ASTM F2709-08 Testing of Skimmer Systems at Ohmsett Facility

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Abstract

The Bureau of Safety and Environmental Enforcement (BSEE) recently conducted independent performance testing of various skimming systems owned by BSEE and the United States Coast Guard (USCG) with the goal of better understanding the relationship between manufactures' published nameplate capacity rates and rates obtained through testing to a prescribed standard. Skimmers were tested at the Ohmsett Facility to ASTM F2709-08 "Standard Test Method for Determining Nameplate Recovery Rate of Stationary Oil Skimmer Systems".

A total of thirteen ASTM F2709-08 tests were conducted on seven skimmers including weir, drum, disc, brush and mop systems. Most skimmers were tested in category I and category II test oils as defined in ASTM F631 "Standard Guide for Collecting Skimmer Performance Data in Controlled Environments". Skimmers were tested in a boomed area within the Ohmsett tank in calm conditions with an initial slick thickness of 75 mm. Prior to qualifying tests, optimization tests were conducted to determine optimum operating parameters of each skimming system. Manufacturer representatives were invited to participate in the testing.

Data collected included Oil Recovery Rate (ORR) and Recovery Efficiency (RE) for each skimming system as well as other data typically collected at the Ohmsett facility and prescribed by ASTM F2709-08. Results were compared to manufacturer's published nameplate capacity values. Several interesting observations were noted and recommendations are indicated from this series of tests.

- Oil viscosity seemed to have little effect on the performance of most of the skimmers tested.
- One of the skimmers did perform significantly different in category I and II oils. For these types of skimmers, manufacturers should provide nameplate capacity data for each category of oil.
- Pump rates were used as nameplate capacity data for several of the skimmers; in some cases this did not provide an accurate estimate of the ORR values obtained in testing. This indicates the importance of system testing to obtain a realistic ORR for the entire system in the condition indicated.
- ORRs collected for this set of tests compared well to previous ASTM 2709-08 test results on the same skimmer (data limited to one skimmer). For this one data point, results indicate that the ASTM 2709-08 test method produces repeatable results.

1 Introduction

The Bureau of Safety and Environmental Enforcement (BSEE) recently conducted independent performance testing of various skimming systems owned by BSEE and the United States Coast Guard (USCG) with the goal of better understanding the relationship between the manufacturers' published nameplate capacity rates and rates obtained through testing with a prescribed standard. Skimmers were tested at the Ohmsett Facility between June and December 2014 using ASTM F2709-08 "Standard Test Method for Determining Nameplate Recovery Rate of Stationary Oil Skimmer Systems". The F2709-08 test is designed to quantify a skimming system's performance in terms of recovery rate and efficiency while in controlled optimum conditions.

2 Background

Skimmer system performance is quantified by nameplate capacity, a number used to indicate the rate at which oil can be collected by the skimmer system. Federal and State regulatory agencies utilize nameplate capacity data to assess adequacy of oil spill response plans, and to determine an operator's ability to effectively respond to a worst case discharge event. Oil Spill Removal Organizations (OSROs) and other prospective skimmer customers use nameplate capacity data to make purchase decisions.

Currently there is no requirement for manufacturers to test their skimmer to determine nameplate capacity; manufacturers may base nameplate capacity solely on the skimmer's offload pump capability (Meyer et al., 2009).which does not give any indication of the effectiveness of other system components such as the skimmer collector. In addition, one manufacturer's nameplate capacity is not necessarily comparable with another manufacturer's nameplate capacity, making it difficult for prospective skimmer buyers to accurately gauge or compare skimmer oil recovery performance (Meyer et al., 2009).

The ASTM International F20 Committee on Hazardous Substances and Oil Spill Response recognized the need for a standard method to evaluate skimmer recovery performance as a system (including the skimmer's hydraulic power unit, skimmer, offload pump, and cargo hose), and developed and adopted ASTM F2709-08 "Standard Test Method for Determining Nameplate Recovery Rate of Stationary Oil Skimmer Systems". The F2709-08 test is intended to provide ideal recovery conditions, allowing the skimmer system to operate and collect oil at its maximum possible recovery rate, thereby testing the mechanical and physical limitations of the system while eliminating other limiting factors that might be encountered in actual field operation. (ASTM, 2013a)

Skimmer testing for this project was conducted at Ohmsett - The National Oil Spill Response Research and Renewable Energy Test Facility. Ohmsett, located on Naval Weapons Station Earle in Leonardo, NJ, is managed by the U.S. Department of the Interior's BSEE as part of its mandated requirements by the Oil Pollution Act of 1990 (OPA, 1990). Figure 1 shows a view of Ohmsett.

Figure 1 Ohmsett Facility

3 Systems Tested

A total of thirteen ASTM F2709-08 tests were conducted on seven skimmers. Six of these skimmers are owned by BSEE and utilized for various purposes at the Ohmsett facility. One skimmer, the Desmi Dop-Dual Terminator with Helix Circular Brush, is a USCG owned skimmer and is included in each of the USCG Strike Teams' response inventories. A brief description of each skimmer follows.

