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Testing of Oil Sands Products Recovery in Fresh Water: White Paper Study

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EXECUTIVE SUMMARY

The U.S. Coast Guard (CG) Research and Development Center (RDC) drafted this white paper to document a test that evaluated the recovery of weathered diluted bitumen in fresh water. In the past, limited recovery tests have been performed for response to diluted bitumen in salt water, but none have been performed in fresh water to ensure that this environment does not cause unique problems.

RDC collaborated with Enbridge to provide the appropriate oil and identified a drum skimmer and a brush skimmer that represent two classes of skimmer commonly found in responders' inventories. The Bureau of Safety and Environmental Enforcement's National Oil Spill Response Research & Renewable Energy Test Facility (Ohmsett) installed a separate test tank adjacent to the main Ohmsett test tank and filled it with fresh water. Ohmsett conducted the test using the ASTM F2709, Standard Test Method for Determining Nameplate Recovery Rate of Stationary Oil Skimmer Systems. The oil was weathered to simulate a spill lasting over 8 days. The recovery efficiency was never below 70% for either skimmer, although the recovery rates varied somewhat due to the skimmer configuration. The data collected during this evaluation indicates that with care, standard skimmers do not need special modifications to recover diluted bitumen in fresh water, especially in the early stages of a spill while the oil is on the surface. These typical skimmers need to be monitored closely for rotational speed during the early stages to ensure efficiency. A lower recovery rate may be acceptable for increased efficiency. More powerful pumps may be needed during the later stages of a spill involving this type of product as the viscosity increases.

We recommend that the Coast Guard make this information available to oil spill responders through training, conferences and Federal On Scene Commander's guidance documents.

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1 INTRODUCTION

There has been an increase in the movement of products from the Canadian Oil Sands in Alberta into the United States. This includes shipment by rail and pipeline of diluted bitumen (dilbit), which is a crude oil that is composed of bitumen and added diluents. Although the characteristics of dilbit are similar to other crude oils, the combination of heavy components with a lighter crude or condensate raises questions about its behavior when spilled and the best methods to use in response to a spill. Earlier research has been done to address some of these questions. In the United States, the National Academy of Science (NAS) has done some assessment to identify issues that need to be addressed during a pipeline spill (NAS 2016). The USCG Research & Development Center (RDC) performed an initial assessment and identified some outstanding issues for behavior and response (Hansen et. al., 2015). Some work on behavior and response to dilbit spills has been done by multiple Canadian organizations including Environment and Climate Change Canada, Natural Resources Canada and researcher Merv Fingas. (Fingas, 2015; Fieldhouse et. al. 2016; Zhou, 2015).

Kinder-Morgan contracted Witt O'Briens and Polaris to determine behavior and perform initial evaluation for the response options of mechanical recovery, dispersants, and in-situ burning for dilbit spills in salt water. (Taylor et. al., 2014 and Witt|O'Briens et. al., 2013). The two samples tested did not sink during a two-week test in artificial salt water. Other results from this test indicate that dilbit may be dispersible shortly after the oil is spilled, and standard mechanical cleanup equipment can be used in the initial stages of a spill. In-situ burning may also be useful during the early stages of a spill of this type as well. However, this work involving response methods did not address specific issues of spills in fresh water.

All of the efforts described above, occurred after 2010 when a large amount of diluted bitumen escaped from a pipeline into the Kalamazoo River (EPA, 2016). Following that spill, there were concerns about what worked and what did not for response, as well as questions about where the oil ended up.

1.1 Objective

The primary objective of this effort was to investigate the ability to recover dilbit spilled in fresh water using two different oleophilic recovery systems while controlling and monitoring the weathering of the dilbit. The RDC contracted with the Bureau of Safety and Environmental Enforcement's (BSEE) National Oil Spill Response Research & Renewable Energy Test Facility (Ohmsett) to conduct these skimmer tests. The two skimmers used in the tests were the USCG Helix Dual-DOP skimmer and an ELASTEC American Marine TDS-118G drum skimmer. Through a Cooperative Research and Development Agreement (CRADA) with the RDC, Enbridge Pipeline arranged to get some Cold Lake Winter Blend (CLWB) for the Ohmsett tests. Before the test, the RDC believed that the oil properties, at a currently unknown degree of weathering, may become too viscous and/or cohesive to recover and transport using mechanical recovery.

1.2 Background

Previous to this RDC effort, limited data was collected for recovery options of oil sand products. Table 1, below, summarizes the data collected in Canadian tests for three different brush skimmers during temperate summer weather in Gainsford, Alberta, Canada (Taylor et al., 2014). The participants conducted recovery tests on six of the ten days that the oil was in the salt water test tanks. There was a wide range of data for the water content, rate of oil recovery and percent (%) of oil content in the collection cube after decanting.

