



Evaluation of the Morrison Bros. Co. Liquid Sensor, Adjustable Level Sensor and Multi-Level Sensor

924LS, 924 and 925 Sensor
for use with the 918AC, 918S, 918D and 918Q Alarm Consoles

Final Report

PREPARED FOR:
Morrison Bros. Co.

September 30, 2015

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**PREPARED FOR:
Morrison Bros. Co.
570 East 7th Street
Dubuque, IA 52001**

September 30, 2015

Preface

This report presents the results of an independent third-party evaluation of the Morison Bros. Co. 924LS, 924 and 925 liquid level sensors. 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.

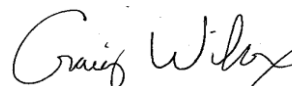
Although every effort was made to assure that this testing meets the requirements for Alternative Testing as described by the federal EPA, Ken Wilcox Associates, Inc. makes no claims that the evaluation will be accepted by any or all regulatory agencies. The test procedures are listed with the National Workgroup on Leak Detection Evaluations (NWGLDE) 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.

This report was prepared by Dr. Ken Wilcox, Ken Wilcox Associates, Inc. Technical questions regarding this evaluation should be directed to Morrison Bros. Co. at (563) 583-5701.

KEN WILCOX ASSOCIATES, INC



H. Kendall Wilcox, Ph.D., President
September 30, 2015



Craig Wilcox, Vice President
September 30, 2015

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1.0 Background

The federal Environmental Protection Agency (EPA) has provided a series of documents, which describe the procedures that are to be used to verify that leak detection equipment meets the performance requirements of the Federal Register. 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, of course, to provide an evaluation procedure which will provide testing which 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).

2.0 Description of the Equipment

918AC, 918S, 918D and 918Q Alarm Consoles

There were two different Morrison Bros. Co. consoles that were used in this evaluation. The two consoles used were the Morrison Bros. Co. 918AC and 918S. The 918AC and 918S consoles are functionally identical with one exception. The only exceptions between the 918AC and 918S is that the 918AC is powered by AC power and the 918S is powered by battery. Both alarm boxes indicate alarms with an audible alarm as well as a visual alarm. The 918S console has 1 single channel. There are two additional versions identical to the 918S with the exception that they include additional channels that allow for more sensors to be connected. The additional versions include the 918D, which is a 2 channel, and the 918Q that has 4 channels.

924LS sensor

Morrison Bros. Co. 924LS sensor is a single float liquid level sensor. The 924LS sensor detects the presence of fluid anywhere the sensor is installed. If the liquid level rises above the threshold of the 924LS sensor, an alarm condition is generated. The 924 LS sensor float can be configured in the normally closed (NC) or normally open (NO) position. If the liquid level rises above (float in NO position) or falls below (float in NC position) the threshold of the 924 LS sensor, an alarm condition is generated. This would indicate there is liquid present or a loss of liquid in the place where the sensor is installed. The sensor can easily be removed, cleaned and reinstalled if an alarm is triggered or for periodic testing.

924 adjustable level sensor

Morrison Bros. Co. 924 sensor is an adjustable level single float liquid level sensor. The 924 sensor detects the presence of fluid anywhere the sensor is installed. The sensor float can be configured in the normally closed (NC) or normally open (NO) position. If the liquid level rises above (float in NO position) or falls below (float in NC position) the threshold of the 924 sensor, an alarm condition is generated. This would indicate there is liquid present or a loss of liquid in the place where the sensor is installed. The sensor can easily be removed, cleaned and reinstalled if an alarm is triggered or for periodic testing.

925 multi-level sensor

Morrison Bros. Co. 925 sensor is a multi-level liquid level sensor. The 925 sensor can have up to 5 floats installed at different levels by the manufacturer. Each of the floats can be configured in the normally closed (NC) or normally open (NO) position. The 925 sensor detects the presence or loss of fluid at multiple levels anywhere the sensor is installed. If the liquid level rises above (float in NO position) or below (float in NC position) the threshold of the 925 sensor, an alarm condition is generated. The sensor can easily be removed, cleaned and reinstalled if an alarm is triggered or for periodic testing. This 925 sensor was evaluated using the floats setup to alarm at the lowest level as well as the highest level. The manufacture has the ability to configure the 925 sensor to alarm at an additional 3 points between the lowest and highest level.