3.1 Elastec TDS 118G Drum Skimmer

The TDS 118G Drum Skimmer is a lightweight, shallow draft grooved drum skimmer. The skimmer, 135cm wide, 91cm long, uses two 43cm diameter, 43cm wide oleophilic grooved drums to recover oil. As the drums rotate through the slick, oil adheres to the surface of the drums and is scraped off by contour conforming scrapers located on the grooved face of the drums. The recovered oil flows into a perimeter trough and continues into a sump where it is offloaded as recovered fluid by the Elastec E150 transfer pump. An Elastec American Marine D-10 hydraulic power unit (HPU) provides the hydraulic power to the motors driving the drums and the offload pump. A 7.6cm diameter, 15m long cargo hose directs the recovered fluids to the elevated recovery tanks. Figure 2 shows the Elastec TDS 118G skimmer.

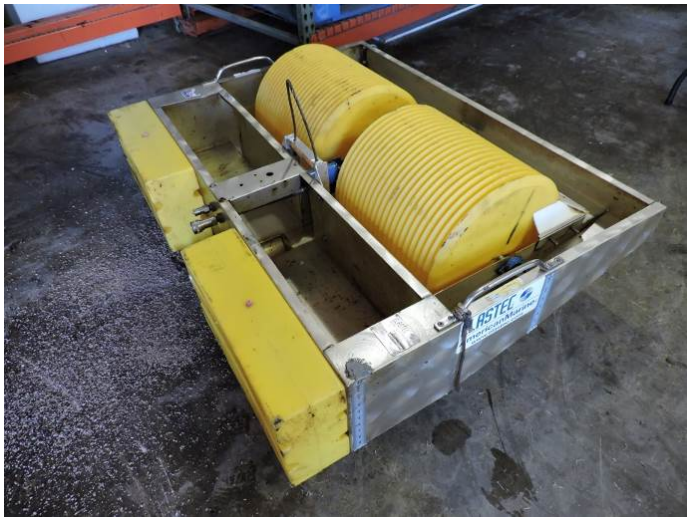

Figure 2 Elastec TDS 118G Drum Skimmer

3.2 Crucial C-14d Mop Wringer System

The Crucial C-14d Mop Wringer System is comprised of a mop drive and wringer unit plus an oleophilic mop. It uses two remotely secured pulleys and mounts to provide pivot points for the mop which is squeezed between two rollers to recover fluid. Recovered fluid flows into a sump and is offloaded using a Crucial PD-75H stand alone transfer pump. Power is supplied by a Crucial HPU model DHP-10MP. A 7.6cm diameter, 15m long cargo hose directs the recovered fluids to the elevated recovery tanks. Figure 3 shows the Crucial C-14d Mop Wringer.

Figure 3 Crucial C-14d Mop Wringer System

3.3 Lamor LWS 500\GTA50 Weir Skimmer

The Lamor LWS 500\GTA50 is a weir skimmer constructed of marine-grade aluminum and stainless steel, with polyethylene floats. The skimmer measures 2.3m x 2.2m x 0.79m high. Recovered fluid is offloaded by a Lamor model GTA-50 pump driven by a Lamor power pack LPP 589D HPU. A 10.1cm diameter, 15m long cargo hose directs the recovered fluids to the recovery tank. Figure 4 shows the Lamor LWS 500\GTA50 skimmer.

Figure 4 Lamor LWS 500\GTA50 Weir Skimmer

3.4 Desmi AFTI MI-2HD Disc Skimmer

The Desmi-AFTI MI-2HD is a 32kg triangular shaped disc skimmer constructed of fiberglass material. The skimmer contains three banks of 18cm diameter PVC discs and an integral offload pump. The MI-2HD is powered by a Desmi-AFTI diesel HPU. A 2.5cm diameter, 15m long cargo hose directs the recovered fluids to the elevated recovery tanks. Figure 5 shows the Desmi AFTI MI-2HD skimmer.

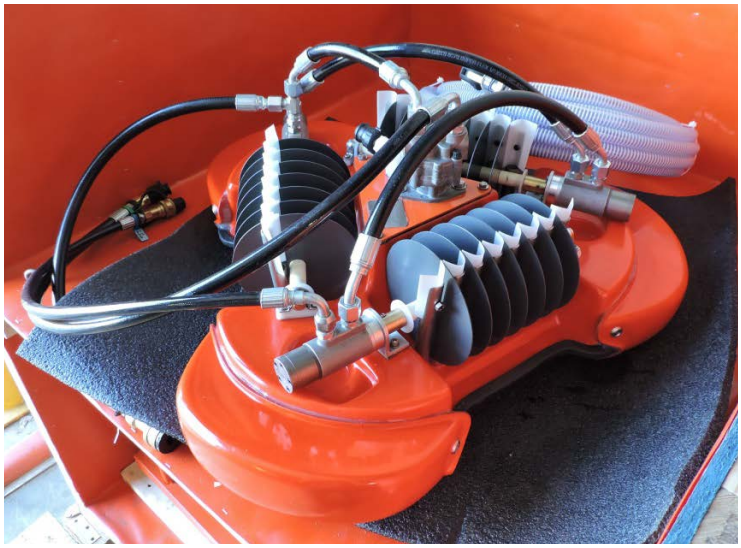

Figure 5 Desmi AFTI MI-2HD Disc Skimmer

3.5 Desmi Terminator Weir Skimmer

The Desmi Terminator is a weir skimmer. It has a 71cm diameter self-adjusting inlet weir and an integral DOP-Dual 250 pump. Its operating draft is 71cm. The skimmer is operated with a custom built 110 hp, 197Lpm open loop system built by Elastec. A 10.1cm diameter, 15m long cargo hose directs the recovered fluids to the elevated recovery tanks. Figure 6 shows the Desmi Terminator skimmer.

