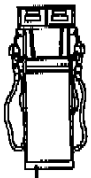

Evaluation of the FE Petro STP-MLD Pipleline Leak Detection System

Volume I. Final Report

PREPARED FOR
FE Petro, Inc.

July 1, 1992

KEN WILCOX ASSOCIATES, INC. - 1312 SW 21ST ST
BLUE SPRINGS, MO 64015 - (816) 229-0860

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Prepared for
FE Petro, Inc.
P.O. Box 139
McFarland, WI 53558

July 1, 1992

PREFACE

The evaluation described in this report was conducted for FE Petro, Inc. of McFarland, Wisconsin, by Ken Wilcox Associates, Inc. The report describes the evaluation and performance of the FE Petro STP-MLD Mechanical Line Leak Detector used as an hourly monitoring device to check for leaks in underground pressurized piping. The test results are presented in Volume I and the test data is presented in Volume II.

The testing was conducted using the U.S. Environmental Protection Agency's protocol "Standard Test Procedures for Evaluating Leak Detection Methods: Pipeline Leak Detection Systems," EPA/530/UST-90/010, September 1990. The test results are reported on the standard forms provided by the EPA. The testing was conducted at the Leak Detection Test Center in Kansas City, Missouri, by Ken Wilcox Associates, Inc. The report was prepared by Dr. Ken Wilcox.

Technical questions should be directed to Mr. Charles Franklin, FE Petro, Inc. at (608) 838-8786.

H. Kendall Wilcox, President
KEN WILCOX ASSOCIATES, INC.

H. Kendall Wilcox

August 6, 1992

EXECUTIVE SUMMARY

The FE Petro Model STP-MLD Mechanical Line Leak Detector is used as an automatic device to test for leaks in pressurized underground piping systems. It has been tested according to the U.S. Environmental Protection Agency (EPA) protocol "Standard Test Procedures for Evaluating Leak Detection Methods: Pipeline Leak Detection Systems" as an hourly monitoring device. The results show that the STP-MLD exceeds the performance requirements of the EPA for hourly line leak detection systems. It is capable of detecting leak rates of 3 gal/hr with a probability of detection of 100% and a probability of false alarm of 0%. Under stable conditions, the STP-MLD may detect leaks as small as 2 gal/hr.

The testing was conducted on a 3-in diameter by 176 ft long fiberglass line (64.6 gal) which means that the STP-MLD is approved for lines up to 129.2 gal capacity.

TEST REPORT FOR THE EVALUATION OF THE FE PETRO, INC. STP-MLD MECHANICAL LINE LEAK DETECTOR

Introduction

This section presents the evaluation of the FE Petro STP-MLD Line Leak Detector. It contains an overview of the EPA Protocol used for testing, a description of the equipment being tested, a description of the test site and operating procedures, and a test results summary. The detailed results of the testing are presented in Appendix A using the forms provided in the EPA protocol.

Overview of EPA Test Protocol

The U.S. Environmental Protection Agency (EPA) has specified that certain performance criteria be met for leak detection equipment used on underground storage tanks and pipeline systems containing petroleum products. These criteria are described in 40CFR Part 280, Subpart D of the Code of Federal Regulations.

To demonstrate that a leak detector meets the performance criteria, the EPA has also produced an evaluation protocol for the different types of line leak detectors entitled "Standard Test Procedures for Evaluating Leak Detection Methods: Pipeline Leak Detection Systems." The testing described in this report was conducted using the hourly line leak detector methods described in the EPA protocol.

Basic requirements of the "hourly" protocol to be met are that the leak detector be capable of detecting a leak greater than 3 gal/hr in less than one hour with a probability of detection (P_D) greater than 95% and a probability of false alarm (P_{FA}) less than 5%. These values must be maintained under noise conditions expected in normal operation, principally thermal contraction and thermal expansion of the fuel in the pressurized pipeline. Additional testing is required to check the leak detector's reaction to vapor trapped in the pipeline, since vapor may affect the equipment's reaction to leaks.

Option 1 of the evaluation protocol was selected for testing of the STP-MLD. This procedure requires that a minimum of 25 tests be conducted under no leak conditions and 25 tests at a leak rate of 3 gal/hr. Each series of tests is conducted under a range of temperature conditions which are designed to test the ability of the leak detection equipment to identify and deal with the problems caused by severe temperature behavior and the vapor pockets previously discussed.

Description of the FE Petro STP-MLD Leak Detector

The STP-MLD Leak Detector is a mechanical line leak detector. It uses a piston/spring mechanism to monitor the line pressure when the pump is off, control the position of the leak

detection mechanism according to the line pressure, and supply a limited amount of liquid to the line should product volume be lost for any reason. If the STP-MLD has sensed a leak (or is in the leak testing mode) it will be closed, restricting flow to the dispenser.

Description of the Test Site and Operating Procedures

Testing was conducted on a 176 ft 3-in diameter fiberglass line. A 560 gal reservoir equipped with a submerged pump was used to circulate product through the test line. Product temperatures in the reservoir tank were adjusted by circulating heated or cooled glycol through cooling coils which were located in the tank.

