Evaluation of Krueger Sensors

Liquid Level Therma Gauge
Overfill Alert Gauge
Overfill Alarm

Final Report

PREPARED FOR:

Krueger Sentry Gauge Co

March 9 2009

KWA

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Krueger Sentry Gauge Co
1873 Siesta Rd.
Green Bay, WI 54313

March 9, 2009

Preface

This report presents the results of an independent third-party evaluation of three Krueger sensors that are used to monitor the liquid level in storage tanks.. 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 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.

This report was prepared by Ken Wilcox Associates, Inc. Technical questions regarding this evaluation should be directed to Lee Geurts, Krueger Sentry Gauge Co., at phone number (920) 434-8860 Ext 4.

KEN WILCOX ASSOCIATES, INC

H. Kendall Wilcox

H. Kendall Wilcox, Ph.D., President
March 9, 2009

Table of Contents

Section		Page No.
Preface		ii
1.0	Background	1
2.0	Description of the Equipment	2
3.0	Evaluation Procedures	3
4.0	Test Results	4
5.0	Discussion	6

Attachment A. Results Forms for the Krueger At-A-Glance Leak Gauge

Liquid Level Therma Gauge
Overfill Alert Gauge
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 Equipment

Three items were tested for this evaluation. These include:

1. The Liquid Level Therma Gauge
2. The Overfill Alert Gauge; and
3. The Overfill Alarm

A summary of each is provided based on the manufacturers published information and on KWA observations during the evaluation. Data sheets for each device have been provided in Attachment C.

2.1 Liquid Level Gauge Description-Type H

The Therma Type H Level Gauge is a swing arm type tank monitor used for measuring all types of liquid levels. Its simple mechanical design promotes durability, minimal upkeep, quick installation, and easy/inexpensive repairs.

This liquid level monitor is custom made in house to fit the customers tank. Tank sizes for this sensor range from 6 inches to 12 feet in depth, The system can be contructd to account for double walls and pipe risers. Multiple materials of construction to are available to accommodate nearly any type of liquid.

This tank gauge has an easily removable bushing which allows the installer to thread the bushing into the tank first, then drop the gauge in and tighten up the red nut. This allows the installer to position the swing arm precisely where it is needed and eliminates the swing arm spinning inside the tank while during installation.

Standard construction Materials include Plastic Calibration, HDPE Lock Nut, Duro Nitrile Gasket, Aluminum Bushing, Galvanized Steel Rods, HDPE Floats. Other materials available include glass, aluminum galvanized steel rods and stainless steel rods and floats.

2.2 Overfill Alert Gauge Description-Type O

The Overfill Alert Gauge is a high level visual gauge designed to visually alert you that your tank is near full. This overfill monitor's simple mechanical design promotes easy installs, maximum durability, and low up front costs.

An Accessory can be added to turn the visual overfill gauge into an audible overfill alarm.

Standard Overfill Alert Gauge Construction-Plastic Calibration, HDPE Lock Nut, Duro Nitrile Gasket, Aluminum Bushing, Aluminum Rods, Polypropylene Floats. . Other construction materials available include glass, aluminum galvanized steel rods and stainless steel rods and floats.

2.3 High/Low Level Audible Alarm Accessory.

This switch is based on a non-contact magnetic reed switch system that is tripped when a magnet attached to the shaft of the overfill alert gauge. When the switch is activated a loud audible alarm (110 db) is produced alerting the operator The device can be installed on existing Krueger gauges include the Therma, Direct Lek, Overfill and Barrel sensors. The switch can function either as a high level or low level alarm by positioning the switch on the sensors. The system is powered by a 9 Volt Lithium battery with an estimated life of 3 to 10 years.

3.0 Evaluation Procedures

The evaluation procedures for these sensors presented some interesting challenges. This is because the construction of the sensors are in often for specific tank sizes and product types. The flexibility of the system allows different floats and positioning to meet the requirements of end users. Installation differences can also have an effect on the high level and low level alarm points. Although the gauges will function with considerable accuracy they are not generally used for indicating precise levels or alarm set points. Some of them like the audible alarm are sensitive to Where the alarm sensor is positioned on the gauge.

The specific numbers reported here are accordingly valid only for these particular gauges and how the alarm set points were chosen. Users of these devices will need to recognize that these gauges are used to indicate the levels of liquid so that the facility operator has an easily readable indication of the product level in the tank and to prevent overfilling. The value of the testing is that it indicates that these sensors provide the information and responses needed by the operator when they are properly designed and installed.

Test Apparatus

The evaluation of this system was designed to determine if these sensors operates as described by the vendor. The sensors were mounted in a test container where the depth of the liquid could be accurately determined and liquid was added until the float threshold was reached and again at the maximum height that resulted in a full indication on the gauge.

