FINAL REPORT

DISPERSANT EFFECTIVENESS TESTING ON VISCOUS, U.S. OUTER CONTINENTAL SHELF CRUDE OILS

For

U.S. Department of the Interior
Minerals Management Service
Herndon, VA

By

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Executive Summary

The objective of the work was to determine the viscosity limit for the effectiveness of chemical dispersants applied to viscous US Outer Continental Shelf (US OCS) crude oils of varied origin. Large-scale tests were completed at Ohmsett, the National Oil Spill Response Test Facility in Leonardo New Jersey.

Presently there is a lack of data and knowledge on the dispersibility of heavy, viscous crude oils under at-sea conditions. It is generally thought that oils with viscosities less than 2000 cSt are dispersible and that oils with viscosities higher than 20000 cSt are not. There is considerable debate and uncertainty regarding the dispersibility of oils with viscosities between 2000 and 20000 cSt.

Much of the past work on the dispersibility of heavy, viscous oils has been done using small-scale laboratory tests that may not give a true picture of the dispersibility of viscous crude oils. This has recently been shown to be the case for heavy fuel oils. Offshore dispersant effectiveness trials in the UK completed in 2003 (Lewis, 2004) and follow-up testing at Ohmsett in 2004 (SL Ross, 2004), have demonstrated that dispersants can be effective on heavy fuel oils. The IFO 180 and 380 fuel oils used in these tests had viscosities, at 15 °C, of 2000 cSt and 7000 cSt, respectively. The results from past small-scale laboratory dispersant effectiveness tests on heavy fuel oils of these types indicated that these oils would not be chemically dispersible yet the large scale test results clearly showed that they could be chemically dispersed, even with relatively low dispersant dosages. Effectiveness values of 90% for IFO 180 and 80% for IFO 380 were measured in the 2004 Ohmsett tests.

Testing in April of 2005 at Ohmsett on viscous crude oils has provided valuable insight into the dispersibility of heavy, viscous crude oils and possibly extended the range of oils that would be considered candidates for dispersant application.

Considerable effort was expending finding crude oils suitable for the test program. The primary criteria for oil selection included:

1) oils from US OCS waters;
2) oils with viscosities above 2000 cP at 15 °C;
3) oils free of production chemicals; and,
4) oils that could be acquired in sufficient quantities and in time for the small and large scale test programs.

The six crude oils selected for final testing were all California outer continental shelf (OCS) crude oils. The names of the oils used, in order of increasing viscosity, were: Harmony, Elly, Gilda, Gina, Irene and Heritage.

A series of small-scale tank tests were completed in April of 2005 on the six oils to provide an indication of the dispersibility of each of these oils prior to large-scale testing at Ohmsett. Tests were completed using SL Ross's small-scale test tank.

The results from the small-scale testing are provided in Table 4 and Figures 1 and Figure 2. The results show a definite trend in effectiveness as a function of both oil viscosity and dispersant to oil ratio (DOR). Oils with viscosity higher than 5000 cP were not dispersible even with DOR's between 1:8 and 1:16. When the dispersant quantity was reduced the effectiveness on the lighter oils was also reduced.

Twenty large-scale dispersant effectiveness tests were completed at the Ohmsett facility in April 2005 using the six viscous OCS crude oils. Two to three drums of the six oils selected during the initial small-scale testing phase of the project were sent to the Ohmsett facility. The oils received at Ohmsett were similar to the small samples with the exception of the Gina and Irene oils. The Gina oil received at Ohmsett was much less viscous than the small sample delivered to SL Ross (5500 cP vs 12,780 cP). The Irene crude oil delivered to Ohmsett was more viscous than the small samples sent to SL Ross (33,400 vs 19,920 cP). Because of this difference care should be taken when comparing the results of the small-scale tank tests and the large-scale Ohmsett work for these oils. The physical oil properties for the oils tested at Ohmsett are shown in Table 5.

The effectiveness of the dispersant was influenced by both oil type (viscosity) and to a lesser extent by DOR (refer to Table 6 and Figure 4 and Figure 5). The least viscous oil, Harmony, was almost completely dispersed when dispersant was applied at a 1:10 ratio but the effectiveness dropped off to about 35% when the DOR was dropped to 1:40.

The crude oils tested with viscosities lower than 6500 cP were dispersible to a significant degree whereas the oils with viscosities of 33,000 cP and greater were not.

Oils with similar viscosities yielded similar dispersant effectiveness results suggesting that viscosity alone was a good measure of likely dispersant effectiveness, at least in this test series.

Short video segments of each test have been provided through hypertext links provided in Table 6.

It was hoped that the Gina crude oil would have shed light on the dispersibility of crude oils in the 10,000 to 12,000 cP range and Irene at 20,000 cP but the samples of oil received had lower and higher viscosities than expected based on preliminary small samples of the oils.