The temperature of the product in the tank was monitored as well as the soil temperatures around the pipeline. Temperatures were monitored using RTD's which were calibrated against an NBS traceable quartz thermometer. These temperatures were used to determine the temperature differential between the product in the tank and the soil using the equations outlined in the EPA protocol.

Leaks were simulated by calibrating a needle valve and variable area flowmeter to deliver the desired leak (nominally 3.0 gal/hr at a pressure of 10 PSI as required by the regulations). Once the calibration was complete, no further adjustments were made in the valve which was connected to the line to simulate the leak. The leak rate would, of course, vary as the pressure on the line changed during the test.

Two types of tests were conducted: Tests with a leak of 3 gal/hr were used to test the ability of the STP-MLD to detect leaks under a variety of temperature conditions; and tests with no leaks were used to confirm a low probability of false alarms on a tight line, again under a variety of temperature conditions. A brief summary of the testing procedures is as follows:

1) The STP-MLD was installed directly on the pump discharge, the usual position for it to operate in.

2) The product in the reservoir tank was adjusted to the desired temperature range.

3) Product was circulated through the line for one hour at a range of approximately 30 gal/min.

4) For a test involving a leak, a leak rate of 3.0 gal/hr at 10 psi was introduced into the line during the circulation period. For a non-leak test, the product was only circulated.

5) At the end of the circulation period the dispenser nozzle was closed and the pump was turned off. The pressure was then dropped to zero by bleeding product from the line through a small valve. This process reset the STP-MLD to the leak detect mode. This process took approximately one minute.

6) The pressure bleed valve was then closed with the leak still present in the line. For a non-leak situation, the bleed valve was closed when the pressure reached zero.

7) With the dispenser nozzle in the closed position, the pump was turned on. If the line pressure rose to full pump pressure (usually 28 to 30 psi) a non-leaking line was indicated.

8) Since the test times were very short, the testing sequence was repeated at least three times for each circulation period by repressurizing the line (without additional circulation) and repeating steps 5 through 7.

Only four types of results were possible. First, a leaking line is found to be leaking (a correct conclusion). Second, a non-leaking line is found to be tight (a correction conclusion). Third, a leaking line is found to be tight (a missed detection) and fourth, a tight line is reported to be leaking (a false alarm). The results of each test were recorded and compared to the correct conclusion.

Test Results Summary

The results of the testing have been reported using the Performance Evaluation forms provided in the EPA protocol which certify the test results. These have been reproduced in Appendix A. The data, test conditions, and other technical information is summarized in several attachments to the Performance Evaluation, which are provided in Appendix B. Table 1 summarizes the test requirements for various temperature conditions. Table 2 summarizes the testing which was conducted for the evaluation arranged from lowest temperature to highest. An effort was made to maintain the flow at 3.0 gal/hr for each test run, but due to the difficulty in maintaining uniform flow through an orifice under operating conditions, some of the rates vary slightly.

A total of 55 tests were conducted using the EPA evaluation protocol. These were divided into 26 leak tests, 26 no-leak tests, and 3 vapor tests. No valid failures were recorded during the evaluation. The leaks tabulated were detected and no false alarms occurred with the "zero leaks". Since the time period for data collection is very short for the STP-MLD (less than 5 minutes were required) up to three tests could be conducted for each temperature condition as discussed in Section 5.2 of the protocol.

Appendix A

EPA Forms for the

FE Petro STP-MLD Pipeline Leak Detector

Results of the Performance Evaluation
Conducted According to EPA Test Procedures

Pipeline Leak Detection System
Used as an
Hourly Monitoring Test

This form summarizes the results of an evaluation to determine whether the pipeline leak detection system named below and described in Attachment 1 complies with federal regulations for conducting an hourly monitoring test. The evaluation was conducted according to the United States Environmental Protection Agency's (EPA's) evaluation procedure, specified in *Standard Test Procedures for Evaluating Leak Detection Methods: Pipeline Leak Detection Systems.* The full evaluation report includes seven attachments.

Tank system owners who use this pipeline leak detection system should keep this form on file to show compliance with the federal regulations. Tank system owners should check with state and local agencies to make sure this form satisfies the requirements of these agencies.

System Evaluated

System Name: STP-MLD

Version of System:

Manufacturer Name: FE Petro, Inc.

4423 Triangle St.
(street address)

McFarland, WI 53558
(city, state, zip code)

(608) 838-8786
(telephone number)

Evaluation Results

1. The performance of this system
   (X) meets or exceeds
   ( ) does not meet
   the federal standards established by the EPA regulation for hourly monitoring tests.

   The EPA regulation for an hourly monitoring test requires that the system be capable of detecting a leak as small as 3 gal/h with a probability of detection (P_D) of 95% and a probability of false alarm (P_{FA}) of 5%.

2. The estimated P_{FA} in this evaluation is 0 % and the estimated P_D against a leak rate of 3 gal/h defined at a pipeline pressure of 10 psi in this evaluation is 100 %.

Criterion for Declaring a Leak

3. This system
(X) uses a preset threshold
( ) measures and reports the output quantity and compares it to a predetermined threshold
to determine whether the pipeline is leaking.

