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White Paper: laboratory testing for KAM LRW Low Range Watercut Meter for custody transfer/BS&W

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INTRODUCTION

This paper summarizes analysis of the results of multiple laboratory tests for the KAM LRW Low Range Watercut Meter. The meter uses a microwave resonance technology, new to the KAM product line up. Tests were conducted both as a part of in-house product development and live customer demonstrations. The chief goal was to understand the accuracy of the technology at different water percentages and across different calibrated ranges for the unit.

TEST METHOD

Tests were conducted at the KAM factory using a flow loop with an LRW placed vertically in line. Mixing was generated via the circulation pump and mixing elements incorporated into liquid vessel. Test was conducted with dry motor oil (5w-30) and diesel. Known quantities of water, measured with a graduated cylinder, were added sequentially to accumulate desired percentages of water within sample fluid at predetermined levels. Results were recorded at each test point once the fluid became well mixed within the flow loop. Results were presented as absolute error (calculated water percentage vs LRW reading) and total error (calculated water percentage plus uncertainty associated with manual volumetric measurement of the water vs LRW reading).

FACTORY TEST DATA

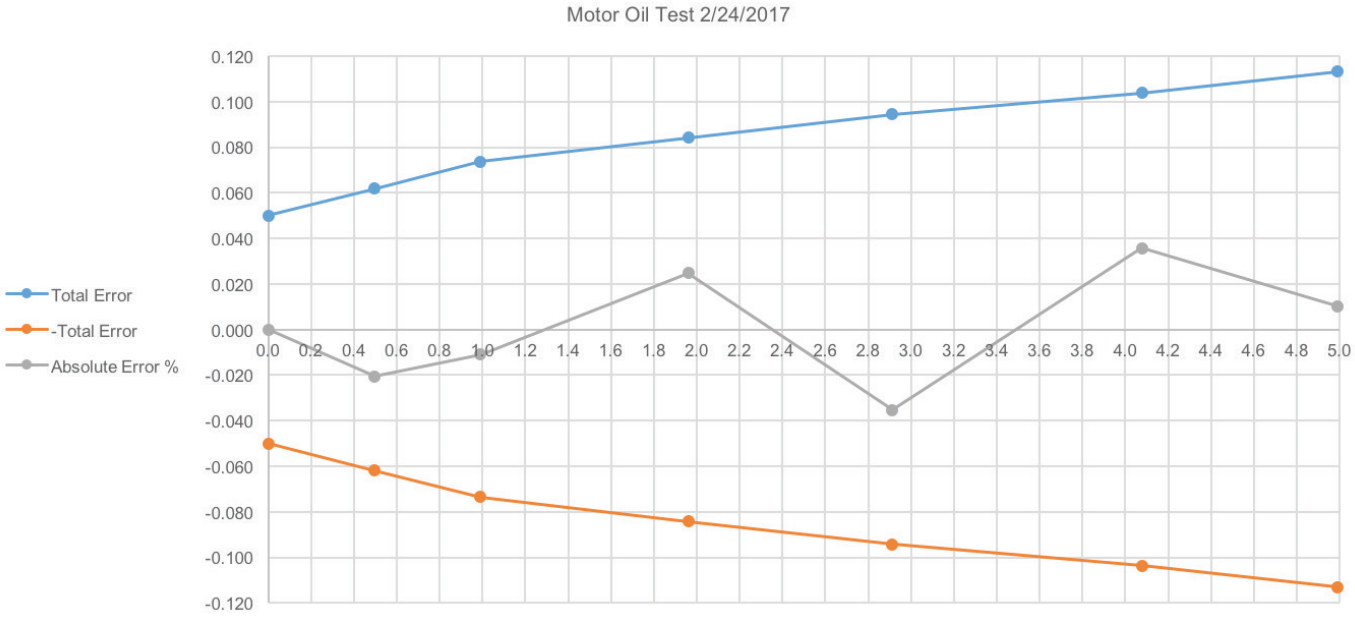
Test 1: motor oil

Instrument LRW 0-5 % Demo
Instrument Error 0.05 % LRW 1" FT No PEEK **Test** 2/24/17
Measuring Equipment Weight Scale & Graduated Cylinder

