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REPORT





Oil in Ice - JIP

Report no.: 7

Testing of Ro-Clean Desmi Ice Skimmer and Helix Skimmer in SINTEF ice basin. Task 3.1: Testing of existing concepts. A technical report.

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SINTEF Materials and Chemistry
Marine Environmental Technology

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Preface

SINTEF has in cooperation with SL Ross Environmental Research Ltd and DF Dickins Associates LLC on behalf of the oil companies AGIP KCO, Chevron, ConocoPhillips, Shell, Statoil and Total initiated an extensive R&D program; *Joint industry program on oil spill contingency for Arctic and ice covered waters.* This program was a 3-year program initiated in September 2006 and finalized in December 2009.

The objectives of the program were;

- To improve our ability to protect the Arctic environment against oil spills.
- To provide improved basis for oil spill related decision-making:
- To advance the state-of-the-art in Arctic oil spill response.

The program consisted of the following projects:

- P 1: Fate and Behaviour of Oil Spills in Ice
- P 2: In Situ Burning of Oil Spills in Ice
- P 3: Mechanical Recovery of Oil Spills in Ice
- P 4: Use of Dispersants on Oil Spills in Ice
- P 5: Remote Sensing of Oil Spills in Ice
- P 6: Oil Spill Response Guide
- P 7: Program Administration
- P 8: Field Experiments, Large-Scale Field Experiments in the Barents Sea
- P 9: Oil Distribution and Bioavailability

The program has received additional financial support from the Norwegian Research Council related to technology development (ending December 2010) and financial in kind support from a number of cooperating partners that are presented below. This report presents results from one of the activities under this program.

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Funding Partners

Eni Agip KCO | ConocoPhillips | Chevron | Shell | Total | Statoil

R&D Partners

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Cooperating Partners

The Research Council of Norway | NOFO | alaska clean seas
UNIS | Kystverket | MMS
Oil Spill Recovery Institute Cordova, Alaska | Coastal Response Research Center at the University of New Hampshire

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SINTEF

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TITLE

Testing of Ro-Clean Desmi Ice Skimmer and Helix Skimmer in SINTEF ice basin. Task 3.1: Testing of existing concepts.

A technical report

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ABSTRACT

This report summarises the main findings from testing of two oil recovery skimmers, produced by Ro-Clean Desmi from Denmark, in the SINTEF ice basin.

The Ice skimmer has potential application to oil spills at low temperatures in open water and also showed relatively high oil uptake in broken ice. However, ice has a tendency tol block the grid thus preventing the flow of oil to the brush drums. Based on the findings from the testing and discussions with the manufacturer and the project Reference Group, it was decided not to plan any further testing of this skimmer in this project.

The Helix 1000 Skimmer is not constructed for operations in ice and cold conditions. In fact, it is actually a brush adapter that can be mounted with floating elements to a weir skimmer attached to a screw auger pump. The skimmer tested in this project had no built-in buoyancy but depends on a crane for vertical and horizontal positioning. The principle of this skimmer is interesting with its helical brush drum arrangement. It does not process ice very effectively, but has an ability to move smaller ice pieces and slush ice into the water to release some oil. The potential application of this skimmer is to operate it at a steady, optimal drum speed and recognise that the recovery rate will not be very high. The free water uptake was very low. The concept of this skimmer and its potential capability were recognised by the project Reference Group as being both interesting and promising. Ro-Clean Desmi indicated that the company would pursue the concept further by constructing a larger modified and improved version. The skimmer was recommended for further testing during the field experiment in 2009.

KEYWORDS	ENGLISH	NORWEGIAN
GROUP 1	Oil spill	Oljesøl
GROUP 2	Oil	Olje
SELECTED BY AUTHOR	Oil recovery skimmers	Oljeopptagere
	Basin testing	Bassengtesting
	Oil recovery in ice	Oljeopptak i is

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1 Introduction

Most mechanical methods for recovering spilled oil are based on technologies developed for open water conditions. They often have serious limitations in ice-covered waters and recovery capabilities can be highly variable depending on a variety of local environmental conditions and logistics constraints. Some of the main challenges of operating skimmers in ice versus open waters are:

- Limited/difficult access to the oil – deflection of oil together with ice
- Limited flow of slicks to the oil recovery mechanism
- Separation of oil from ice and water
- Pressure in the ice field – structural and strength considerations of the skimmer
- Increased oil viscosity due to low temperatures
- Icing/freezing of oil removal and transfer components
- Detection / surveillance of the oil slick, potentially over a long time
- Moving ice of variable size as well as residual currents

It is expected that the largest potential for improving mechanical oil recovery in Arctic and ice-covered waters will be to further improve and adapt existing skimming technologies. Taking into account the remoteness of many of the Arctic areas in question, it is important that equipment for combating oil in ice also can be used in open waters.