4. This system
(X) uses a single test
( ) uses a multiple-test sequence consisting of _____ tests (specify number of tests required) separated by _____ hours (specify the time interval between tests)
to determine whether the pipeline is leaking.

5. This system declares a leak if the output of the measurement system exceeds a threshold of 2 gal/h (specify flow rate in gal/h) in 1 out of 1 tests (specify, for example, 1 out of 2, 2 out of 3). If more detail is required, please specify in the space provided.

Evaluation Approach

6. There are five options for collecting the data used in evaluating the performance of this system. This system was evaluated

(X) at a special test facility (Option 1)
( ) at one or more instrumented operational storage tank facilities (Option 2)
( ) at five or more operational storage tank facilities verified to be tight (Option 3)
( ) at 10 or more operational storage tank facilities (Option 4)
( ) with an experimentally validated computer simulation (Option 5)

7. A total of 55 tests were conducted on nonleaking tank(s) between 6/1/92 (date) and 6/10/92 (date). A description of the pipeline configuration used in the evaluation is summarized in Attachment 3.

Answer questions 8 and 9 if Option 1, 2, or 5 was used.

8. The pipeline used in the evaluation was 3 in. in diameter, 176 ft long and constructed of fiberglass (fiberglass, steel, or other).

9. A mechanical line leak detector
( ) was
(X) was not
present in the pipeline system.

Answer questions 10 and 11 if Option 3 or 4 was used.

10. The evaluation was conducted on _____ (how many) pipeline systems ranging in diameter from _____ in. to _____ in., ranging in length from _____ ft to _____ ft, and constructed of _____ (specify materials).

11. A mechanical line leak detector
(X) was
( ) was not
present in the majority of the pipeline systems used in the evaluation.

12. Please specify how much time elapsed between the delivery of product and the start of the data collection:
(X) 0 to 6 h (time after completition of circulation and start of test)
( ) 6 to 12 h
( ) 12 to 24 h
( ) 24 h or more

Temperature Conditions

This system was evaluated under the range of temperature conditions specified in Table 1. The difference between the temperature of the product circulated through the pipeline for 1 h or more and the average temperature of the backfill and soil between 2 and 12 in. from the pipeline is summarized in Table 1. If Option 1, 2 or 5 was used, a more detailed summary of the product temperature conditions generated for the evaluation is presented in Attachment 4. If Option 3 or 4 was used, no artificial temperature conditions were generated.

Table 1. Summary of Temperature Conditions Used in the Evaluation

Minimum Number of Conditions Required	Number of Conditions Used*	Range of ΔT(°F)**
1	3	$\Delta T < -25$
4	8	$-25 \leq \Delta T < -15$
5	10	$-15 \leq \Delta T < -5$
5	10	$-5 \leq \Delta T < +5$
5	10	$+5 \leq \Delta T < +15$
4	8	$+15 \leq \Delta T < +25$
1	3	$\Delta T > 25$

*This column should be filled out only if Option 1, 2, or 5 was used.

**ΔT is the difference between the temperature of the product dispensed through the pipeline for over an hour prior to the conduct of a test and the average temperature of the backfill and soil surrounding the pipe.

Data Used to Make Performance Estimates

13. The induced leak rate and the test results used to estimate the performance of this system are summarized in Attachment 5. Were any test runs removed from the data set?

(X) no
( ) yes

If yes, please specify the reason and include with Attachment 5. (If more than one test was removed, specify each reason separately.)

Sensitivity to Trapped Vapor

14. (X) According to the vendor, this system can be used even if trapped vapor is present in the pipeline during a test.
( ) According to the vendor, this system *should not be used* if trapped vapor is present in the pipeline.

15. The sensitivity of this system to trapped vapor is indicated by the test results summarized in Table 2. These tests were conducted at 28 psi with 110 ml of vapor trapped in the line at a pressure of 0 psi. The data and test conditions are reported in Attachment 6.

Table 2. Summary of the Results of Trapped Vapor Tests

Test No.	ΔT (°F)	Induced Leak Rate (gal/h @ 10 psi)	Measured Leak Rate (gal/h)
1	-8.91	0	Tight
2	-8.91	3.25	Leak
3	-2.15	2.75	Leak

Performance Characteristics of the Instrumentation

16. State below the performance characteristics of the primary measurement system used to collect the data. (Please specify the units, for example, gallons, inches.)

Quantity Measured: meters flow into line at approx. 2 gpm
Resolution: system not quantitative
Precision: system not quantitative
Accuracy: system not quantitative
Minimum Detectable Quantity: approximately 2 gph
Response Time: less than 30 seconds
Threshold is exceeded when the flow rate due to a leak exceeds 2 gal/h.

