



# Evaluation of the TRM Sensors TRM-DFS-3 Fuel Sensor

**TRM-DFS-3 Fuel Sensor  
for use with TRM-Easy5 Leak Detection Monitoring Panel,**

## **Final Report Version 1**

**PREPARED FOR:  
TRM Sensors LLC**

**February 24, 2020**

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TRM Sensors LLC  
P.O. Box 2822  
Redwood City, CA 94064**

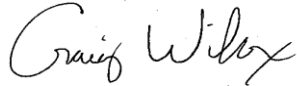
**February 24, 2020**

## Preface

This report presents the results of an independent third-party evaluation of the TRM Sensors TRM-DFS-3 Fuel Sensor. The evaluation was conducted by Ken Wilcox Associates, Inc. using procedures described in section 4.5.1, "Liquid Phase Sensor Test Procedures", of the 2019 revised standard protocol "Standard Test Procedures For Evaluating Release Detection Methods: Volumetric And Non- volumetric Tank Tightness Testing", May 2019. 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.

This report was prepared by Craig D. Wilcox, Ken Wilcox Associates, Inc. Technical questions regarding this evaluation should be directed to Craig Wilcox at (816) 443-2494.

KEN WILCOX ASSOCIATES, INC



Craig Wilcox, President  
February 24, 2020

## Table of Contents

<u>Section</u>	<u>Page No.</u>
Preface	3
1.0 Description of the TRM Sensors Console, Remote Alarm and Sensor	5
2.0 Evaluation Procedures	6
3.0 Test Results	7
3.1 Results for Discriminating Sensors and E85/Water mixture	8
4.0 Conclusions	9
5.0 Calibrated Equipment Used During the Evaluation	9

Attachment A. Results Forms for the Sensor

## **1.0 Description of the TRM Sensors Leak Detection Monitoring Panel, Remote Alarm and Fuel Sensor**

### TRM-DFS-3 Fuel Sensor, TRM-Easy5 Leak Monitoring Panel and Fuel Spill Remote Alarm

TRM Sensor's TRM-DFS-3 Fuel Sensor is a discriminating sensor that is typically installed in a spill containment area. The TRM-DFS-3 Fuel Sensor detects the presence of fuel wherever it is mounted. The TRM-DFS-3 Fuel Sensor is designed to be used with the TRM-Easy5 Leak Detection Monitor Panel with an optional Fuel Spill Remote Alarm. The Fuel Spill Remote Alarm can be mounted remotely anywhere desired within a fueling facility.

The TRM-DFS-3 Fuel Sensor contains a fuel sensitive strip that is used to detect the presence of fuel but is designed to ignore the presence of water. If the fuel level rises above the threshold of the TRM-DFS-3 Fuel Sensor wherever it is installed, an alarm condition is generated indicating that there is fuel present wherever the sensor is installed. The TRM-Easy5 Leak Detection Monitoring Console signals an alarm condition with output relays that can be connected to the owner's existing monitoring systems (PLC, BMS, etc.) and with an optional Fuel Spill Remote Alarm that indicates an alarm with an audible alarm as well as a visual alarm.

The sensor can easily be removed, cleaned and reinstalled if an alarm is triggered or for periodic testing. The manufacturer has specific recommendations for restoring a fuel exposed product sensitive strip when an alarm has activated. Once the product sensitive strip is exposed, the sensor should be removed from the sensor body and submerged in lighter fluid for 15 seconds and then placed into a low heat over for 15 minutes. Once the cleaning and heating procedures are finished, the product sensitive strip should return to its unexposed state for immediate use. It is also possible to replace the fuel exposed product sensitive strip with a new strip for immediate use if an alarm has been triggered. The replacement of the product sensitive strip is accomplished by simply unplugging the old strip and plugging in the new strip on the bottom of the sensor body.

## 2.0 Evaluation Procedures

### 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 test container in which different types of liquid were added including water, diesel fuel, unleaded gasoline, E-85 and three different percentage mixtures of E85 and water. The water/E85 mixture percentages included a mixture of 20/80%, 40/60% and 70/30% of water/E85 content.