If crude oils with fresh viscosities of 10,000 to 25,000 cP can be sourced in the future it would be instructive to test their dispersibilities at Ohmsett to further define the dispersant effectiveness versus oil viscosity relationship developed in this project

Dispersant Effectiveness Testing On Viscous, U.S. Outer Continental Shelf Crude Oils

1. Objective

The objective of the work was to determine the viscosity limit for the effectiveness of chemical dispersants applied to viscous US Outer Continental Shelf (US OCS) crude oils of varied origin.

2. Background

The use of chemical dispersants in US waters is on the verge of achieving a similar status to that of conventional booming and skimming countermeasures. Oil spill response equipment requirement guidelines (Summary Report of Public Workshop for Response Plan Equipment CAPs http://www.uscg.mil/vrp/reg/caps.shtml) currently being proposed by the US Coast Guard mandate that a dispersant application capability must be included in spill response plans for those regions where dispersant pre-authorization has been established. This includes all US coastal waters with the exception of Washington and Oregon. When these guidelines are established and industry gears-up its ability to apply dispersants the number of spill incidents where dispersants will be considered will increase. There will be an increased need to know when dispersants will likely be effective on different oil types to assist in the dispersant-use decision-making process.

Presently there is a lack of good data and knowledge on the dispersibility of heavy, viscous crude oils under at-sea conditions. It is generally thought that oils with viscosities less than 2000 cSt are dispersible and that oils with viscosities higher than 20000 cSt are not. There is considerable debate and uncertainty regarding the dispersibility of oils with viscosities between 2000 and 20000 cSt.

Much of the past work on the dispersibility of heavy, viscous oils has been done using small-scale laboratory tests (swirling and rotating flask tests) that may not give a true picture of the dispersibility of viscous crude oils. This has recently been shown to be the case for heavy fuel oils. Offshore dispersant effectiveness trials in the UK (Lewis, 2004) and follow-up testing at Ohmsett (SL Ross, 2004) have demonstrated that dispersants can be effective on heavy fuel oils. The IFO 180 and 380 fuel oils used in these tests had viscosities, at 15 °C, of 2000 cSt and 7000 cSt, respectively. The dispersibility of these same fuel oils was tested using a number of small-scale test methods (Clark, 2005). The test results from the most commonly used small-scale laboratory dispersant effectiveness tests, the swirling flask and rotating flask, on the same heavy fuel oils show that these oils might not be readily chemically dispersible (yet the large scale test results (Lewis, 2004 and SL Ross, 2004) clearly showed that they could be chemically dispersed, even with relatively low dispersant dosages.

Similar testing at Ohmsett on viscous crude oils would provide valuable insight into the dispersibility of heavy, viscous crude oils and possibly extend the range of oils that would be considered candidates for dispersant application.

3. Oil Acquisition and Analysis

3.1 Identification of Appropriate Oils

Considerable effort was expending in the process of finding crude oils suitable for the test program. The primary criteria for oil selection included:

1) oils from US OCS waters;
2) oils with viscosities above 2000 cP at 15 °C;
3) oils free of production chemicals; and,
4) oils that could be acquired in sufficient quantities and in time for the small and large scale test programs.

The sources shown in Table 1 were consulted to identify potential oils for the study. With the exception of the Environment Canada database, none of the sources were able to provide oil viscosity measurements for the oils. Because of this, the API gravity of prospective oils was used to estimate their likely viscosities.

Table 1. Information Sources Utilized to Identify Potential Oils

Information Source	Contact Name
MMS California	Craig Ogawa
MMS New Orleans	Rusty Wright, Michael Keda
California Department of Fish and Game	Mike Sowbey
Aera Energy LLC	Dan Woo, Cindy Cagle, Steve Shehorn
Exxon Mobil	Donnie Ellis
Dos Cuadras Offshore Resources (DCOR)	Mike Finch
Marathon Oil Company	Terry Guillory, Jennifer Satterwhite
Venoco Incorporated	Keith Wenal
Plains Exploration and Production Company	Byron Everist
A Catalogue of Crude Oil and Oil Product Properties for the Pacific Region. Environment Canada	Paula Smith (www.etc-cte.ec.gc.ca/databases/OilProperties/Default.aspx)

While there are many viscous crude oils produced around the world there are very few produced in US OCS waters and most of these are in California. The crude oils shown in Table 2 were identified as potential oils for the study. A total of nine oils were acquired in small quantities to confirm that their current properties would be appropriate for the project. These oils are identified in Table 2.

Table 2. Viscous OCS Crude Oils Considered for the Project

Crude Oil Name	Geographic Source	Field/Platform Name
Elly	California OCS	Beta/Platform Elly
Ewing Bank	Gulf of Mexico OCS	Ewing Bank / 873
Gilda	California OCS	Santa Clara
Gina	California OCS	Hueneme
Harmony	California OCS	Hondo
Heritage	California OCS	Pescado
Hondo	California OCS	Hondo
Irene	California OCS	Point Pedernales
Gail	California OCS	Sockeye

3.2 Preliminary Oil Property Analysis and Oil Selection

One-gallon samples of each of the oils identified in Table 2 were acquired for basic physical property analysis to identify those oils most suited to the study and for small-scale emulsion formation testing. The oil samples provided had varying amounts of water present both as free water in the container and incorporated into the oil as a water-in-oil emulsion. Basic physical properties of the oils are reported in Table 3. Viscosities are provide both for the oil after de-watering using an emulsion breaking chemical and for the parent oil from a sample taken from the top of the containers without re-mixing any free water that may have been present in the bottom of the shipping containers. The two viscosities for the oils with low water contents were very similar (Elly, Ewing Bank, Irene and Venoco). The oils with significant water contents demonstrated lower viscosities when the water was removed with the exception of the Hondo crude oil and this difference may be due to the very high water content of this oil. The viscosities of the oils prior to water removal by de-emulsifier have been used in the remainder of the study as it is believed that these values best reflect the viscosity of the oils used in the tests.