3.0 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 water, E85, unleaded gasoline and diesel fuel was added.

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 6 times for each test fluid and an alarm was verified for both the 918AC and 918S console.

Detection Time

The time required for the sensor to respond to product levels beyond 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 raised or lowered within 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 this sensor will respond to any liquid, the testing conducted for this evaluation determined the sensor's response to water, unleaded gasoline and diesel fuel.

4.0 Test Results

The data and results for the 924LS, 924 and 925 sensors are 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)

Six replicates were conducted for the liquid level for each of the sensors and an alarm was verified for both the 918AC and 918S console. Also included in this report are the 918D and 918Q since they are functionally identical with the exception of additional channels. The standard deviation was determined from these replicates.

Detection Time

The sensor alarms within a few seconds after the threshold was reached. This will be true for any liquid in the reservoir. The manufacturer supports a detection time of less than 5 seconds.

Fall Time

The sensor stops alarming within a few seconds after the liquid level is within the threshold of the sensor. This will be true for any liquid in the reservoir. The manufacturer supports a fall time of less than 5 seconds.

Specificity

This sensor will respond to any liquid that is compatible with the system in which it is installed. Water, unleaded gasoline and diesel fuel were used for this evaluation.

Time to Alarm under Operating Conditions

The time for a liquid level 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.

Table 1. Test Results for the Morrison Bros. Co. 924LS, 924 and 925 Sensors

Test Results for the 924 LS Sensor - Normally Closed

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	0.631	0.7075	0.715	0.722
2	0.628	0.703	0.717	0.725
3	0.633	0.694	0.72	0.724
4	0.6365	0.6945	0.7185	0.728
5	0.633	0.7	0.712	0.731
6	0.6265	0.707	0.7145	0.7285

Mean **0.6313** **0.7010** **0.7162** **0.7264**
STDEV **0.0037** **0.0059** **0.0029** **0.0033**
Threshold **0.6449** **0.7229** **0.7270** **0.7387**

Test Results for the 924 LS Sensor - Normally Open

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	0.788	0.8945	0.9195	0.929
2	0.799	0.8955	0.9225	0.9315
3	0.794	0.888	0.927	0.932
4	0.795	0.8995	0.9175	0.929
5	0.801	0.8945	0.919	0.928
6	0.8015	0.893	0.9205	0.9345

Mean **0.7964** **0.8942** **0.9210** **0.9307**
STDEV **0.0051** **0.0037** **0.0034** **0.0024**
Threshold **0.8155** **0.9080** **0.9335** **0.9397**

Test Results for the 924 Sensor - NC position

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	2.007	2.1625	2.219	2.2285
2	2.0115	2.175	2.216	2.224
3	2.001	2.1685	2.212	2.2165
4	2	2.176	2.1995	2.215
5	2.003	2.1695	2.199	2.227
6	2.0055	2.171	2.199	2.2235
Mean	2.0047	2.1704	2.2074	2.2224
STDEV	0.0043	0.0049	0.0093	0.0055
Threshold	2.0205	2.1886	2.2419	2.2428

Test Results for the 924 Sensor -NO position

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	2.315	2.4965	2.5315	2.547
2	2.315	2.484	2.5375	2.552
3	2.326	2.487	2.5455	2.5465
4	2.321	2.484	2.5395	2.5505
5	2.314	2.485	2.5425	2.545
6	2.326	2.497	2.542	2.545
Mean	2.3195	2.4889	2.5398	2.5477
STDEV	0.0056	0.0062	0.0049	0.0029
Threshold	2.3403	2.5118	2.5578	2.5585