Figure 6 Desmi Terminator Weir Skimmer

3.6 Crucial C-13/24 Coated Disc Skimmer

The Crucial C-13/24 is a disc skimmer constructed of marine grade aluminum. The skimmer measures 111cm x 119cm x 66cm high and has thirteen 61cm diameter discs coated with a special blend of oleophilic polymers. Recovered oil is removed from the coated discs when rotated through a set of scrapers. The scraped oil then flows into a sump area where it can be offloaded. The skimmer is operated with a Model DHP-10 HPU and a Megator 2" Yellow Series DD pump model 50BY02. A 7.6cm diameter, 15m long cargo hose directs the recovered fluids to the elevated recovery tanks. Figure 7 shows the Crucial C-13/24 Skimmer.

Figure 7 Crucial C-13/24 Coated Disc Skimmer

3.7 Desmi Dop-Dual Terminator with Helix Circular Brush Skimmer

The Desmi Dop-Dual Terminator with Helix brush is a weir skimmer with a circular set of 27.9cm diameter oleophilic brushes. It is equipped with an integral Dop-Dual 250 offloading pump. The rotating brushes are hydraulically driven. The skimmer is powered by a custom built 110 hp, 197Lpm open loop system built by Elastec. A 10.2cm diameter, 15m long cargo hose directs the recovered fluids to the elevated recovery tanks. Figure 8 shows the Desmi with Helix Circular Brush skimmer.

Figure 8 Desmi Dop-Dual Terminator with Helix Circular Brush Skimmer

4 Overview of Test

Tests were performed at Ohmsett's outdoor saltwater test tank in a boomed area. Test area dimensions were set according to ASTM F2709-08 guidelines. Test oils were categorized per ASTM F631 and oil properties were reported at test conditions. The test oils chosen were Hydrocal 300 and Calsol 8240, ASTM F631 category I and II type oils respectively at nominal a temperature of 20➡C. Oil was added to the boomed area to create an initial oil thickness of 75mm. The skimmer's performance was measured as it recovered oil from a diminishing slick thickness of 75mm to 50mm. Performance data was determined from three repeatable qualifying tests and included Oil Recovery Rate (ORR) and Recovery Efficiency (RE). ORR is the total volume of oil recovered by the device per unit of time (water that is recovered along with the oil is not included in this calculation). RE is the ratio of the volume of oil recovered to the volume of total fluid recovered. The test method is further detailed in the following sections.

5 Test Details

5.1 Test Area

Tests were conducted in a boomed section of the Ohmsett test tank. The boomed area was individualized for each skimmer test to ensure that the area was a minimum of three times the size of the skimmer dimensions and provided a sufficient oil volume within the oil layer to allow a minimum of thirty seconds of steady state recovery as the layer was reduced from 75mm to 50mm (ASTM, 2013a). The skimmer was placed in the middle of the boomed area to allow for unrestricted oil replenishment around the device. ASTM 2709-08 requires a static head to be imposed on the skimmer system equal to 3.5m of fluid. To meet this requirement, the connected cargo hose was routed from the skimmer to the recovery tanks elevated 3.5m as shown in Figure 9.

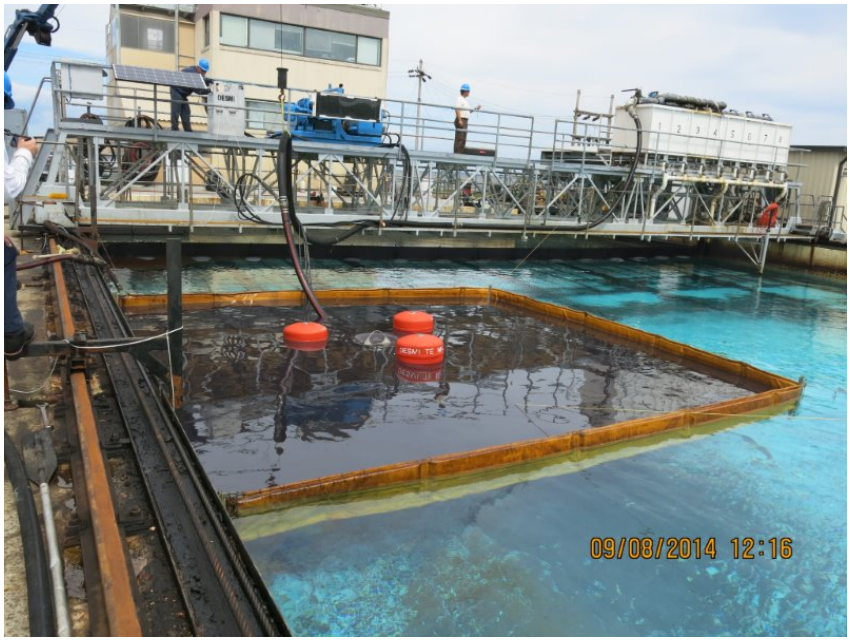

Figure 9 Boomed test area at Ohmsett

5.2 Test Fluids

All skimmers with the exception of the Desmi-AFTI MI-2HD skimmer were tested in two different standard Ohmsett test oils, Hydrocal 300 and Calsol 8240. The Desmi-AFTI MI-2HD was tested only in Hydrocal 300. The two test oils represent a category I and category II oil at 20➡C as defined in ASTM standard F631, Appendix X, Table X1.1 (ASTM, 2013b). However, skimmer tests occurred over a six month period in varying ambient temperatures and corresponding oil viscosities. Because of this, several of the oil viscosities fell outside of the defined ranges specified in ASTM F631. Noteable variations included the Desmi Helix tests in Hydrocal and Calsol and the Lamor LWS 500\GTA50 test with Calsol. The most significant variation occurred during the December Desmi Terminator test; oil viscosity was 22,600 cP which defined the Calsol for that particular test as a category III oil. Table 1 shows the nominal properties of the test oils at 20ºC. Table 2 shows the average fluid temperatures, water salinity, and oil viscosity each skimmer encountered during actual testing.