In this project, oil spill response equipment manufacturers known to produce equipment with an expected potential for the recovery of oil in ice were asked to “nominate” existing skimmers for testing in the SINTEF ice basin. The manufacturers were required to prepare a short description of the “nominated” equipment for communication with the project Reference Group (RG) and decision by the Steering Committee (SC). Approximately 15 manufacturers were invited and six of them responded to the request. After discussions in the RG, a total of six skimmers from four manufacturers were selected for testing in the ice basin. One of the skimmers was equipped with a centrifugal pump unable to pump the viscous emulsion used in the testing. Testing finally involved a total of five skimmers from three different manufacturers.

Ro-Clean Desmi A/S from Denmark suggested including their Ice Skimmer and Helix 1000 Skimming Adapter in the testing. The testing was performed in week 13/2007.

2 Objectives

The main objective of this project was to document the capability and potential application of commercially available skimmers for recovering oil in ice. Based on this documentation, suggestions should be possible for defining and improving the operational spill response window in ice and cold conditions. The testing should also lead to a better understanding of the potential use of these skimmers in ice-covered waters. The aim was to identify one or two skimmers with potential use in Arctic areas.

3 Test set-up

3.1 The ice basin

The basic ice basin configuration is shown in figure 3.1; some additional minor modifications were also needed.

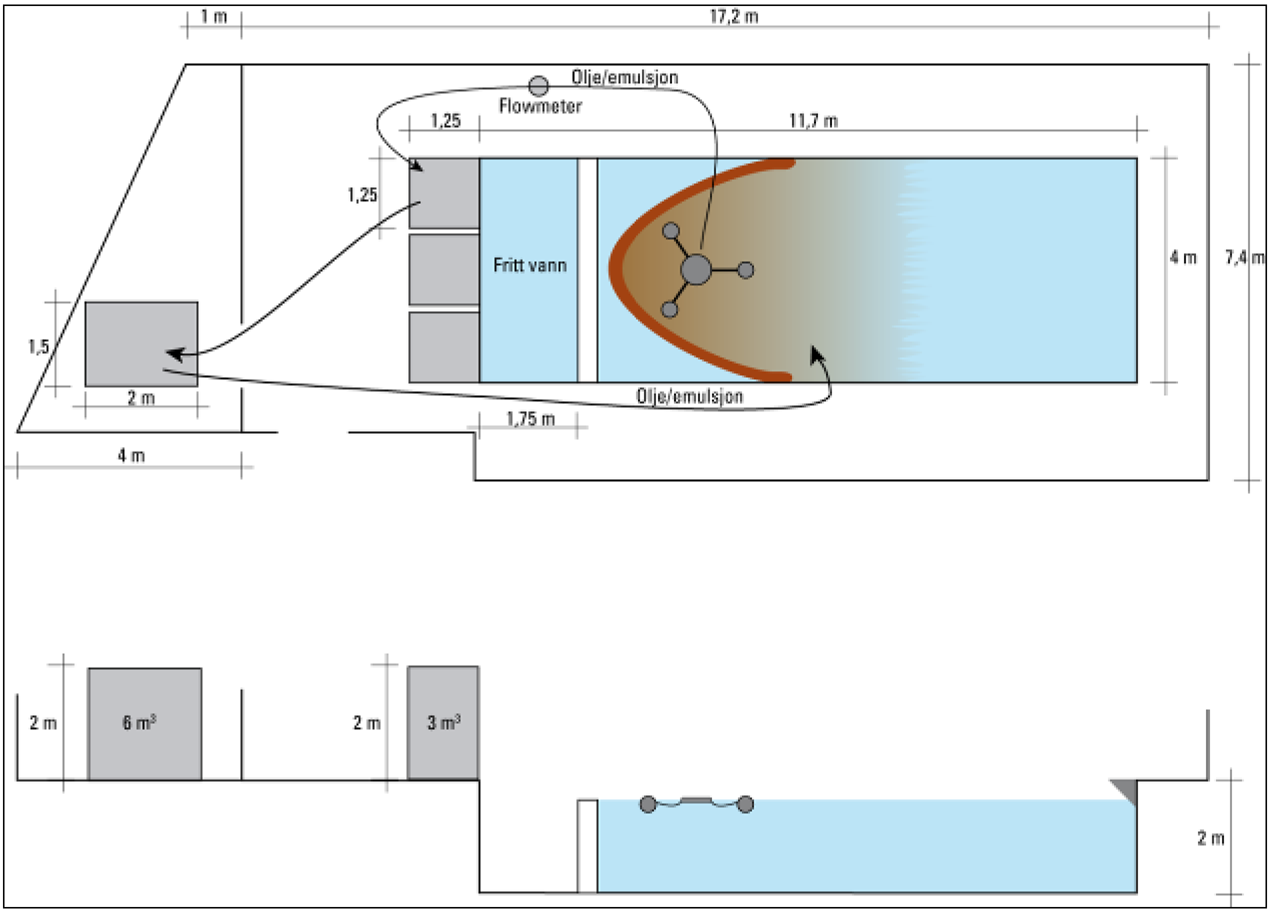

Figure 3.1 Sketch of the ice basin configuration during the testing.

