



# Evaluation of the Vaporless Manufacturing LD 3000 and LD 3000S Mechanical Line Leak Detector on Large Rigid and Flexible Pipelines

(Addendum to the August 20, 1993  
Evaluation of the Vaporless LD 3000  
and LD 3000S Line Leak Detectors)

**Final Report**

PREPARED FOR  
**Vaporless Manufacturing, Inc**

**April 17, 2006**



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# **Evaluation of the Vaporless Manufacturing LD 3000 AND LD 3000S Mechanical Line Leak Detector On Large Rigid and Flexible Pipelines**

**(Addendum to the August 20, 1993  
Performance Evaluation of the Vaporless  
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## **Final Report**

**PREPARED FOR**  
**Vaporless Manufacturing, Inc**  
**8700 E. Long Mesa Drive**  
**Prescott Valley, AZ 86314**

**April 17, 2006**

## Preface

This report contains the testing, data, and results of an independent performance evaluation of the Vaporless LD 3000 and LD 3000S mechanical line leak detectors on large piping, both rigid and flexible, and a combination of the two. This report is an addendum to the August 20, 1993 evaluation of the Vaporless LD 3000 and LD3000S which was conducted on large rigid lines.

The purpose of the current testing was to demonstrate that the LD 3000 and LD3000S detectors meet performance guidelines when used on large rigid and flexible piping having volumes larger than previously tested. Testing for this evaluation was performed in accordance with the Federal EPA's "Standard Test Procedures for Evaluating Leak Detection Methods: Pipeline Leak Detection Systems," EPA/530/UST-90/010, September 1990, with the exception of the number of tests performed.

The work was conducted at the Fuels Management Research Center, Grain Valley, Missouri, operated by Ken Wilcox Associates, Inc. The laboratory testing was conducted by Craig Wilcox and this report was prepared by Wayne Hill in association with KWA.

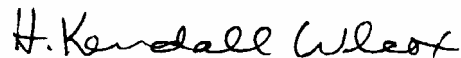
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## 1.0 Introduction

The Vaporless LD 3000 mechanical leak detector is designed for hourly monitoring of large-capacity, high through-put pumps and lines. The LD 3000S is identical to the LD 3000 with the exception of a electrical switch added to provided external control signals.

The LD 3000 and LD 3000S were previously evaluated and reported on in 1993 using 350' of Ameron fiberglass pipe containing 158 gallons of product. The evaluation was conducted using the Federal EPA's "Standard Test Procedures for Evaluating Leak Detection Methods: Pipeline Leak Detection Systems," EPA/530/UST-90/01 0, September 1990. The evaluation results were published in the report "Evaluation of the Vaporless LD 3000 and LD 3000S Line Leak Detector for Hourly Monitoring", August 20, 1993. This report and the EPA Protocol should be referred to for full details of the 1993 evaluation.

Since that evaluation was performed, larger volume rigid and flexible pipelines are available for use in new construction and site upgrades. These larger pipelines can exceed the maximum 316 gallons pipeline volume allowed for the LD 3000/3000S in the 1993 evaluation.

This new evaluation was performed on larger diameter rigid and flexible lines with increased volumes. Three types of pipe line configurations were used: rigid pipe only, flexible pipe only and rigid/flexible pipe combined. The testing procedures satisfy all of the requirements for a full EPA evaluation with the exception that only 6 tests were run per pipeline configuration rather than the minimum 50 tests called for by the Standard Test Procedures.

## 2.0 Description of the Testing Location & Equipment

The Vaporless Manufacturing LD 3000/LD 3000S was evaluated at the Fuels Management Research Center located in Grain Valley, Missouri, which is operated by Ken Wilcox Associates, Inc. Three different pipeline configurations were tested during the evaluation.

The evaluation system consisted of:

- A 600 gallon steel product tank containing gasoline that was kept at predetermined temperature by an external heat exchanger.
- A 1½ HP submersible turbine pump (STP), controlled by a dispenser switch and used to circulate the gasoline through the piping system and to house the Vaporless LD 3000 leak detector.
- A 30' long X 3⅛" diameter FRP rigid pipe that led from the pump to the junction of two branches of large diameter pipes used for the evaluation. One branch was a 200' long X 4" diameter FRP rigid pipe connected by a 150' long X 3⅛" diameter FRP rigid pipe back to the product tank. The other branch was a 130' long X 3" diameter flexible pipe that ran back to the product tank. Both branches of piping had valves at the pump end and dispensing end, allowing them to be isolated from each other or ran simultaneously.
- Thermocouples were used to measure gasoline temperature. The fuel temperature in the tank was obtained from the tank gauge that was permanently installed in the tank. Three thermocouples were used to measure soil temperature at 2", 4", and 12" from the piping per the EPA protocol. The product tank temperature and weighted soil temperature were used to compute the temperature differential.