### Threshold Determination

A peristaltic pump was used to add or remove the liquid from the test cylinder containing the sensor until the sensor alarmed. The threshold was measured directly with a dial micrometer. This procedure was repeated a total of 10 times for each test fluid.

### Detection Time

The time required for the sensor to respond to product levels beyond the sensors threshold is the sensors detection time. The average time to alarm for the 10 tests conducted for each product type is reported as the detection time.

### Fall Times

The time required for the sensor to stop responding once the product level has been raised or lowered within the sensors threshold is the sensors fall time. The average fall time for the 10 tests conducted for each product type is reported as the fall time.

### Specificity

The specificity defines the different products that liquid level sensor will respond to. Most sensors will respond to any liquid once the sensors threshold level has been exceeded unless the sensor has been designed otherwise. In the case of this sensor, it is designed to only respond to fuel. The testing conducted for this evaluation determined the sensors response to water, diesel fuel, unleaded gasoline, E-85 and three different percentage mixtures of E85 and water. The water/E85 mixture percentages included 20/80%, 40/60% and 70/30% of water/E85 content.

### **3.0 Test Results**

The data and results for the TRM-DFS-3 Fuel Sensor is contained in Table 1.

#### Lower Detection Level (Threshold)

The sensor was only tested for its ability to detect liquid levels at the alarm levels.

#### Precision (Standard Deviation)

Ten replicates were conducted for each liquid level for the sensor. The standard deviation was determined from these replicates.

#### Detection Time

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

#### Fall Time

The sensor stops alarming within 15 minutes after cleaning the sensor and placing it into a 140 degree oven as recommended by the manufacturer. During this evaluation, after each alarm for all fuel types, the product sensitive strip portion of the sensor was submerged in lighter fluid for approximately 15 seconds and then placed into a low heat oven set at 140 degrees Fahrenheit. The manufacturer supports a fall time of 15 minutes when the proper cleaning and heating procedures are followed. Another option to reset the alarm is that a new product sensitive strip can be plugged into the sensor body for immediate use. For each of the fuel types after the 10 threshold tests, the fall time was recorded as 15 minutes after following the cleaning and heating procedures as recommended by the manufacturer.

#### Specificity

This sensor will respond to any fuel after the sensors threshold is exceeded. The liquids used for this evaluation were water, unleaded gasoline and diesel fuel.

#### Time to Alarm under Operating Conditions

The time for a liquid sensor to alarm will depend on the size and geometry of the space 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. In the case of this sensor, an alarm will be generated by any thin layer of fuel that is present wherever the sensor is installed.

### **3.1 Results for Discriminating Sensors and E85/Water mixture**

#### Three Mixtures of Water/E85

Three mixtures of E85 were created and used in this evaluation to emulate water being dumped into a tank of E85. The three mixtures include a 20/80%, 40/60% and 70/30% mixture of water/E85. When water is dumped into a tank of E85, the water mixes in with the alcohol in the E85 and creates a bottom layer of water/alcohol mixture and the remaining hydrocarbon creates a top layer with a very distinct separation of the upper/lower liquids. Even when agitated the upper layer will not mix with the bottom layer. The two layers also did not show any phase separation or change at all after sitting for a period of 24 hours. There is a much different outcome when E85 runs into a container or sump with a layer of water present if the two liquids are not stirred or agitated. Without agitation or the stirring effects of a fuel/water drop into a tank, the E85/Water remain separate with a cloudy phase separation transition between the E85 layer and the water layer. This separation did not change after sitting for a period of 24 hours. During this evaluation for the water/E85 mixtures, the sensor was tested on both the lower and upper layers of each of the different percentage mixtures. When the sensor was tested using the upper layer of the three mixtures, an alarm was generated within seconds for all 3 mixtures. When the sensor was tested using the lower layer of the three mixtures, an alarm was generated only with the 20% water with 80% E85 mixture and there was no response to the lower layer of 40/60% and 70/30% water/E85.



