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Field Evaluation of Oil Mop and Preheat Unit

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FIELD EVALUATION OF OIL MOP AND PREHEAT UNIT

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ABSTRACT

The Oil Mop II-9D was previously tested to evaluate its oil recovery performance and although the unit was determined to be effective, it was not found suitable for the processing of highly viscous oils such as Bunker C. Oil Mop Pollution Control Ltd. subsequently designed and built a prototype preheater unit consisting of a hot water bath, to allow the processing of a wide range of fuels. A field evaluation was undertaken to assess the performance of an Oil Mop Unit with the preheater. When tested with Bunker C oil in a 5 millimeter slick it was found to recover 5 litres per minute with an oil content of 43%. Testing with Bunker C but without the preheater unit was not attempted since previous experience had shown that the Oil Mop did not function in such circumstances. The evaluation also showed that the Oil Mop, with and without the preheater unit, was capable of recovering crude oil at rates of 9 and 18 litres per minute in oil thicknesses of 1 and 5 millimeters. The percentage of oil in the recovered fluid varied with the slick thickness from 70 to 80% in the test conducted without the preheater unit and from 49 to 78% when the preheater unit was used. In all these tests the recovery unit showed little tendency to emulsify the recovered product. Overall, it was concluded that the preheater unit did not significantly affect the recovery ability of the Oil Mop in less viscous oils such as crude oil, but did, in fact, permit the recovery of heavier oils such as Bunker C.

RÉSUMÉ

Le lécheur Oil Mop II-9D a déjà été éprouvé pour ses capacités de récupération, lesquelles ont démontré son efficacité, sauf pour la récupération d'hydrocarbures très visqueux comme le Bunker C. La société Oil Mop Pollution Control Ltd. a par la suite imaginé et mis au point le prototype d'un dispositif de pré-chauffage, constitué d'un bain d'eau chaude qui permettrait la récupération d'une grande variété d'hydrocarbures. On a entrepris, sur le terrain, l'évaluation du lécheur muni de ce dispositif. Des essais sur une nappe de Bunker C de 5 mm d'épaisseur ont donné une récupération de 5 l/mn, avec une teneur en pétrole de 43%. Les essais sur le Bunker C sans le dispositif de pré-chauffage ont été omis puisque des essais antérieurs avaient démontré l'inefficacité du lécheur dans ce cas. Les essais ont de plus démontré que le lécheur, munis ou non du dispositif du pré-chauffage, permettait de récupérer des nappes de 1 et de 5 mm au rythme de 9 et 18 l/mn respectivement. La teneur en pétrole du liquide récupéré variait, selon l'épaisseur de la nappe, de 70 à 80% dans les essais effectués sans le dispositif de pré-chauffage, et de 49 à 78% avec ce dispositif. Dans tous ces essais, le lécheur n'a montré que peu de tendance à émulsifier le pétrole récupéré. Dans l'ensemble, on a conclu que le dispositif de pré-chauffage n'influait pas de façon significative sur la capacité de récupération du lécheur pour des pétroles moins visqueux comme le pétrole brut, tout en permettant la récupération de pétroles plus lourds comme le Bunker C.

FOREWORD

The work described in this report was performed by Montreal Engineering Company Limited under contract to the Environmental Emergency Branch with Mr. L.B. Solsberg of the branch acting as scientific authority. Testing was conducted at the Canadian Coast Guard base in Sorel, Québec. Mr. G. Duchesneau of the Coast Guard played a major role in making available materials and space for the evaluation program. Mr. N. Tribe of Oil Mop Pollution Control Limited of Mississauga, Ontario provided much sound advice on the operation and set-up of the test unit.

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1 INTRODUCTION

In 1976, Oil Mop Pollution Control Limited designed a preheater unit for use with their Mark II - 9D oil spill recovery device. This preheater unit was intended to allow the processing of high viscosity fuels by the recovery device. The construction of a prototype was subsequently funded by the Department of Supply and Services as well as Fisheries and Environment Canada under the unsolicited proposal program. Fisheries and Environment Canada then designed a program to assess the operational capabilities of the Oil Mop Mark II - 9D, both with and without the preheat unit. The program was conducted at the Canadian Coast Guard Base in Sorel from April 19 to April 26, 1977.

