Alaska Shippers Skimming Tests, Phase 2:
Testing at Ohmsett to Determine Nameplate Capacity
Supplementary Tests with Modified Crucial Disc Skimmer

Report to:
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Background

In March 2008, four oleophilic skimmers were tested at Ohmsett to evaluate their potential use as alternatives to the skimmers currently used in the Prince William Sound (PWS) oil spill response plan. The skimmers currently used in the PWS plan are weir-type devices, which generally have low recovery efficiencies, i.e., they recover a substantial volume of water along with the oil. This can add greatly to the storage requirement, which is logistically complex and costly. It was thought that oleophilic devices might offer an advantage in this regard because of their generally higher recovery efficiencies. In subsequent tests in July 2008, described in this report, a modified version of one of the four skimmers was tested again.

Description of Skimmer

In the test series in March, a disc skimmer produced by Crucial Inc. was tested. The skimmer uses two banks of aluminum discs, 28 discs on each side for a total of 56 discs. The discs are 30-inches in diameter. In the latter part of the tests, the aluminum discs were substituted with prototypes that had a fibrous outer layer. The discs were spaced slightly more along the drive shaft, with the result that only 44 discs in total were used. In operation, the discs rotate down through the surrounding oil slick, then a series of flat scrapers cleans the discs, the oil emptying into a central sump between the disc banks. The discharge pump is a positive-displacement lobe pump.

For the July tests, the skimmer was modified to include 52 discs, all of which were coated with a fibrous outer layer. Compared with the prototype that was used in March, the scrapers for each disc were made of a thicker gauge of polyethylene, which was intended to exert more pressure on the disc and therefore scrape it more effectively.

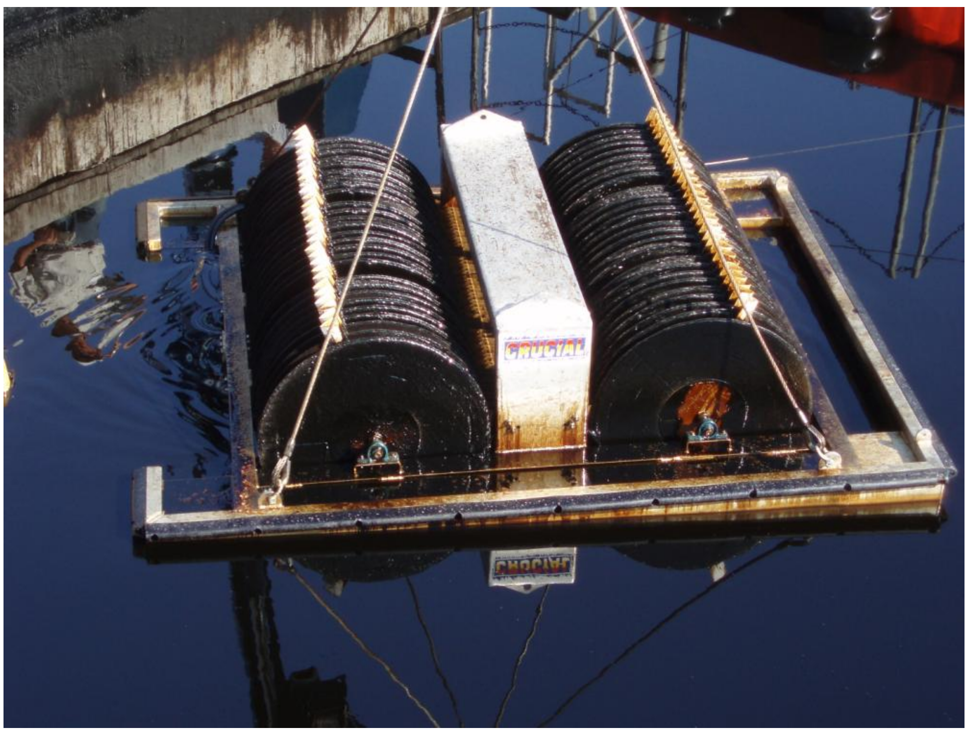

Figure 1: Modified Crucial disc-type skimmer

Test Methodology

Background

The American Society of Testing and Materials (ASTM) subcommittee on oil skimmers (F20.12) has been working on a standard methodology for measuring the nameplate recovery rate for skimmers for a couple of years, and may be nearing consensus on the major issues associated with testing (ASTM 2008a,b). The methodology used in these tests was based on the key points in the present draft of the standard methodology, all of which have general agreement among key players involved in the development and approval of the standard.