Table 1 Test Oil Nominal Properties

Oil	Density, (g/mL @ 20➡C)	Viscosity, (cP @ 20➡C)
Hydrocal 300	0.91	300
Calsol 8240	0.94	1900

Table 2 Average Temperature and Viscosity for Test Oils During Testing

Skimmer	Avg Water Temp (➡C) Hydrocal/ Calsol	Water Salinity (ppt)	Avg Temp Hydrocal (➡C)	Viscosity, Hydrocal (cP)	Avg Temp Calsol (➡C)	Viscosity, Calsol (cP)
Elastec TDS 118G	25/24	30	22	180	24	1770
Crucial C-14d Mop	27/25	30	26	150	26	1180
Lamor LWS 500\GTA50	24/27	29	29	120	34	670
Desmi AFTI MI-2HD	26/N/A	27	32	130	N/A	N/A
Desmi Terminator	24/6	27/24	24	160	2	22,600
Crucial C-13/24	19/19	26	24	170	23	1850
Desmi Dop-Dual Helix	10/10	25	9	620	11	5750

5.3 Slick Thickness

To simulate ideal conditions for recovery, the slick thickness should be substantial. Testing at Ohmsett in the summer of 2007 showed there was no significant change in performance, as measured by ORR, when the slick thickness was increased above 5cm (Ohmsett, 2007).

Following ASTM F2709-08 guidelines, the boomed area for each test was preloaded with sufficient oil to create a nominal slick thickness of 75 mm. Additional oil was added to provide for the hold-up volume in the cargo hose during startup and to bring the skimmer to steady state recovery conditions. As required by ASTM 2709-08, tests were conducted until the slick diminished from 75mm to 50mm and for a minimum time of 30 seconds. Table 3 shows the testing matrix and parameters based on ASTM F2709-08 requirements and selected test oils.

Table 3 Skimmer Test Matrix and Parameters

Skimmer	Boomed Area (m)	Pre-load Volume (Liter)	Estimated Hold-up Volume (Liter)	Total Pre-load (Liter)	Nominal Discharge Size (cm)	Test Oils
Desmi AFTI MI-2HD	2.5 x 2.5	480	20	500	2.5	Hydrocal
Crucial C-13/24	3.7 x 3.4	950	110	1060	7.6	Hydrocal Calsol
Elastec TDS 118G	4.0 x 2.7	840	150	990	7.6	Hydrocal Calsol
Crucial C-14d Mop	Triangular 3.0 x 7.6	800	150	950	7.6	Hydrocal Calsol
Desmi Dop-Dual Helix	7.3 x 6.6	3650	150	3800	10.2	Hydrocal Calsol
Desmi Terminator	6.8 x 6.8	3590	150	3740	10.2	Hydrocal Calsol
Lamor LWS 500\GTA50	6.8 x 6.6	3410	150	3560	10.2	Hydrocal Calsol

Hydrocal = Hydrocal 300
Calsol = Calsol 8240

5.4 Oil Distribution

Pre-load and replenishment oil was distributed from a 5,700L calibrated storage tank located on the Ohmsett Main Bridge. Oil volumes in the storage tank were carefully measured and metered to the boomed test area. Pre-charging these oil lines eliminated mass balance accounting for residual oil in the lines during transfers. Oil samples were taken during this process for laboratory analysis of pretest oil properties.

5.5 Oil Recovery

A series of eight calibrated recovery tanks, located on Ohmsett's auxiliary bridge, were used during the test. Each of the eight recovery tanks has a capacity of approximately 950L which equates to 0.9L of fluid for every mm of tank depth. Fluid depth was measured using a 1.2m aluminum ruler; readings are accurate to within 3mm. The exception to this setup was for the Desmi AFTI MI-2HD test. Recovered fluids for this test were collected in conical bottom drums located on the Auxiliary Bridge. The smaller cross sectional area of these drums allowed for accurate accounting of the small volumes collected.

During a test, oil discharged from the skimmer traveled a minimum of 3.5m vertically to a manifold located just above the recovery tanks. Valves attached to the manifold allowed the fluid flow to be directed to individual recovery tanks for measurement and decanting of free water. Initial flow was diverted to a 'slop tank' to purge oil within the cargo hose and allow for steady state operation to occur. This continued until the calculated holdup volume of oil was collected. Flow was then diverted to the selected recovery tank. Recovery was timed and continued until the estimated recovery of 25mm of oil was collected (and for a minimum collection time of 30 seconds). At this point flow was directed back to slop and timing stopped.

6 Test Procedure

6.1 Optimization Tests

ASTM 2709-08 requires performance data to be the result of three measurements that produce results within 20% of the arithmetic mean. Prior to the three qualifying tests, skimmer operation was "optimized". Skimmer optimization is the process of determining parameters at which a skimmer should operate to provide the maximum ORR while meeting 70% RE as required by ASTM F2709-08. This process was accomplished by performing a series of shorter duration tests in which ORR and RE values were measured relative to the operational parameters such as rotational speed for disc or drum skimmers, and hydraulic pressure and flow.