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There was not adequate discussion to determine the cause for such a wide range of data. The conclusions in that report were:

- No performance shortcomings were observed in the current inventory of recovery equipment available to Trans Mountain Pipeline ULC (TMPL) and its contractors;
- The more viscous oil encountered on three of the days caused no skimmer malfunctions including stalls, seizures, or poor recovery;
- Operational adjustments to compensate for increased dilbit viscosity were no different than field adjustments made to equipment during actual spill events for most types of oils;
- This particular dilbit behaved similarly to any other crude oil that the participating spill response professionals had experienced in the past.

The Coast Guard's interest was in determining if any issues related to dilbit recovery were different when fresh water was involved.

Table 1. Results from Gainsford, Alberta, Canada.

Date of Test	Approx. Elapsed Time from Oil Release that Test was Conducted (Hrs.)	Duration of Peak Test	Density of Oil Sample (lab result; Absolute; kg/m ³ @ 15 °C)	Viscosity of Oil Sample (lab result; cSt extrapolated to 15 °C) *	Number of Skimmers Tested	Range of Water Content in Oil Sample from Cal. Cubes (lab result; %)		Range in Rate of Oil Recovery (liters/sec.)		Range of % of Oil Content in Cal. Cube	
						High	Low	High	Low	High	Low
13-May	4	2 min	925.2 [^]	220	3	22.0	5.7	0.86	0.21	33	19
15-May	46	4 min	952.4 [^]	1252	3	11.8 [#]	8.2	0.59	0.58	95	81
17-May	96	4 min	970.1 - 985.1	6603 - 15523	3	50.4	24.1	0.70	0.31	98	79
19-May	144	4 min	982.5 - 989.9	7982 – 17234*	3	47.5	20.0	0.71	0.40	94	28
21-May	192	4 min	986.2 - 993.0	15903 – 30304	3	49.0	26.2	0.82	0.25	95	79
22-May	216	4 min	975.1 ^{^^}	9642	2	17.0	13.2	0.26	0.12	97	73

Notes

[^] Values were for the oil at the beginning of the test and the oil came from the common discharge tank. After the modification of the test, such that the skimmers were discharging to their own tanks, there was a high and low value from the three tanks.

^{^^} Value is from one tank which had been left for 10 days undisturbed.

* One tank extrapolated values for May 18 not included in range as curve was outlier.

[#] Following laboratory analysis, the initial sample jar returned an anomalous 91.1% water content. The results from a second jar are presented here with confidence that this alternate is more representative of the product recovered in the test.



2 TESTING SETUP AND RESULTS

2.1 Testing

2.1.1 Testing Configuration

The Ohmsett staff set up a temporary tank in a location called Lake Zelman, a secondary containment area adjacent to the main Ohmsett test tank. The configuration included a 4-foot deep, 16-foot diameter tank (Figure 1, left). Multiple 330-gallon metal blue totes were used for recovering the oil collected during the tests. The arrangement included a three-way valve and manifold with a 4-inch Cam-lock inlet to permit flow to be directed into a “slop” tote for initial oil collection while the system was stabilized and a “collect” tote for oil collected during the timed test (Figure 1, right). As mentioned earlier, two skimmers were used for these tests, an ELASTEC TDC-118G drum skimmer and a Desmi Ro-clean Helix brush skimmer. They were powered by two respective hydraulic power packs. These skimmers represent two general types normally available in the field during a response.



Figure 1. Test area configuration.

2.1.2 Test Oil

Ohmsett received two deliveries of Cold Lake Winter Blend (CLWB). The first delivery was a 5-gallon batch to conduct some preliminary weathering trials. The second was a 2,000-gallon batch for the actual testing. The initial 5-gallon batch was weathered by placing it into a metal tray just below the deck of the Ohmsett test basin to avoid direct sunlight. Oil samples were collected on 2 hour intervals during the first day, at 4-hours intervals the second day, and then every 24 hours after 2 days as the rate of evaporation changed. The Ohmsett staff measured the density and viscosity of the samples and these values were used to set up a schedule for weathering the large batch. The staff placed the full amount of test oil (2,000 gallons) into a large tank (Figure 2) and a horizontal air sparging system consisting of a 10-foot pipe with 20 air holes sized at 1/8 inch. Only two of the four 20-inch manholes were opened at the top of this tank. Air was initially introduced at 75 pounds per square inch (psi) and 4 cubic feet per minute (CFM) and later increased to 100 psi and 7 CFM. Almost immediately from the start, the density/weathering data did not match the data collected from the preliminary 5-gallons sample. As seen in Figure 3, the values for the oil in the large tank (pre-test) were lower than that of the small batch in the pan (preliminary). The staff installed a second air sparging system with 150 holes sized at 1/16 inch, however, the weathering data again

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did not match. The data is not reported because there was no change in the viscosity values. Multiple weathering attempts using small batches of the oil on trays and in totes were also unsuccessfully matched.