Test Results for the 925 Sensor - Low Level - Bottom Float - NC position

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	2.2575	2.4405	2.479	2.506
2	2.2495	2.4345	2.486	2.5055
3	2.2525	2.4445	2.489	2.507
4	2.255	2.439	2.4815	2.5015
5	2.2565	2.44	2.486	2.5035
6	2.251	2.4385	2.4795	2.508
Mean	2.2537	2.4395	2.4835	2.5053
STDEV	0.0032	0.0032	0.0041	0.0024
Threshold	2.2654	2.4515	2.4986	2.5141

Test Results for the 925 Sensor - Low Level - Bottom Float - NO position

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	2.566	2.768	2.8065	2.825
2	2.5785	2.7695	2.7995	2.8205
3	2.572	2.764	2.804	2.8295
4	2.569	2.7705	2.805	2.828
5	2.5725	2.7655	2.8035	2.8285
6	2.5685	2.767	2.8015	2.824
Mean	2.5711	2.7674	2.8033	2.8259
STDEV	0.0044	0.0024	0.0025	0.0034
Threshold	2.5872	2.7765	2.8126	2.8385

Test Results for the 925 Sensor -Low Level - Top Float - Normally Closed

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	4.7705	4.921	4.955	4.981
2	4.7755	4.925	4.9525	4.9775
3	4.769	4.9265	4.948	4.975
4	4.7715	4.9275	4.9495	4.981
5	4.774	4.9205	4.955	4.982
6	4.771	4.923	4.9545	4.978
Mean	4.7719	4.9239	4.9524	4.9791
STDEV	0.0024	0.0029	0.0030	0.0027
Threshold	4.7808	4.9346	4.9636	4.9891

Test Results for the 925 Sensor - Low Level - Top Float - Normally Open

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	5.0715	5.2585	5.2735	5.2875
2	5.069	5.247	5.271	5.292
3	5.0675	5.2495	5.274	5.297
4	5.0735	5.2515	5.275	5.2955
5	5.0695	5.2555	5.2705	5.2905
6	5.0705	5.251	5.273	5.296
Mean	5.0703	5.2522	5.2728	5.2931
STDEV	0.0021	0.0042	0.0018	0.0037
Threshold	5.0780	5.2676	5.2793	5.3068

Test Results for the 925 Sensor -High Level - Bottom Float - Normally Closed

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	52.75	52.9895	53.0255	53.079
2	52.748	52.985	53.0215	53.0705
3	52.747	52.989	53.028	53.0775
4	52.7505	52.9905	53.0245	53.0765
5	52.752	52.9865	53.023	53.068
6	52.7525	52.987	53.028	53.0725
Mean	52.7500	52.9879	53.0251	53.0740
STDEV	0.0022	0.0021	0.0026	0.0043
Threshold	52.7580	52.9956	53.0349	53.0901

Test Results for the 925 Sensor - High Level - Bottom Float - Normally Open

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	53.052	53.299	53.3295	53.3755
2	53.0505	53.3005	53.329	53.3745
3	53.055	53.309	53.3275	53.373
4	53.0575	53.2975	53.338	53.3795
5	53.052	53.3045	53.3285	53.3785
6	53.0545	53.3085	53.337	53.377
Mean	53.0536	53.3032	53.3316	53.3763
STDEV	0.0026	0.0049	0.0046	0.0025
Threshold	53.0631	53.3214	53.3488	53.3855

Test Results for the 925 Sensor -High Level - Top Float - Normally Closed

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	55.225	55.466	55.5015	55.549
2	55.228	55.4625	55.504	55.5485
3	55.2295	55.4685	55.5055	55.5415
4	55.227	55.4675	55.506	55.545
5	55.223	55.4705	55.501	55.547
6	55.2245	55.4665	55.507	55.5435
Mean	55.2262	55.4669	55.5042	55.5458
STDEV	0.0024	0.0027	0.0025	0.0029
Threshold	55.2351	55.4769	55.5133	55.5567