A 5 m^3 tank for storing the original bunker oil was placed outside the building housing the ice basin. Two 3 m^3 tanks were installed in a heated room next to the ice basin for the storage of emulsion for testing and also for use as recovery tanks. One 3 m^3 tank was also installed in the ice basin room for the potential recovery of emulsion. Altogether, four tanks with a total capacity of 14 m^3 were used in the testing.

3.2 Test oil

It would have been desirable to use a weathered crude oil for the testing; however, that would have required distillation of large amounts of crude oil – tentatively 6-7 m^3 of fresh oil to yield approximately 5 m^3 of residue. The distillation of sufficient amounts of crude oil would have taken weeks and been quite expensive, so it was decided to use an IF-30 bunker fuel. 5 m^3 of bunker fuel that was purchased from the Slagen refinery and from this oil a 50% water-in-oil emulsion was prepared. The resulting emulsion had the following characteristics:

IF-30 bunker oil – 50% emulsion => viscosity ca. 6-8.000 cP at 0^{o}C.

An aim was to use an emulsion that did not differ too much in water content and viscosity from test to test. As expected, however, pumping of the emulsion by the skimmer contributed somewhat to increased water uptake and hence increased viscosity. This increase was within acceptable limits and the IF-30 with 50% emulsified water proved to be a good medium for testing under these conditions.

3.3 Ice conditions

The testing was performed in two different ice conditions. The first target ice scenario was approximately 50% with broken ice pieces and floes with a size up to approximately 1 m in diameter. The ice thickness was approximately 15 cm. This is referred to as the 50% broken ice scenario. The other target ice scenario was a mixture of small ice pieces and slush ice with an ice cover of up to 100%. This scenario is referred to as the slush ice scenario.

3.4 Measuring parameters

It was important to have good documentation of the emulsion used and the physical parameters in the basin.

For the emulsion the following parameters were measured between each test:

- Water content
- Viscosity

In the basin, the following parameters were measured:

- Water temperature
- Air temperature
- Emulsion layer thickness
- Temperature in the emulsion prior to testing

In addition to physical-chemical measurements of the emulsion before and after recovery, the amount of emulsion was calculated, recovery rate was measured, and the testing was documented by video recordings and photos.

During testing the following test parameters were recorded:

Parameter	**Measurement/registration**
Flow of oil to the skimmer - access	Visual, photo, video
Deflection of oil/ice	Visual, photo, video
Separation of recovered oil – water - ice	Settling, mixing, draining
Increased emulsion viscosity	Physical/chemical analyses
Icing / freezing of equipment	Leave at low temperature + visual
Recovery effectiveness	Recovery per unit time. Portions of emulsion, free water and ice. Measurements in recovery tanks.
Free water recovered	Settling – measurement in recovery tanks
Water in emulsion before and after recovery	Emulsion breaker and heating/settling
Viscosity of emulsion	Physical/chemical analyses.

4 Skimmers for testing

4.1 The Ro-Clean Desmi Ice Skimmer

Technical data skimmer:

- Diameter: 2.25 m.
- Overall height (with pump): 1.65 m.
- Weight: 680 kg.
- Outer diameter of brush drum: 500 mm.
- Width of brush belt: 500 mm.
- Bristle length: 25 mm.

Technical data off-loading pump (DOP-DUAL 250):

- Type: Archimedes screw pump.
- Capacity: 100 m^3/hr.
- Discharge pressure: 10 bar max.
- Discharge connections: 3” Camlock – male.
- Hydraulic flow required: 0 - 160 l/min
- Hydraulic pressure required: 210 bar max.
- Hydraulic connections: 3/4” supply/return, 3/8” drain

Figure 4.1 Brush drums and discharge coupling of the Ice Skimmer

Figure 4.2 Outer grid of the Ice Skimmer

4.2 Ro-Clean Desmi Helix 1000 Skimmer

Technical data skimmer:

- Dimensions: 2.2 x 2.4 x 1.1 m.
- Weight: 215 kg.
- Brush discs: 24 x 290 mm.

