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Evaluation of Remote System For Oil Pollution Detection

Final Report

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Equipment:	Remote System For Oil Pollution Detection
Version:	ROW O-2300A
Test procedure:	U.S. EPA Standard Test Procedures for Evaluating Leak Detection Methods: Liquid-phase Out-of-Tank Product Detectors, EPA/530/UST-90/009

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1 Accuracy, Detection Time and Fall Time

1.1 Summary of Test Method

Remote System For Oil Pollution Detection ROW O-2300A is an autonomous non-contact sensor that uses oil's native fluorescence for detection. The detector probe was supported over the container (25 cm height) that had a layer of liquid hydrocarbon test product on water. For determination of accuracy and detection and fall times detector was tested five times at three test product thickness: 0.01cm, 0.02cm, and 0.04cm. Detector response was monitored for up to 24 hours. The performance of detector was tested with Marine Diesel Oil and Crude Oil.

1.2 Apparatus and Materials

Apparatus used for experiments included: Remote System For Oil Pollution Detection (LDI, Estonia), cylindrical glass container with anodized black plate on the bottom for noise reduction (diameter 9 cm, nominal volume 1 l), calipers with 0.1 mm gradation for measurement of inside diameter of test container and data acquisition system „ROW Configuration Software 5.1.0.2" (LDI, Estonia), capable unambiguously identify activated and inactivated states. Drinking water was used in all experiments with temperature 17-19 °C. Test products were provided by LDI AS (Estonia) and kept at room temperature.

1.3 Calibration and Standardization

Data recording system and detector was calibrated according to instructions from the manufacturer. Test container area was calculated with the following formula: Area, $cm^2 = 0.785 \times d_c^2$, where d_c – test container inside diameter, cm.

1.4 Procedure

The detector was tested five times for each test product and hydrocarbon layer thickness listed in p.1.1. Before each experiment a blank test was performed by monitoring the detector output for 30 minutes. The amount of product to add to the water was calculated with the following equation:

$$\text{Volume, ml} = t \times a_c,$$

where t – desired product thickness, cm;

a_c – test container cross-sectional area, cm^2.

The detector response was monitored immediately after adding the product to the test container until it activates or 24 hours elapse, whichever is shorter. The detector output was recorded at the end of the test period.

1.5 Results

Accuracy: Accuracy for qualitative detectors is the ratio of number of positive responses (r_p) to the number of tests for particular test product at a particular thickness (n), expressed in percents:

$$\text{Accuracy,\%} = 100 \times (r_p/n).$$

Results are presented in Table 1.

Detection time: The elapsed time between when the test product was added to the container and when the detector responded (output went from an inactivated state to an activated state) is the detection time. The detection time for Remote System for Oil Pollution Detection ROW O-2300A was less than one second (See Table 1).

Fall time: The elapsed time after the test product is removed from the container until detector's output returns to inactivated state is the fall time. The fall time for Remote System for Oil Pollution Detection ROW O-2300A was less than one second (See Table 1).

Table 1. Accuracy, Detection Time and Fall Time results.

	Product	Layer thickness, cm	Number of tests	Positive responses	Accuracy, %	Detection time	Fall time
1	**Marine diesel oil**	0,01	5	5	100	<1s	<1s
		0,02	5	5	100	<1s	<1s
		0,04	5	5	100	<1s	<1s
2	**Crude oil**	0,01	5	5	100	<1s	<1s
		0,02	5	5	100	<1s	<1s
		0,04	5	5	100	<1s	<1s

2 Lower Detection Limit

2.1 Summary of Test Method

Detector probe was supported over the container (25 cm height) that had a layer of liquid hydrocarbon test product on water. For determination of Lower Detection Limit (LDL) the detector was screened at several different test product thicknesses (Tables 2 and 3) to determine the lowest thickness of which the detector would respond reliably. Detector response was monitored for up to 24 hours. The performance of detector was tested with Marine Diesel Oil and Crude Oil.