A length and volume summary of the piping configurations is provided in Table 1.

**Table 1. Description of Pipelines Used in This Evaluation**

Line Description	Length-ft (Volume-gal) of Each Pipe Segment				Bulk Modulus (psi)
	3.125" dia FRP	4" dia FRP	3" dia Flex	Total Gal.	
Flex Line Evaluation	30 (12)*	0	130 (48)	48*	8,360
Rigid Line Evaluation	180 (72)	200 (131)	0	203	34,458
Combined Flex & Rigid Evaluation	180 (72)	200 (131)	130 (48)	251	na

\*The National Workgroup does not allow volume of rigid line to be included in flex line volume for purposes of calculating maximum applicable line size.

**3.0 Overview of Evaluation Procedures**

The Vaporless LD 3000 was installed in the pipeline system described above. The STP delivered the gasoline through the LD 3000 to the pipeline configurations that were used in this evaluation. The fuel passed through both rigid and flexible segments of the line simultaneously. The temperature of the product in the pipeline system tank was varied relative to the surrounding soil temperature to obtain one of the temperature differentials shown in Table 3. The conditioned product was circulated through the line for one hour. Leaks were induced as specified in the EPA protocol. The induced leaks were established during the circulation period either by adjusting the flow of fuel through a flow meter set to 3.0 gal/h at a pressure of 10 psig or as a non-leak condition.

At the end of the circulation period, a pre-determined piping segment was valved off, product flow was blocked at the dispenser end of the line, the STP was turned off, the line pressure was dropped to zero, the STP was turned back on and the zero leak or 3 gal/hr leak test was conducted automatically by the LD 3000. Testing continued until an alarm occurred or the LD 3000 indicated a pass condition had occurred. The second segment, or combined segments, was then valved off and testing repeated.

This evaluation consisted of one 3 gal/hr leak test and one tight test conducted at each of the temperature differential extremes indicated in Table 2. Thus, a total of 6 tests were conducted on each of the three pipeline configurations for a total of 18 tests, rather than the 50 tests prescribed by the EPA protocol.

The test results reported by the Vaporless LD 3000 leak detector were recorded and compared to the leak conditions that were introduced into the line for the temperature condition. The results are tabulated in Tables 3-5.

**Table 2. Summary of Test Conditions Used in Each Pipeline Evaluation**

Range of $\Delta T^*$ (°F)	Number of Leak Tests	Leaks Induced
$\Delta T < -25$	2	1 tight + 1@3gal/hr
$-5 \leq \Delta T < +5$	2	1 tight + 1@3gal/hr
$\Delta T > 25$	2	1 tight + 1@3gal/hr

Total = 6 Tests per Evaluation

\*  $\Delta T$  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.

Since the test times were less than 15 minutes, the protocol allows for conducting 3 tests for each circulation. In this case the test times were less than one minute so that 3 tests could be conducted on each line for each circulation. The entire process of conducting the six tests was usually less than 10 minutes.

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### 4.0 Test Results and Discussion

**Table 3. Evaluation of the Vaporless LD 3000, Tested on Large Rigid Pipelines-  
3.0 gal/hr Leak Tests, Pipe Line Leak Detection System, Options 1 & 5**  
Data Summarizing the Product Temperature Conditions Used in the Evaluation

Test No.	Date Test Began	Nominal Product Temperature Before Circulation Was Started	Time Circulation Started	Time Circulation Ended	Duration of Circulation	Time of Temperature Measurements	T(TB)	T(1)	T(2)	T(3)	T(G)	T(TB)-T(G)	Temperature Test Matrix Category
	(D-M-Y)	(deg F)	(local military)	(local military)	(h-min)	(local military)	(deg F)	(deg F)	(deg F)	(deg F)	(deg F)	(deg F)	(Table 5.1)
1	23-Sep-05	94.6	14:35	15:35	1:00	14:35	94.6	67.9	68.2	68.3	68.3	26.3	>+25
2	23-Sep-05	94.6	14:35	15:35	1:00	14:35	94.6	67.9	68.2	68.3	68.3	26.3	>+25
3	26-Sep-05	42	12:08	13:08	1:00	12:08	42	68.4	68.3	68.3	68.3	-26.3	<-25
4	26-Sep-05	42	12:08	13:08	1:00	12:08	42	68.4	68.3	68.3	68.3	-26.3	<-25
5	26-Sep-05	67.5	14:00	15:00	1:00	14:00	67.5	64.2	67.4	68.1	67.5	0	-5 to +5
6	26-Sep-05	67.5	14:00	15:00	1:00	14:00	67.5	64.2	67.4	68.1	67.5	0	-5 to +5