Technical data off-loading pump (DOP-DUAL 250):

- Type: Archimedes screw pump.
- Capacity: 125 m^3/hr.
- Discharge pressure: 10 bar max.
- Discharge connections: 3” Camlock – male.
- Hydraulic flow required: 0 - 160 l/min
- Hydraulic pressure required: 210 bar max.
- Hydraulic connections: 3/4” supply/return, 3/8” drain

Figure 4.3 Helix 1000 brush skimmer with the pump.

Figure 4.4 Upper part of the Helix 1000 brush skimmer.

Note: The Helix 1000 is actually a brush skimmer adapter designed for use with the company’s weir skimmers which in turn are outfitted with a screw auger pump.

4.3 Diesel hydraulic power supply

Technical data power supply:

- Length: 2000 mm.
- Width 1000 mm.
- Height: 1250 mm.
- Weight: 900 kg (1100 kg full diesel tank).
- Hydraulic flow range: 0 - 160 l/min.
- Max. cont. pressure: 210 bar.
- Power: 47,6 kW at 2600 rpm (DIN 6271).
  50 kW (DIN 70020).

Figure 4.5 Diesel hydraulic power pack used during the tests.

5 Ice basin testing log

<table>
<tr><th>Testing log</th><th>Illustrations</th></tr>
<tr><td>

27. March 2007.
Test no. 1: Ice Skimmer in emulsion, no ice:

- 2700 l emulsion released to the basin
- Air temperature: -10^{o}C
- Water temperature: -1,5^{o}C
- Emulsion Temperature: Surface: 0,2^{o}C
10 cm depth: 1,5^{o}C
- Emulsion layer: 10-12 cm

<u>*Observations:*</u>

Operated with 2 drums. Speed: approximately 43 rpm. Good flow to the drums.

Good recovery rate with a steady flow of emulsion to the skimmer and the pump. Recovered some free water especially after some time when the emulsion layer became thinner.

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Figure 5.1 Preparations for Test no. 1

Figure 5.2 Testing of Ice Skimmer without ice.

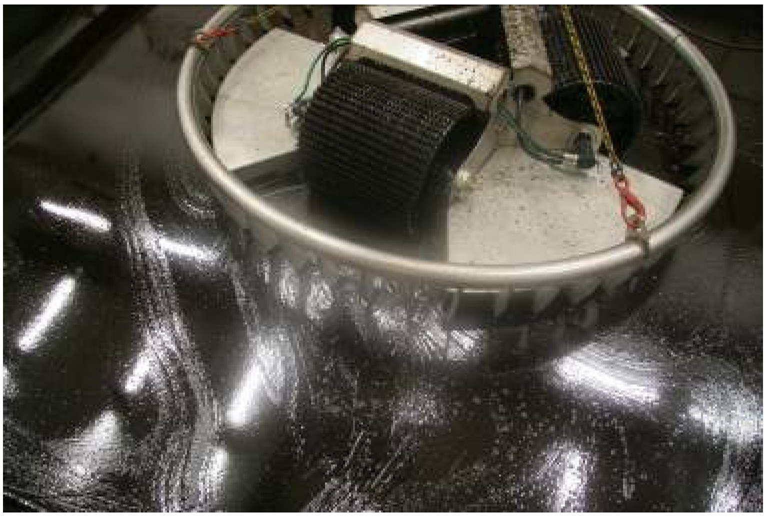

Figure 5.3 Testing of Ice Skimmer without ice.

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Testing log	Illustrations
28. March 2007. **Test no 2: Ice Skimmer in emulsion, 50 % broken ice** • Approx. 2700 l emulsion added to the basin • Air temperature: -10^{o}C • Water temperature: -1,5^{o}C • Emulsion Temperature: -0,3^{o}C • Emulsion layer: approx 15 cm *<u>Observations:</u>* Worked relatively well in the beginning with sufficient emulsion available close to the skimmer. Less flow of emulsion to the skimmer when ice is present than without ice. More free water in front of the drums. After some time, much ice was stuck to the grid resulting in a decreasing flow of emulsion to the drums. Lifted and moved the skimmer within the ice field. Decreasing flow of emulsion to the skimmer over time resulted in increasing recovery of free water.	 *Figure 5.4 Testing of Ice Skimmer in broken ice scenario.*  *Figure 5.5 Testing of Ice Skimmer in broken ice scenario.*  *Figure 5.6 Ice stuck at the grid – decreased emulsion flow.*

<table>
<tr><th>Testing log</th><th>Illustrations tions</th></tr>
<tr><td>

28. March 2007.
Test no 3: Helix Skimmer in emulsion, 50% broken ice.

- 1200 l emulsion released to the basin
- Air temperature: -10°C
- Water temperature: -1,5°C
- Emulsion Temperature: -0,3°C
- Emulsion layer: 7-10 cm

<u>*Observations:*</u>

Brush speed: approximately 8 rpm. Worked very well at low speed. Pushes the ice and emulsion down and is able to recover emulsion with a steady flow, but with reduced recovery rate.

