

# Wave Tank Tests to Determine the Effectiveness of Corexit 9500 Dispersant on Hibernia Crude Oil under Cold Water Conditions

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## Abstract

The results of meso-scale dispersant effectiveness testing completed in December 2001, in SL Ross's wave tank are presented. The tests investigated the effectiveness of Corexit 9500 on fresh and evaporated (9, 12 and 28 % by volume) Hibernia crude under cold water conditions (0° to 1 °C). The test results indicate that Hibernia crude oil spills will be amenable to chemical dispersion in cold, winter conditions (1 °C) until the oil loses about 10% by volume through evaporation.

## 1.0 Background

Developing a serious dispersant-use capability for marine oil spills off Newfoundland and on the Grand Banks could involve much effort and expense and must certainly involve the support of various industrial groups and government regulators. The main reason for this study was to confirm that Hibernia crude is indeed a dispersible oil, providing confidence to all stakeholders that dispersant use is a viable spill countermeasures method for the area and deserving of a major development effort.

For many years the Grand Banks crude oils from the Hibernia and Terra Nova fields were believed to be waxy, highly emulsifiable and undispersible. Recent analysis of Hibernia oil by SL Ross (1999) indicates that the oil now being processed is relatively light (35° API gravity), is only moderately viscous (30 cp at 15 °C) and has a low pour point (-6 °C). The analysis also indicated that spills of processed Hibernia oil will not emulsify quickly, as do many crude oils, and this should serve to keep the oil relatively non-viscous for many hours depending on spill and environmental conditions.

Preliminary dispersant testing with the oil using a standard bench-scale test (the Labofina (or WSL) test) indicated that unemulsified Hibernia oil spills in summer (10 °C) should be dispersible and that somewhat emulsified oils should be dispersible as well (SL Ross 1999). Tests were not done at winter temperatures. The small-scale test results were promising, but they only provide a first "go/no-go" assessment of the oil's likely dispersibility in the field. It was believed that larger-scale testing was required. Testing at full scale in the field would be ideal, but this would be prohibitively expensive and also uncontrollable in many ways.

The next best approach would be to use a very large test tank, such as the Ohmsett Tank in Edison, NJ. (see [www.ohmsett.com](http://www.ohmsett.com)). This tank is known to be very good for testing marine spill response systems at full scale. However, because testing at Ohmsett is relatively expensive, it was felt advisable to conduct screening tests in a mid-size tank before proceeding to Ohmsett. The mid-size tank used in this study is the wave tank available at SL Ross in Ottawa, ON. This tank has been used at low

cost to do a number of recent dispersant experiments (Belore 2000a, 2000b and 2000c). The main benefits of the tank over small-scale tests are (1) dispersant application systems are used at full scale; (2) sizable oil slicks can be produced and allowed to spread; and (3) mixing is accomplished realistically through surface wave action.

## 2.0 Objective

The objective of the study was to determine the effectiveness of Corexit 9500 on Hibernia crude oil in cold-water conditions (1 °C).

## 3.0 Test Conditions

The following test parameters or conditions were used in the testing.

1. Oil thickness- One thickness: 3 mm, 700 ml of oil per test.
2. Energy level- Non-breaking waves with 15 cm amplitude and 1.5 second period.
3. Oil type- Hibernia oil sampled November 2001 from the rundown line that feeds the production mix to the Gravity Base Structure storage cells.
4. Oil weathered states- Fresh oil and evaporated oil (0%, 9.2%, 12.3 % & 27.6% by volume). Physical properties for these are shown in Table 1.
5. Dispersant type- Corexit 9500 applied neat (undiluted).
6. Dispersant to Oil Ratio (DOR)- From 1:10 to 1:120.
7. Temperature- 1°C water temperature.

Table 1 Physical Properties of Hibernia Test Oils (at 15°C): Nov 2001 sample

Weathered State (by Volume)	Pour Point (°C)	Density (kg/m <sup>3</sup> )	Viscosity <sup>1</sup> (cP)
Fresh	3	845	21
9.2 %	13	861	47
12.3 %	13	865	76
27.6 %	27	888	semi-solid

<sup>1</sup>Viscosities measured using Brookfield cone/plate viscometer and a shear rate of 100 s<sup>-1</sup>.