Test Results for the 925 Sensor - High Level - Top Float - Normally Open

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	55.553	55.8005	55.831	55.8765
2	55.5505	55.797	55.836	55.876
3	55.5535	55.7965	55.8385	55.8705
4	55.5565	55.8025	55.829	55.872
5	55.554	55.804	55.8365	55.8785
6	55.551	55.796	55.8355	55.876
Mean	55.5531	55.7994	55.8344	55.8749
STDEV	0.0022	0.0034	0.0036	0.0030
Threshold	55.5612	55.8120	55.8479	55.8861

***Detection Time for both alarm consoles and all liquids - <5 seconds**

***Fall Time for both alarm consoles and all liquids - <5 seconds**

Attachment A

Results Forms for the Morrison Bros. Co. Sensors

924LS, 924 and 925 Liquid Sensors

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 Morrison Bros. Co. Liquid Sensors

Version number(s) 924LS, 924 and 925 Sensors

For use with the 918AC, 918S, 918D and 918Q alarm boxes

Vendor Morrison Bros. Co.

(Name of Manufacturer)

570 East 7th Street

(Address)

Dubuque

(City)

IA

(State)

52001

(Zip Code)

(563) 583-5701

(Phone)

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.

924 LS Sensor

Table 1. Results of the 924 LS with Water

Parameter	Data - NO	Data - NC
Threshold Level (inches)	0.8155	0.6449
Precision - Standard Deviation (inches)	0.0051	0.0037
Detection Time (seconds)	<5	<5
Fall Time (seconds)	<5	<5

Table 2. Results of the 924 LS with Diesel

Parameter	Data - NO	Data - NC
Threshold Level (inches)	0.9080	0.7229
Precision - Standard Deviation (inches)	0.0037	0.0059
Detection Time (seconds)	<5	<5
Fall Time (seconds)	<5	<5

Table 3. Results of the 924 LS with E85

Parameter	Data - NO	Data - NC
Threshold Level	0.9335	0.7270
Precision - Standard Deviation (inches)	0.0034	0.0029
Detection Time (seconds)	<5	<5
Fall Time (seconds)	<5	<5

Table 4. Results of the 924 LS with Unleaded

Parameter	Data - NO	Data - NC
Threshold Level	0.9397	0.7387
Precision - Standard Deviation (inches)	0.0024	0.0030
Detection Time (seconds)	<5	<5
Fall Time (seconds)	<5	<5

924 Sensor

Table 5. Results of the 924 with Water

Parameter	Data - NO	Data - NC
Threshold Level (inches)	2.3403	2.0205
Precision - Standard Deviation (inches)	0.0056	0.0043
Detection Time (seconds)	<5	<5
Fall Time (seconds)	<5	<5

Table 6. Results of the 924 with Diesel

Parameter	Data - NO	Data - NC
Threshold Level (inches)	2.5118	2.1886
Precision - Standard Deviation (inches)	0.0062	0.0049
Detection Time (seconds)	<5	<5
Fall Time (seconds)	<5	<5

Table 7. Results of the 924 with E85

Parameter	Data - NO	Data - NC
Threshold Level	2.5578	2.2419
Precision - Standard Deviation (inches)	0.0049	0.0093
Detection Time (seconds)	<5	<5
Fall Time (seconds)	<5	<5

Table 8. Results of the 924 with Unleaded

Parameter	Data - NO	Data - NC
Threshold Level	2.5585	2.2428
Precision - Standard Deviation (inches)	0.0029	0.0055
Detection Time (seconds)	<5	<5
Fall Time (seconds)	<5	<5

925 Sensor

Table 9. Results of the 925 lowest level bottom float with Water

Parameter	Data - NO	Data - NC
Threshold Level (inches)	2.5872	2.2654
Precision - Standard Deviation (inches)	0.0044	0.0032
Detection Time (seconds)	<5	<5
Fall Time (seconds)	<5	<5