This report contains the results of field trials and observations made on the operational performance of the Oil Mop equipment. The test data are compared against a set of broad evaluation criteria. Results are also compared with those obtained in field trials conducted on the Oil Mop in Halifax in 1975.

This report is presented in four parts:

Part I contains an introduction to the study and details the test program background as well as evaluation criteria. Part II presents the principal findings and offers specific recommendations. In Part III, a description of the equipment has been drawn up including physical specifications. This same section also describes test results and observations and provides a more comprehensive account of the equipment and testing recommendations. Appendix A completes the report and offers specifics of the test procedures.

1.1 Background

In a field evaluation of oil recovery equipment undertaken for Fisheries and Environment Canada in Halifax in 1975, the Oil Mop Mark II - 9D was found to be among the most versatile and efficient of the devices tested (See Report EPS 4-EC-76-3). The Oil Mop demonstrated its ability to recover both crude and emulsified crude oils at reasonable rates from the water surface under the cold weather operating conditions encountered during these trials. Mechanical reliability, personnel safety features, and ease of operation were generally judged to be superior to the other devices tested although the idler (or tail) pulley was found to require a remotely located anchoring point; this procedure complicated the initial deployment of the unit. One of the most attractive features of the Oil Mop is the fact that the unit is completely self-contained and requires little outside support other than oil removal vehicles or storage vessels and a small boat to deploy the idler pulley. From the experience of these trials, it was concluded that the Oil Mop was a well designed, versatile oil recovery device which potentially could be used in ice-infested waters where conventional recovery units would have difficulty operating.

Despite the success encountered with the Oil Mop in these trials, considerable difficulty has been experienced elsewhere recovering stiff emulsions or heavy oils such as Bunker C from cold water (Terry Hayes, Canadian Coast Guard; Norm Tribe, Oil Mop Pollution Control Ltd. - Personal Communication). The problem was not attributed to the inability of the polypropylene rope to adsorb the oil but rather the inability of the wringers in the drive unit to strip off the oil clinging to the rope mop which resulted in the collected oil building up on the rope mop and wringers, effectively jamming the drive unit.

In recognition of the overall capabilities of the device under other conditions, Oil Mop Pollution Control Limited of Mississauga, Ontario was contracted by the Environmental Emergency Branch of the Department of Fisheries and the Environment through the Federal Department of Supply and Services to develop a preheating unit to warm these heavier types of oil on the rope mop before entering the drive unit and to facilitate oil removal through the normal wringing action. The device developed is essentially a hot water bath through which the rope mop travels to heat the recovered oil to a temperature well above its pour point before entering the wringing unit.

The objective of this program was to evaluate the ability of the Oil Mop, with and without this prototype preheat unit, to collect heavier oils under cooler ambient water and air temperature conditions. Testing was to be conducted under controlled field conditions to specifically identify any features that would limit its overall performance, compromise personnel safety, or affect its reliability under actual spill conditions.

1.2 Evaluation Criteria

A number of factors must usually be considered in assessing the overall effectiveness of mechanical devices designed to selectively remove oil from the water surface and these are as follows:

- oil collection performance which indicates the ability of a device to selectively collect and recover oil under varying spill and environmental conditions,
- operational capabilities which indicate flexibility of application, safety hazards, and ease of operation,
- operational availability which indicates reliability and ease of maintenance, and
- support requirements which indicate the amount and type of support required to effectively utilize a device.

These criteria include not only quantitative measurements directly related to the oil recovery capabilities of a device under field trial conditions, but also qualitative observations as well as support requirements which could limit its application under certain oil spill emergency conditions.

The quantitative measurements made during the trials relate to oil collection performance and included the following parameters:

Recovery Rate	-	a measure of the volume of oil recovered per unit time (maximum recovery rates were not determined)
Oil Content Factor	-	a measure of the oil collected in relation to the total amount of liquid recovered
Emulsification Factor	-	a measure of the volume of water mixed into the recovered oil.

In addition to the above measurements made during the trials, general observations were also recorded. These related to equipment reliability, personnel safety and debris sensitivity. Observations on design of the device as well as on the overall general support requirements of the device were also noted and logged during the field trials. See Section 3 for these detailed comments.