Table 3. Physical Properties of Oils Used in Small-Scale Testing

Crude Oil Name	Viscosity (cP) (at 15 °C and 10 s^{-1})		Density (kg/m^3) (at 15 °C)	Water Content (% by Volume)
	(after de-watering)	(with water)	(after de-watering)	
Elly	3450	3600	0.964	0
Ewing Bank	84	100	0.929	2
Gilda	2200	4800	0.951	6
Gina	9200	12780	0.982	17
Harmony	not available	1825	0.957	50-65
Heritage	31250	36000	0.976	8
Hondo	3350	1800	not available	90
Irene	22400	19900	0.971	2
Venoco	1500	1590	0.952	2

The Harmony and Hondo samples contained large quantities of visible free water as well as smaller amounts of water present in the oil in the form of a water-in-oil emulsion.

The six crude oils selected for final testing, in order of increasing viscosity, were:

1. Harmony,
2. Elly,
3. Gilda,
4. Gina,
5. Irene, and;
6. Heritage.

The Ewing Bank crude was rejected from the test program due to its low viscosity. The Harmony oil was selected over the Venoco and Hondo crude oils due to its slightly higher viscosity. The Hondo oil also was rejected due to the high water content in the sample.

Approximately 600 liters of each of the six crude oils were acquired from the producers and shipped to the Ohmsett facility for full-scale dispersant effectiveness testing.

4. Small-Scale Testing

4.1 Methods

A series of small-scale tank tests were completed on the six oil selected for testing to provide an indication of the dispersibility of each of these oils prior to large-scale testing at Ohmsett. Tests were completed using SL Ross's small-scale test tank. The test apparatus and detailed methods used in this testing can be found in an earlier report (SL Ross 2003a). All tests were completed with the wave paddle set to 34 rpm which generated a wave height of approximately 20 cm. Dispersant was applied to the oil using an overhead spray bar prior to wave generation. Waves were started immediately after the dispersant application. Waves were applied for a 20-minute period and the oil remaining within the containment zone was collected immediately after the water surface calmed. The amount of oil collected was used to determine the dispersant's effectiveness.

4.2 Test Results

The results from the small-scale testing are provided in Table 4 and Figure 1 and Figure 2. The results show a definite trend in effectiveness as a function of both oil viscosity and dispersant to oil ratio (DOR). Oils with viscosity higher than 5000 cP were not dispersible even with DOR's between 8 and 16. When the dispersant quantity was reduced the effectiveness on the lighter oils was also reduced as seen in Table 4 and Figure 1 and Figure 2.

Table 4. Small-Scale Tank Test Results

Oil Name	Viscosity (cP)	Oil Thickness (mm)	DOR	% Dispersed	Run #
Harmony	1825	8	1:12	97	4
Harmony	1825	6.3	1:40	44	9
Harmony	1825	7	1:40	50	10
Elly	3600	6.7	1:12	99	8
Elly	3600	8.3	1:23	74	6
Gilda	4800	6.6	1:8	27	7
Gilda	4800	8.5	1:27	7	5
Irene	19920	7.8	1:14	12	1
Gina	12780	1.1	1:15	6	2
Heritage	36000	1.5	1:16	7	3