Table 10. Results of the 925 lowest level bottom float with Diesel

Parameter	Data - NO	Data - NC
Threshold Level (inches)	2.7765	2.4515
Precision - Standard Deviation (inches)	0.0024	0.0032
Detection Time (seconds)	<5	<5
Fall Time (seconds)	<5	<5

Table 11. Results of the 925 lowest level bottom float with E85

Parameter	Data - NO	Data - NC
Threshold Level	2.8126	2.4986
Precision - Standard Deviation (inches)	0.0025	0.0041
Detection Time (seconds)	< 5	< 5
Fall Time (seconds)	< 5	< 5

Table 12. Results of the 925 lowest level bottom float with Unleaded

Parameter	Data - NO	Data - NC
Threshold Level	2.8385	2.5141
Precision - Standard Deviation (inches)	0.0034	0.0024
Detection Time (seconds)	< 5	< 5
Fall Time (seconds)	< 5	<5

Table 13. Results of the 925 lowest level top float with Water

Parameter	Data - NO	Data - NC
Threshold Level (inches)	5.0780	4.7808
Precision - Standard Deviation (inches)	0.0021	0.0024
Detection Time (seconds)	< 5	<5
Fall Time (seconds)	<5	<5

Table 14. Results of the 925 lowest level top float with Diesel

Parameter	Data - NO	Data - NC
Threshold Level (inches)	5.2676	4.9346
Precision - Standard Deviation (inches)	0.0042	0.0029
Detection Time (seconds)	< 5	< 5
Fall Time (seconds)	<5	<5

Table 15. Results of the 925 lowest level top float with E85

Parameter	Data - NO	Data - NC
Threshold Level	5.2793	4.9636
Precision - Standard Deviation (inches)	0.0018	0.0030
Detection Time (seconds)	< 5	< 5
Fall Time (seconds)	< 5	< 5

Table 16. Results of the 925 lowest level top float with Unleaded

Parameter	Data - NO	Data - NC
Threshold Level	5.3068	4.9891
Precision - Standard Deviation (inches)	0.0037	0.0027
Detection Time (seconds)	< 5	< 5
Fall Time (seconds)	< 5	< 5

Table 17. Results of the 925 highest level bottom float with Water

Parameter	Data - NO	Data - NC
Threshold Level (inches)	53.0631	52.7580
Precision - Standard Deviation (inches)	0.0026	0.0022
Detection Time (seconds)	< 5	<5
Fall Time (seconds)	<5	<5

Table 18. Results of the 925 highest level bottom float with Diesel

Parameter	Data - NO	Data - NC
Threshold Level (inches)	53.3214	52.9956
Precision - Standard Deviation (inches)	0.0049	0.0021
Detection Time (seconds)	< 5	< 5
Fall Time (seconds)	<5	<5

Table 19. Results of the 925 highest level bottom float with E85

Parameter	Data - NO	Data - NC
Threshold Level	53.3488	53.0349
Precision - Standard Deviation (inches)	0.0046	0.0026
Detection Time (seconds)	< 5	< 5
Fall Time (seconds)	< 5	< 5

Table 20. Results of the 925 highest level bottom float with Unleaded

Parameter	Data - NO	Data - NC
Threshold Level	53.3855	53.0901
Precision - Standard Deviation (inches)	0.0025	0.0043
Detection Time (seconds)	< 5	< 5
Fall Time (seconds)	< 5	< 5

Table 21. Results of the 925 highest level top float with Water

Parameter	Data - NO	Data - NC
Threshold Level (inches)	55.5612	55.2351
Precision - Standard Deviation (inches)	0.0022	0.0024
Detection Time (seconds)	< 5	< 5
Fall Time (seconds)	<5	<5

Table 22. Results of the 925 highest level top float with Diesel

Parameter	Data - NO	Data - NC
Threshold Level (inches)	55.8120	55.4769
Precision - Standard Deviation (inches)	0.0034	0.0027
Detection Time (seconds)	< 5	< 5
Fall Time (seconds)	<5	<5