2.2 Apparatus and Materials

Apparatus used for experiments included: Remote System For Oil Pollution Detection (LDI, Estonia), two cylindrical glass containers with anodized black plate on the bottom for noise reduction, the first container with diameter 9 cm, nominal volume 1 l, and second one with diameter 21.4 cm and volume 10 l, calipers with 0.1 mm gradation for measurement of inside diameter of test container and data acquisition system „ROW Configuration Software 5.1.0.2“ (LDI, Estonia), capable unambiguously identify activated and inactivated states. Drinking water was used in all experiments with temperature 17-19 °C. Test products were provided by LDI AS (Estonia) and kept at room temperature.

2.3 Calibration and Standardization

Data recording system and detector was calibrated according to instructions from their manufacturer. Test container area was calculated with the following formula: Area, $cm^2 = 0.785 \times d_c^2$, where d_c – test container inside diameter, cm.

2.4 Procedure

The detector was tested for each test product at several hydrocarbon layer thicknesses (Table 2) to determine the LDL and LDL- thicknesses. Then six experiments for LDL and six experiments for LDL- thicknesses were carried out, in order to state with 95% confidence that the detector will respond to a minimum of 50 percent to the LDL thickness and a maximum of 50% to the LDL- thickness. Before each experiment a blank test was performed by monitoring the detector output for 30 minutes. The amount of product to add to the water was calculated with the following equation:

$$\text{Volume, ml} = t \times a_c,$$

where t – desired product thickness, cm;

a_c – test container cross-sectional area, cm^2.

The detector response was monitored immediately after adding the product to the test container until it activates or 24 hours elapse, whichever is shorter. The detector baseline and output was recorded at the end of the test period.

2.5 Results

The results of LDL and LDL- experiments for Marine Diesel Oil and Crude Oil are presented in Tables 2 and 3.

Table 2. LDL and LDL- for Marine Diesel Oil

Product	Sample nr	Baseline	Layer thickness, µm	Output with product	State*
Marine diesel oil	r1	1 341,70	100,00	47 990,99	Alarm
	r1	1 341,70	20,00	25 147,40	Alarm

	r1	1 341,70	5,00	25 147,40	Alarm
	r1	1 333,20	1,00	3 268,40	Alarm
	r1	1 341,70	0,50	1 871,36	Alarm
	r1	1 321,30	0,35	1 812,16	Alarm
	r1	1 391,93	0,25	1 910,03	Alarm
	r1	1 385,07	0,19	1 745,53	Alarm
	r1	1 393,24	0,17	1 878,37	Alarm
LDL	r1	1 364,03	0,14	1 721,65	Alarm
	r2	1 371,26	0,14	1 745,92	Alarm
	r3	1 412,30	0,14	1 881,19	Alarm
	r4	1 382,84	0,14	1 876,84	Alarm
	r5	1 327,25	0,14	1 729,74	Alarm
	r6	1 355,84	0,14	2 081,34	Alarm
	r1	1 391,82	0,11	1 632,30	OK-Alarm
	r2	1 355,41	0,11	1 698,90	Alarm
	r3	1 361,04	0,11	1 624,68	OK-Alarm
LDL-	r1	1 365,17	0,08	1 626,38	OK
	r2	1 393,29	0,08	1 602,77	OK
	r3	1 342,40	0,08	1 531,70	OK
	r4	1 347,39	0,08	1 593,74	OK
	r5	1 337,02	0,08	1 594,74	OK
	r6	1 312,98	0,08	1 618,48	OK

Table 3. LDL and LDL- for Crude Oil

Product	Sample nr	Baseline	Layer thickness, µm	Output with product	State*
Crude oil	r1	1 367,49	100,00	9 861,31	Alarm
	r1	1 329,90	20,00	10 309,62	Alarm
	r1	1 284,93	5,00	7 780,43	Alarm
	r1	1 335,48	1,00	3 770,40	Alarm
	r1	1 386,43	0,50	2 690,05	Alarm
	r1	1 320,68	0,25	2 044,80	Alarm
LDL	r1	1 369,54	0,17	1 723,06	Alarm
	r2	1 368,52	0,17	1 849,08	Alarm
	r3	1 331,22	0,17	1 719,08	Alarm
	r4	1 371,46	0,17	1 829,25	Alarm
	r5	1 364,27	0,17	1 765,17	Alarm
	r6	1 328,50	0,17	1 710,73	Alarm
	r1	1 329,34	0,14	1 684,94	Alarm-OK
	r2	1 345,72	0,14	1 696,84	OK-Alarm-OK
	r3	1 376,29	0,14	1 617,17	OK-Alarm
LDL-	r1	1 331,10	0,11	1 622,20	OK
	r2	1 344,43	0,11	1 506,03	OK
	r3	1 373,81	0,11	1 611,18	OK

	r4	1 320,64	0,11	1 608,85	OK
	r5	1 369,83	0,11	1 597,51	OK
	r6	1 317,10	0,11	1 631,70	OK

* **Alarm** – refers to the state of the detector response when indicating the presence of hydrocarbons

OK – refers to the state of the detector response when indicating that no hydrocarbons are detected.

