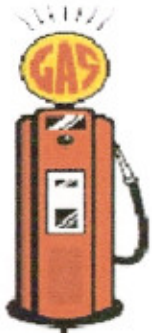

Evaluation of the Greenleaf Gauge Interstitial Monitor

Final Report

PREPARED FOR:

Greenleaf Gauge

August 12, 2008

Ken Wilcox Associates, Inc.
1125 Valley Ridge Drive, Grain Valley, MO 64029, USA
Voice (816) 443-2494, Fax (816) 443-2495
E-mail kwilcox@kwaleak.com, Web http://www.kwaleak.com

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Final Report

PREPARED FOR:

Greenleaf Gauge
P.O. Box 309
20675 Friends Road
Greenleaf, Idaho 83626

August 12, 2008

Preface

This report presents the results of an independent third-party evaluation of the Interstitial monitor manufactured by Greeenleaf Gauge. The evaluation included measuring the performance of external float switches used for interstitial monitoring and other applications.

The evaluation was conducted by Ken Wilcox Associates, Inc. using procedures described in the standard protocol "Alternative Test Procedures for Evaluating Leak Detection Methods: Evaluation of Liquid Level Sensors", September 1996. The official results of this evaluation are contained in Attachment A of this report on the EPA Results forms. All work was conducted by Ken Wilcox Associates, Inc. at the Fuels Management Research Center in Grain Valley, Missouri.

Although every effort was made to assure that this testing meets the requirements for Alternative Testing as described by the federal EPA, Ken Wilcox Associates, Inc. makes no claims that the evaluation will be accepted by any or all regulatory agencies. The test procedures are listed with the National Workgroup on Leak Detection Evaluations (NWGLDE) [1] and meet the federal EPA requirements for Alternate Test Protocols as described in the forward to all of the standard EPA protocols for evaluating leak detection methods.[2]

This report was prepared by Ken Wilcox, Ken Wilcox Associates, Inc. Technical questions regarding this evaluation should be directed to Mr. Brad Holton at Greeenleaf Gauge, phone no. 888-884-2843.

KEN WILCOX ASSOCIATES, INC

H. Kendall Wilcox

H. Kendall Wilcox, Ph.D., President
August 12, 2008

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[1] In 1994, the EPA established the National Work Group for Leak Detection Evaluations that consists of a group of State and Federal Regulators that review leak detection evaluations, new evaluation protocols, and other issues affecting the leak detection and underground storage tank industry.

[2] "Standard Test Procedures for Evaluating Leak Detection Methods," EPA/530 UST-90/001-7, March to October 1990. Seven different procedures were developed for different leak detection methods and released between March and October 1990.

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Attachment A. Results Forms for the Greenleaf Gauge Interstitial Monitor

1.0 Background

The federal Environmental Protection Agency (EPA) has provided a series of documents[1], which describe the procedures that are to be used to verify that leak detection equipment meets the performance requirements of the Federal Register.[2] The requirements for evaluating interstitial sensors were not, however, included in those documents. It has therefore been necessary to develop independent methods for evaluating the performance of these systems. The objective is to provide an evaluation procedure that will provide testing that is at least as rigorous as those described for other types of leak detectors. At a minimum the evaluation method must determine the minimum liquid threshold for which a liquid level sensor will alarm.

To achieve this objective, the applicable sections of standard EPA protocols have been adapted to the specialized requirements of liquid level sensors. The test procedures followed in this evaluation are the KWA document "Alternative Test Procedures for Evaluating Leak Detection Methods: Liquid Level Sensors" September 1996. The procedures described in this document meet the requirements specified by the EPA for alternative test protocols and they were based on the procedures described in the EPA protocols. Additionally, the test procedures are listed with the National Workgroup on Leak Detection Evaluations (NWGLDE).[3]

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[1] "Standard Test Procedures for Evaluating Leak Detection Methods," EPA/530 UST-90/001-7, March to October 1990. Seven different procedures were developed for different leak detection methods and released between March and October 1990.

[2] 40CFR Part 280, Subpart D.

[3] In 1994, the EPA established the National Work Group for Leak Detection Evaluations, which consists of a group of State and Federal Regulators that review leak detection evaluations, new evaluation protocols, and other issues affecting the leak detection and underground storage tank industry.