Finally, Ohmsett staff placed small batches in several of the totes and installed air sparging systems specifically designed for the totes. They were run for several weeks before the higher viscosity levels were attained that matched the values for the small batch that weathered normally. It appears that the lower temperature in the outdoor tank and the limited air exchange with the manholes, reduced the efficiency in the forced weathering effort. Values of over 40,000 centipoises (cP) were eventually reached.



Figure 2. Large tank for large batch of oil (2,000 gallons).



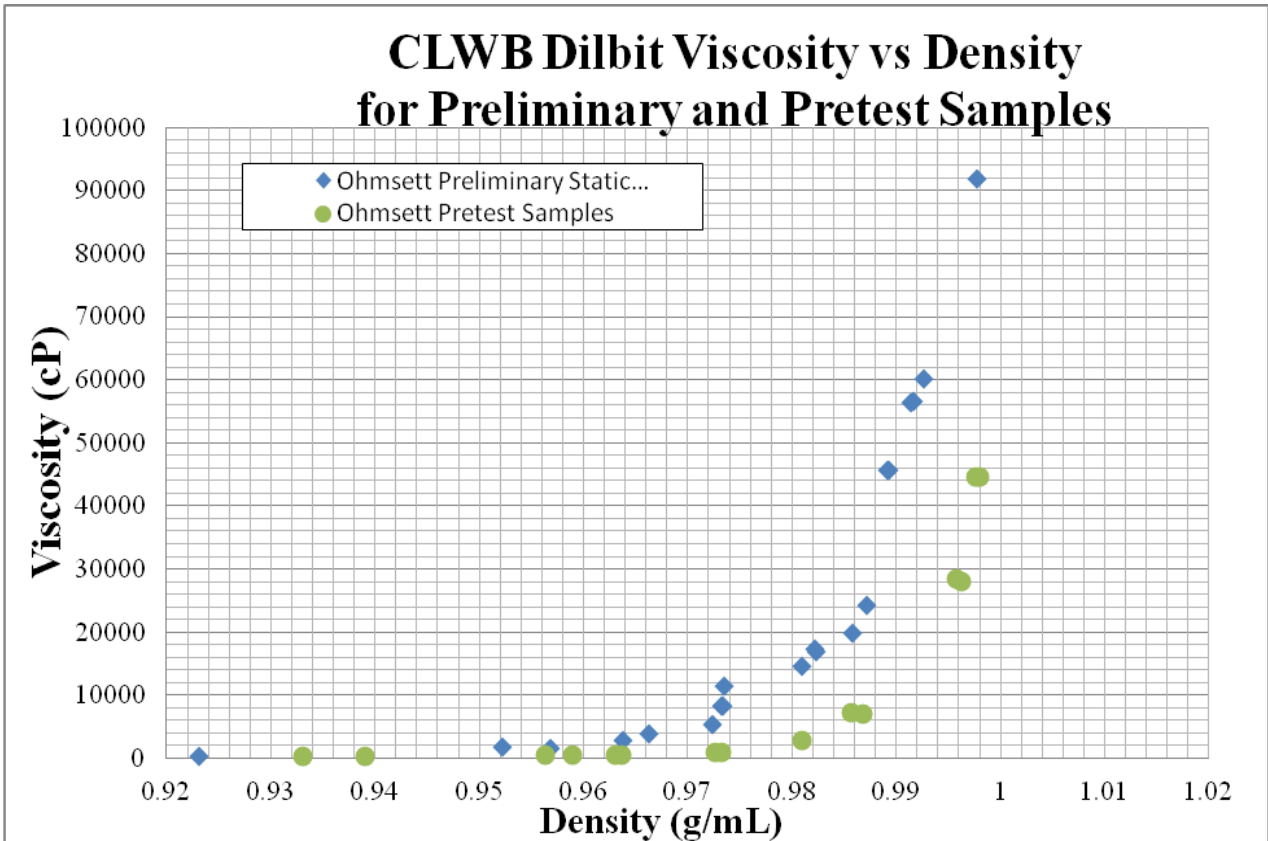


Figure 3. Data for preliminary (small batch in pan) and pre-test (from larger test batch).