Table 23. Results of the 925 highest level top float with E85

Parameter	Data - NO	Data - NC
Threshold Level	55.8479	55.5133
Precision - Standard Deviation (inches)	0.0036	0.0025
Detection Time (seconds)	< 5	< 5
Fall Time (seconds)	< 5	< 5

Table 24. Results of the 925 highest level top float with Unleaded

Parameter	Data - NO	Data - NC
Threshold Level	55.8861	55.5567
Precision - Standard Deviation (inches)	0.0030	0.0029
Detection Time (seconds)	< 5	< 5
Fall Time (seconds)	< 5	< 5

Specificity – The sensors will respond to any liquid after the threshold is exceeded.
This testing was specifically done to determine performance using water, E85, 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)

Craig Wilcox, Vice President
(printed name)

H. Kendall Wilcox

Craig Wilcox

(Signature)

(Signature)

Ken Wilcox Associates, Inc.
(organization performing evaluation)

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

September 30, 2015
(date)

(816) 443-2494
(phone number)

Laboratory Data

Morrison Bros. Co. Sensor Data

Test Results for the 924 LS Sensor - Normally Closed

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	0.631	0.7075	0.715	0.722
2	0.628	0.703	0.717	0.725
3	0.633	0.694	0.72	0.724
4	0.6365	0.6945	0.7185	0.728
5	0.633	0.7	0.712	0.731
6	0.6265	0.707	0.7145	0.7285
Mean	0.6313	0.7010	0.7162	0.7264
STDEV	0.0037	0.0059	0.0029	0.0033
Threshold	0.6449	0.7229	0.7270	0.7387

Test Results for the 924 LS Sensor - Normally Open

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	0.788	0.8945	0.9195	0.929
2	0.799	0.8955	0.9225	0.9315
3	0.794	0.888	0.927	0.932
4	0.795	0.8995	0.9175	0.929
5	0.801	0.8945	0.919	0.928
6	0.8015	0.893	0.9205	0.9345
Mean	0.7964	0.8942	0.9210	0.9307
STDEV	0.0051	0.0037	0.0034	0.0024
Threshold	0.8155	0.9080	0.9335	0.9397

Test Results for the 924 Sensor - NC position

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	2.007	2.1625	2.219	2.2285
2	2.0115	2.175	2.216	2.224
3	2.001	2.1685	2.212	2.2165
4	2	2.176	2.1995	2.215
5	2.003	2.1695	2.199	2.227
6	2.0055	2.171	2.199	2.2235
Mean	2.0047	2.1704	2.2074	2.2224
STDEV	0.0043	0.0049	0.0093	0.0055
Threshold	2.0205	2.1886	2.2419	2.2428

Test Results for the 924 Sensor -NO position

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	2.315	2.4965	2.5315	2.547
2	2.315	2.484	2.5375	2.552
3	2.326	2.487	2.5455	2.5465
4	2.321	2.484	2.5395	2.5505
5	2.314	2.485	2.5425	2.545
6	2.326	2.497	2.542	2.545
Mean	2.3195	2.4889	2.5398	2.5477
STDEV	0.0056	0.0062	0.0049	0.0029
Threshold	2.3403	2.5118	2.5578	2.5585

Test Results for the 925 Sensor - Low Level - Bottom Float - NO position

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	2.2575	2.4405	2.479	2.506
2	2.2495	2.4345	2.486	2.5055
3	2.2525	2.4445	2.489	2.507
4	2.255	2.439	2.4815	2.5015
5	2.2565	2.44	2.486	2.5035
6	2.251	2.4385	2.4795	2.508
Mean	2.2537	2.4395	2.4835	2.5053
STDEV	0.0032	0.0032	0.0041	0.0024
Threshold	2.2654	2.4515	2.4986	2.5141