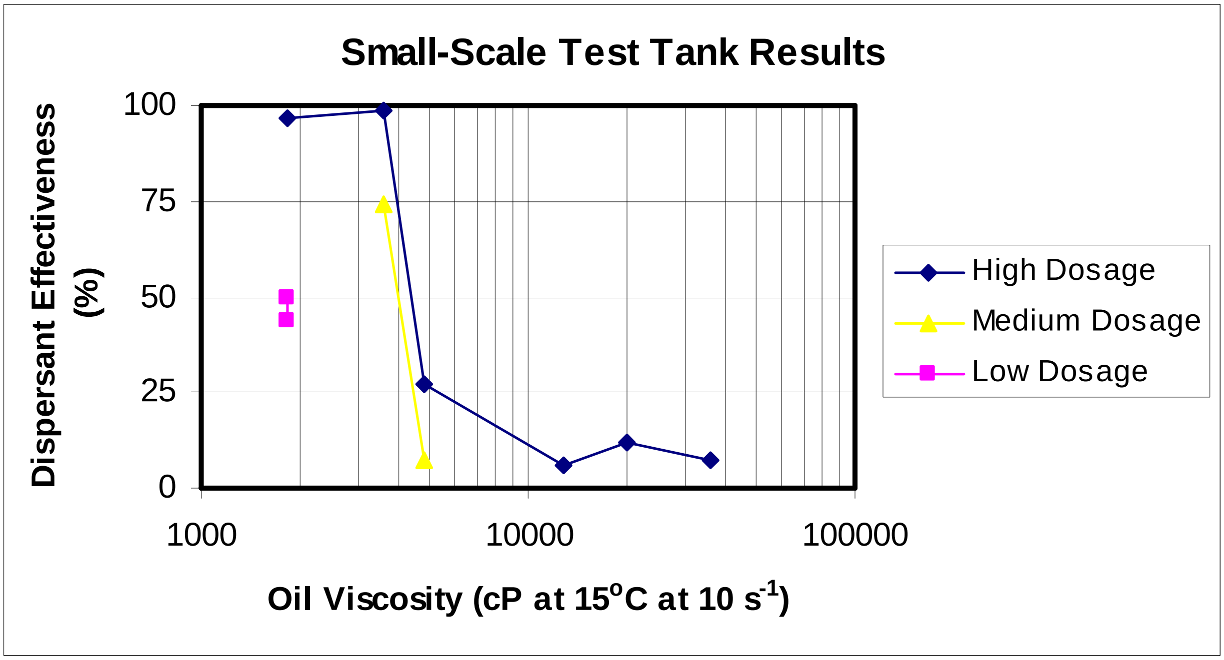

Figure 1. Small-Scale Tank Test Dispersant Effectiveness versus Oil Viscosity

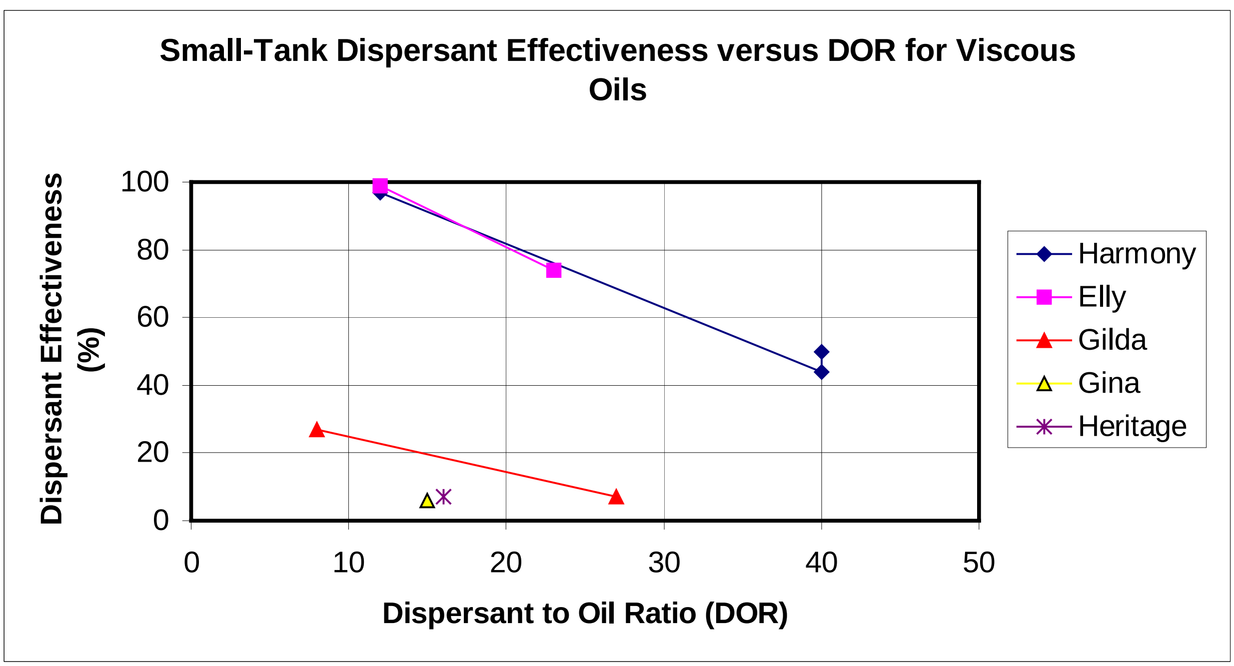

Figure 2. Small-Scale Tank Test Dispersant Effectiveness versus DOR by Oil Name

5. Large-Scale Tank Testing at Ohmsett

5.1 Background

Twenty large-scale dispersant effectiveness tests were completed at the Ohmsett facility in April, 2005 using the six viscous OCS crude oils. Two to three drums of oil from the six sources selected during the initial small-scale testing phase of the project were sent to the Ohmsett facility. The physical properties of these new samples were measured to ensure that the oils were similar to the small samples. The oils received at Ohmsett were similar to the small samples with the exception of the Gina and Irene oils.