2.2 Test Process

The testers followed the ASTM Standard F2709, Standard Test Method for Determining Nameplate Recovery Rate of Stationary Oil Skimmer Systems. This standard recommends a test area at least three times the dimensions of the skimmer. This area was slightly reduced for the Desmi skimmer, but for the objectives of this test, the area was adequate. The general steps followed were:

- 1) Collect initial data (temperature and oil samples for density, viscosity, etc.).
- 2) Set rotational speed of skimmer.
- 3) Place skimmer into test area, preload oil into test area (Figure 4, left).
- 4) Start skimmer and divert first amount into “slop” tote. Switch discharge to “collect” tote and continue until 1 inch of slick is recovered (Figure 4, right). Record time and move tote out for decanting and oil sampling.
- 5) Perform final sampling and data collection.
- 6) Switch out skimmers and repeat.



Figure 4. Helix skimmer during oil preload and testing.

2.3 Test Results

A summary of the test data is shown in Table 2 for each skimmer. The last two columns for efficiency and oil recovery rate are plotted in Figure 5. The results indicate that efficiency for the first six tests were close to 100 percent. This shows that these skimmers performed well when the oil was fresh. The Ohmsett staff noted that some of the lower numbers for efficiency rate and recovery rate in the data suggests that the skimmer parameters may not have been set correctly. The ELASTEC skimmer can be adjusted for the rotational speed of the drum, and the Helix brushes' rotation can also be adjusted. It proved difficult to count the rotations and adjust exactly after the drum and brushes were coated with oil. Adjustments could also be made for the pumps that move the oil from the collection site into the storage container for both skimmers. Getting the recovered oil to flow to the pump in both skimmers was problematic starting at viscosities of about 14,000 cP, especially for the drum skimmer. In addition, at the higher viscosities, a large amount of oil attached on the drum and brush during the first few revolutions and the scrapping mechanisms had difficulty in clearing the oil for additional oil to attach. At higher rotational speeds, this was more visually apparent.

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Table 2. Results from Ohmsett dilbit tests.

Test #	Skimmer	Slick Thickness	Viscosity at Test Temp	Collection Time	Drum/Disc Spd	Recovery Tank (Initial)	Recovery Tank (Final)	Total Fluid Volume (Gross)	Fluid Collect Rate	% BS&W Initial	% BS&W Recovered	Volume of Oil Collected	RE Oil Recovery Efficiency	RR Oil Recovery Rate
		(inches)	(cP)	(min)	(rpm)	(inches)	(inches)	(gal)	(gpm)	(%)	(%)	(gal)	(%)	(gpm)
3	Desmi	3	325	0.93	20.0	13.50	13.50	116.8	125.6	1.8	3.0	115.3	98.8	124.0
4	Elastec	3	236	2.99	30.0	13.25	13.25	114.6	38.3	1.5	2.0	114.0	99.5	38.1
9	Desmi	3	1119	0.589	20.0	14.63	14.50	126.5	214.8	6.0	8.5	122.3	96.7	207.6
10	Elastec	3	1379	1.66	30.0	15.75	15.38	136.2	82.1	6.0	6.5	132.3	97.1	79.7
13	Desmi	3	1860	0.81	20.0	14.75	14.75	127.6	157.5	9.0	11.0	125.0	98.0	154.4
14	Elastec	3	1757	2.08	30.0	14.63	14.63	126.5	60.8	12.0	14.0	124.0	98.0	59.6
19	Elastec	2	5720	1.22	30.0	5.00	4.88	43.3	35.5	15.0	33.5	34.4	79.5	28.2
20	Desmi	2	3857	0.833	30.5	14.75	12.75	127.6	153.3	14.0	34.0	88.2	69.2	106.0
21	Elastec	2	14160	6.18	19.0	5.00	5.00	43.3	7.0	20.0	40.0	34.6	80.0	5.6
22	Desmi	2	14820	1.76	30.0	15.75	15.75	136.2	77.4	19.0	36.0	113.1	83.0	64.2
23	Desmi	2	44610	1.25	33.0	14.75	14.75	127.6	102.1	18.0	27.0	116.1	91.0	92.9
24	Elastec	2	40520	3.13	15.0	4.00	4.00	34.6	11.1	20.0	25.5	32.7	94.5	10.4

Note: Only full skimmer test results were recorded.