## Test Results for the TRM-DFS-3 Fuel Sensor

### Time to Alarm Test Results for the TRM-DFS-3 Fuel Sensor

Run #	Time To Alarm with <1/16" of fuel				
	Water (seconds)	Unleaded (seconds)	Diesel (seconds)	E85 (seconds)	Jet Fuel (seconds)
1	No response	7	5	5	6
2	No response	6	7	5	5
3	No response	7	6	6	7
4	No response	6	6	7	5
5	No response	7	5	5	6
6	No response	6	5	6	5
7	No response	5	6	6	5
8	No response	6	7	5	7
9	No response	6	6	7	6
10	No response	7	7	6	6

<b>Mean</b>	<b>No response</b>	<b>6.3</b>	<b>6.0</b>	<b>5.8</b>	<b>5.8</b>
<b>STDEV</b>	<b>No response</b>	<b>0.7</b>	<b>0.8</b>	<b>0.8</b>	<b>0.8</b>
<b>Threshold</b>	<b>No response</b>	<b>8.8</b>	<b>9.0</b>	<b>8.7</b>	<b>8.7</b>

### Height at Alarm Test Results for the TRM-DFS-3 Fuel Sensor

Run #	Height at Alarm (inches)				
	Water (inches)	Unleaded (inches)	Diesel (inches)	E85 (inches)	Jet Fuel (inches)
1	No response	< 0.0625	< 0.0625	< 0.0625	< 0.0625
2	No response	< 0.0625	< 0.0625	< 0.0625	< 0.0625
3	No response	< 0.0625	< 0.0625	< 0.0625	< 0.0625
4	No response	< 0.0625	< 0.0625	< 0.0625	< 0.0625
5	No response	< 0.0625	< 0.0625	< 0.0625	< 0.0625
6	No response	< 0.0625	< 0.0625	< 0.0625	< 0.0625
7	No response	< 0.0625	< 0.0625	< 0.0625	< 0.0625
8	No response	< 0.0625	< 0.0625	< 0.0625	< 0.0625
9	No response	< 0.0625	< 0.0625	< 0.0625	< 0.0625
10	No response	< 0.0625	< 0.0625	< 0.0625	< 0.0625

<b>Mean</b>	<b>No response</b>	<b>&lt;0.0625</b>	<b>&lt;0.0625</b>	<b>&lt;0.0625</b>	<b>&lt;0.0625</b>
<b>STDEV</b>	<b>No response</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>Threshold</b>	<b>No response</b>	<b>&lt;0.0625</b>	<b>&lt;0.0625</b>	<b>&lt;0.0625</b>	<b>&lt;0.0625</b>

\*Fall Time for each fuel type is 15 minutes when recommended procedures are followed

**Time to Alarm Test Results for the TRM-DMS-3 Fuel Sensor - Water/E85 Top and Bottom Layer**

Run #	Height at Alarm <1/16" of Water/E85 Mixture Top and Bottom Layer					
	20/80% Top Layer (seconds)	40/60% Top Layer (seconds)	70/30% Top Layer (seconds)	20/80% Bottom (seconds)	40/60% Bottom (seconds)	70/30% Bottom (seconds)
1	5	6	6	29	no response	no response
2	5	5	6	30	no response	no response
3	6	5	5	32	no response	no response
4	6	6	5	28	no response	no response
5	7	7	7	17	no response	no response
6	5	6	6	26	no response	no response
7	6	5	5	28	no response	no response
8	5	6	7	21	no response	no response
9	6	6	6	31	no response	no response
10	6	7	6	29	no response	no response

**Mean            5.7            5.9            5.9            27.1            no response            no response**  
**STDEV          0.7            0.7            0.7            4.7            no response            no response**  
**Thresho       8.2            8.6            8.6            44.4            no response            no response**