Application of the System

17. This leak detection system is intended to test pipeline systems that are associated with underground storage tank facilities, that contain petroleum or other chemical products, that are typically constructed of fiberglass or steel, and that typically measure 2 or 3 in. in diameter and 150 ft or less in length. The performance estimates are valid when:

- the system that was evaluated has not been substantially changed by subsequent modifications
- the manufacturer's instructions for using the system are followed
- the mechanical line leak detector
(X) is present in
( ) has been removed from
the pipeline (check both if appropriate)
- the waiting time between the last delivery of product to the underground storage tank

and the start of data collection for the test is 0 h

- the waiting time between the last dispensing of product through the pipeline system and the start of data collection for the test is 0 h
- the total data collection time for the test is less than 0.5 min
- the volume of the product in the pipeline is less than twice the volume of the product in the pipeline system using in the evaluation, unless separate written justification for testing larger pipeline systems is presented by the manufacturer, concurred with by the evaluator, and attached to this evaluation as Attachment 8
- please give any other limitations specified by the vendor or determined during the evaluation: _____

Disclaimer: This test procedure only addresses the issue of the system's ability to detect leaks in pipelines. It does not test the equipment for safety hazards or assess the operational functionality, reliability or maintainability of the equipment.

Attachments

Attachment 1 - Description of the System Evaluated

Attachment 2 - Summary of the Performance of the System Evaluated

Attachment 3 - Summary of the Configuration of the Pipeline System(s) Used in the Evaluation

Attachment 4 - Data Sheet Summarizing Product Temperature Conditions Used in the Evaluation

Attachment 5 - Data Sheet Summarizing the Test Results and the Leak Rates Used in the Evaluation

Attachment 6 - Data Sheet Summarizing the Test Results and the Trapped Vapor Tests

Attachment 7 - Data Sheet Summarizing the Test Results Used to Check the Relationship Supplied by the Manufacturer for Combining the Signal and Noise

Certification of Results

I certify that the pipeline leak detection system was operated according to the vendor's instructions. I also certify that the evaluation was performed according to the procedure specified by the EPA and that the results presented above are those obtained during the evaluation.

H. Kendall Wilcox, President
(name of person performing evaluation)

H. Kendall Wilcox
(signature)

July 1, 1992
(date)

(816) 229-0860
(telephone number)

Ken Wilcox Associates, Inc.
(organization performing evaluation)

1200 S. Outer Road, Suite 221
(street address)

Blue Springs, Missouri 64015
(city, state, zip)

Attachment 1

Description

Pipeline Leak Detection System

This form provides supporting information on the operating principles of the leak detection system or on how the equipment works. This form is to be filled out by the evaluating organization with assistance from the manufacturer before the start of the evaluation.

Describe the important features of the system as indicated below. A detailed description is not required, nor is it necessary to reveal proprietary features of the system.

To minimize the time required to complete this form, the most frequently expected answers to the questions have been provided. For those answers that are dependent on site conditions, please give answers that apply in "typical" conditions. Please write in any additional information about the system that you believe is important.

Check all appropriate boxes for each question. Check more than one box per question if it applies. If 'Other' is checked, please complete the space provided to specify or briefly describe the matter. If necessary, use all the white space next to a question to complete a description.

System Name and Version: STP-MLD

Date: July 1, 1992

Applicability of the System

1. With what products can this system be used? (Check all applicable responses.)

   (X) gasoline
   (X) diesel
   (X) aviation fuel
   (X) fuel oil #4
   ( ) fuel oil #6
   (X) solvent
   ( ) waste oil
   (X) other (specify) Contact manufacturer for other hydrocarbon applications.

2. What types of pipelines can be tested? (Check all applicable responses.)

   (X) fiberglass
   (X) steel
   (X) other (specify) Contact manufacturer for other applications.

3. Can this leak detection system be used to test double-wall pipeline systems?

   (X) yes ( ) no

4. What is the nominal diameter of a pipeline that can be tested with this system?

(X) 1 in. or less
(X) between 1 and 3 in.
(X) between 3 and 6 in. Contact manufacturer for application to lines greater than 3 in.
( ) between 6 and 10 in.
( ) other _____

5. The system can be used on pipelines pressurized to 50 psi.

The safe maximum operating pressure for this system is 150 psi.

6. Does the system conduct a test while a mechanical line leak detector is in place in the pipeline?

(X) yes ( ) no

General Features of the System

7. What type of test is the system conducting? (Check all applicable responses.)

( ) 0.1 gal/h Line Tightness Test
( ) 0.2 gal/h Monthly Monitoring Test
(X) 3 gal/h Hourly Test

8. Is the system permanently installed on the pipeline?

(X) yes ( ) no

Does the system test the line automatically?

(X) yes ( ) no

If a leak is declared, what does the system do? (Check all applicable responses.)

( ) displays or prints a message
( ) triggers an alarm
( ) alerts the operator
( ) shuts down the dispensing system
(X) other restricts fuel flow to dispenser

9. What quantity or quantities are measured by the system? (Please list.)
3 gal/hr or greater product loss

10. Does the system use a preset threshold that is automatically activated or that automatically turns on an alarm?

(X) yes (If yes, skip question 11.)
( ) no (If no, answer question 11.)

11. Does the system measure and report the quantity?
( ) yes (X) no

If so, is the output quantity converted to flow rate in gallons per hour?