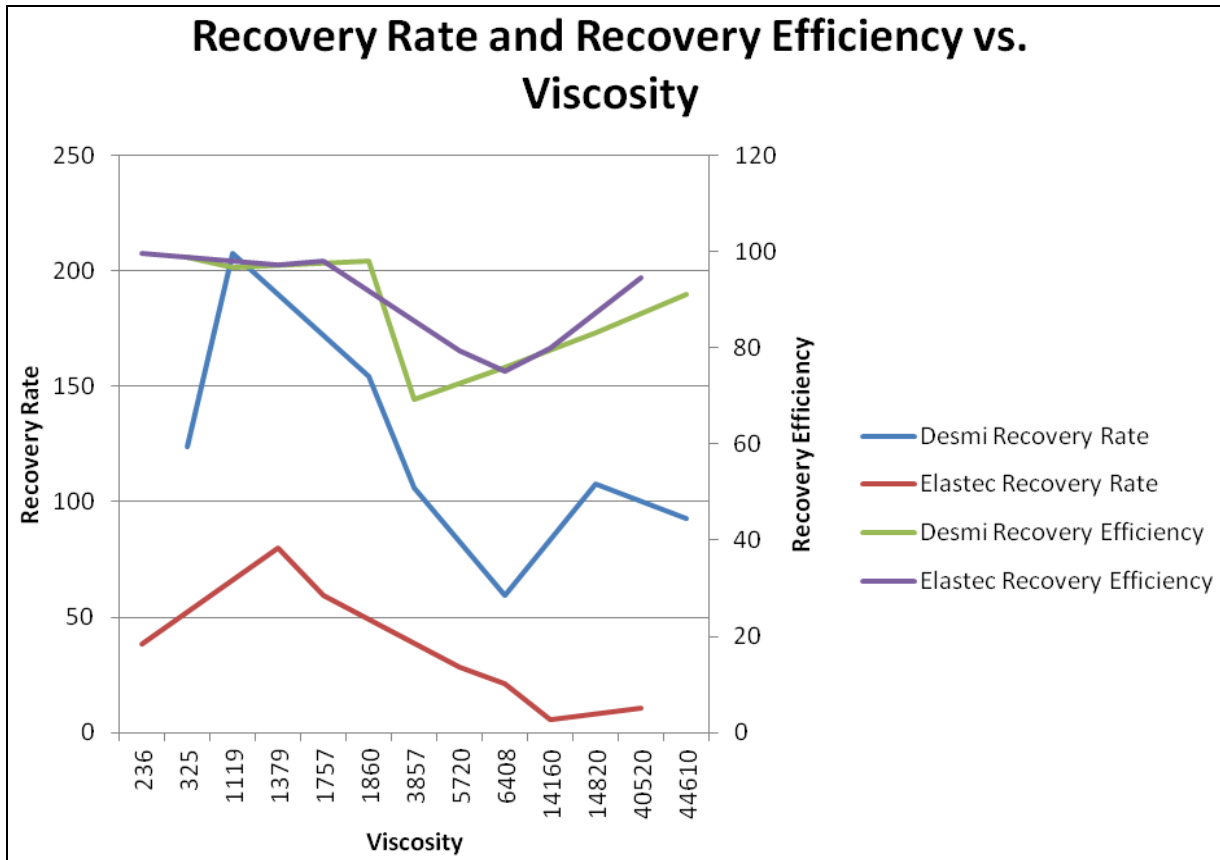


Figure 5. Skimmer recovery rates and efficiency data from tests.

3 CONCLUSIONS

This Ohmsett skimmer test added to the limited data on actual efficiencies of various skimmers. The results increase the body of knowledge from the previous tests in Canada and Ohmsett. When this test is compared to the skimmer tests at Ohmsett during “Ice Month” (SL Ross and MAR 2013), it must be noted that test used a refined product called Hydrocal with a viscosity of approximately 1,000 cP. The Ice Month tests were conducted with approximately 30% ice. The Helix skimmer was about 70% efficient with recovery rates of 27-42 gallons per minute (GPM) and the drum skimmer was over 65% efficient with recovery rates of over 21 GPM, both lower than the dilbit tests.

When the dilbit test is compared to the tests in Canada (Table 1), the viscosities were lower due to the higher temperatures. Unfortunately, the Canada tests grouped the skimmer performances, so it is not possible to pull out specific skimmer performance for comparison from the Canadian data.

The data collected during this skimmer test indicates that with care, standard skimmers do not need special modifications to recover diluted bitumen in fresh water, particularly in the early stages of a spill while the oil is on the surface. While there is a large variability, the skimmer performance can be refined for increased recovery rate by adjusting the rotation rate of the collection device and the collection pump. These types of skimmers need to be monitored closely for rotational speed during the early stages of operation. A lower recovery rate may be acceptable when traded off for increased efficiency. Pumps that are more powerful may be needed during the later stages of a spill of this type of material.

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