The rationale behind developing the standard is that the current practice for establishing nameplate capacity may be arbitrary and does not reflect actual skimmer performance. The objectives of the new standard are that it be inexpensive to perform, that it not require a specific test facility, and that it produce accurate and reproducible results. It is accepted that the reported nameplate rates may not be achievable under real spill conditions and that de-rating factors should still be used as they are now in planning guidelines.

Summary of Test Method

The main contentious issue in developing the test standard has been the required slick thickness for the test. Some on the committee argued that “ideal conditions” meant an abundance of oil (and perhaps all oil, with no water present). Further, this would simplify testing, and make it less expensive because the recovered oil would not be contaminated with water and could therefore be re-used. Others argued that the test would be unrealistic if it did not include water. All agreed that the test was to simulate ideal conditions for recovery, so the slick thickness should be substantial; eventually the consensus was that a slick of at least 2 inches (50 mm) should be used in testing. Testing at Ohmsett was performed in the summer of 2007 to investigate this question. The tests showed that there was no significant change in performance, as measured by recovery rate, when the slick thickness was varied from 2 inches to “infinity”. On this basis, it was agreed that the nameplate test could be performed in a tank full of oil (i.e., no water, producing an unlimited slick thickness) if the only concern was recovery rate. If recovery efficiency were of concern, the test should be performed with an oil layer on water. If possible, the oil layer should be maintained at a constant thickness of 2 inches by replenishing oil to the test tank at approximately the same rate as the skimmer's oil recovery rate. For simplicity, the test can be performed with a declining oil thickness, and measurements taken of the rate and efficiency when the slick thickness is approximately 2 inches.

In the tests described here, recovery efficiency is of concern so the tests were performed with a layer of oil on water. The general approach was to start with a slick thickness of 3 inches and take measurements of rate and efficiency as the slick thickness declined from 3 to 2 inches. This was repeated twice to produce a minimum of three timed measurements.

Test Oils

The tests in March were intended to resemble the 72-hour spill cleanup scenario mandated by the State of Alaska. The tests were performed with two oils: a fresh Alaska North Slope (ANS) crude oil and with the same oil weathered to approximately 20% evaporative loss by volume. Tests with the weathered oil were intended to provide an indication of skimmer performance at the end of the 72-hour scenario. The oil remaining from the March tests was retained in two separate tanks for use in the July tests. During the four-month intervening period, water contained in the oil settled out and was pumped off the bottom of the tank. Note that the "fresh" oil can no longer be regarded as fresh, having undergone some weathering through successive tests in the March program. The oil properties are summarized in Table 1.

Table 1: Test oil properties

Oil	Density, g/mL @ 77°F	Viscosity, cP @ 82°F
"Fresh" ANS crude oil	0.876	14
Weathered ANS	0.895	28

Viscosity is reported for 82°F, which was the average temperature for the test series, as measured in the recovered oil. This is much warmer than the temperatures for the March test series (45°F). Consequently, the oil was much less viscous than in the March tests, and there was little viscosity difference between the "fresh" and weathered oils. At the temperatures in this test series, the viscosity was in the range of an unweathered product, for both the “fresh” and weathered oils.

Test Equipment and Setup

The draft ASTM nameplate methodology mandates that the test tank have lateral dimensions that are three times the length and width of the skimmer device. (The rationale for this is to ensure that there is adequate space for the oil to flow freely to the skimming mechanism.) If the test is performed without the presence of water the tank maybe smaller, however the skimmer must free float throughout the test and be clear of the tank walls. The Crucial skimmer has a footprint of approximately 7 x 8 feet, so a test area of 24 feet by 24 feet was used. Figure 5 shows the boomed test area that was created at one end of the Ohmsett tank.