	Calculated % Water	Water added	Total mL	Oil mL	Water mL	LRW Reading %	Absolute Error %	Volumetric Error %	Total Error		Water Range Min	Water Range Max
1	**0.000**	0	4000	4000	0	0	0.000	0.000	0.050	-0.050	-0.050	0.050
2	**0.498**	20	4020	4000	20	0.518	-0.020	0.012	0.062	-0.062	0.436	0.559
3	**0.990**	20	4040	4000	40	1.001	-0.011	0.024	0.074	-0.074	0.917	1.064
4	**1.961**	40	4080	4000	80	1.936	0.025	0.034	0.084	-0.084	1.877	2.045
5	**2.913**	40	4120	4000	120	2.948	-0.035	0.044	0.094	-0.094	2.818	3.007
6	**4.077**	50	4170	4000	170	4.041	0.036	0.054	0.104	-0.104	3.973	4.180
7	**4.988**	40	4210	4000	210	4.978	0.010	0.063	0.113	-0.113	4.875	5.101

Laboratory testing for KAM LRW Low Range Watercut Meter for custody transfer/BS&W continued

Test 1: LRW vs total error

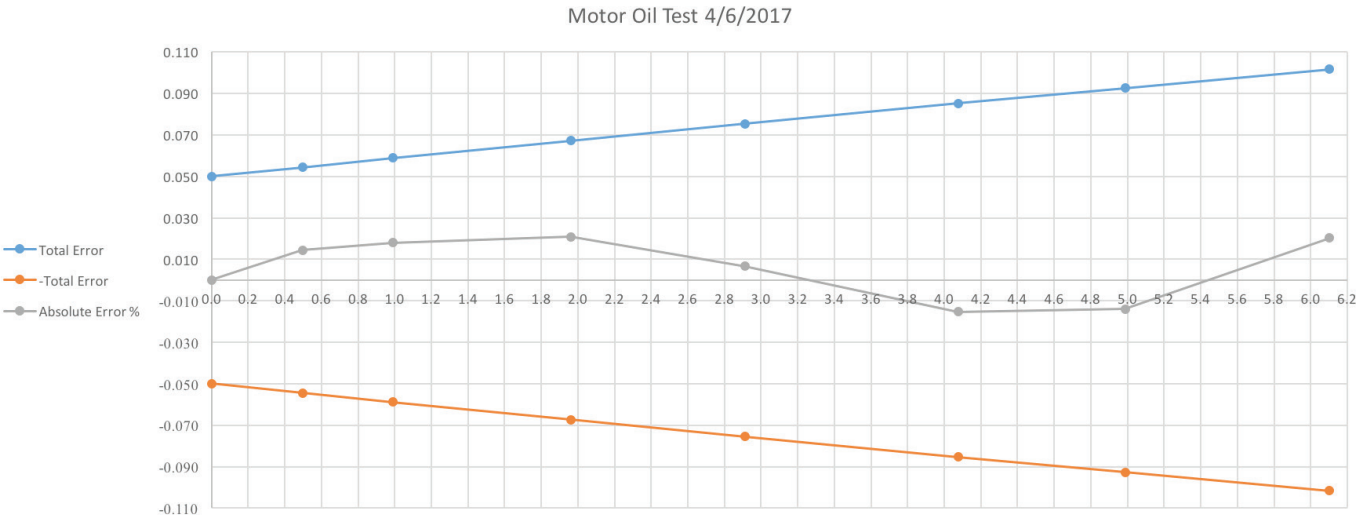


Test 2: motor oil

Instrument	LRW 0-5 % Demo			
Instrument Error	0.05 %	LRW 1" FT No PEEK	**Test**	4/6/17 Motor Oil Test
Measuring Equipment	Weight Scale & Graduated Cylinder			

	Calculated % Water	Water added	Total mL	Oil mL	Water mL	LRW Reading %	Absolute Error %	Volumetric Error %	Total Error		Water Range	
											Min	Max
1	**0.000**	0	4000	4000	0	0.000	0.000	0.000	0.050	-0.050	-0.050	0.050
2	**0.498**	20	4020	4000	20	0.483	0.015	0.004	0.054	-0.054	0.443	0.552
3	**0.990**	20	4040	4000	40	0.972	0.018	0.009	0.059	-0.059	0.931	1.049
4	**1.961**	40	4080	4000	80	1.940	0.021	0.017	0.067	-0.067	1.893	2.028
5	**2.913**	40	4120	4000	120	2.906	0.007	0.025	0.075	-0.075	2.837	2.988
6	**4.077**	50	4170	4000	170	4.092	-0.015	0.035	0.085	-0.085	3.991	4.162
7	**4.988**	40	4210	4000	210	5.002	-0.014	0.043	0.093	-0.093	4.895	5.081
8	**6.103**	50	4260	4000	260	6.083	0.020	0.052	0.102	-0.102	6.002	6.205