( ) yes ( ) no

12. What is the specified line pressure during a test?

(X) operating pressure of line
( ) 150% of operating pressure
( ) a specific test pressure of _____ psi

Test Protocol

13. What is the minimum waiting period required between a delivery of product to an underground storage tank and the start of the data collection for a pipeline leak detection test?

(X) no waiting period
( ) less than 15 min
( ) 15 min to 1 h
( ) 1 to 5 h
( ) 6 to 12 h
( ) 12 to 24 h
( ) greater than 24 h
( ) variable (Briefly explain.) _____

14. What is the minimum waiting period required between the last dispensing of product through the pipeline and the start of the data collection for a pipeline leak detection test?

(X) no waiting period
( ) less than 15 min
( ) 15 min to 1 h
( ) 1 to 4 h
( ) 4 to 8 h
( ) greater than 8 h
( ) variable (Briefly explain.) _____

15. What is the minimum amount of time necessary to set up equipment and complete a leak detection test? (Include setup time, waiting time and data collection time. If a multiple-test sequence is used, give the amount of time necessary to complete the first test as well as the total amount of time necessary to complete the entire sequence.)

<30 sec (single test) STP-MLD is permanently installed in the system
_____ h (multiple test)

16. Does the system compensate for those pressure or volume changes of the product in the pipeline that are due to temperature changes?

(X) yes (up to 3 cu in) ( ) no

17. Is there a special test to check the pipeline for trapped vapor?

( ) yes (X) no

18. Can a test be performed with trapped vapor in the pipeline?

(X) yes ( ) no

19. If trapped vapor is found in the pipeline, is it removed before a test is performed?

(X) yes ( ) no

20. Are deviations from this protocol acceptable?

( ) yes (X) no

If yes, briefly specify: _____

21. Are elements of the test procedure determined by on-site personnel?

( ) yes (X) no

If yes, which ones? (Check all applicable responses.)

( ) waiting period between filling the tank and the beginning of data collection for the test
( ) length of test
( ) determination of the presence of vapor pockets
( ) determination of "outlier" (or anomalous) data that may be discarded
( ) other (Describe briefly.) _____

Data Acquisition

22. How are the test data acquired and recorded?

( ) manually
( ) by strip chart N/A
( ) by computer
( ) by microprocessor

23. Certain calculations are necessary to reduce and analyze the data. How are these calculations done?

( ) manual calculations by the operator on site
( ) interactive computer program used by the operator N/A
( ) automatically done with a computer program
( ) automatically done with a microprocessor

Detection Criterion

24. What threshold is used to determine whether the pipeline is leaking?

gal/h (in the units used by the measurement system)
2 gal/h (in gal/h)

25. Is a multiple-test sequence used to determine whether the pipeline is leaking?

( ) yes (If yes, answer the three questions below)
(X) no (If no, skip the three questions below)

How many tests are conducted? _____
How many tests are required before a leak can be declared? _____
What is the time between tests? _____
(Enter 0 if the tests are conducted one after the other.)

Calibration

26. How frequently are the sensor systems calibrated?

( ) never
( ) before each test
( ) weekly
( ) monthly
( ) semi-annually
(X) yearly or less frequently

Attachment 2

Summary of Performance Estimates

Pipeline Leak Detection System
Used as an
Hourly Monitoring Test

Complete this page if the pipeline leak detection system has been evaluated as an hourly test. Please complete the first table. Completion of the last three tables is optional. (The last three tables present the performance of the system for different combinations of thresholds, probabilities of false alarm, and probabilities of detection. They are useful for comparing the performance of this system to that of other systems.)

Performance of the Pipeline Leak Detection System as Evaluated

Description	Leak Rate (gal/h)	P_D	P_{FA}	Threshold (gal/h)
Evaluated System	3	100	0	2
EPA Standard	3	0.95	0.05	N/A

Probability of False Alarm as a Function of Threshold

Threshold (gal/h)	Probability of False Alarm
Not determined	0.10
	0.075
	0.05
	0.05

Probability of Detection as a Function of Threshold for a Leak Rate of 3.0 gal/h

Threshold (gal/h)	Probability of Detection
Not determined	0.95
	0.90
	0.80
	0.50

Smallest Leak Rate that Can be Detected with the Specified Probability of Detection and Probability of False Alarm

Leak Rate (gal/h)	Probability of Detection	Probability of False Alarm
Not determined	0.95	0.10
	0.95	0.075
	0.95	0.05
	0.90	0.05
	0.80	0.05
	0.50	0.05

Attachment 3

Summary of the Configuration of the Pipeline System(s) Used in the Evaluation

Pipeline Leak Detection System
Options 1, 2, and 5

Specialized Test Facility, Operational Storage Tank System, or Computer Simulation	
Inside diameter of pipeline (in.)	3 in
Length of pipeline (tank to dispenser) (ft)	176 ft
Volume of product in line during testing (gal)	64.57 gal
Type of material (fiberglass, steel, other[1])	fiberglass
Type of product in tank and pipeline (gasoline, diesel, other[2])	gasoline
Was a mechanical line leak detector present? (yes or no)	yes
Was trapped vapor present? (yes or no)	in 3 of 55 tests
Bulk Modulus (B) (psi)	33,087
B/V_o (psi/ml)	-0.295
Storage tank capacity (gal)	560 gal

[1]Specify type of construction material.
[2]Specify type of product for each tank.