The Gina oil received at Ohmsett was much less viscous than the small sample delivered to SL Ross (5500 cP vs 12,780 cP). The Irene crude oil delivered to Ohmsett was more viscous than the small samples sent to SL Ross (33,400 vs 19,920 cP). Because of these differences care should be taken when comparing the results of the small-scale tank tests and the large-scale Ohmsett work for these oils. The physical oil properties for the oils tested at Ohmsett are shown in Table 5.

The properties of different samples of the oils were measured at Ohmsett and SL Ross. The samples sent to SL Ross for analyses were taken from drums of the oil that had water decanted from them during the test program as seen by the lower water contents in the SL Ross results. The SL Ross viscosities were measure after de-watering the samples further using a de-emulsifier whereas the Ohmsett analyses were completed on the oils as sampled from the top of the large oil supplies. Both densities shown in Table 5 were completed on de-watered oil.

Major differences in viscosities were recorded only for the two heaviest oils, Heritage and Irene. The values measured at Ohmsett are most representative of the viscosities of the oils used in the actual testing and so these values are used in the remainder of the report.

Table 5. Physical Properties of Oils Used in Ohmsett Testing

Crude Oil Name	Viscosity (cP) (at 15 °C and 10 s^{-1})		Density (g/cm^3 at 20°C)		Water Content (% by Volume)	
	MAR[a]	SL Ross[a] (after de-watering)	MAR	SL Ross	MAR	SL Ross
Elly	4980	5420	0.959	0.963	2	0
Gilda	6530	5250	0.956	0.968	32	5.7
Gina	5500	4820	0.968	0.970	14	2.3
Harmony	1530	2480	0.939	0.949	14	0
Heritage	40100	85730[b]	0.974	0.977	17	0
Irene	33400	65680[b]	0.973	0.977	30	2.3

[a]Samples of oil analyzed at Ohmsett and by SL Ross in Ottawa [b]Shear rate of 1 s^{-1}

5.2 Test Methods and Equipment

The dispersant effectiveness testing protocol developed over the past four years at Ohmsett was used in the testing. Detailed descriptions of the test protocol, and its development, and equipment used in the testing can be found in previous publications (SL Ross et al 2000a, 2000b, 2002a, 2002b, 2003a, 2003b, 2004). Significant improvements to the oil delivery system were implemented in this test series to facilitate the discharge of viscous oils. Problems were encountered in delivering viscous oils in a previous test series (SL Ross. 2003a) and these modifications successfully addressed the problem.

The new oil discharge system includes:

1. a progressing cavity pump,
2. a pump speed control system,
3. a gravity fed oil hopper supply,
4. three-inch oil supply lines, and;
5. a stainless steel oil discharge manifold.

Oil is pumped into the hopper from drums or other supply tanks using the progressing cavity pump in reverse. The flow rate for this pump is precisely controlled by altering its rpm using the digital control module. The pump generates 0.19 gallons per minute per revolution of the pump. The quantity of oil discharged from the hopper is measured using a sonic probe mounted above the oil supply. Photographs of the oil supply system and oil discharge header are provided in Figure 3.

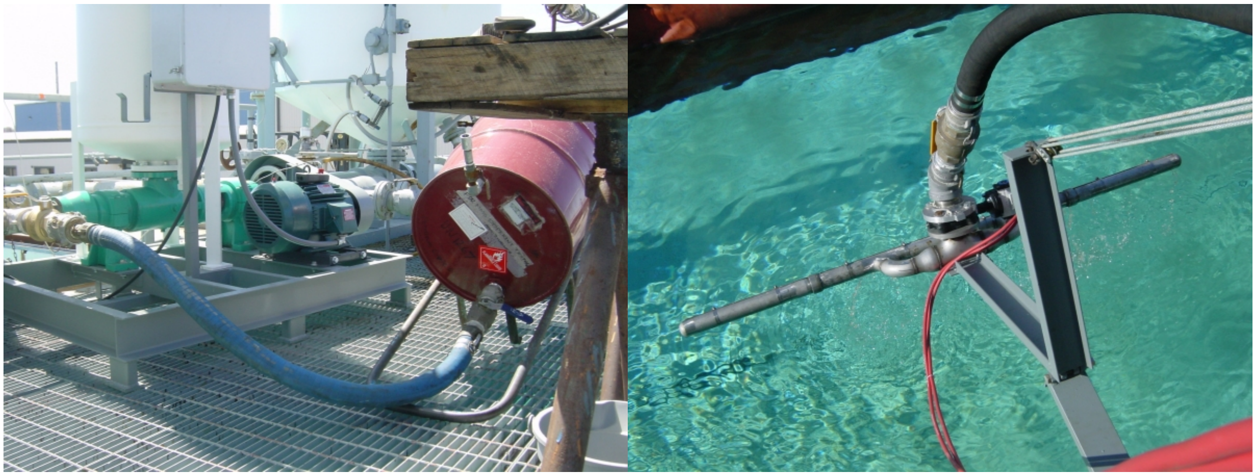

Figure 3. Oil Supply System and Discharge Header

The dispersant spray system used in the testing was the same as that used in previous dispersant tests at Ohmsett. Corexit 9500 dispersant was used in all of the tests where dispersant was applied.