**Time to Alarm Test Results for the TRM-DMS-3 Fuel Sensor - Water/E85 Top and Bottom Layer**

Run #	Height at Alarm <1/16" of Water/E85 Mixture Top and Bottom Layer					
	20/80% Top Layer (seconds)	40/60% Top Layer (seconds)	70/30% Top Layer (seconds)	20/80% Bottom (seconds)	40/60% Bottom (seconds)	70/30% Bottom (seconds)
1	< 0.0625	< 0.0625	< 0.0625	< 0.0625	no response	no response
2	< 0.0625	< 0.0625	< 0.0625	< 0.0625	no response	no response
3	< 0.0625	< 0.0625	< 0.0625	< 0.0625	no response	no response
4	< 0.0625	< 0.0625	< 0.0625	< 0.0625	no response	no response
5	< 0.0625	< 0.0625	< 0.0625	< 0.0625	no response	no response
6	< 0.0625	< 0.0625	< 0.0625	< 0.0625	no response	no response
7	< 0.0625	< 0.0625	< 0.0625	< 0.0625	no response	no response
8	< 0.0625	< 0.0625	< 0.0625	< 0.0625	no response	no response
9	< 0.0625	< 0.0625	< 0.0625	< 0.0625	no response	no response
10	< 0.0625	< 0.0625	< 0.0625	< 0.0625	no response	no response

**Mean            < 0.0625    < 0.0625    < 0.0625    < 0.0625    no response            no response**  
**STDEV          0.0            0.0            0.0            0.0            no response            no response**  
**Thresho       < 0.0625    < 0.0625    < 0.0625    < 0.0625    no response            no response**

\*Fall Time for each mixture percentage is 15 minutes when recommended procedures are followed

## 4.0 Conclusions

Ken Wilcox Associates, Inc. has conducted this evaluation in accordance to the procedures described in section 4.5.1, "Liquid Phase Sensor Test Procedures", of the 2019 revised standard protocol "Standard Test Procedures For Evaluating Release Detection Methods: Volumetric And Non- volumetric Tank Tightness Testing", May 2019. Ken Wilcox Associates, Inc. has come to the conclusion that the TRM Sensors TRM-DFS-3 Fuel Sensor evaluated in this report, when connected to the TRM-Easy 5 Leak Detection Monitoring Panel with the optional Fuel Spill Remote Alarm, will detect the presence of fuel wherever the sensor is installed once the sensors threshold is exceeded. The TRM-DFS-3 Fuel Sensor contains a fuel sensitive strip that will accurately indicate whether there is fuel present wherever the sensor is installed. When the TRM-DFS-3 Fuel Sensor is exposed to E85 that also contains a percentage of water, the sensor will alarm when exposed to the top layer of hydrocarbon. The TRM-DFS-3 Fuel Sensor also alarmed on the lower layer of water/E85 mixture at 20% water and 80% E85. However, when exposed to the lower layer of water/E85 at 40/60% water/E85 and 70/30% water/E85, the sensor did not produce an alarm. The TRM-DFS-3 Fuel Sensor, as designed, will not respond to the presence of water. Once an alarm is triggered, the fuel sensitive strip on the TRM-DFS-3 Fuel Sensor can be reset by submerging it in lighter fluid for 15 seconds and placing it in a low heat over at 140 degrees Fahrenheit for 15 minutes. The fuel exposed product sensitive strip can also be replaced with a new one for immediate use.

## 5.0 Calibrated Equipment Used During the Evaluation

Digi-Sense Timer Serial # 191906216

Digi-Sense Timer - calibrated 5/20/2019, expires 5/20//2020

Calibrated Equipment ID - TM1

Craftsman 0 to 300 inch tape measure - Calibrated 8/29/2019, expires 8/29/2021

Calibrated Equipment Serial # - 15117417

Mitutoyo Height Gage - Calibrated 4/25/2019, expires 4/25/2020 (accuracy verified by Craftsman Tape Measure ID TM1 at start of evaluation)

Calibrated Equipment ID - CP305723

Corning, Inc. 100ml burette with 0.2ml increments - Calibrated 2/26/2019, expires 2/26/2020

## **Attachment A**

### **Results Forms for the TRM Sensors TRM-DFS-3 Fuel Sensor with TRM Easy5 Leak Detection Monitoring Panel and Fuel Spill Remote 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.

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### Method Description

Name TRM Sensors TRM-DFS-3 Fuel Sensor with TRM-Easy5 Leak Monitoring  
Panel and optional Fuel Spill Remote Alarm

Version number(s) TRM-DFS-3 Fuel Sensor  
for use with TRM-Easy5 Leak Monitoring Panel and Fuel Spill Remote Alarm

Vendor TRM Sensors LLC  
(Name of Manufacturer)

P.O. Box 2822  
(Address)

Redwood City      California      94064      (415) 860-2044  
(City)                      (State)                      (Zip Code)                      (Phone)

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### Evaluation Parameters

The sensor listed above was tested for the abilities to respond to liquids when the sensor is 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.