Figure 2: Boomed test area in Ohmsett tank

The draft ASTM standard requires that the skimmer’s offloading pump deliver the recovered oil to an elevated tank such that the static head is 3.5 m. The Ohmsett recovery tanks, located on the auxiliary bridge, are sufficiently elevated for this. The skimmer discharged to a 50-foot length of 6-inch discharge hose that led to a manifold atop the recovery tanks. The manifold has a series of valves discharging to each of eight separate recovery tanks, providing the ability to quickly switch the flow from tank to tank to facilitate an accurate timed test.

Test Duration

The draft ASTM standard suggests a minimum measurement period of 30 seconds for a valid test. As this value had varied somewhat through successive revisions of the draft standard, a test period of 30 seconds to 1 minute was used to be conservative.

Performance Measurements

The measurement period for each test began when:

- The skimmer operation had been adjusted to its optimum settings.
- The discharge hose was full.
- The recovery and discharge 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, the flow of recovered fluid was diverted from the slop tank to a collection tank. The volume of fluid collected over a timed period was measured. After a minimum 30-minute settling period, free water was decanted off the bottom of each collection tank to allow the measurement of "free" water content in the recovered fluid. Immediately following the decanting, the remaining fluid in the collection tank was agitated and a representative sample was taken of the fluid to determine the amount of entrained or emulsified water (as measured with ASTM D4007). Both free and entrained water were then deducted from the total fluid recovered, resulting in a total volume of oil recovered in the measurement period. The volume of free and entrained water was also used in calculating the recovery efficiency of the skimmer. The two performance measurements are thus:

- 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).

- Oil Recovery Efficiency (ORE): The ratio, expressed as a percentage, of the volume of oil recovered to the volume of total fluids recovered.

The ASTM draft standard also mandates that the tests be repeated three times for any given set of parameters. Test result values are considered valid if no values deviate more than 20% from the arithmetic mean.

The limited amount of oil available for testing did not allow successive tests over a broad range of speed settings on the skimmer. However, the skimmer operator had a good idea of the optimum settings from the previous testing in March, and these were bracketed to ensure that the maximum recovery rate and efficiency were achieved.

Results

Results in terms of Oil Recovery Rate and Oil Recovery Efficiency are summarized below with detailed data for each of the tests provided in Appendix A.

The performance results in fresh oil were within the acceptable range for consistency, with an average ORR of 386 gpm and average ORE of 77% (tests #11, #12, and #15). Performance in weathered oil was similar, with an average ORR of 402 gpm (Tests #6, #8, and #9) and corresponding ORE of 87%. The results from all tests were consistent, with the exception of test #14, which had a much lower ORR and ORE. This was likely due to a measurement error: the three-way valve that diverts recovered fluid from "slop" to a recovery tank was momentarily stuck during the test.

Table 2: Summary of results for Crucial disc skimmer

Test	Speed, rpm	Test oil	ORR, gpm	ORE, %
5	34	Weathered	387	69.3
6	26	Weathered	415	86.1
7	37	Weathered	339	53.8
8	25	Weathered	443	89.7
9	19	Weathered	349	86.5
10	24	Fresh	353	79.0
11	29	Fresh	387	76.9
12	25	Fresh	390	81.2
13	19	Fresh	339	87.2
14	26	Fresh	299	56.6
15	26	Fresh	380	71.5

The minimal difference between the results for fresh and weathered oil is not surprising given the minimal viscosity difference between the two oils at the high test temperatures, relative to the March test series.

The results are approximately triple the recovery rate achieved with the standard aluminum discs in the March test series, in which the skimmer had a maximum ORR of 128 gpm. The results are approximately double that achieved with the fiber-covered discs and prototype scraping system in the march tests, when a maximum recovery rate of 234 gpm was achieved. Although it cannot be quantified, it is likely that the ORR's in the most recent test series would have been even higher if not for the high temperatures in July (80 to 90°F rather than 45 to 50°F). and the resulting decrease in the viscosity of the test oil.

A brief test series was performed with a prototype fiber-covered drum skimmer, the Crucial 1-CD18H-36, the results summarized in Table 3.

Table 3: Summary of results for Crucial drum skimmer

Test	Speed, rpm	Test oil	ORR, gpm	ORE, %
16	26	Fresh	17	98.6
17	31	Fresh	22	98.8
18	32	Fresh	23	98.5
19	32	Fresh	23	98.8

The results were consistent, with an average ORR of 23 gpm and ORE of 99%.