Attachment 4
Data Sheet Summarizing the Product Temperature Conditions Used in the Evaluation
Pipeline Leak Detection System
Options 1 and 5

Test No. (Based on Temperature Condition)	Date Test Began (D-M-Y)	Nominal Product Temperature Before Circulation Was Started (deg F)	Time Circulation Started (military)	Time Circulation Ended (deg F)	Duration of Circulation (h-min)	Time of Temperature Measurements (military)	Tlb (deg F)	T1 (deg F)	T2 (deg F)	T3 (deg F)	Tg (deg F)	Tlb-Tg (deg F)	Temperature Matrix Category (Table 5)
1	1-6-92	37.98	1224	1324	1 hr	1224	37.98	60.52	61.39	64.10	63.10	-25.12	<-25
2	1-6-92	37.98	1224	1324	1hr	1224	37.98	60.52	61.39	64.10	63.10	-25.12	<-25
3	1-6-92	37.98	1224	1324	1hr	1224	37.98	60.52	61.39	64.10	63.10	-25.12	<-25
4	2-6-92	69.33	0802	0913	1hr&11min	0802	69.33	63.48	63.43	64.25	63.98	5.35	+5 to +15
5	2-6-92	69.33	0802	0913	1hr&11min	0802	69.33	63.48	63.43	64.25	63.98	5.35	+5 to +15
6	2-6-92	69.33	0802	0913	1hr&11min	0802	69.33	63.48	63.43	64.25	63.98	5.35	+5 to +15
7	2-6-92	73.49	0945	1045	1hr	0945	73.49	64.25	63.80	64.30	64.19	9.30	+5 to +15
8	2-6-92	73.49	0945	1045	1hr	0945	73.49	64.25	63.80	64.30	64.19	9.30	+5 to +15
9	2-6-92	73.49	0945	1045	1hr	0945	73.49	64.25	63.80	64.30	64.19	9.30	+5 to +15
10	2-6-92	90.76	1236	1336	1hr	1236	90.76	65.39	64.49	64.44	64.56	26.20	>+25
11	2-6-92	90.76	1236	1336	1hr	1236	90.76	65.39	64.49	64.44	64.56	26.20	>+25
12	2-6-92	90.76	1236	1336	1hr	1236	90.76	65.39	64.49	64.44	64.56	26.20	>+25
13	2-6-92	85.95	1343	1446	1hr&3min	1343	85.95	66.82	65.32	64.46	64.91	21.04	+15 to +25
14	2-6-92	85.95	1343	1446	1hr&3min	1343	85.95	66.82	65.32	64.46	64.91	21.04	15 to +25
15	2-6-92	85.95	1343	1446	1hr&3min	1343	85.95	66.82	65.32	64.46	64.91	21.04	+15 to +25
16	2-6-92	88.27	1451	1551	1hr	1451	88.27	67.69	66.05	64.50	65.20	23.07	+15 to +25
17	2-6-92	88.27	1451	1551	1hr	1451	88.27	67.69	66.05	64.50	65.20	23.07	+15 to +25
18	2-6-92	88.27	1451	1551	1hr	1451	88.27	67.69	66.05	64.50	65.20	23.07	+15 to +25
19	2-6-92	85.54	1925	2025	1hr	1925	85.54	67.57	66.79	64.92	65.63	19.91	+15 to +25
20	2-6-92	85.54	1925	2025	1hr	1925	85.54	67.57	66.79	64.92	65.63	19.91	+15 to +25
21	3-6-92	74.04	0754	0854	1hr	0754	74.04	65.58	65.42	65.41	65.43	8.61	+5 to +15
22	3-6-92	74.04	0754	0854	1hr	0754	74.04	65.58	65.42	65.41	65.43	8.61	+5 to +15
23	3-6-92	79.04	1005	1105	1hr	1105	79.04	66.05	65.61	65.40	65.52	13.52	+5 to +15
24	3-6-92	79.04	1005	1105	1hr	1105	79.04	66.05	65.61	65.40	65.52	13.52	+5 to +15
25	3-6-92	70.30	1133	1233	1hr	1133	70.30	66.93	66.02	65.42	65.72	4.58	-5 to +5
26	3-6-92	70.30	1133	1233	1hr	1133	70.30	66.93	66.02	65.42	65.72	4.58	-5 to +5
27	3-6-92	70.30	1133	1233	1hr	1133	70.30	66.93	66.02	65.42	65.72	4.58	-5 to +5
28	3-6-92	66.69	1247	1347	1hr	1247	66.69	66.58	66.09	65.40	65.68	1.01	-5 to +5
29	3-6-92	66.69	1247	1347	1hr	1247	66.69	66.58	66.09	65.40	65.68	1.01	-5 to +5
30	5-6-92	64.07	1124	1224	1hr	1124	64.07	65.18	65.06	65.53	65.39	-1.32	-5 to +5