The basic test procedure used for all dispersant effectiveness tests is as follows.

1. The oil containment area is established in the center of the Ohmsett tank.
2. The oil and dispersant are loaded into their respective supply tanks on the main bridge deck.
3. The main bridge is positioned at the southern quarter point within the boomed area. The wave paddle is started and the waves are allowed to develop to a stage just prior to the formation of breaking waves.
4. The wave paddle settings used in all of these tests were a 3.5 inch stroke and 34 to 35 strokes per minute.
5. The bridge is moved south at the required speed to achieve proper slick dimensions and dispersant application dosage (between 0.25 and 1 knots).
6. The oil is pumped at the required rate onto the surface through the discharge manifold mounted on the south side of the bridge.
7. The dispersant is applied onto the oil slick from the spray bar system mounted on the north side of the bridge in the same pass.
8. The waves are left on for 30 minutes and the wave paddle is stopped.

9. The water spray from the bridge fire monitors is used to sweep any surface oil remaining on the water surface at the end of the test to a common collection area at one corner of the containment boom.
10. The oil is then removed from the water surface using a double-diaphragm pump and suction wand and placed in a collection drum.
11. The drum is allowed to stand at least overnight and most of the free water present is pumped from the bottom of the drum.
12. The remaining oil and water are well mixed and a sample is taken for water content and physical property determination.
13. The quantity of liquid in the drum is measured and the amount of oil determined by subtracting the amount of water as determined using the water content analysis.
14. The effectiveness of the dispersant is reported as the volume of oil discharged minus the amount collected from the surface all divided by the amount discharged (times 100 to convert to a percentage).
15. Each test was video taped for future visual reference.

5.3 Results

The test conditions and estimated Dispersant Efficiencies (DE) for all of the large-scale tank tests are summarized in Table 6. The air and water temperatures during the test program were generally within a few degrees of 15° C. The raw DE' values in the table were determined using the following simple formula: DE'= (volume spilled – volume collected from the surface) / volume spilled * 100.

The second DE value in Table 6 is the DE' value minus the amount of oil unaccounted for or lost in the control run (no dispersant) for that oil. The DE values have been used in Figure 4 and Figure 5 that show the variation in dispersant effectiveness with dispersant-to-oil ratio and viscosity for the six oils tested.

Hypertext links are provided in Table 6 to video clip segments of each of the tests. The video records can be viewed by double-clicking on a link when accessing this document through MS

Word. The clips are in order from the start of the test progressing through to the end of each test. The video clips provide a good record of the behavior of the oil in each of the tests completed and it is highly recommended that they be viewed to get a full appreciation of the test program.

As seen in Table 6 and Figure 4 the effectiveness of the dispersant was influenced by both oil type (viscosity) and to a lesser extent by DOR. The least viscous oil, Harmony, was almost completely dispersed when dispersant was applied at a 1:10 ratio but the effectiveness dropped off to about 35% when the DOR was dropped to 1:40.

Table 6. Ohmsett Tank Dispersant Effectiveness (DE) Test Results Summary

Oil	Oil Temp °C	Water Temp °C	Oil Volume (liters)	Oil Thickness (mm)	DOR	DE' (%)	DE (%)	Links to Video Segments	Test #
Harmony	8	9	68	3.3	Control	12.8		T1a, T1b, T1b	1
Harmony	18	14	66	4.7	9	86.3	73.6	T16a, T16b, T16c, T16d	16
Harmony	22	14	67	5.6	11	100.0	87.2	T7a, T7b, T7c, T7d, T7e	7
Harmony	12	13	68	7.8	39	46.0	33.3	T19a, T19b, T19c, T19d	19
Elly	16	14	78	7.2	Control	29.9		T11a, T11b, T11c, T11d	11
Elly	12	13	74	13.8	13	58.1	28.2	T20a, T20b, T20c	20
Elly	17	15	85	7.2	14	65.2	35.3	T12a,T12b,T12c,T12d,T12e,T12f,T12g,T12h,T12i	12
Elly	9	14	68	8.1	17	69.8	39.9	T13b, T13c, T13d, T13e, T13f, T13g, T13h, T13i	13
Gina	14	14	63	7.0	Control	12.5		T18a, T18b, T18c, T18d	18
Gina	20	13	31	9.7	9	54.4	41.9	T5a, T5b, T5c, T5d	5
Gina	14	13	70	5.9	12	30.9	18.4	T6a, T6b, T6c, T6d, T6e	6
Gilda	14	14	51	7.4	Control	11.2		T17a, T17b, T17c, T17d	17
Gilda	13	13	27	12.1	12	57.5	46.3	T15b, T15c, T15d, T15e, T15f, T15g	15
Gilda	11	12	54	8.6	20	48.5	37.4	T14a, T14b, T14c, T14d, T14e, T14f, T14g, T14h	14
Irene	14	11	54	9.7	Control	17.1		T2a, T2b, T2c, T2d	2
Irene	14	10	33	6.7	7	29.5	12.4	T4a, T4b, T4c, T4d	4
Irene	14	11	57	8.0	17	26.4	9.3	T3a, T3b, T3c, T3d, T3e, T3f	3
Heritage	27	18	36	9.6	Control	26.2		T9a, T9b, T9c	9
Heritage	13	14	87	8.4	Control	17.0		T10b, T10c, T10d	10
Heritage	24	16	35	6.4	6	31.7	10.1	T8a, T8b, T8c, T8d	8

Note: DE' is the dispersant effectiveness estimate prior to accounting for oil lost in the control run.