Data Summarizing the Test Results and the Leak Rates Used in the Evaluation

Test No. (Based on Temperature Condition)	Date Test Began	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)	(gal/h)	(h-min)	(local military)	(local military)	(leak or tight)	(yes or no)
1	23-Sep-05	0.0	9	15:44	15:44	0.0	no
2	23-Sep-05	3.0	10	15:45	15:46	3.0	yes
3	26-Sep-05	0.0	0	13:08	13:08	0.0	no
4	26-Sep-05	3.0	1	13:09	13:10	3.0	yes
5	26-Sep-05	0.0	4	15:04	15:04	0.0	no
6	26-Sep-05	3.0	4	15:04	15:05	3.0	yes



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**Table 4. Evaluation of the Vaporless LD 3000, Tested on Large Flexible Pipelines- 3.0 gal/hr Leak Tests, Pipe Line Leak Detection System, Options 1 & 5**

Data Summarizing the Product Temperature Conditions Used in the Evaluation

Test No.	Date Test Began	Nominal Product Temperature Before Circulation Was Started	Time Circulation Started	Time Circulation Ended	Duration of Circulation	Time of Temperature Measurements	T(TB)	T(1)	T(2)	T(3)	T(G)	T(TB)-T(G)	Temperature Test Matrix Category
	(D-M-Y)	(deg F)	(local military)	(local military)	(h-min)	(local military)	(deg F)	(deg F)	(deg F)	(deg F)	(deg F)	(deg F)	(Table 5.1)
1	23-Sep-05	94.6	14:35	15:35	1:00	14:35	94.6	67.9	68.2	68.3	68.3	26.3	>+25
2	23-Sep-05	94.6	14:35	15:35	1:00	14:35	94.6	67.9	68.2	68.3	68.3	26.3	>+25
3	26-Sep-05	42	12:08	13:08	1:00	12:08	42	68.4	68.3	68.3	68.3	-26.3	<-25
4	26-Sep-05	42	12:08	13:08	1:00	12:08	42	68.4	68.3	68.3	68.3	-26.3	<-25
5	26-Sep-05	67.5	14:00	15:00	1:00	14:00	67.5	64.2	67.4	68.1	67.5	0	-5 to +5
6	26-Sep-05	67.5	14:00	15:00	1:00	14:00	67.5	64.2	67.4	68.1	67.5	0	-5 to +5

Data Summarizing the Test Results and the Leak Rates Used in the Evaluation

Test No. (Based on Temperature Condition)	Date Test Began	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)	(gal/h)	(h-min)	(local military)	(local military)	(leak or tight)	(yes or no)
1	23-Sep-05	0.0	5	15:40	15:40	0.0	no
2	23-Sep-05	3.0	6	15:41	15:42	3.0	yes
3	26-Sep-05	0.0	4	13:12	13:12	0.0	no
4	26-Sep-05	3.0	4	13:12	13:13	3.0	yes
5	26-Sep-05	0.0	0	15:00	15:00	0.0	no
6	26-Sep-05	3.0	1	15:01	15:02	3.0	yes

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**Table 5. Evaluation of the Vaporless LD 3000, Tested on Large Rigid & Flexible Combined Pipelines- 3.0 gal/hr Leak Tests, Pipe Line Leak Detection System, Options 1 & 5**

Data Summarizing the Product Temperature Conditions Used in the Evaluation

Test No.	Date Test Began	Nominal Product Temperature Before Circulation Was Started	Time Circulation Started	Time Circulation Ended	Duration of Circulation	Time of Temperature Measurements	T(TB)	T(1)	T(2)	T(3)	T(G)	T(TB)-T(G)	Temperature Test Matrix Category
	(D-M-Y)	(deg F)	(local military)	(local military)	(h-min)	(local military)	(deg F)	(deg F)	(deg F)	(deg F)	(deg F)	(deg F)	(Table 5.1)
1	22-Sep-05	68.3	10:20	11:20	1:00	10:20	68.3	68.4	68.4	68.4	68.4	-0.1	-5 to +5
2	22-Sep-05	68.3	10:20	11:20	1:00	10:20	68.3	68.4	68.4	68.4	68.4	-0.1	-5 to +5
3	22-Sep-05	42.5	15:30	16:30	1:00	15:30	42.5	68.4	68.4	68.4	68.4	-25.9	-5 to +5
4	22-Sep-05	42.5	15:30	16:30	1:00	15:30	42.5	68.4	68.4	68.4	68.4	-25.9	-5 to +5
5	23-Sep-05	94.6	14:35	15:35	1:00	14:35	94.6	67.9	68.2	68.3	68.3	26.3	-5 to +5
6	23-Sep-05	94.6	14:35	15:35	1:00	14:35	94.6	67.9	68.2	68.3	68.3	26.3	-5 to +5