2.0 Description of the Solar Gauge Interstitial Sensor

One of the Solar Gauge products functions as an interstitial sensor for double wall tanks or other containment vessels. The basic gauge is normally comprised of a display console and a float switch that is installed in the interstice with the wiring routed back to the control console. The float switch will respond to virtually any type of liquid that is compatible with the float material.

The gauging device consists of a fully self-contained console, is powered by light and maintained by a rechargeable and stand-by battery. If a low power condition were to occur, a low battery display is shown for several months before the numeric display goes blank. When used on small or short tanks the display console may be mounted directly to the transducer. On larger tanks the console and transducer are connected by a three conductor shielded cable installed in appropriate means meeting local code requirements.

The float switch tested in this evaluation was a simple on/off switch that was normally closed. The switch was designed to be used as the interstitial monitor for a double wall tank. It could, however be used in any application where monitoring for the presence of liquid is needed. This particular switch provided by Greenleaf Gauge is mounted in a PVC housing with a nominal diameter of 1 inch. The switch was tested by mounting in a graduated cylinder to which fuel was slowly added until an alarm was produced. The threshold for the alarm was determined from multiple measurements with gasoline, diesel fuel and water. The time to alarm and reset were also determined.

To setup a solar gauge for interstitial monitoring requires that the float switch be installed in the interstitial space and that the wiring be routed back to the control console. The switch is installed in the normally closed mode, usually at or near the lowest part of the interstice or the containment vessel.

When the liquid level in interstice reaches the threshold level of the switch, the switch will close, triggering an alarm at the console.The gauge will then provide a visual alarm on the display panel that is activated immediately and continues to flash until the alarm is reset. An audible alarm is sounded every 90 seconds after the alarm has been triggered and will continue until the alarm is reset. Resetting the alarm is accomplished by the float switch returning to a point below the alarm threshold.

Operation manuals are always available on a web site and customer assistance by phone is possible week days. This device is not a typical consumer device and should be purchased and maintained by qualified personnel familiar with tank equipment and the handling of the products contained within the tanks. Normal operational error is less than 1% and nominally not greater than 2%.

3.0 Evaluation Procedures

Three sets of liquids were conducted using the float switch provided for interstitial monitoring. Each of these tests consisted of six independent measurements specific for gasoline, water and #2 diesel fuel.

3.1 Test Apparatus

The test apparatus consisted of a 2000 ml graduated cylinder with the switch located on the bottom and an external micrometer with a resolution of 0.001 inch. The micrometer was set to zero at the bottom of the cylinder and was adjusted to measure the top of the liquid. Liquid was added slowly to the graduate using a peristaltic pump so that the liquid could be added at a very slow rate.

3.2 Threshold Measurement Accuracy

The level measurement accuracy of the float switch was determined by removing and adding product to the graduated cylinder until an alarm was produced. A total of six measurements were made for each liquid and the results used to calculate the standard deviation of the alarm threshold

3.3 Float Switch Functional Characteristics

Several performance parameters are routinely determined for alarm set points. These include:

Threshold
A peristaltic pump was used to add or remove liquid from the test cylinder containing the sensor until the sensor alarmed. The volume of liquid added to the cylinder was recorded and the height was recorded using a micrometer. This procedure was repeated a total of 6 times for each liquid. This threshold is expected to be only slightly different than for each liquid due to the density differences.

Detection Time
The time required for the sensor to respond to product levels above the sensor's threshold is the sensor's detection time. The average time to alarm for the six tests conducted for each product type is reported as the detection time. In the case of on/off float switches this time is very short.

Fall Times

The time required for the sensor to stop responding once the product level has been lowered below the sensor's threshold is the sensor's fall time. The average fall time for the six tests conducted for each product type is reported as the fall time.

Specificity

The specificity defines the different products that liquid level sensors will respond to. Most sensors will respond to any liquid once the sensor's threshold level has been exceeded unless the sensor has been designed otherwise. Although these sensors will respond to any liquid, the testing conducted for this evaluation determined the sensor's response to water, diesel fuel and unleaded gasoline.

4.0 Test Results

The test results for each of the functions of the Solar Gauge are presented in the following sections. A summary of the results is shown in Table 1.

Lower Detection Level (Threshold)
The sensors were only tested for their ability to detect liquids at the alarm levels.