Reported Lower Detection Limit was found as an average of LDL and LDL- values**: 0.11** and **0.14 µm** for Marine Diesel Oil and Crude Oil correspondingly.

3 Specificity

3.1 Summary of Test Method

The detector probe was supported over the container (25 cm height) that had a 100 µm-thick layer of liquid hydrocarbon test product on water.. Detector was exposed to each of seventeen (Table 4) different test products. Detector response was monitored for up to 24 hours.

3.2 Apparatus and Materials

Apparatus used for experiments included: Remote System For Oil Pollution Detection (LDI, Estonia), cylindrical glass container with anodized black plate on the bottom for noise reduction (diameter 9 cm, nominal volume 1 l), calipers with 0.1 mm gradation for measurement of inside diameter of test container and data acquisition system „ROW Configuration Software 5.1.0.2“ (LDI, Estonia), capable unambiguously identify activated and inactivated states. Drinking water was used in all experiments with temperature 17-19 °C. Test products were provided by LDI AS (Estonia) and kept at room temperature.

3.3 Calibration and Standardization

Data recording system and detector was calibrated according to instructions from their manufacturer. Test container area was calculated with the following formula: Area, $cm^2 = 0.785 \times d_c^2$, where d_c – test container inside diameter, cm.

3.4 Procedure

The detector was tested with each of the test product listed in Table 4 at a hydrocarbon layer thickness of 100 µm (0.01 cm). Products IFO-380 and Bunker oil were dissolved in hexane with final concentration of 44 and 77 %(W) correspondingly. Before each experiment a blank test was performed by monitoring the detector output for 30 minutes. The amount of product to add to the water was calculated with the following equation:

$$\text{Volume, ml} = t \times a_c,$$

where t – desired product thickness, cm;

a_c – test container cross-sectional area, cm^2.

The detector response was monitored immediately after adding the product to the test container until it activates or 24 hours elapse, whichever is shorter. The detector baseline and output was recorded at the end of the test period.

3.5 Results

Specificity results are presented in Table 4.

Table 4. Specificity results

	Product	Baseline	Layer thickness, µm	Output with product	State***
1	Crude oil	1 367,49	100,00	9 861,31	Alarm
2	Marine diesel oil	1 373,45	100,00	40 362,60	Alarm
3	Brut Paraffin	1 308,27	100,00	18 364,28	Alarm
4	Diesel no 2	1 340,93	100,00	6 882,58	Alarm
5	Hydraulic oil	1 388,67	100,00	8 830,05	Alarm
6	Heating oil	1 303,93	100,00	12 977,99	Alarm
7	Gear oil	1 352,05	100,00	4 067,22	Alarm
8	Engine oil	1 157,49	100,00	28 580,95	Alarm
9	Gas oil	1 321,12	100,00	33 847,33	Alarm
10	Sunflower oil	1 330,05	100,00	1 887,99	Alarm
11	Olive oil	1 327,83	100,00	1 690,37	Alarm
12	Gasoline 95E	1 370,13	100,00	3 136,78	Alarm
13	Xylene	1 362,21	100,00	1 477,34	OK**
14	IFO-380*	1 385,88	100,00	5 591,71	Alarm
15	Toluene	1 331,66	100,00	1 544,26	OK**
16	Calsol 8240	1 413,90	100,00	33 417,31	Alarm
17	Bunker oil*	1 314,30	100,00	2 168,19	Alarm

* product dissolved in hexane
** output at the end of 24h
*** **Alarm** – refers to the state of the detector response when indicating the presence of hydrocarbons

OK – refers to the state of the detector response when indicating that no hydrocarbons are detected.

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