Attachment 4 (continued)
Data Sheet Summarizing the Product Temperature Conditions Used in the Evaluation
Pipeline Leak Detection System
Options 1 and 5

Test No. (Based on Temperature Condition)	Date Test Began (D-M-Y)	Nominal Product Temperature Before Circulation Was Started (deg F)	Time Circulation Started (military)	Time Circulation Ended (deg F)	Duration of Circulation (h-min)	Time of Temperature Measurements (military)	Ttb (deg F)	T1 (deg F)	T2 (deg F)	T3 (deg F)	Tg (deg F)	Ttb-Tg (deg F)	Temperature Matrix Category (Table 5)
31	5-6-92	64.07	1124	1224	1hr	1124	64.07	65.18	65.06	65.53	65.39	-1.32	-5 to +5
32	5-6-92	64.07	1124	1224	1hr	1124	64.07	65.18	65.06	65.53	65.39	-1.32	-5 to +5
33	5-6-92	61.53	1246	1346	1hr	1246	61.53	64.58	64.77	65.53	65.26	-3.73	-5 to +5
34	5-6-92	61.53	1246	1346	1hr	1246	61.53	64.58	64.77	65.53	65.26	-3.73	-5 to +5
35	8-6-92	59.92	1317	1418	1hr&1min	1317	59.92	65.27	65.18	65.49	65.40	-5.48	-5 to -15
36	8-6-92	59.92	1317	1418	1hr&1min	1317	59.92	65.27	65.18	65.49	65.40	-5.48	-5 to -15
37	8-6-92	59.92	1317	1418	1hr&1min	1317	59.92	65.27	65.18	65.49	65.40	-5.48	-5 to -15
38	8-6-92	56.92	1426	1534	1hr&8min	1426	56.92	64.57	64.95	65.56	65.32	-8.40	-5 to -15
39	8-6-92	56.92	1426	1534	1hr&8min	1426	56.92	64.57	64.95	65.56	65.32	-8.40	-5 to -15
40	8-6-92	56.92	1426	1534	1hr&8min	1426	56.92	64.57	64.95	65.56	65.32	-8.40	-5 to -15
41	8-6-92	54.26	1635	1735	1hr	1635	54.26	63.89	64.36	65.44	65.03	-10.77	-5 to -15
42	8-6-92	54.26	1635	1735	1hr	1635	54.26	63.89	64.36	65.44	65.03	-10.77	-5 to -15
43	9-6-92	42.33	1322	1422	1hr	1322	42.33	65.13	65.06	65.71	65.50	-23.17	-15 to -25
44	9-6-92	42.33	1322	1422	1hr	1322	42.33	65.13	65.06	65.71	65.50	-23.17	-15 to -25
45	9-6-92	42.33	1322	1422	1hr	1322	42.33	65.13	65.06	65.71	65.50	-23.17	-15 to -25
46	9-6-92	44.97	1430	1530	1hr	1430	44.97	63.73	64.58	65.70	65.23	-20.26	-15 to -25
47	9-6-92	44.97	1430	1530	1hr	1430	44.97	63.73	64.58	65.70	65.23	-20.26	-15 to -25
48	9-6-92	44.97	1430	1530	1hr	1430	44.97	63.73	64.58	65.70	65.23	-20.26	-15 to -25
49	9-6-92	47.85	1634	1734	1hr	1634	47.85	62.20	63.25	65.74	64.80	-16.95	-15 to -25
50	9-6-92	47.85	1634	1734	1hr	1634	47.85	62.20	63.25	65.74	64.80	-16.95	-15 to -25
51	9-6-92	50.49	1745	1845	1hr	1745	50.49	61.93	62.96	65.68	64.66	-14.17	-5 to -15
52	9-6-92	50.49	1745	1845	1hr	1745	50.49	61.93	62.96	65.68	64.66	-14.17	-5 to -15

Attachment 5

Data Sheet Summarizing the Test Results and the Leak Rates Used in the Eval
Options 1 and 5