Precision (Standard Deviation)
Six replicates were conducted for each liquid level for each float. The standard deviation was determined from these replicates.

Detection Time
The sensor will alarm within several seconds after the threshold is reached. This will be true for any liquid in the reservoir. The manufacturer supports a detection time of less than 1 minute.

Fall Time
The sensor stops alarming within several seconds after contacting liquid. This will be true for any liquid in the reservoir. The manufacturer supports a fall time of less than 1 minute.

Specificity
This sensor will respond to any liquid after its threshold is exceeded. Water, diesel fuel, and unleaded gasoline were used in this evaluation.

Time to Alarm under Operating Conditions
The time for a given liquid level sensor to alarm will depend on the size and geometry of the tank or sump in which it is installed and the rate of leakage into this space. The time to alarm can be calculated by dividing the volume necessary to reach the threshold by the leak rate.

Table 1. Test Results for Greenleaf Interstitial Sensor

Run No.	Unleaded Regular Gasoline	#2 Diesel Fuel	Water
1	1.97	1.86	2.09
2	1.96	1.86	2.08
3	1.97	1.87	2.09
4	1.97	1.86	2.09
5	1.97	1.86	2.08
6	1.97	1.86	2.09
Average (in)	1.97	1.86	2.09
Stdev (in)	0.0047	0.0033	0.0033
Threshold (in)	1.98	1.87	2.1
Detection Time	<1 Min		
Fall Time	<1 Min		

Attachment A

Official Results Forms for the Greenleaf Gauge Interstitial Monitor

Results of U.S. EPA Alternative Evaluation

Liquid Level Sensor

This form documents the performance of the liquid level sensor described below. The evaluation was conducted by the equipment manufacturer or a consultant to the manufacturer according to the U.S. EPA's requirements for alternative protocols. The full evaluation report also includes a report describing the method, a description of the evaluation procedures, and a summary of the test data.

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

Method Description

Name Greenleaf Gauge Interstitial Monitor

Version number(s) _____

Vendor Greenleaf Gauge
(Name of Manufacturer)

20675 Friends Road
(Address)

Greenleaf	Idaho	83626	208-453-1714
(City)	(State)	(Zip Code)	(Phone)

Evaluation Parameters

The sensors listed above were tested for their abilities to respond to liquids when the sensors are installed in underground storage tank applications. The following parameters were determined from this evaluation.

Threshold Levels – The liquid levels at which alarms are triggered.

Precision (standard deviation) - Agreement between multiple measurements of the same product level.

Detection Time - Amount of time the detector must be exposed to product before it responds.

Fall Time - Amount of time before the detector stops responding after being removed from the product.

Specificity - Types of products that the sensor will respond to.

Evaluation Results

Note: If the test data can be presented in a more appropriate manner, the evaluator may select to present the information below in a data table, which can be attached to these forms.

Table 1. Test Results for the TSP-DMS-24

Run No.	Unleaded Regular Gasoline	#2 Diesel Fuel	Water
1	1.97	1.86	2.09
2	1.96	1.86	2.08
3	1.97	1.87	2.09
4	1.97	1.86	2.09
5	1.97	1.86	2.08
6	1.97	1.86	2.09
Average (in)	1.97	1.86	2.09
Stdev (in)	0.0047	0.0033	0.0033
Threshold (in)	1.98	1.87	2.1
Detection Time	<1 Min		
Fall Time	<1 Min		

Specificity – This sensor will respond to any liquid after its threshold is exceeded. This testing was conducted with water, diesel fuel and unleaded gasoline.

Additional Limitations or Considerations - None

> Safety Disclaimer: This test procedure only addresses the issue of the methods ability to respond to liquids. It does not test the equipment for safety hazards.

Certification of Results

I certify that the liquid level sensor was tested under conditions according to the vendor's operating instructions. I also certify that the evaluation was performed using methods described in the attached Alternative EPA Test Procedures for Liquid level sensors, and that the results presented above are those obtained during the evaluation.

H. Kendall Wilcox, Ph.D., President
(printed name)

H. Kendall Wilcox
(signature)

August 12, 2008
(date)

Ken Wilcox Associates, Inc.
(organization performing evaluation)

Grain Valley, MO 64029
(city, state, zip)

1-816-443-2494
(phone number)