A steady flow of emulsion into the pump. Little free water recovered. The pumping capacity is much higher than the brushes were able to deliver to it at the selected rotational speed of the brushes.

The relatively high viscosity of the emulsion has a positive effect on skimming. The emulsion layer in this experiment was thinner than the testing of the Ice Skimmer in the similar ice scenario.

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Figure 5.7 Testing of Helix Skimmer in broken ice scenario.

Figure 5.8 Steady flow of emulsion into the pump.

Figure 5.9 Pumping capacities higher than the brushes were able to deliver.

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Testing log	Illustrations
28. March 2007. **Test no 4: Helix Skimmer in slush ice.** • Approx. 2700 l emulsion pumped to the basin • Air temperature: -10,3°C • Water temperature: -1,5°C • Emulsion Temperature: 2°C • Emulsion layer: 15 cm *<u>Observations:</u>* Helix brush speed: approximately 8 rpm. The Helix Skimmer works very well in slush ice – at relatively low speed. It recovers the emulsion between the small ice pieces and pushes the ice down into the water.	 *Figure 5.10 Preparations for Helix testing in slush ice scenario.*  *Figure 5.11 Testing of Helix Skimmer in slush ice scenario.*  *Figure 5.12 Testing of Helix Skimmer in slush ice scenario.*

<table>
<tr><th>Testing log</th><th>Illustrations</th></tr>
<tr><td>

28. March 2007.
Test no 5: Ice Skimmer in slush ice.

- Approx. 2000 l emulsion released to the basin
- Air temperature: -10,3^{o}C
- Water temperature: -1,5^{o}C
- Emulsion Temperature: -0,3^{o}C
- Emulsion layer: 10-15 cm

<u>*Observations:*</u>

High viscosity of the emulsion. Some problems encountered with pumping emulsion to the basin. Low flow of emulsion to the skimmer due to the high viscosity. Tried to move the skimmer in the ice field by use of the crane. Low recovery of emulsion – high recovery of free water.

The skimmer was left overnight in the basin while the air temperature was taken down to -18^{o}C. The pump could easily be started but it was difficult to get the drums to rotate. The emulsion in the basin had solidified overnight and it was decided to terminate the testing.

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Figure 5.13 Testing of Ice Skimmer in slush ice scenario.

Figure 5.14 Ice pieces and slush ice went through the grid.

Figure 5.15 Somewhat reduced flow due to increased emulsion viscosity.

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6 Results

Table 6.1 presents the key results from testing of the Ice Skimmer and the Helix 1000 Skimmer in the ice basin. Table 6.2 indicates the viscosities measured during the testing. Figure 6.1 presents the recovery rates calculated for the two skimmers

Table 6.1 Results from the basin testing of the Ice Skimmer and the Helix 1000 Skimmer.

		Recovered liquid				Recovery rate calculated		
Skimmer and ice conditions	Recovery time, min	Total amount, l	Free water, l	Free water, %	* Water in emulsion, %	Total m^3/hr.	Emulsion m^3/hr.	* Oil m^3/hr.
Ice skimmer, No ice	28	2342	568	24	50	7,6	5,7	2,9
Ice skimmer, Broken ice	43	2040	520	26	50	4,2	3,2	1,6
Ice skimmer, Slush ice	15	735	559	76	50	2,9	0,7	0,4
Helix skimmer, Broken ice	52	1167	142	12	50	1,4	1,2	0,6
Helix skimmer, Slush ice	15	1314	0	0	50	5,3	5,3	2,6

* Water content in emulsion was measured to 50 % prior to testing. No measurements after that. Estimated to 50 % for the whole testing periode.

Table 6.2 Viscosity of the emulsion measured during testing. Measured at 0^oC and at a shear rate of 10 s^{-1}.

Sample ID	Sample from	Viscosity, mPas
D1	Pumping to basin, day 1 – Ice skimmer, No ice	7.960
D2	Emulsion in basin, day 1 – Ice skimmer, No ice	8.080
D3	Recovered, day 1 – Ice skimmer, No ice	9.150
D5	Pumping to basin, day 2 – Ice skimmer, Broken ice	15.700
D6	Emulsion in basin, day 2 – Ice skimmer, Broken ice	16.500
D7	Emulsion in basin, day 2 – Ice skimmer, Broken ice	11.400
D8	Emulsion in basin, day 2 – Helix skimmer, Slush ice	10.000
D10	Emulsion in basin, day 2 – Ice skimmer, Slush ice	18.700