Data Summarizing the Test Results and the Leak Rates Used in the Evaluation

Test No. (Based on Temperature Condition)	Date Test Began	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)	(gal/h)	(h-min)	(local military)	(local military)	(leak or tight)	(yes or no)
1	22-Sep-05	0.0	0	11:20	11:20	0.0	no
2	22-Sep-05	3.0	1	11:21	11:22	3.0	yes
3	22-Sep-05	0.0	0	16:30	16:30	0.0	no
4	22-Sep-05	3.0	1	16:31	16:32	3.0	yes
5	23-Sep-05	3.0	0	15:35	15:36	3.0	yes
6	23-Sep-05	0.0	1	15:36	15:36	0.0	no

**Accuracy of Detection**

The Vaporless LD 3000 AND LD3000S leak detector was correct in its determination of a leak for all 9 of the 3gal/h leak tests under different temperature conditions.

**Accuracy of False Alarm**

The LD 3000 AND LD3000S was correct in its determination of a tight pipeline for all 9 of the tight tests under different temperature conditions.

**Maximum Pipeline Size, Flexible Pipe**

The EPA allows for line leak detectors to be used on flexible pipelines containing up to 200% of the pipeline volume that they were evaluated on. However, the volume of any rigid line that is connected to the flexible line branch cannot be included in the test pipeline's volume. The LD 3000 was evaluated on a flexible pipeline that was 130 feet in length by 3-inches in diameter plus rigid pipe that was 30-feet in length by 3.125-inches in diameter. While the total volume of the line as tested was 60 gallons, only the volume of the flex line, 48 gallons, by itself can be included in the calculations for the maximum line size. Applying the EPA protocol limitations to the LD 3000 and LD 3000S leak detectors, the results of this evaluation would apply to flexible pipelines having a maximum volume of 96 gallons.

**Maximum Line Size, Rigid Pipe**

The EPA allows for line leak detectors to be used on rigid pipelines containing up to twice the volume that they were evaluated on. During this testing, the Vaporless LD 3000 was evaluated on a FRP line consisting of a total of 180 ft of 3.125 inch diameter FRP and 200 ft of 4 inch diameter FRP with a combined volume of 202 gallons. Applying the EPA protocol value of 200% of the test pipeline size, the LD 3000 AND LD3000S can be used on pipelines up to 404 gallons.

**Maximum Pipeline Size, Combined Rigid and Flexible Pipe**

As discussed above, the EPA protocol does not allow the volume of rigid piping used in a flexible piping branch to be used in the maximum pipeline volume calculation. In this evaluation using one branch of flexible piping and one branch of rigid piping, combining the individual limitations of 96 and 404 gallons respectively gives a 500 gallons maximum volume for piping systems combined.

**Time to Conduct a Test**

All of the tests were completed in less than one minute.

**Waiting Times**

Waiting times after the delivery of product, after product is circulated through the line or after pumping has stopped are not necessary before valid tests can be conducted. All of the tests were conducted immediately after product circulation through the pipeline was stopped.

**Table 8. Performance Parameters for the Vaporless Manufacturing LD 3000 AND LD3000S Leak Detector for Large Rigid, Flexible, and Combined Pipeline Tests Using the EPA Protocol**

Parameter	Rigid Pipeline	Flex Pipeline	Combined Rigid/Flex
Detections of a 3 gal/hr leak	100% (3 of 3)	100% (3 of 3)	100% (3 of 3)
False Alarms, 0.0 gal/hr leak	0% (0 of 3)	0% (0 of 3)	0% (0 of 3)
Maximum Line Volume	404 gallons	96 gallons*	500 gallons
Waiting Time After Delivery of Product Before Conduction a Test	None		
Waiting Time After Product Circulation Through Line Before Conducting a Test	None		
Hourly Test Times with 3.0 gal/hr Leak	Range: 0 to 1 Minutes		
Hourly Test Times without a Leak	Range: 0 to 1 Minutes		

\* Volume of flexible section of line only

### **5.0 Conclusions**

The Vaporless Manufacturing LD 3000 AND LD3000S detected 3 gal/hr leaks with 100% accuracy and 0 false alarms during an abbreviated test on large rigid and flexible lines per the EPA protocol. This is a continuation of the accuracy of the LD 3000 AND LD3000S found in the original full evaluation on smaller lines.