6.2 Qualifying Tests

Three qualifying tests were conducted for each skimmer. The measurement period for each test began when:

- The skimmer operation had been adjusted to its optimum settings,
- The oil recovery and discharge flow appeared to be at steady state.

At the start of each test, the flow of recovered fluid was initially sent to a tank designated as slop. When the above conditions were achieved and holdup volume had been collected, the flow of recovered fluid was diverted from the slop tank to a recovery tank, and the measurement period began. Recovery continued until 25mm of oil was collected. After collection, the volume of total fluid recovered was measured. After a minimum thirty minute settling period, free water was decanted from the bottom of the recovery tank. Immediately following the decanting, the remaining fluid was stirred, and a representative sample was taken and sent to Ohmsett's on-site lab to determine emulsification and Bottom Solids and Water (BS&W), as measured in accordance with ASTM D4007 "Standard Test Method for Water and Sediment in Crude Oil by the Centrifuge Method"(ASTM, 2013c). Both free and entrained water were then deducted from the total fluid recovered, resulting in a total volume of oil.

7 Results

Per ASTM F2709-08, two performance measurements were calculated including:

Oil Recovery Rate (ORR): Total volume of oil recovered by the device per unit of time (water that is recovered along with the oil is not included in this calculation).

and: Recovery Efficiency (RE): The ratio of the volume of oil recovered to the volume of total fluid recovered.

These were calculated using the following formulas:

$$ORR = \frac{V_{oil}}{t} \quad (1)$$

Where: ORR = Oil Recovery Rate, liter/minute (Lpm) (gallon/min (gpm))
V_{oil} = Volume of oil recovered, liter (gallon) (decanted and lab corrected)
t = Elapsed time of recovery, minutes

and:

$$RE = \frac{V_{oil}}{V_{total\ fluid}} \text{ X } 100 \quad (2)$$

Where: RE = Recovery Efficiency, %
$V_{total\ fluid}$ = Volume of total fluid (water and oil) recovered

7.1 Results: Elastec TDS 118G Drum Skimmer

Optimization tests were performed using Hydrocal 300 at drum speeds of 30, 64, 70 and 80 rpm, the maximum rotational speed of the drum. The results indicated that maximum recovery rates were achieved at 80 rpm while meeting the 70% required oil recovery efficiency. Optimization tests were performed using Calsol 8240 at 51, 59 and 70 rpm and indicated that approximately 60 rpm was the optimal drum rotational speed at which the offload pump rate was comparable to the drum recovery.

Manufacturer's data for the Elastec TDS 118G skimmer lists nameplate capacity of 341 Lpm (Elastec AmericanMarine, 2013). Oil recovery rates during these tests exceeded the manufacturer's nameplate capacity; average test results over three official tests resulted in an ORR of 388 Lpm and RE of 91% for Hydrocal 300 oil, and ORR of 366 Lpm and RE of 85% for the Calsol 8240 oil. Figure 10 shows the Elastec skimmer, and Table 4 lists test results for the Elastec TDS 118G.

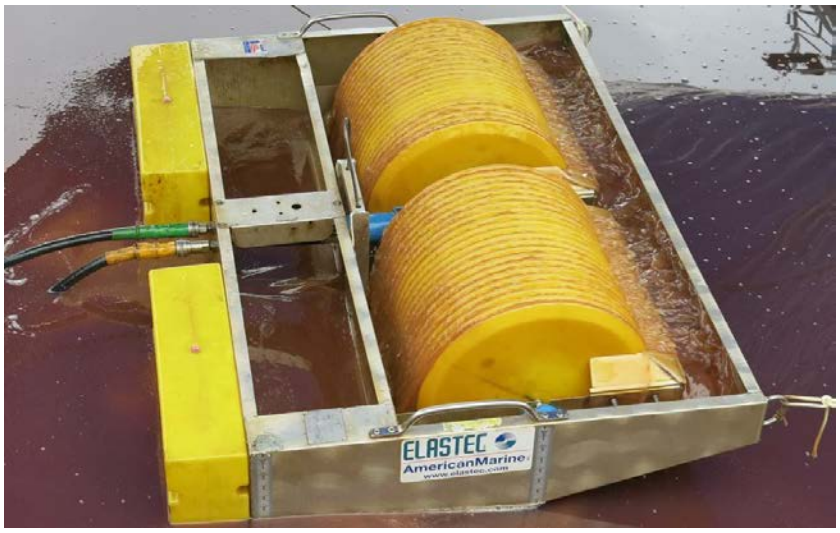

Figure 10 Elastec TDS 118G Drum Skimmer

Table 4 Skimmer Test Matrix and Parameters

ELASTEC TDS 118G SKIMMER - SUMMARIZED DATA					
Test #	Test Oil	Drum Speed	Collection Time	RE Oil Recovery Efficiency	ORR Oil Recovery Rate
		(rpm)	(min)	(%)	(Lpm)
5	Hydrocal 300	78.0	0.86	91.0	365
6	Hydrocal 300	77.0	0.73	91.0	413
7	Hydrocal 300	79.8	0.78	91.2	387
			Average	91.1	388
11	Calsol 8240	58.0	0.81	84.8	337
12	Calsol 8240	56.0	0.68	84.0	389
13	Calsol 8240	59.0	0.75	87.4	371
			Average	85.4	366

7.2 Results: Crucial C-14d Mop Wringer System

The Crucial C-14d mop wringer system is direct drive with a fixed running speed set by the factory and therefore cannot be optimized by varying mop speed. Several preliminary tests were performed prior to the qualifying tests, however, to verify the mop rotational speed and corresponding recovery rate. A Crucial representative was on site to view the testing. Figure 11 shows the Crucial C-14d mop wringer system.