2 PRINCIPAL FINDINGS AND RECOMMENDATIONS

The principal findings arising from this program are as follows:

1. The oil recovery performance data reveal that the Oil Mop can recover crude oil without the assistance of the preheat unit, and can effectively recover and process Bunker C with the preheat unit integrated into the recovered cycle.
2. The recovery rates for crude oil are equivalent with and without the preheat unit on-line although the oil content factor is reduced when the preheat unit is used. The recovery rates are significantly higher in thicker oil slicks.

	OIL MOP UNIT		OIL MOP WITH PRE-HEATER	
Thickness (mm)	Recovery Rate (l/min)	Oil Content Factor (%)	Recovery Rate (l/min)	Oil Content Factor (%)
1	9.8	70	9	49
5	17.3	80	19.8	78

3. The Oil Mop recovery rates are viscosity-dependent given equivalent operating thicknesses (5mm as presented below).

	Recovery Rates (l/min)	Oil Content Factor (%)
Crude Oil	25.4	78
Emulsion (1975 Halifax tests)	17.2	71
Bunker C	6.0	43

4. There was little tendency to emulsify either crude oil or Bunker C during the recovery process.
5. Bath operating temperatures in excess of 60°C were needed to adequately heat the oil and prevent accumulation in the tank.
6. Observations showed the device to be mechanically reliable, simple to operate, and safe for operating personnel under the existing conditions.

The recommendations made as a result of this program are as follows:

1. Design modifications are recommended for the idler pulley; a method for depressing the rope mop below the surface is also suggested.

2. Sleeves around the heating coils and an explosive atmosphere "sniffer" are recommended for the preheat unit.
3. The electrical requirements of the unit should be precisely defined.
4. The unit should be tested under "worst case" environmental conditions over an extended trial period.

3 DETAILS OF TEST PROGRAM

3.1 Equipment Description

3.1.1 Principle of Operation. The Oil Mop is, in principle, a sorbent surface device. It utilizes a buoyant, continuous, oleophilic rope mop composed of polypropylene fibres woven into a core to selectively adsorb oil and remove it from the water's surface (Figure 1). The polypropylene rope mop travels in a continuous loop between the wringer-drive unit and one or a series of remotely fixed buoyant idler (or tail) pulleys. The rope mop is wrung by a series of rollers in the drive unit and the recovered fluid falls into a sump from which it is pumped into a storage or disposal unit. The operating length of the rope can be adjusted simply by adding or deleting sections of rope mop to a maximum of about 150 metres.

The model Mark II - 9D tested employs a 23-cm diameter rope mop and has double-pass wringer and guide roller assembly driven by a single cylinder 8 hp diesel engine through a torque-limiting clutch and chain drive assembly. The sump has a storage capacity for about 630 litres of recovered fluid and the unit is equipped with a double action 7.6 cm diaphragm pump for offloading purposes. The pump is driven off the main drive engine through a belt and centrifugal clutch assembly.

The preheating unit is essentially a large hot water bath through which the rope mop is pulled (Figure 2). The insulated tank is 3.58 m long, 1.12 m wide and 1.19 metres deep and holds 3.64 m^3 of water. It comes equipped with a four-section insulated tank cover for use in cold-temperature operating conditions, but the unit can be operated with or without the covers installed.