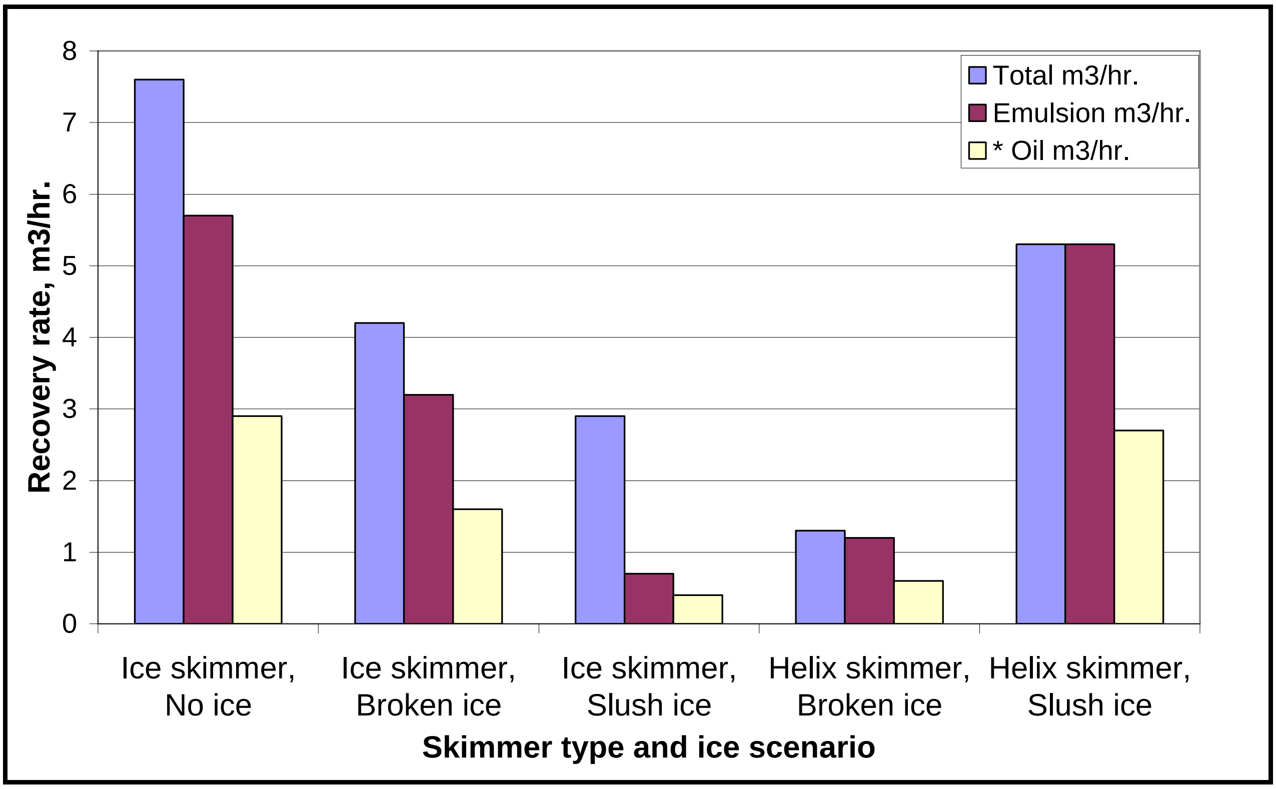

Figure 6.1 Recovery rate for total liquid, emulsion and oil calculated from the testing of the Ice skimmer and the Helix 1000 skimmer.

6.1 Flow of emulsion to the skimmer

Access to the oil is one of the major challenges of recovering oil in ice-covered waters. The following observations were recorded during this testing:

Ice Skimmer:

- There was good flow of emulsion with no ice present even when the drum speed was relatively high.
- With ice present, there was a tendency for the ice to stick to the grid and thereby reduce the flow of emulsion considerably. The skimmer had to be moved around in the basin by the crane in order to gain access to the emulsion.

Helix 1000 skimmer:

- At a relatively low but steady drum speed, this skimmer was able to recover emulsion in broken ice with a steady flow of emulsion into the pump. Unlike the Ice Skimmer, the Helix 1000 was able to move the ice pieces and hence recover some of the cohesive emulsion located between the ice pieces, however, with a relatively low recovery rate.
- Oil recovery in the slush ice scenario was even higher than in the broken ice scenario. The skimmer pushed the small ice pieces into the water and recovered emulsion with a higher recovery rate than for the broken ice scenario.

6.2 Ice processing

In this context, ice processing is defined as the skimmer's ability to deflect the ice for easier access to the oil. The following related observations were made:

Ice skimmer:

- Because the skimmer was equipped with a grid and the brush drums were placed some distance inside the grid, the ice had a tendency to collect at the grid leaving free water in front of the brush drums. Due to the distance between the grid and the brush drums, the brushes could not contribute to moving the ice to enhance oil collection. It was concluded that this skimmer is unable to process ice.