Figure 11 Crucial C-14d Mop Wringer System

The nameplate capacity data supplied by the manufacturer (Crucial, email communication, March 11,2015) is 83 Lpm. Average test results over three official tests resulted in an ORR of 37 Lpm and RE of 99.9% for Hydrocal 300 oil, and ORR of 37 Lpm and RE of 100% for the Calsol 8240 oil. Table 5 lists test results for the Crucial C-14d Mop Wringer System.

Table 5 Crucial C-14d Mop Wringer Summarized Data

CRUCIAL MOP C-14d SKIMMER - SUMMARIZED DATA					
Test #	Test Oil	Mop Rope Revolution Time	Collection Time	RE Oil Recovery Efficiency	ORR Oil Recovery Rate
		(min)	(min)	(%)	(Lpm)
4	Hydrocal 300	1.4	7.80	99.9	38
5	Hydrocal 300	1.4	8.42	99.9	33
6	Hydrocal 300	1.4	7.17	99.9	40
			Average	99.9	37
11	Calsol 8240	1.4	9.53	99.8	32
12	Calsol 8240	1.4	8.53	100.0	35
13	Calsol 8240	1.3	8.45	100.0	43
			Average	99.9	37

7.3 Results: Lamor LWS 500\GTA50 Weir Skimmer

Optimization tests were performed on the Lamor LWS 500\GTA50 skimmer varying hydraulic pressure and measuring corresponding recovery rates. For the optimization tests using Calsol 8240, hydraulic pressure was varied from 750 PSI to 1200 PSI and recovery rate increased with increasing hydraulic pressure. The three qualifying tests were conducted using a hydraulic pressure of 1300 PSI. For the optimization tests using Hydrocal 300, hydraulic

pressure was varied from 1100 to 1200 PSI. The three qualifying tests were conducted with an average hydraulic pressure of 1150 PSI.

Manufacturer's data for the Lamor LWS 500\GTA50 skimmer lists nameplate capacity for the skimmer as 833Lpm (Lamor, 2010) The Lamor LWS 500\GTA50 exceeded nameplate capacity data, achieving an average ORR of 982 Lpm and RE of 89% while collecting Hydrocal 300, and an average ORR of 1017Lpm and RE of 95% while collecting Calsol 8240. Figure 12 shows the Lamor LWS 500\GTA50 skimmer and table 6 lists test results.

Figure 12 Lamor LWS 500\GTA50 Weir Skimmer

Table 6 Lamor LWS 500\GTA50 Weir Summarized Data

LAMOR LWS 500 SKIMMER - SUMMARIZED DATA				
Test #	Test Oil	Collection Time	RE Oil Recovery Efficiency	ORR Oil Recovery Rate
		(min)	(%)	(Lpm)
11	Hydrocal 300	1.18	95.8	1079
12	Hydrocal 300	1.21	86.9	963
13	Hydrocal 300	1.23	83.9	905
		Average	88.9	982
5	Calsol 8240	1.13	95.0	1071
6	Calsol 8240	1.15	94.4	996
7	Calsol 8240	1.16	96.6	983
		Average	95.3	1017

7.4 Results: Desmi AFTI MI-2HD Disc Skimmer

The Desmi AFTI MI-2HD Disc skimmer was tested only in the Hydrocal 300 oil. Ten optimization tests were performed with disc speed ranging from 149 rpm to 213 rpm. A Desmi representative was on site to help with the optimization tests. The three qualifying tests were

conducted with a pump speed set at 100% capacity and a disc speed of between 168 and 174 rpm. Figure 13 shows the Desmi AFTI MI-2HD Disc Skimmer.

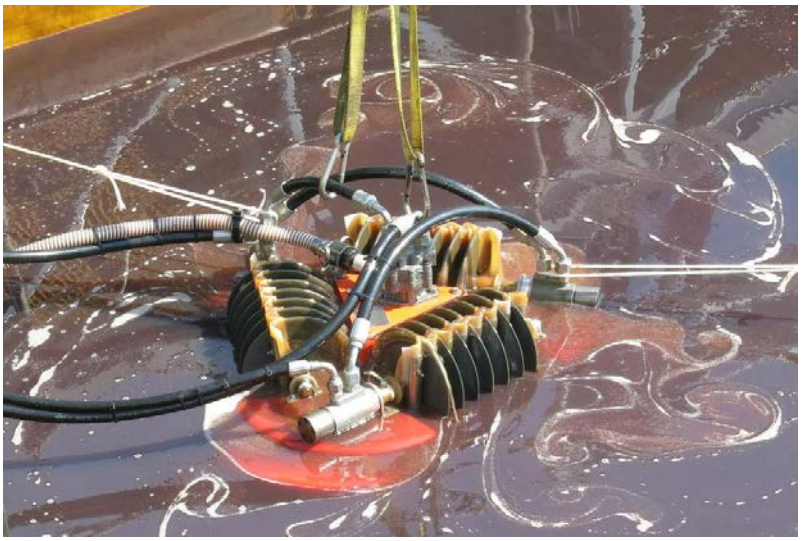

Figure 13 Desmi AFTI MI-2HD Disc Skimmer

Manufacturer supplied nameplate capacity is 23Lpm (Desmi-AFTI, Inc., 2015). The skimmer achieved an average ORR of 34Lpm with an RE of 96% which exceeded manufacturer's nameplate capacity. Table 7 lists test results for the Desmi AFTI MI-2HD Disc.