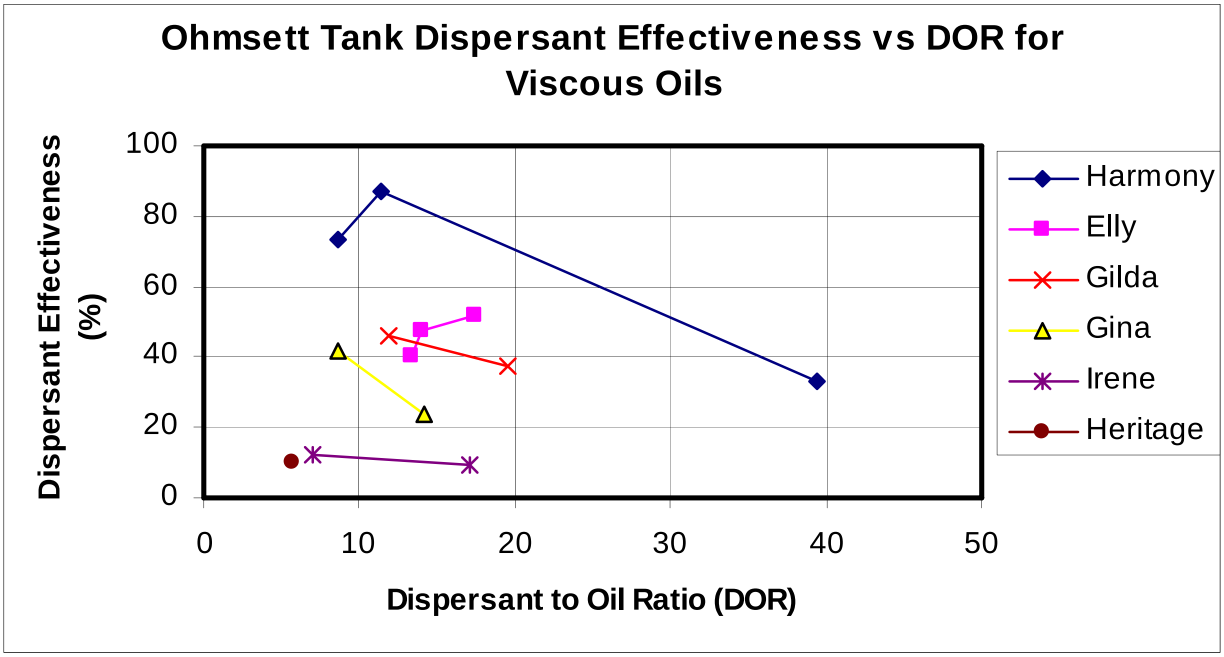

Figure 4. Ohmsett Test Tank Results: Dispersant Effectiveness versus DOR by Oil Name

With reference to Figure 4 above, the dispersant effectiveness results for Elly, Gilda and Gina oils were very similar (40 to 50%) over the range of DOR's tested (1:8 to 1:20). This is not unexpected since these oils all have similar viscosities (4980 to 6530 cP). The lightest oil tested, Harmony, dispersed the easiest of all oils but the dispersant effectiveness dropped off dramatically with a reduction of DOR from 1:10 to 1:40. Both the Irene and Heritage crude oils were very difficult to disperse even at DOR's of 1:6 and 1:7.

The DOR used had minimal effect on the test results in the in the high- to mid-range DOR's used (1:6 to 1:20) as seen in Figure 5. There was a significant drop in effectiveness for the one test on the lighter Harmony oil where a 1:39 DOR was used.

In general the oils with viscosities lower than 6500 cP were dispersible to a significant degree whereas the oils with viscosities of 33,000 cP and greater were not. Unfortunately, the viscosity of the large sample of Gina oil provided for the Ohmsett testing was less than expected and the Irene oil was more viscous than expected. As a result oils between 6500 and 33,000 cP were not available for testing to identify the trend between these two viscosities.