Helix 1000 skimmer:

- This skimmer is very limited in its ability to process ice. However, it is capable of pushing smaller ice pieces and ice floes into the water and thereby recovers some oil in-between the ice pieces. This skimmer is also dependent on being moved inside the ice field by use of a crane. Lack of floating elements makes it more difficult to operate the skimmer efficiently.

6.3 Separation of emulsion, water and ice

Uptake of free water along with emulsion is undesirable for effective recovery. Skimmers with screw pumps are probably capable of recovering small ice pieces along with the emulsion, but it is not desirable. In this testing, attempts were made to measure uptake of free water and ice. This proved to be difficult since the free water settled very slowly from the emulsion and small ice pieces and slush ice were difficult to find and measure in the viscous emulsion. The following observations were made:

Ice Skimmer:

- This skimmer recovered considerable amounts of free water measured to be approximately 25% without ice present and in the broken ice scenario. In the slush ice scenario, as much as 75% of free water was recovered. It should be noted that in that experiment, the viscosity of the emulsion was quite high, which could be unfavourable in avoiding free water uptake.
- The recovery of ice in the testing of this skimmer could not be measured nor observed.

Helix 1000 skimmer:

- The Helix Skimmer took up very small amounts of free water that was easily settled and separated in the receiving tank.
- No uptake of ice was observed for this skimmer.

6.4 Icing / freezing of equipment

Icing / freezing of the skimmer and auxiliary equipment is a serious challenge in Arctic areas at low temperatures and especially combined with strong winds. Winterisation of equipment to be used under these conditions is highly recommended. Although this testing did not focus on icing / freezing, some relevant observations were possible:

Ice skimmer:

- The skimmer was left in the basin overnight at an air temperature of -18^{o}C. The pump which was submerged in the water worked fine, but there was a problem in starting the rotation of the drums. Due to the low temperature, the emulsion froze during the night and the testing had to be terminated.

Helix 1000 skimmer:

- According to the manufacturer, the Helix Skimmer is not constructed for cold conditions and potential freezing was not tested.

6.5 Skimmer effectiveness related to oil type

As mentioned a 50 % water in oil emulsion of a IF-30 bunker oil was used in this testing. One reason for choosing this oil was practical because it was fairly easy to prepare stable emulsions. If we should have used a crude oil it would have been necessary to evaporate (top off) the light components to be able to prepare a stable emulsion, which would have been very time consuming and expensive.

Another reason for using IF-30 is that we have used it as reference oil in previous skimmer testing (Singsaas *et al.,* 2000). This testing was performed with a rope mop skimmer (Foxtail) and the recovery rate using the IF-30 oil was very close to the maximum recovery rate as given by the manufacturer of the skimmer. The IF-30 proved to have good cohesion and adhesion properties related to this skimmer type. Figure 6.2 shows the results from this testing, all results normalised to the IF-30 as the reference oil.

This testing indicates that IF-30 and emulsions of IF-30 can be close to optimal testing oil for skimmers that are dependant on good adhesion between the emulsion and the skimmer brushes and strong cohesion forces within the emulsion. However, for logistic and economic reasons it has not been within the scope of this project to do testing with several oil types. Even if ice processing seems to be the main challenge recovering oil in ice, the oil type and weathering degree still has a significant impact on the recovery effectiveness of different skimmer types.