Table 7 Desmi AFTI MI-2HD Summarized Data

DESMI-AFTI MI-2HD SKIMMER - SUMMARIZED DATA					
Test #	Test Oil	Disc Speed	Collection Time	RE Oil Recovery Efficiency	ORR Oil Recovery Rate
		(rpm)	(min)	(%)	(Lpm)
11	Hydrocal 300	174.0	4.97	94.5	33
12	Hydrocal 300	168.0	4.87	95.0	34
13	Hydrocal 300	174.0	4.87	97.3	35
			Average	95.6	34

7.5 Results: Desmi Terminator Weir Skimmer

Optimization tests were performed to determine the most efficient hydraulic flow and hydraulic pressure for this skimmer. Once these parameters were optimized, three official

qualifying tests were conducted. This skimmer was tested with Hydrocal 300 in September, 2014 with an average hydraulic pressure of 2450 PSI and hydraulic flow of 37.3 gpm. The skimmer was tested with Calsol 8240 in December, 2014 with an average hydraulic pressure of 2500 PSI and hydraulic flow of 48.8 gpm. The viscosity of the Calsol during the December test was an average of 22,600 cP which defined it as a category III oil. Figure 14 shows the Desmi Terminator Weir Skimmer while operating.

Figure 14: Desmi Terminator Weir Skimmer

Nameplate capacity for this skimmer is published as the pumping rate of 2082Lpm (Desmi, 2015b). The skimmer achieved an average ORR of 1275Lpm and RE of 94% when tested with Hydrocal 300, and an average ORR of 1529Lpm and RE of 81% when tested with Calsol 8240. Table 8 lists test results for the Desmi Terminator.

Table 8 Desmi Terminator Weir Summarized Data

DESMI TERMINATOR SKIMMER - SUMMARIZED DATA				
Test #	Test Oil	Collection Time	RE Oil Recovery Efficiency	ORR Oil Recovery Rate
		(min)	(%)	(Lpm)
5	Hydrocal 300	0.92	92.5	1317
6	Hydrocal 300	1.10	95.9	1195
7	Hydrocal 300	0.97	92.0	1313
		Average	93.5	1275
3	Calsol 8240	0.75	72.3	1395
4	Calsol 8240	0.72	82.5	1549
5	Calsol 8240	0.68	88.8	1642
		Average	81.2	1529

7.6 Results: Crucial C-13/24 Coated Disc Skimmer

Seven optimization tests were conducted on the Crucial C-13/24 disc skimmer using Hydrocal 300. Initially, the Crucial PD-75H off load pump was used in testing. However the capacity of this pump lower than the rate of fluid collection by the skimmer, and the sump area overflowed with oil. After trying a second pump which did not solve the issue and after consulting with a representative of Crucial who was on site for the testing, a Megator 2" Yellow Series DD pump Model P50PY02 was inserted into the system and used for the remaining optimization tests as well as the qualifying tests. During the three qualifying tests using Hydrocal 300, the nominal hydraulic pressure used was 800 PSI and the average disc speed was 45 rpm. Figure 15 shows the Crucial C-13-24 Coated Disc Skimmer.

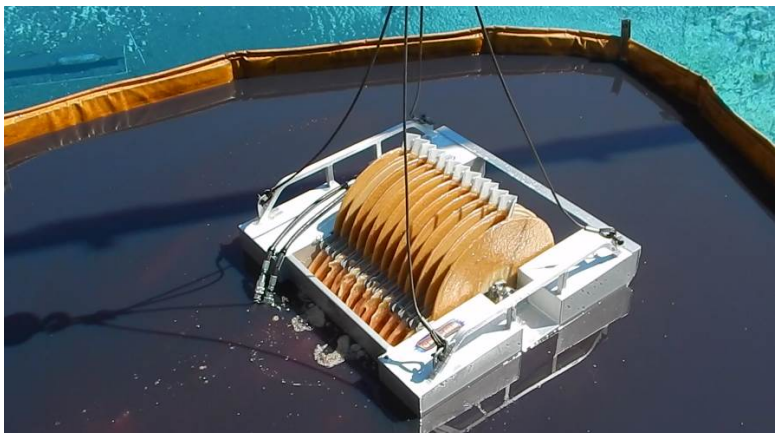

Figure 15 Crucial C-13/24 Coated Disc Skimmer

Seven optimization tests were performed with the Calsol 8240 to determine optimal hydraulic pressure and disc speed. Initial tests with rpms of 39 and 33 resulted in RE values less than the 70% minimum required. Rpm was reduced to increase RE. During the three qualifying tests using Calsol 8240, nominal hydraulic pressure was 933PSI and the average disc speed was 19.2 rpm.

The nameplate capacity supplied by the manufacturer (Crucial, email communication, March 11,2015) was 321Lpm. The average ORR and RE for Hydrocal 300 was 458Lpm at 90% which exceeded the manufacturer's nameplate capacity. Average ORR and RE for Calsol 8240 was 188Lpm at 86%. Table 9 test results for the Crucial Model C-13/24.

