( ) every 31-60 minutes

( ) less than once per hour

( ) variable (explain) _____

> Identifying and correcting for interfering factors

How does the Method determine the presence and level of the ground water above the bottom of the tank?

(X) level of ground water above bottom of the tank not determined

( ) observation well near tank

( ) information from USGS, etc.

( ) information from personnel on-site

( ) presence of water in the tank

( ) other (describe briefly) _____

Does the method measure inflow of water as well as loss of product?

(X) yes

( ) no

Additional Comments: _____

_____

_____

How does the Method correct for the interference due to the presence of ground water above the bottom of the tank?

( ) no action

(X) system tests for water incursion

( ) different product levels tested and leak rates compared

( ) other (describe briefly) _____

> Interpreting test results

How are level changes converted to volume changes (i.e., how is height-to-volume conversion factor determined)?

( ) actual level changes observed when known volume is added or removed (e.g., liquid metal bar)

(X) theoretical ratio calculated from tank geometry

(X) interpolation from tank manufacturer's chart

( ) other (describe briefly)

( ) not applicable; volume measured directly

How is the coefficient of thermal expansion (Ce) of the product determined?

( ) actual sample taken for each test and Ce determined from specific gravity

( ) value supplied by vendor of product

( ) average value for type of product

(X) other (describe briefly) Not required - method is self-compensating for product temperature changes.

How is the leak rate (gallon per hour) calculated?

( ) average of subsets of all data collected

( ) difference between first and last data collected

(X) from data from last 24 hours of test period

(X) from data determined to be valid by statistical analysis

( ) other (describe) _____

What threshold value for product volume change (gallon per hour) is used to declare that a tank is leaking?

(X) 0.05 gal/h	( ) 0.1 gal/h	( ) 0.2 gal/h
( ) 0.5 gal/h	( ) 1.0 gal/h	( ) 2.0 gal/h

( ) Other _____

Additional Comments: _____

Under what conditions are test results considered inconclusive?

( ) ground water level above the bottom of the tank

( ) soil not sufficiently porous

( ) too much variability in the data (standard deviation beyond a given value)

( ) unexplained product volume increase

( ) other (describe briefly)_____

(X) none

Exceptions

Are there any conditions under which a test should not be conducted?

( ) ground water level above the bottom of the tank

( ) large difference between ground temperature and delivered product temperature

( ) extremely high or low ambient temperature

( ) invalid for some products (specify) _____

( ) other (describe briefly) _____

(X) none

What are acceptable deviations from the standard testing protocol?

( ) lengthen the duration of test

( ) other (describe briefly) _____

(X) none

What elements of the test procedure are determined by personnel on-site?

(X) product level when test is conducted

(X) when to conduct test

(X) waiting period between filling tank and beginning test

(X) length of test

( ) determination of "outlier" data that may be discarded

( ) other (describe briefly) _____

( ) none