Two tests were performed with the skimmer under tow, but these were for qualitative purposes only and the recovery performance is not reported.

References

American Society for Testing and Materials. 2008a. F 631 – 99(2008) Standard guide for collecting skimmer performance data in controlled environments *in* 2008 Annual Book of ASTM Standards: Volumes 11.05. ASTM. West Conshohocken, PA.

American Society for Testing and Materials. 2008b. Draft standard test method for determining nameplate recovery rate of stationary oil skimmer systems. F20.12 Work item WK11447. ASTM. West Conshohocken, PA.

American Society for Testing and Materials. 2008c. ASTM D4007 Standard test method for water and sediment in crude oil by the centrifuge method (laboratory procedure). ASTM. West Conshohocken, PA.

Appendix A:

Detailed Test Results

Test	Skimmer	Time	Speed	Depth Collected Fluid (gross)	Volume Collected Fluid (gross)*	Depth Collected Fluid (decanted)	Volume Collected Fluid (decanted)	Volume Oil Collected (corrected)	H_2O pre-test	H_2O rec tank	H_2O pick up	RE	ORR	ORR/rpm	Test Oil	Oil Temp	Slick Thickness (initial)	Notes
		(min)	(rpm)	(inches)	(gal)	(inches)	(gal)	(gal)	(%)	(%)	(%)	(%)	(gpm)	(gal/rev)		(°F)	(inches)	
	70T-2			Tests 1 through 4: Tow Test, no oil														
5	70T-2	0.77	34	73.50	429	71.75	418	297.0	18.0	47.0	29.0	69.3	387	11.4	Wthrd ANS	80	2 - 3	
6	70T-2	0.85	26	70.00	408	68.50	399	351.4	3.0	15.0	12.0	86.1	415	16.0	Wthrd ANS	84	2 - 3	
7	70T-2	0.56	37	60.50	353	32.75	191	189.8	3.0	3.6	0.6	53.8	339	9.2	Wthrd ANS	84	2 - 3	
8	70T-2	0.68	25	58.00	338	54.00	315	303.3	3.5	7.1	3.6	89.7	443	17.7	Wthrd ANS	94	2 - 3	
9	70T-2	0.94	19	65.25	380	63.75	372	328.9	**50.0**	11.5	11.5	86.5	349	18.4	Wthrd ANS	94	2 - 3	
10	70T-2	0.77	24	59.25	345	48.50	283	272.9	1.3	4.8	3.5	79.0	353	14.7	Fresh ANS	82	2 - 3	
11	70T-2	0.67	29	58.25	340	47.00	274	261.2	1.9	6.6	4.7	76.9	387	13.4	Fresh ANS	82	2 - 3	
12	70T-2	0.75	25	61.50	359	52.75	308	291.1	1.9	7.3	5.4	81.2	390	15.6	Fresh ANS	83	2 - 3	
13	70T-2	0.89	19	59.50	347	56.50	329	302.4	1.3	9.5	8.2	87.2	339	17.8	Fresh ANS	87	2 - 3	
14	70T-2	0.62	26	56.00	326	32.50	189	184.9	0.8	3.2	2.4	56.6	299	11.5	Fresh ANS	84	2 - 3	3-way valve stuck
15	70T-2	0.66	26	60.50	353	45.00	262	252.2	1.1	5.0	3.9	71.5	380	14.6	Fresh ANS	88	2 - 3	
16	1-CD18H-36	2.00	26	6.00	35	6.00	35	34.5	0.0	1.4	1.4	98.6	17	0.7	Fresh ANS	106	2 - 3	
17	1-CD18H-36	2.00	31	7.75	45	7.75	45	44.6	0.0	1.2	1.2	98.8	22	0.7	Fresh ANS	107	2 - 3	
18	1-CD18H-36	2.00	32	8.00	47	8.00	47	45.9	0.0	1.5	1.5	98.5	23	0.7	Fresh ANS	108	2 - 3	
19	1-CD18H-36	2.00	32	8.00	47	8.00	47	46.1	0.0	1.2	1.2	98.8	23	0.7	Fresh ANS	108	2 - 3	
20	70T-2	3.47	20	Qualitative tow tests, no performance data reported														
21	70T-2	3.39	20	Qualitative tow tests, no performance data reported														