Table 9 Crucial Model C-13/24 Coated Disc Summarized Data

CRUCIAL C-13/24 COATED DISC SKIMMER - SUMMARIZED DATA				
Test #	Test Oil	Collection Time (min)	RE Oil Recovery Efficiency (%)	ORR Oil Recovery Rate (Lpm)
8	Hydrocal 300	0.74	88.5	435
9	Hydrocal 300	0.72	88.5	475
10	Hydrocal 300	0.72	91.5	463
		Average	89.5	458
18	Calsol 8240	1.77	86.5	181
19	Calsol 8240	1.69	85.5	201
20	Calsol 8240	1.78	86.0	181
		Average	86.0	188

7.7 Results: Desmi Terminator with Helix Circular Brush Skimmer

Optimization tests were performed to determine the most efficient hydraulic flow and hydraulic pressure for this skimmer. Once these parameters were optimized, three qualifying tests were conducted. Nameplate capacity for this skimmer is published as the pumping rate of 2082Lpm (Desmi, 2015a). The skimmer achieved an average ORR of 902Lpm and RE of 93% when tested with Hydrocal 300, and an average ORR of 862Lpm and RE of 96% when tested with Calsol 8240. Figure 16 shows the Desmi Dop-Dual Terminator with helix Circular Brush, and table 10 lists test results for the Desmi Dop-Dual Terminator with Helix Circular Brush.

Figure 16 Desmi Dop-Dual Terminator with Helix Circular Brush Skimmer

Table 10 Desmi Terminator w/ Helix Circular Brush Summarized Data

DESMI DOP-DUAL TERMINATOR with HELIX CIRCULAR BRUSH - SUMMARIZED DATA				
Test #	**Test Oil**	**Collection Time**	**RE Oil Recovery Efficiency**	**ORR Oil Recovery Rate**
		(min)	(%)	(Lpm)
2	Hydrocal 300	1.45	95.0	911
3	Hydrocal 300	1.26	94.5	931
4	Hydrocal 300	1.31	89.0	864
		Average	92.8	902
9	Calsol 8240	1.40	96.0	840
10	Calsol 8240	1.38	96.0	873
11	Calsol 8240	1.38	96.5	872
		Average	96.2	862

7.8 Summary of Results

Table 11 summarizes test results for the thirteen tests conducted.

Table 11 Summary of Test Results

Skimmer	Mfg nameplate capacity Lpm[gpm]	ORR (Hydrocal) Lpm[gpm]	RE (Hydrocal) (%)	ORR (Calsol) Lpm[gpm]	RE (Calsol) (%)
Elastec TDS 118G	341[90]	388[103]	91	366[97]	85
Crucial C-14d Mop Wringer System	83[22]	37[10]	100	37[10]	100
Lamor LWS 500\GTA50	833[220]	982[260]	89	1017[269]	95
Desmi AFTI MI-2HD	23[6]	34[9]	96	N/A	N/A
Desmi Terminator	2082[550]	1275[337]	94	1529[404]	81
Crucial C-13/24 Coated Disc	321[85]	458[121]	90	189[50]	86
Desmi Dop-Dual Helix	2082[550]	902[238]	93	862[227]	96

8 Conclusions

- Oil viscosity within the range tested seemed to have little effect on the performance of most of the skimmers tested. Performance of all skimmers except for the Terminator and the Crucial C-13/14 varied less than 6% between the two oils tested. The Terminator's performance varied by 17% between the two test oils; however, the Terminator test using the Calsol oil (nominally a category II oil) was conducted when the temperature was very cold and the viscosity of the Calsol oil was above 22,600 cP (making it a category III oil for this test).
- The performance of the Crucial C-13/24 Coated Disc Skimmer varied as oil viscosity varied. While collecting the less viscous Hydrocal 300, its ORR exceeded the manufacturer's nameplate capacity value by 42%. However, while collecting the Calsol 8240, it performed at 59% of manufacturer's nameplate capacity. This reinforces the recommendation set forth in ASTM F2709-08 that skimmers be tested in more than one category of oil. Further, it suggests that for skimmers whose performance is affected by category of oil, manufacturers provide nameplate capacity data for each category of oil. Note that alternatively, testing at one viscosity does not necessarily indicate maximum performance of the skimmer, but only quantifies performance for the given condition. The Crucial Mop skimmer did not achieve ORR that compared to the manufacturer's nameplate capacity values in these tests. However, this skimmer may perform better in recovering an oil that is even less viscous than a category I oil.
- Manufacturer pump rates were used as nameplate capacity data for the Lamor LWS 500\GTA50, Desmi Helix and Terminator skimmers. ORR values for the LWS 500\GTA50 exceeded the pump rate. ORRs for the Helix and Terminator were less than named pump rates; between 61% to 73% for the Terminator and 41% to 43% for the Helix. This indicates the importance of ASTM 2709-08 testing to present a representative picture how the entire skimmer system will perform. Note that these ORRs were obtained for the skimmers operating in stationary mode and do not reflect how the skimmers might perform in an advancing mode.
- Nameplate capacity data based on testing to a prescribed test method informs stakeholders on performance of skimmers as a system. To maximize its usefulness it is recommended that manufactures provide additional information on the system components used in the test setup such as pump, HPU, cargo hose, as the collector may not be the limiting factor in overall performance.
- ORRs collected for this set of tests compared well to previous ASTM 2709-08 test results on the same skimmer (data limited to one skimmer). For this one data point, results indicate that the ASTM 2709-08 test method produces repeatable results.

9 Acknowledgements

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