Test No. (Based on Temperature Condition)	Date Test Began (D-M-Y)	Induced Leak Rate (gal/hr)	Time between End of Circulation and Start of Data Collection for Test (h-min)	Time Data Collection Began (military)	Time Data Collection Ended (military)	Test Result (leak or tight)	Was Threshold Exceeded? (yes or no)
1	1-6-92	2.95	6 min	1330	1331	leak	yes
2	1-6-92	0	8 min	1332	1333	tight	no
3	1-6-92	2.95	10 min	1334	1335	leak	yes
4	2-6-92	2.95	1 min	0914	0915	leak	yes
5	2-6-92	0	3 min	0916	0917	tight	no
6	2-6-92	2.95	5 min	0918	0919	leak	yes
7	2-6-92	0	1 min	1046	1047	tight	no
8	2-6-92	2.95	2 min	1047	1048	leak	yes
9	2-6-92	0	4 min	1049	1050	tight	no
10	2-6-92	0	2 min	1338	1339	tight	no
11	2-6-92	2.95	3 min	1339	1340	leak	yes
12	2-6-92	0	5 min	1341	1342	tight	no
13	2-6-92	0	1 min	1447	1448	tight	no
14	2-6-92	2.95	2 min	1448	1449	leak	yes
15	2-6-92	0	4 min	1450	1451	tight	no
16	2-6-92	2.95	1 min	1552	1553	leak	yes
17	2-6-92	0	2 min	1554	1555	tight	no
18	2-6-92	2.95	3 min	1556	1557	leak	yes
19	2-6-92	0	2 min	2027	2028	tight	no
20	2-6-92	2.95	4 min	2029	2030	leak	yes
21	3-6-92	2.95	1 min	0855	0856	leak	yes
22	3-6-92	0	5 min	0859	0900	tight	no
23	3-6-92	0	1 min	1106	1107	tight	no
24	3-6-92	2.95	2 min	1107	1108	leak	yes
25	3-6-92	0	1 min	1234	1235	tight	no
26	3-6-92	2.95	2 min	1235	1236	leak	yes
27	3-6-92	0	4 min	1237	1238	tight	no
28	3-6-92	0	1 min	1348	1349	tight	no
29	3-6-92	2.95	2 min	1349	1350	leak	yes
30	5-6-92	2.95	1 min	1225	1226	leak	yes
31	5-6-92	0	3 min	1227	1228	tight	no
32	5-6-92	2.95	4 min	1228	1229	leak	yes
33	5-6-92	2.95	1 min	1347	1348	leak	yes
34	5-6-92	0	3 min	1349	1450	tight	no
35	8-6-92	2.95	1 min	1419	1420	leak	yes
36	8-6-92	0	3 min	1421	1422	tight	no
37	8-6-92	2.95	4 min	1422	1423	leak	yes
38	8-6-92	0	1 min	1535	1536	tight	no
39	8-6-92	2.95	2 min	1536	1537	leak	yes
40	8-6-92	0	4 min	1538	1539	tight	no
41	8-6-92	2.95	1 min	1736	1737	leak	yes
42	8-6-92	0	3 min	1738	1739	tight	no
43	9-6-92	0	1 min	1423	1424	tight	no
44	9-6-92	2.95	2 min	1424	1425	leak	yes
45	9-6-92	0	4 min	1426	1427	tight	no
46	9-6-92	2.95	1 min	1531	1532	leak	yes
47	9-6-92	0	3 min	1533	1534	tight	no
48	9-6-92	2.95	4 min	1534	1535	leak	yes
49	9-6-92	0	1 min	1735	1736	tight	no
50	9-6-92	2.95	2 min	1736	1737	leak	yes
51	9-6-92	0	1 min	1846	1847	tight	no
52	9-6-92	2.95	2 min	1847	1848	leak	yes

Attachment 6
Data Sheet Summarizing the Test Results and the Trapped Vapor Tests
Pipeline Leak Detection system
Options 1 and 5

Summary of Temperature Conditions

Nominal Product Temperature Before Circulation Was Started	Time Circulation Started	Time Circulation Ended	Duration of Circulation	Time of Temperature Measurements	Ttb	T1	T2	T3	Tg	Ttb-Tg	Temperature Test Matrix Category
(deg F)	(military)	(deg F)	(h-min)	(military)	(deg F)	(deg F)	(deg F)	(deg F)	(deg F)	(deg F)	(Table 5)
57.05	0935	1035	1hr	0935	57.05	65.94	65.94	65.97	65.96	-8.91	-5 to-15
57.05	0935	1035	1hr	0935	57.05	65.94	65.94	65.97	65.96	-8.91	-5 to -15
63.59	1117	1217	1hr	1117	63.59	65.11	65.33	65.74	65.74	-2.15	-5 to +5

Summary of Leak Rates

Test No.	Date Test Began	Pipeline Pressure	Induced Leak Rate	Time between End of circulation and Start of Data Collection for Test	Time Data Collection Began	Time Data Collection Ended	Measured Test Result	Was Threshold Exceeded?
	(D-M-Y)	(psi)	(gal/h)	(h-min)	(military)	(military)	(gal/h)	(yes or no)
1	10-6-92	28	0	1 min	1036	136:20	tight	no
2	10-6-92	28	3.25	5 min	1039	1040	leak	yes
3	10-6-92	28	2.75	1 min	1218	1219	leak	yes

Attachment 7

Data Sheet Summarizing the Test Results Used to Check the Relationship Supplied by the Manufacturer for Combining the Signal and Noise

Pipeline Leak Detection System
Options 1 and 5

NOT APPLICABLE TO THIS EVALUATION

First Check		
Test No.	Actual Leak Rate* (gal/h)	Measured Leak Rate (gal/h)
1		
2		
3		
4		
5		
6		

* Recommended leak rates for monthly monitoring tests and line tightness tests: 0.0, 0.05, 0.10, 0.20, 0.30 and 0.40 gal/h. Recommended leak rates for hourly tests: 0.0, 2.0, 2.5, 3.0, 3.5, and 4.0 gal/h.

Second Check		
Test No.	Actual Leak Rate* (gal/h)	Measured Leak Rate (gal/h)
A		
B		
C		
A + B*		

* A + B is the summation of the results of Tests A and B using the manufacturer's relationship for combining the signal and the noise.