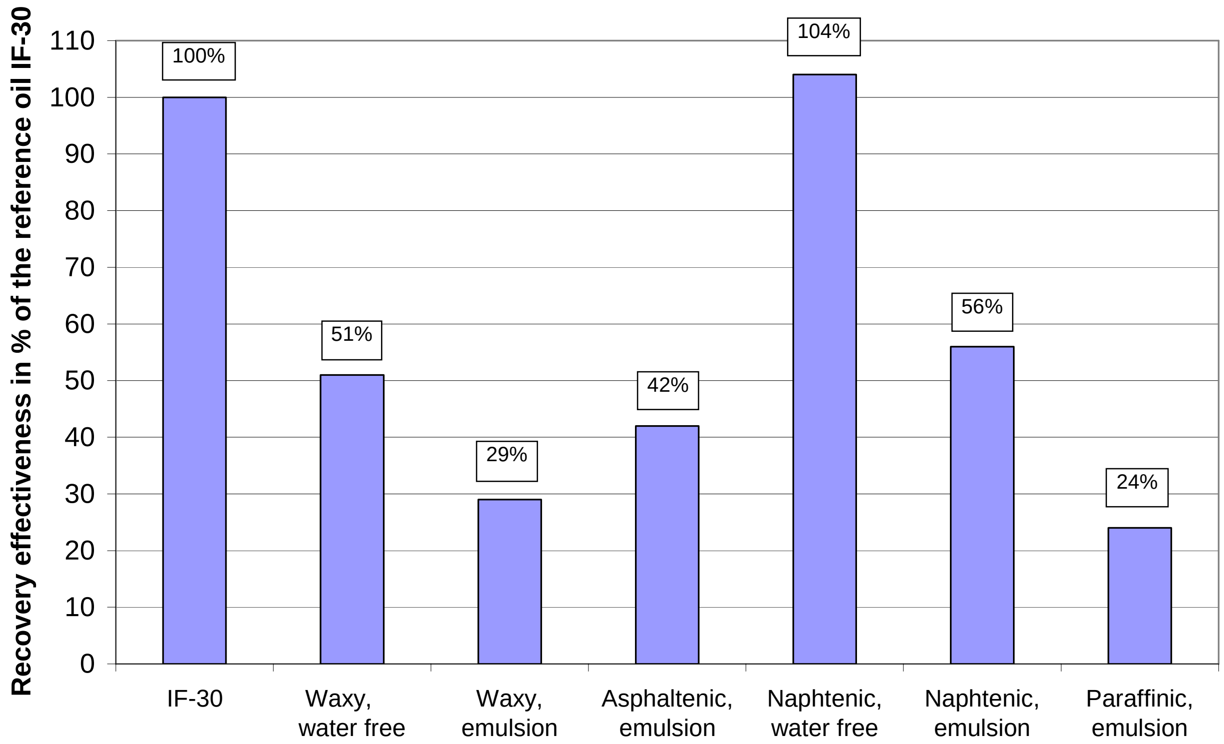

Figure 6.2 *Testing of previous rope mop skimmer testing in the SINTEF basin, using IF-30 as reference oil (Singsaas et al.,* 2000).

7 Conclusions and recommendations

Based on this testing it was concluded:

The Ice skimmer has potential application to oil spills at low temperatures in open water and also showed relatively high oil uptake in broken ice. However, ice will block the grid preventing the flow of oil to the brush drums. Also the water uptake was relatively high for this skimmer. The Ice Skimmer has different brushes (i.e., short and stiff) compared to the other brush skimmers tested in this project. This aspect was not examined further. Based on the findings from the testing and discussions with the manufacturer and the project Reference Group, it was decided not to plan any further testing of this skimmer in this project.

The Helix 1000 Skimmer is not constructed for operations in ice and cold conditions. In fact, it is actually a brush adapter that can be mounted with floating elements to a weir skimmer attached to a screw auger pump. The skimmer tested in this project had no built-in buoyancy but depends on a crane for vertical and horizontal positioning. The principle of this skimmer is interesting with its helical brush drum arrangement. It does not process ice very effectively, but has an ability to move smaller ice pieces and slush ice into the water to release some oil. However, the skimmer must be moved around in the ice field by the crane in order for it to access oil. The brushes recovered emulsion that was available to it quite effectively, but the skimmer should probably not be operated at high drum speeds (i.e., higher than between 5 and 10 rpm). The potential application of this skimmer is to operate it at a steady, optimal drum speed and recognise that the recovery rate will not be very high. The free water uptake was very low. The concept of this skimmer and its potential capability were recognised by the project Reference Group as being both interesting and promising. Ro-Clean Desmi indicated that the company would pursue the concept further by constructing a larger modified and improved version. The skimmer was recommended for further testing during the field experiment in 2009.

If the present version of the Helix 1000 Skimmer should be recommended for use as a skimmer for the recovery of oil in ice, it must be modified. This modification program should consider:

- Flotation: Some sort of buoyancy should be built in.
- Protection: The skimmer is small and unprotected and should incorporate features that prevent damage from collisions with ice floes.
- Winterisation: The skimmer should be "winterised" to avoid freezing of components of the skimmer under cold conditions that are critical to its operation, e.g., scraping of brushes.
- Location of hoses: Discharge hose and hydraulic hoses should be connected on top of the skimmer and not under the skimmer as it was presented for testing.

It was concluded that if this skimmer were to be used in its present configuration under more moderate weather conditions and in low ice concentrations (up to 40 – 50 %) and operated from an adequate crane, it could be a very versatile device.

8 Acknowledgement

Lauri Solsberg from Counterspil Research Inc. is acknowledged for a thorough and valuable review of this report. Thanks also to the project Reference Group that discussed the results from this testing in a meeting 18th to 20th June 2007 and gave recommendations to further testing. Members of the project Reference Group has been: John Parson and Lee Majors, Alaska Clean Seas; Hans V. Jensen, NOFO; Kari Lampela, SYKE; Johan M. Ly, Norwegian Coastal Administration; Joe Mullins, MMS; Ian Denness, ConocoPhillips and Lauri Solsberg, Counterspil Research Inc.

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