## 4.0 Experimental Design

All tests were completed in the SL Ross indoor wave tank. A detailed description of the test facility and methods used in the dispersant effectiveness determination is provided in Belore 2000a. The use of this relatively large tank allows the use of full-scale spray nozzles for dispersant application. The test tank is 10 metres long by 1.2 metres wide by 1.2 metres deep and is fitted with a wave-generating paddle at one end and a wave-dissipating beach at the other. The tank was filled with 32 ppt salt water to a depth of 85 cm. A photo of the insulated test tank, as used in the cold-water tests, is shown in Figure 1.

A 3-ton refrigeration unit and two 15-metre long heat transfer coils were installed in the tank to bring the water temperature down to 1°C. The water in the tank was moved over the cooling coils using an electric trolling motor. The refrigeration equipment is seen in Figure 1.



Figure 1 Test Tank with Insulation and Refrigeration Unit

The test set-up is as follows. Surface oil is held in a 1.0 m by 0.75 m rectangular area in the middle of the tank using an air bubble curtain barrier. Surface oil remains within this confinement zone in the presence of the 15-cm amplitude, 1.5-second period waves used in the tests.

Dispersant is applied using an overhead spray boom mounted to the ceiling above the center of the test tank, using Spraying System Company flat-fan nozzles. These are the same types of nozzles used in full-scale, vessel-based dispersant application systems. The volume median diameter (VMD) of the dispersant spray from these nozzles is between 300 and 500 microns.

The design dispersant dosage for each oil type is determined prior to testing. Small volumes of each oil are pre-mixed with various quantities of dispersant. These samples are then placed in the test tank under wave conditions specified above and the resulting dispersion observed. The minimum pre-mixed dosage (up to a DOR of 1:10) that achieved full dispersion is then selected as a reasonable target dosage for the full spray tests.

The amount of dispersant applied per unit area of surface is measured for each test by collecting the spray in a “cookie” tray suspended just above the water surface at one edge of the oil containment zone. The tray is weighed before and immediately after the application to determine the quantity of dispersant applied.

The final estimate of dispersant effectiveness for each test is made by sorbing the oil left in the containment area immediately at the end of the test and comparing the amount sorbed with the amount used in the test. The mixing level in the tests is such that relatively large, visible drops of oil in the water are seen to quickly return to the surface slick; fine oil droplets in the form of a “cloud” are seen to mix into and stay in the underlying water. The quantity of dispersed oil that re-surfaces after the wave energy is stopped is negligible over a period of ten minutes. To remove any water that is sorbed with the oil, the sorbents are left to drip-dry overnight and

weighed the next day. To correct for evaporation loss, both during the time the oil was on the water surface and while drying overnight, a quantity of oil (about 1.5 litres) was placed on the tank in the containment area and allowed to “weather” for 30 minutes (duration of all tests). This oil was then sorbed from the surface and allowed to drip-dry. The weight of the sorbents and oil was measured after 24 hours to determine the approximate amount of oil loss through evaporation.

## 5.0 Test Procedure

The key elements of the test method or procedure can be summarized as follows.

1. The dispersant spray apparatus is prepared by fitting the appropriate nozzles to the spray boom, filling the dispersant application pressure vessel, adjusting the air pressure used to drive the dispersant flow, and setting the boom drive motor for the appropriate application speed.
2. The underwater lights, dispersant measurement tray, video camera and air bubble barrier are started or put in place.
3. The oil is placed within the containment zone and its approximate area determined, the dispersant applied, the dispersant measurement tray removed and weighed, and the wave paddle started.
4. After 30 minutes the wave paddle is stopped and the oil remaining in the containment zone is sorbed to estimate the dispersion efficiency.

## 6.0 Results

The results of the testing program are summarized in Table 2 and Figure 2.

