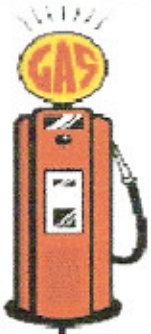

Evaluation of the Model EFG-8000 Greenleaf Gauge Overfill Alarm

Final Report

PREPARED FOR:

Greenleaf Gauge

July 31, 2008

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Final Report

PREPARED FOR:

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July 31, 2008

Preface

This report presents the results of an independent third-party evaluation of the overfill alarm on the Solar Gauge manufactured by Greeenleaf Gauge, a division of ITM Electronics, Inc. .

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
July 31, 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. EPA Forms For the Greenleaf Gauge Model EFG-800 Overfill Alarm

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 liquid level 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

The Solar Gauge products or sometimes referred to as "The Greenleaf Gauge" operate as a liquid level gauge by means of measuring the displacement of a probe by liquid in a tank. The basic gauge is normally comprised of a display console, a transducer mounted at the top of the tank, and a probe suspended from the base of the transducer inside the tank to just above the bottom of the tank floor. The weight of the probe hanging from the transducer changes in a known predictable manor as the volume of liquid in the tank changes. This is normally displayed directly in the number of gallons of liquid presently held in the tank although other units can be used. The display console and transducers are standardized items and meeting a range of requirements for tanks 8 inches to 45 feet tall. Various types of tanks shapes can be programmed into the gauge console to monitor liquids of a known specific gravity. Each probe must be built specific to the tank dimensions (the height of the primary tank) and the specific gravity of the liquid being monitored.

The gauging device is fully self-contained and 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.

In order to use a solar gauge correctly five pieces of information must be know and the gauge set up appropriately based on the information.

1. The shape of the tank is, i.e. rectangular, horizontal cylindrical, or special shapes like a large Armor cast tank with the angled sides near the base.
2. The true total capacity of the tank.
3. The specific gravity of the liquid to be monitored, i.e. 100LL, motor oil, diesel, gasoline.
4. The height of the primary tank.
5. A measurement of the total distance down through the top of a 2" nipple mounted on top of the tank to the inside tank floor.

With this information a gauge console with the appropriate tank program and weight range of transducer will be provided. This information is also needed to build the probe. Which is made of a sealed weighted tube. For larger tanks the probe is produced in multiple sealed sections and assembled as it is installed inside the tank. The probe is made normally two inches shorter than the primary tank and when operating never touches the bottom of the tank and is never completely submerged by the liquid. When operating the probe can never truly float, it must at all times have some weigh pulling down from the transducer. When the tank is empty the probe weighs the most, when full the probe weighs the least. The top of the probe is attached to the bottom of the transducer by a stainless steel bead chain during installation before the transducer is screwed onto the 2" nipple on top of the tank. A screwed plug on top of the transducer housing is connected by a small bead chain inside the transducer housing to the base of

the transducer. By unscrewing the plug and gently pulling up allows a service technician to physically test the gauge for a high level alarm out put by simulating a high level condition. Then screwing the plug back in place and the gauge returning to the current liquid amount checks for normal operation.

Gauge consoles are field programmable but are normally supplied programmed to a specific tank and liquid. Standard programs require user entries for tank shape, total capacity, low set point, high set point, low level alarm %, high level alarm %, off set, low calibration number, and high calibration number. With these entries the gauge can be programmed. The high level alarm cannot exceed 95% and is normally programmed for 90%. This is the percentage of total tank capacity. Low level alarm settings range from off at 0% to normally 10-20% but higher levels are used up to 75% on some generator sets. When the product level in the tank reaches a preset value, the gauge will provide an audible and visual alarm alerting the operator that the tank has reached its alarm level. The alarm level can be field adjusted to meet the user or regulatory requirements for overfill protection.

In addition to the measurement of fuel levels in the tank, the system will also respond to external switches such as those designed to monitor the interstitial space of a double wall tank. These are basically on/off type switches. For this evaluation a single float switch was used to check this feature.

Each gauge is serialized and the setup information normally recorded at manufacture. Gauge consoles and transducers may be used in other applications than ordered, but the probe will always be specific to the tank and liquid. 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

The overfill alarm capabilities of the Solar Gauge were determined by installing the gauge in a test cell and adding diesel fuel until an alarm occurred.