Test Results for the 925 Sensor - Low Level - Bottom Float - NC position

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	2.566	2.768	2.8065	2.825
2	2.5785	2.7695	2.7995	2.8205
3	2.572	2.764	2.804	2.8295
4	2.569	2.7705	2.805	2.828
5	2.5725	2.7655	2.8035	2.8285
6	2.5685	2.767	2.8015	2.824
Mean	2.5711	2.7674	2.8033	2.8259
STDEV	0.0044	0.0024	0.0025	0.0034
Threshold	2.5872	2.7765	2.8126	2.8385

Test Results for the 925 Sensor -Low Level - Top Float - Normally Closed

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	4.7705	4.921	4.955	4.981
2	4.7755	4.925	4.9525	4.9775
3	4.769	4.9265	4.948	4.975
4	4.7715	4.9275	4.9495	4.981
5	4.774	4.9205	4.955	4.982
6	4.771	4.923	4.9545	4.978
Mean	4.7719	4.9239	4.9524	4.9791
STDEV	0.0024	0.0029	0.0030	0.0027
Threshold	4.7808	4.9346	4.9636	4.9891

Test Results for the 925 Sensor - Low Level - Top Float - Normally Open

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	5.0715	5.2585	5.2735	5.2875
2	5.069	5.247	5.271	5.292
3	5.0675	5.2495	5.274	5.297
4	5.0735	5.2515	5.275	5.2955
5	5.0695	5.2555	5.2705	5.2905
6	5.0705	5.251	5.273	5.296
Mean	5.0703	5.2522	5.2728	5.2931
STDEV	0.0021	0.0042	0.0018	0.0037
Threshold	5.0780	5.2676	5.2793	5.3068

Test Results for the 925 Sensor -High Level - Bottom Float - Normally Closed

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	52.75	52.9895	53.0255	53.079
2	52.748	52.985	53.0215	53.0705
3	52.747	52.989	53.028	53.0775
4	52.7505	52.9905	53.0245	53.0765
5	52.752	52.9865	53.023	53.068
6	52.7525	52.987	53.028	53.0725
Mean	52.7500	52.9879	53.0251	53.0740
STDEV	0.0022	0.0021	0.0026	0.0043
Threshold	52.7580	52.9956	53.0349	53.0901

Test Results for the 925 Sensor - High Level - Bottom Float - Normally Open

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	53.052	53.299	53.3295	53.3755
2	53.0505	53.3005	53.329	53.3745
3	53.055	53.309	53.3275	53.373
4	53.0575	53.2975	53.338	53.3795
5	53.052	53.3045	53.3285	53.3785
6	53.0545	53.3085	53.337	53.377
Mean	53.0536	53.3032	53.3316	53.3763
STDEV	0.0026	0.0049	0.0046	0.0025
Threshold	53.0631	53.3214	53.3488	53.3855

Liquid Level Sensor - Results Form

Test Results for the 925 Sensor -High Level - Top Float - Normally Closed

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	55.225	55.466	55.5015	55.549
2	55.228	55.4625	55.504	55.5485
3	55.2295	55.4685	55.5055	55.5415
4	55.227	55.4675	55.506	55.545
5	55.223	55.4705	55.501	55.547
6	55.2245	55.4665	55.507	55.5435
Mean	55.2262	55.4669	55.5042	55.5458
STDEV	0.0024	0.0027	0.0025	0.0029
Threshold	55.2351	55.4769	55.5133	55.5567

Test Results for the 925 Sensor - High Level - Top Float - Normally Open

Run #	Height at Alarm(inches)			
	Water	Diesel	E85	Unleaded
1	55.553	55.8005	55.831	55.8765
2	55.5505	55.797	55.836	55.876
3	55.5535	55.7965	55.8385	55.8705
4	55.5565	55.8025	55.829	55.872
5	55.554	55.804	55.8365	55.8785
6	55.551	55.796	55.8355	55.876
Mean	55.5531	55.7994	55.8344	55.8749
STDEV	0.0022	0.0034	0.0036	0.0030
Threshold	55.5612	55.8120	55.8479	55.8861

***Detection Time for both alarm consoles and all liquids - <5 seconds**

***Fall Time for both alarm consoles and all liquids - <5 seconds**