The Therma Liquid Level gauge, was installed in a large diameter test cell was used to determine the operational characteristics of the float sensor. The smaller overfill alarm was installed in a vertical cylinder and the liquid level was adjusted to produce the threshold for a low level alarm and a high level alarm. Liquids included in the evaluation were water, gasoline and diesel fuel.

Threshold Determination

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 test cell was recorded and the height was calculated based on the surface area of the test cell. This procedure was repeated a total of 6 times for each liquid and each type of sensor to determine the threshold level. The threshold level is the liquid level that will result in a detection with a 95% probability of detection and a false alarm rate of 5% or less.

Detection Time

The time required for the sensor to respond to solution levels above the sensor's threshold is the sensor's detection time. The average time to alarm for the six tests conducted is reported as the detection time. In the case of float switches this time is very short, usually within a couple seconds, depending on the characteristics of the alarm system to which it is connected. This system as tested depends on a visual observation by the operator so that the detection time is not applicable to either the Therma Gauge or the overfill Alert system.

The audible alarm occurs in less than one second when the liquid level reaches the alarm set point.

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. This does not apply to either sensor because they are based on the operators visual observation of t the liquid level indicated on the gauge. When the audible alarm option has been installed the has the alarm continues until it is manually reset by the operator. The fall time is near instantaneous when the switch is toggled.

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 changes in Water, Diesel Fuel and Unleaded Gasoline levels as well as almost all other liquids.

4.0 Test Results

4.1. Over fill Alert

The data and results for the Krueger Overfill Alert Sensors have been provided in Table 1. The liquid level was increased until an alarm occurred

Table 1. Test Results for the Krueger Overfill Alert Sensor (in Inches)

Water		Diesel		Unleaded Gasoline	
Run #	Inches at Alarm	Run #	Inches at Alarm	Run #	Inches at Alarm
1	1.755	1	1.671	1	1.4
2	1.765	2	1.664	2	1.409
3	1.703	3	1.613	3	1.346
4	1.703	4	1.613	4	1.375
5	1.773	5	1.676	5	1.415
6	1.704	6	1.611	6	1.355
Mean	1.734		1.641		1.383
Stdev	0.034		0.032		0.029
Threshold	1.883		1.783		1.511
Upper alarm level	3.983		3.883		3.611

<u>Detection Level (Threshold)</u>
This sensor was only tested for its ability to detect a high liquid level with a probability of 95% or greater. The “Inches at Alarm” is the minimum depth of liquid on the float that is necessary to move the visual indicator into the alert range. The visually observable alarm indication covers a range of 2 inches. 2-inchs. If installed correctly, the operator will be alerted initially when the liquid is between the threshold and the upper Alert level. The upper alert level is approximately 2 inches from the tank top. The length of the rod holding the float can be adjusted to provide a an alarm at a greater distance from the tank top if needed.

<u>Precision (Standard Deviation)</u>
Six replicates were conducted for each liquid level. For all three liquids the standard deviation was approximately 0.03 inches giving an threshold range of ± 0.13 inches.

<u>Detection Time</u>
The sensor alarmed in less than one second after the threshold was reached.

<u>Fall Time</u>
Once the alarm has been triggered it must be manually reset.

Specificity
This sensor will respond to any liquid in the interstice that is compatible with the float.

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. Once the threshold has been reached an alarm will occur in less than one second.

4.2. Therma Gauge

The data for the Therma Gauge is shown in Table 2. The testing was conducted to determine the empty level and the full level for the gauge. The testing was conducted only once at the "empty" position and at the "full" level for water, diesel fuel and gasoline.. Product levels below the threshold will be indicated as "empty". When the float is at its maximum level the tank will be indicated as "full". The actual levels will depend on the length of the tank size and probe assembly. Since the resolution of this gauge is low { visual indicator is divided into 1/8th increments) the gauge is used only as an indicator of an approximation of the amount of fuel in the tank.

Table 2. Test Results for the Krueger Therma Gauge (in Inches)

Level	Water	Diesel	Gasoline
Empty	1.8	2.3	2.6
Full	21.6	22.0	22.4

Detection Level (Threshold)
Not determined for this gauge.

Precision (Standard Deviation)
Not determined for this gauge

Detection Time
The level gauge will respond to new product levels in only a few seconds.

Fall Time
Not determined.

Specificity
This will work with any liquid that is compatible with the float.

4.3. Over Fill Alarm

The Over Fill Alarm is an optional accessory that can be used to provide an audible indication of an impending overfill. This device is installed on the Overfill Alert Sensor at a location between the visual alert range. When the float position rises to near full the swtch is activated producing a loud audible alarm.

Table 2. Test Results for the Krueger Over Fill Alarm

No. Tests	Alarm	Alarm Failure
25	25	0

Detection Level (Threshold)
User adjustable, depends on tank and sensor confifuation.