Test Apparatus

The evaluation of this system was designed to determine if the liquid level sensor operates as described by the vendor. The sensor was mounted in a vertical tube with a nominal diameter of 6 inches and a length of 10 ft. The top of the tube was fitted with a 2 inch diameter pipe to mount the Solar Gauge as it would be on an actual tank.

The Tube was initially filled with fresh diesel fuel to approximately 90%. The level in the test vessel was adjusted by slowly adding or removing fuel from the bottom of the tube using a pressurized tank. Fuel was returned to the tank by removing pressure and allowing the fuel to flow back to the tank until the alarm reset. A schematic of the test apparatus is shown in Figure 1.

Overfill Alarm

Fuel was added slowly to the test cell until an overfill alarm was produced. The product level in the test cell was then recorded from an external sight glass equipped with a tape measure with 1/8 inch divisions.

Fuel was then drained from the test cell until the alarm reset. The empty fill cycle was repeated six times and the standard statistical analysis was performed according to the standard EPA protocols. 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 most sensors of this type the detection 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 diesel fuel. The difference for other liquids varies by only a small amount due to fuel density differences.

The overfill alarm tested in this evaluation was an electronic switch that closed a circuit when the fuel level exceeded the preset value. as determined from the position of the fuel float.

4.0 Test Results

The test results for each of the functions of the GreenLeaf Gauge are presented in the following sections. The actual data is displayed in Table 1.

Table 1. High Level Alarm

Test No.	Inches	Gallons
1	11.38	12390
2	11.50	12410
3	11.75	12440
4	11.63	12410
5	11.63	12410
6	11.50	12410
Mean	11.56	12411.67
Stdev	0.131	16.021
Threshold	12.14	12482.

The threshold for the system can be specified as either level or gallons according to how the gauge is set up. The calculations in Table 1 have been determined for a flat bottom tank with a diameter of 183.69 inches ft and a height of 120 inches. The capacity of this tank would be 13,767 gallons. A custom chart for other sizes of tanks is prepared specifically for each application.

4.1. Overfill Alarm Characteristics

For this specific flat bottom tank example, the 90% alarm level can be expressed as 12387 gallons or 108 inches. The data shown in Table 1 indicate that an alarm will occur at least 95% the time before the level exceeds 12.14 inches or 12,482 gallons.

4.2 Alarm Level measurement Accuracy

The alarm threshold In this application is approximately 0.6 inch or 71 gallons higher than the 90% set point. This is 0.6% higher than the set point.

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 one second after the threshold is reached. This will be true for any liquid in the reservoir. The manufacturer supports a detection time of one second

Fall Time

The sensor stops alarming within one second after the product level drops below the reset level which is approximately 3/8 inches below the alarm threshold. This will be true for any liquid in the tank. The manufacturer supports a fall time of less than 1 minute.

Specificity

This sensor will respond to any liquid after its threshold is exceeded. Diesel fuel was used in this evaluation.

Attachment A

Results Forms for the Greenleaf Gauge Model EFG-8000 Overfill Alarm

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

Version number(s) Model EFG-8000

Vendor Greenleaf Gauge
(Name of Manufacturer)

20675 N. Friends Road, P.O. Box 309
(Address)

Greenleaf	ID	83626	(888) 884-2843
(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 Greenleaf Gauge

Table 1. High Level Alarm

Test No.	Inches	Gallons
1	11.38	12390
2	11.50	12410
3	11.75	12440
4	11.63	12410
5	11.63	12410
6	11.50	12410
Mean	11.56	12411.67
Stdev	0.131	16.02
Threshold	12.14	12482.38

Threshold Levels – The overfill alarm will be activated at least 95 % of the time when the level reaches 3/8 inch above the high level set point.

Precision (standard deviation) – The standard deviation for the overfill alarm is 0.131 inches or 16.02 gallons.

Detection Time – The response time for this sensor is less than one second after the overfill alarm level is reached.

Fall Time – The alarm will automatically shut off within one second after the fuel level drops below the reset level.

Specificity – This overfill alarm will respond to any liquid after its threshold is exceeded. This testing was conducted with diesel fuel.

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 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)

Ken Wilcox Associates, Inc.
(organization performing evaluation)

H. Kendall Wilcox
(signature)

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

July 31, 2008
(date)

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