Test 2: LRW vs total error



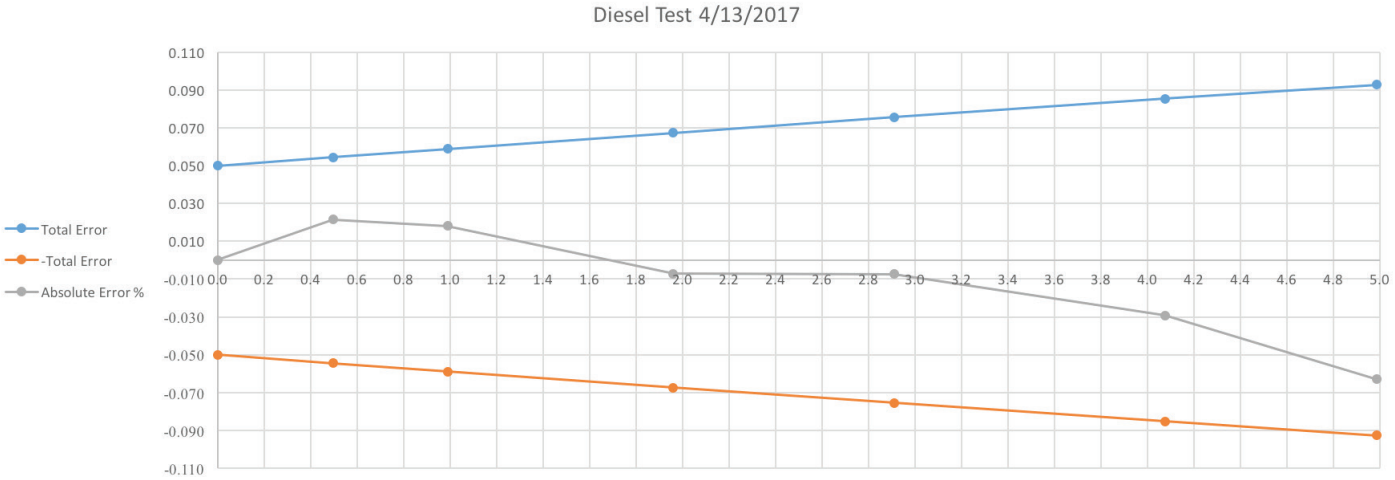
Laboratory testing for KAM LRW Low Range Watercut Meter for custody transfer/BS&W continued

Test 3: diesel

Instrument LRW 0-5 %
Instrument Error 0.05 % LRW 1" FT No PEEK **Test** 4/13/17 Diesel Test
Measuring Equipment Weight Scale & Graduated Cylinder

	Calculated % Water	Water added	Total mL	Diesel mL	Water mL	LRW Reading %	Absolute Error %	Volumetric Error %	Total Error		Water Range Min	Water Range Max
1	**0.000**	0	4000	4000	0	0.000	0.000	0.000	0.050	-0.050	-0.050	0.050
2	**0.498**	20	4020	4000	20	0.476	0.022	0.004	0.054	-0.054	0.443	0.552
3	**0.990**	20	4040	4000	40	0.972	0.018	0.009	0.059	-0.059	0.931	1.049
4	**1.961**	40	4080	4000	80	1.968	-0.007	0.017	0.067	-0.067	1.893	2.028
5	**2.913**	40	4120	4000	120	2.920	-0.007	0.025	0.075	-0.075	2.837	2.988
6	**4.077**	50	4170	4000	170	4.106	-0.029	0.035	0.085	-0.085	3.991	4.162
7	**4.988**	40	4210	4000	210	5.051	-0.063	0.043	0.093	-0.093	4.895	5.081

Test 3: LRW vs total error



Test 4: motor oil

Instrument LRW 0-3 %
Instrument Error 0.03 % LRW 1" FT No PEEK **Test** 6/8/17 Motor Oil Test
Measuring Equipment Weight Scale & Graduated Cylinder