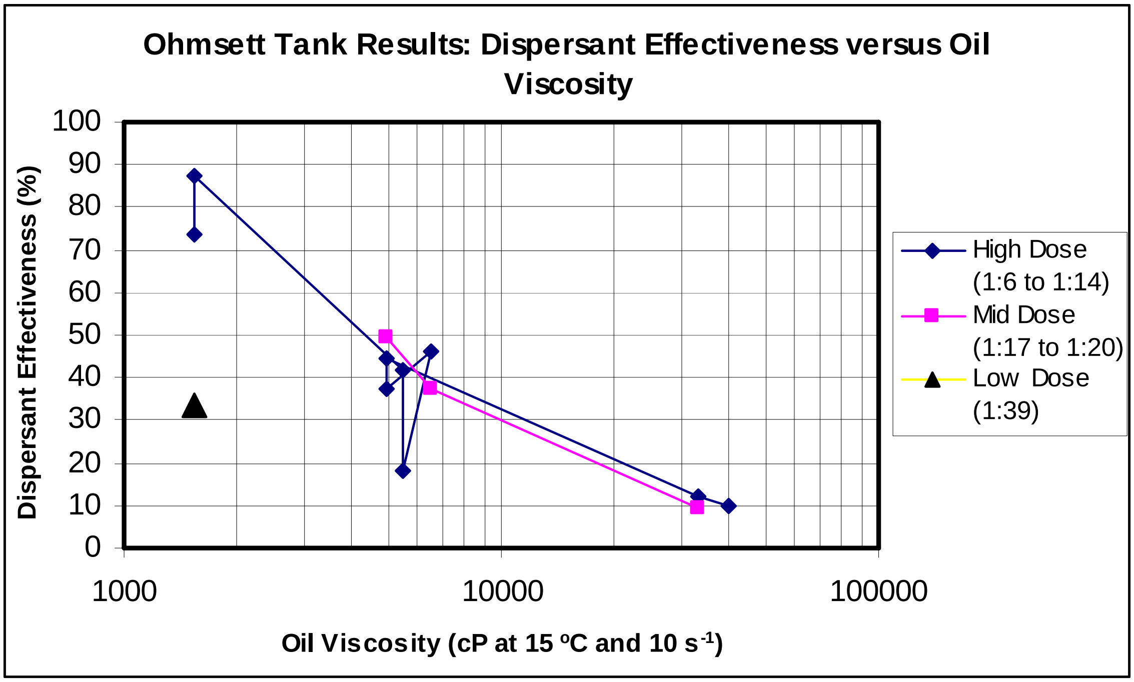

Figure 5. Ohmsett Test Tank Results: Dispersant Effectiveness versus Oil Viscosity

5.3.1 Change in Oil Properties

For those tests where quantities allowed, the oil remaining in the containment boom at the end of the tests was collected for volume, water content and density determination. Table 7 summarizes the density and water content data. All of the collected oils show an increase in density indicating that some oil was lost to evaporation. The largest density change was seen in Harmony, the lightest oil, as would be expected. No attempt was made to quantify the amount of oil lost due to evaporation but it is unlikely the amount would be significant for these heavy oils over the short time period they were on the water surface.

The water contents of the post-test oils were generally somewhat higher than the spilled oil values but in most tests there was not a high degree of water-in-oil emulsification.

Table 7. Oil Properties at End of Ohmsett Tank Tests

Oil Type	Run #	Density (g/cm^3 at 20 ˚C)		Water Content (% by volume)	
		Parent Oil	Oil After Test	Parent Oil	Oil After Test
Harmony	1	0.939	0.978	14	19
Harmony	16	0.939	0.977	14	28
Harmony	7	0.939	No Sample	14	No Sample
Harmony	19	0.939	0.97	14	12
Elly	11	0.959	0.972	2	15
Elly	20	0.959	0.975	2	14
Elly	12	0.959	0.977	2	14
Elly	13	0.959	0.971	2	22
Gina	18	0.968	0.972	14	18
Gina	5	0.968	0.958	14	22
Gina	6	0.968	0.974	14	15
Gilda	17	0.956	0.954	32	30
Gilda	15	0.956	0.957	32	42
Gilda	14	0.956	0.962	32	30
Irene	2	0.973	0.978	30	24
Irene	4	0.973	0.98	30	35
Irene	3	0.973	0.982	30	30
Heritage	9	0.974	0.983	17	25
Heritage	10	0.974	0.982	17	26
Heritage	8	0.974	0.98	17	28

6. Summary of Results and Recommendations

The crude oils tested with viscosities lower than 6500 cP were dispersible to a significant degree (40% to 90% dispersed) whereas the oils with viscosities of 33,000 cP and greater were not (only 10% dispersed). This trend was similar in both the small- and large-scale test tank results.

Oils with similar viscosities yielded similar dispersant effectiveness results suggesting that viscosity alone was a good measure of likely dispersant effectiveness, at least in this test series.

It was hoped that the Gina crude oil would have shed light on the possible dispersibility of crude oils in the 10,000 to 12,000 cP range but the large sample of oil received had a lower viscosity than expected based on an earlier small sample of the oil. Similarly, It was hoped that the Irene crude oil would have shed light on the possible dispersibility of crude oils around 20,000 cP but the large sample of Irene crude received had a higher viscosity than expected based on an earlier small sample of the oil.

If crude oils with fresh viscosities between 10,000 and 30,000 cP can be sourced in the future it would be instructive to test their dispersibilities at Ohmsett to further define the dispersant effectiveness versus oil viscosity relationship developed in this project.

7. References

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