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### Evaluation Results of the TRM-DFS-3 Fuel Sensor

**Table 1. Results of the TRM-DMS-3 with Water**

<b>Parameter</b>	<b>Result</b>
Threshold Level (inches)	No response
Precision - Standard Deviation (inches)	No response
Detection Time (seconds)	No response
Fall Time (minute)	No response

**Table 2. Results of the TRM-DMS-3 with Diesel**

<b>Parameter</b>	<b>Result</b>
Threshold Level (inches)	< 0.0625 inches
Precision - Standard Deviation (inches)	0.0
Detection Time (seconds)	9.0 seconds
Fall Time (minute)	< 15 minutes

**Table 3. Results of the TRM-DMS-3 with E85**

<b>Parameter</b>	<b>Result</b>
Threshold Level	< 0.0625 inches
Precision - Standard Deviation (inches)	0.0
Detection Time (seconds)	8.7 seconds
Fall Time (minute)	< 15 minutes

**Table 4. Results of the TRM-DMS-3 with Unleaded**

<b>Parameter</b>	<b>Result</b>
Threshold Level	< 0.0625 inches
Precision - Standard Deviation (inches)	0.0
Detection Time (seconds)	< 8.8 seconds
Fall Time (minute)	< 15 minutes

**Table 5. Results of the TRM-DMS-3 with Jet Fuel**

<b>Parameter</b>	<b>Result</b>
Threshold Level	< 0.0625 inches
Precision - Standard Deviation (inches)	0.0
Detection Time (seconds)	< 8.7 seconds
Fall Time (minute)	< 15 minutes

**Table 6. Results of the TRM-DMS-3 with Water/E85 20/80% Mixture**

<b>Parameter</b>	<b>Top Layer Result</b>	<b>Bottom Layer Result</b>
Threshold Level (inches)	< 0.0625	< 0.0625
Precision - Standard Deviation (inches)	0.0	0.0
Detection Time (seconds)	8.2	44.4
Fall Time (minutes)	< 15 Minutes	< 15 Minutes

**Table 7. Results of the TRM-DMS-3 with Water/E85 40/60% Mixture**

<b>Parameter</b>	<b>Result</b>	<b>Bottom Layer Result</b>
Threshold Level (inches)	< 0.0625	No Response
Precision - Standard Deviation (inches)	0.0	No Response
Detection Time (seconds)	8.6	No Response
Fall Time (minutes)	< 15 Minutes	Does Not Apply

**Table 8. Results of the TRM-DMS-3 with Water/E85 70/30% Mixture**

<b>Parameter</b>	<b>Result</b>	<b>Bottom Layer Result</b>
Threshold Level	< 0.0625	No Response
Precision - Standard Deviation (inches)	0.0	No Response
Detection Time (seconds)	8.6	No Response
Fall Time (minutes)	< 15 Minutes	Does Not Apply



Specificity – The sensor evaluated will respond to any liquid after its threshold is exceeded. This testing was specifically for performance using water, diesel fuel, Jet Fuel, unleaded fuel, E85 and three different percentage mixtures of water and E85 including the top and bottom layers of 20/80%, 40/60% and 70/30% of water/E85.

Additional Limitations or Considerations - None

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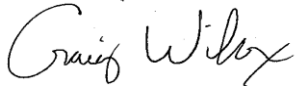
**> Safety Disclaimer: This test procedure only addresses the issue of the methods ability to respond to liquids. It does not test the equipment for safety hazards.**

---

**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 CAN/ULC-S675.2-14 standard under protocol “Alternative Test Procedures for Evaluating Leak Detection Methods: Evaluation of Liquid Level Sensors”, Ken Wilcox Associates, September 1996 and that the results presented above are those obtained during the evaluation.

Craig Wilcox, President  
(printed name)



\_\_\_\_\_  
(Signature)

Ken Wilcox Associates, Inc.  
(organization performing evaluation)

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

February 24, 2020  
(date)

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