Table 2 Effectiveness of Corexit 9500 on Hibernia Crude Oil on Cold Water (1°C)

Hibernia Oil	Dispersant Effectiveness at Given DOR (Dispersant Applied by Spray except where 'Premixed' is Specified)			
	1:68 DOR 100%	1:96 DOR 96.5%	1:104 DOR 98%	
Fresh				
Evaporated 9.2% by volume	Premixed 1:20 91%	1:22 DOR 95%	1:41 DOR 89%	1:100 DOR 84%
Evaporated 12.3% by volume	1:116 DOR 25%	1:20 DOR 36.5% , 38%		
Evaporated 27.6% by volume	1:13 DOR 6%	Premixed 1:100 0% (visual)	Premixed 1:10 0% (visual)	

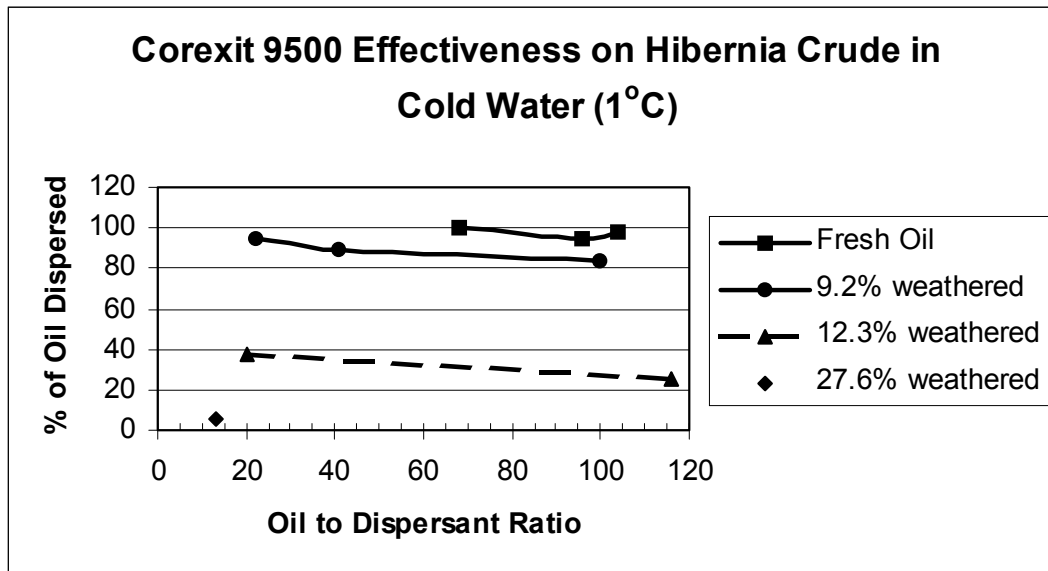


Figure 2 Effectiveness of Corexit 9500 on Hibernia Crude in Cold Water (1°C)

The fresh Hibernia crude oil was completely dispersed in the cold water at dispersant to oil ratios as low as 1:100, as evidence by the results in the first row of Table 2 and the top curve of Figure 2. The heavily evaporated oil (27.6 % by volume) was not dispersed to any extent even when the oil was pre-mixed with dispersant at a ratio of 1:10. When dispersant was sprayed onto the oil with a 1:13 DOR only 6% dispersion was measured. This weathered oil was a semi-solid at room temperature and had to be heated before it could be poured on the water surface. The oil re-solidified immediately upon contacting the cold water. The 12.3% weathered Hibernia was also not easily dispersed in these cold conditions and an effectiveness of only 35 to 40% was achieved when dispersant was sprayed at a 1:20 ratio. Only 25% dispersion was recorded at the lowest application rate tested for this oil (1:116). The 9.2% weathered oil was dispersible at the cold temperature. Corexit 9500 was between 85 to 95% effective when applied at 1:100 to 1:22 dispersant to oil ratios (see Table 1 and Figure 7). From these results it would appear that Hibernia crude oil would be amenable to chemical dispersion in cold, Hibernia winter conditions (1°C), until it evaporates by about 9 or 10% by volume. Once it evaporates past this point, the oil becomes semi-solid at these temperatures and is difficult to disperse.

## 7.0 Conclusions and Recommendations

The test results indicate that Hibernia crude oil will be amenable to chemical dispersion, in cold, winter conditions (1°C), until it evaporates to about 9 or 10% by volume. Once the oil evaporates past this point, it becomes semi-solid at this temperature and becomes difficult to disperse.

## 8.0 Acknowledgments

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## 9.0 References

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