Precision (Standard Deviation)
Not determined

Detection Time
Alarms in less than one second after switch is triggered.

Fall Time
Must be manually reset

Specificity
Responds with any liquid that will raise the float.

5.0 Discussion

The Krueger At-A=Glance Tank Gauge meets the requirements for detecting a leak in the interstitial space of an underground tank or other containment vessel. It provides a low cost device that requires low maintenance and can be used on any liquid that is compatible with the float materials. It can be easily fitted with an audible alarm, either on the sensor or at a remote location. The alarm height is also adjustable making it useful for a variety of applications where either a high level or low level alarm is needed.

Although the thresholds may vary some from different liquid types this should not be a problem for any of the fuels typically found at service stations or other locations where automotive products are stored.

Attachment A

Results Forms for the Krueger

Liquid Level Therma Gauge
Overfill Alert Gauge
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 Liquid Level Therma Gauge

Version number(s) Type H

Vendor Krueger Sentry Gauge Co
(Name of Manufacturer)

1873 Siesta Rd
(Address)

Green Bay, WI 54313 (920) 434-8860
(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.

Test Results

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.

Test Results

Therma Gauge Level Sensor

Level	Water	Diesel	Gasoline
Empty	1.834	2.258	2.608
Full	21.625	22.049	22.399

Threshold Levels – No determined. Custom specified.

Precision (standard deviation) – Not determined

Detection Time – Not applicable. Operator visually observes float position

Fall Time – No applicable

Specificity – This sensor will respond to any liquid after its threshold is exceeded. The system was tested with Diesel Fuel, Unleaded Fuel and Water.

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

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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)

Ken Wilcox Associates, Inc.
(organization performing evaluation)

H. Kendall Wilcox
(signature)

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

March 9, 2009
(date)

(816) 443-2494
(phone number)

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Name Liquid Level Therma Gauge

Version number(s) Type H

Vendor Krueger Sentry Gauge Co
(Name of Manufacturer)

1873 Siesta Rd
(Address)

Green Bay, WI 54313 (920) 434-8860
(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.

Test Results

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.

Test Results

Therma Gauge Level Sensor

Level	Water	Diesel	Gasoline
Empty	1.834	2.258	2.608
Full	21.625	22.049	22.399

Threshold Levels – No determined. Custom specified.

Precision (standard deviation) – Not determined

Detection Time – Not applicable. Operator visually observes float position

Fall Time – Not applicable

Specificity – This sensor will respond to any liquid after its threshold is exceeded. The system was tested with Diesel Fuel, Unleaded Gasoline and Water.

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

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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.

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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 Overfill Alert Gauge

Version number(s) Type O

Vendor Krueger Sentry Gauge Co
(Name of Manufacturer)

1873 Siesta Rd
(Address)

Green Bay, WI 54313 (920) 434-8860
(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.

Test Results

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.

Test Results

Run #	Water Inches at Alarm	Diesel Inches at Alarm	UL Gasoline Inches at Alarm
1	1.755	1.671	1.4
2	1.765	1.664	1.409
3	1.703	1.613	1.346
4	1.703	1.613	1.375
5	1.773	1.676	1.415
6	1.704	1.611	1.355
Mean	1.734	1.641	1.383
Stdev	0.034	0.032	0.029
Threshold*	1.883	1.783	1.511
Upper alarm level**	3.983	3.883	3.611

* This is the depth of liquid on the float required to provide detection

** This is the maximum depth of liquid range to produce an alarm

Threshold Levels – Depends on density of the liquid – (See above table)

Precision (standard deviation) – 0.03 for all liquids tested.

Detection Time – Not applicable. Operator visually observes float position

Fall Time – Not applicable

Specificity – This sensor will respond to any liquid after its threshold is exceeded. The system was tested with Diesel Fuel, Unleaded Gasoline and Water.

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)	Ken Wilcox Associates, Inc. (organization performing evaluation)
H. Kendall Wilcox (signature)	Grain Valley, MO 64029 (city, state, zip)
March 9, 2009 (date)	(816) 443-2494 (phone number)

Results of U.S. EPA Alternative Evaluation

Liquid Level Sensor

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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 High Level Audible Alarm Accessory

Version number(s) none specified

Vendor Krueger Sentry Gauge Co
(Name of Manufacturer)

1873 Siesta Rd
(Address)

Green Bay, WI 54313 (920) 434-8860
(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.

Test Results

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.

Test Results

Therma Gauge Level Sensor

Level	Water	Diesel	Gasoline
Empty	1.834	2.258	2.608
Full	21.625	22.049	22.399

Threshold Levels – Not determined – This is an on/off sensor.

Precision (standard deviation) – Not determined

Detection Time – Not applicable. Less than one second after threshold setting is reached

Fall Time – Must be manually reset

Specificity – Not dependent on type of liquid

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

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Certification of Results

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