	Calculated % Water	Water added	Total mL	Diesel mL	Water mL	LRW Reading %	Absolute Error %	Volumetric Error %	Total Error		Water Range Min	Water Range Max
1	**0.000**	0	4000	4000	0	0.000	0.000	0.000	0.030	-0.030	-0.030	0.030
2	**0.249**	10	4010	4000	10	0.238	0.011	0.002	0.032	-0.032	0.217	0.281
3	**0.498**	10	4020	4000	20	0.487	0.011	0.004	0.034	-0.034	0.464	0.531
4	**0.744**	10	4030	4000	30	0.763	-0.019	0.006	0.036	-0.036	0.708	0.780
5	**0.990**	10	4040	4000	40	1.011	-0.021	0.008	0.038	-0.038	0.952	1.028
6	**1.961**	40	4080	4000	80	1.977	-0.016	0.018	0.048	-0.048	1.913	2.009
7	**2.913**	40	4120	4000	120	2.913	0.000	0.027	0.057	-0.057	2.855	2.970

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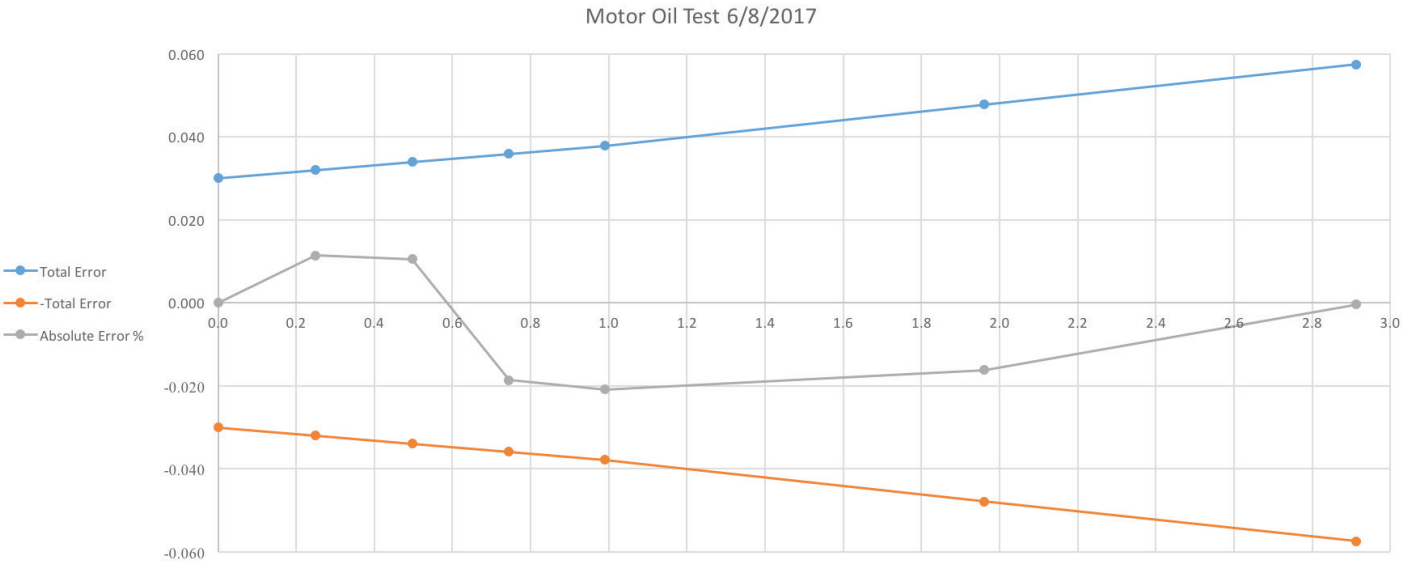
Test 4: LRW vs total error



Conclusion:

In all cases, the LRW performed better than stated accuracy with a maximum differentiation off total error of 0.043% on 0-5% models and 0.027% on 0-3% models. Meter sensitivity to water change was nearly instantaneous and readings were extremely stable once fluid achieved homogeneity.

The high accuracy and consistency of LRW provides a better solution for BS&W measurement, in particular in custody transfer situations, including automatic ticketing where it is key to minimize overall system uncertainty.

Morever, the microwave technology used has a linear relationship to changes associated with density, allowing for a straightforward correction to any change in density when density readings are fed to the LRW, generally from a mass flow meter. This is key factor in truck unloading stations seeing large changes in density from batch to batch. These differences can be as great as batches in the low 20s to batches in the 60s API gravity.