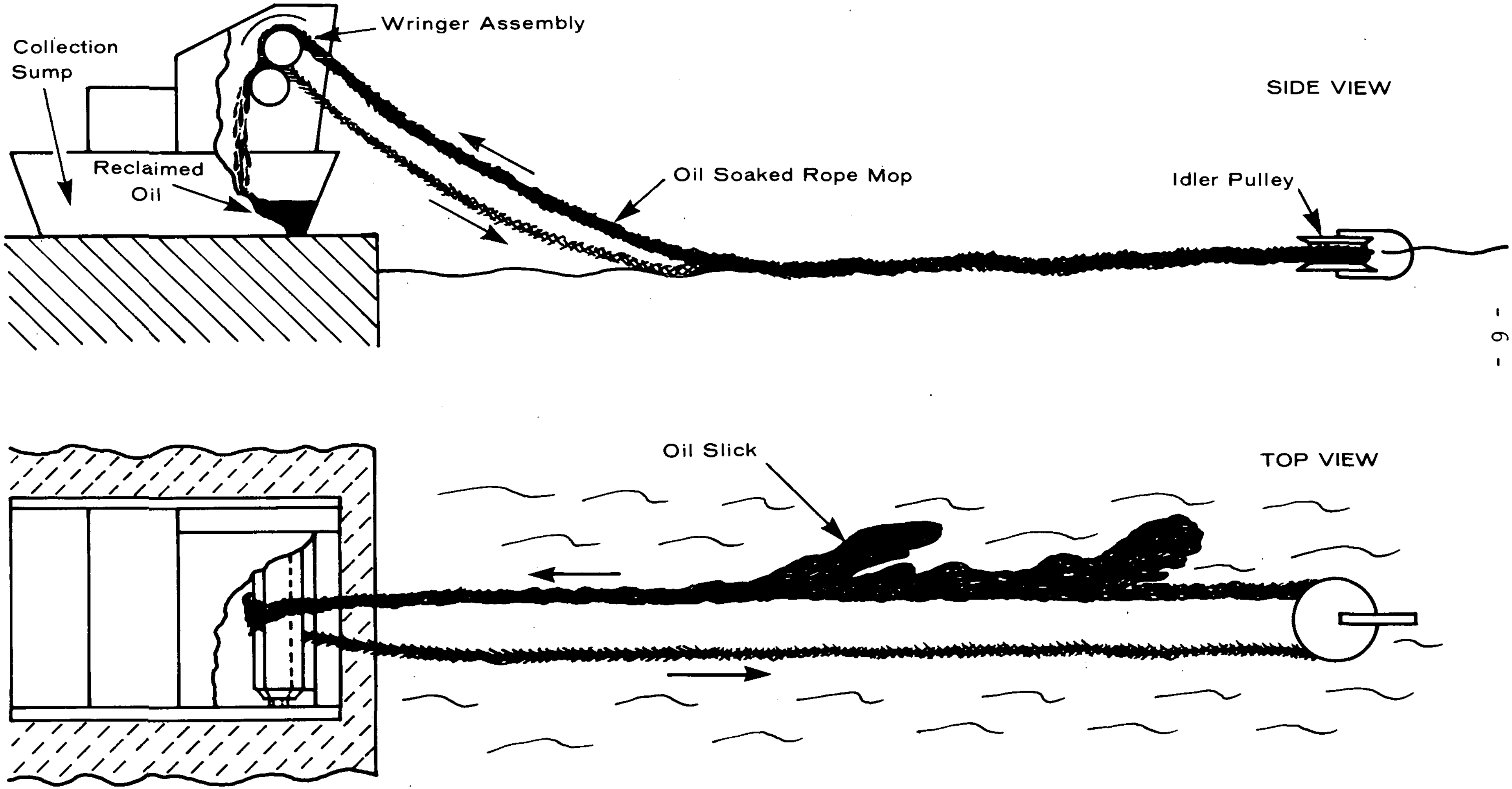


Fig.1 Oil Mop Concept

Heating is provided by four 50 kw Chromalox immersion heaters capable of raising the temperature of the bath in excess of 90°C and theoretically sustaining it under "worst case" operating conditions. The unit has been designed to minimize friction losses so that it can be operated within the power constraints of the standard diesel engine installed on the Mark II-9D wringer-drive unit. The temperature of the bath is controlled by a thermocouple and ten-step electrical control integrated into the control panel which can maintain the temperature within 1°C of the selected setting.

With the preheat unit on-line, the rope mop is led into the tank over a guide roller, around two grooved drums spaced about 2.5 m apart, over three guide sheaves and into the drive engine (Figure 2). The objective is to insure complete immersion of the mop in the bath for a sufficient period of time to warm the oil well above its pour point before it is pulled into the drive unit and wrung. The rope mop has to be cut for threading or removal from the preheat unit. Depending upon the threading option selected, either 24 m or 18 m of rope mop are immersed in the tank at any one time during the operating cycle.

The tank is equipped with both oil-level and water-level sensors and automatic relief valves to limit oil buildup in the tank and ensure that the water does not drop below prescribed levels. The unit was equipped with a small pump to add water to compensate for both evaporative losses and liquid removed by the rope mop during the operating cycle.

3.1.2 Specifications. The physical specifications of the machine and the heating element as supplied by the manufacturer are as follows:

Oil Mop Unit

- Manufacturer-Oil Mop Pollution Control Ltd.
- Length - 1.75 m
- Width - 1.12 m
- Height - 1.19 m
- Dry weight - 454 kg
- Operating weight - 953 kg
- Pan Size - 635 litres
- Roller size - 22.9 cm

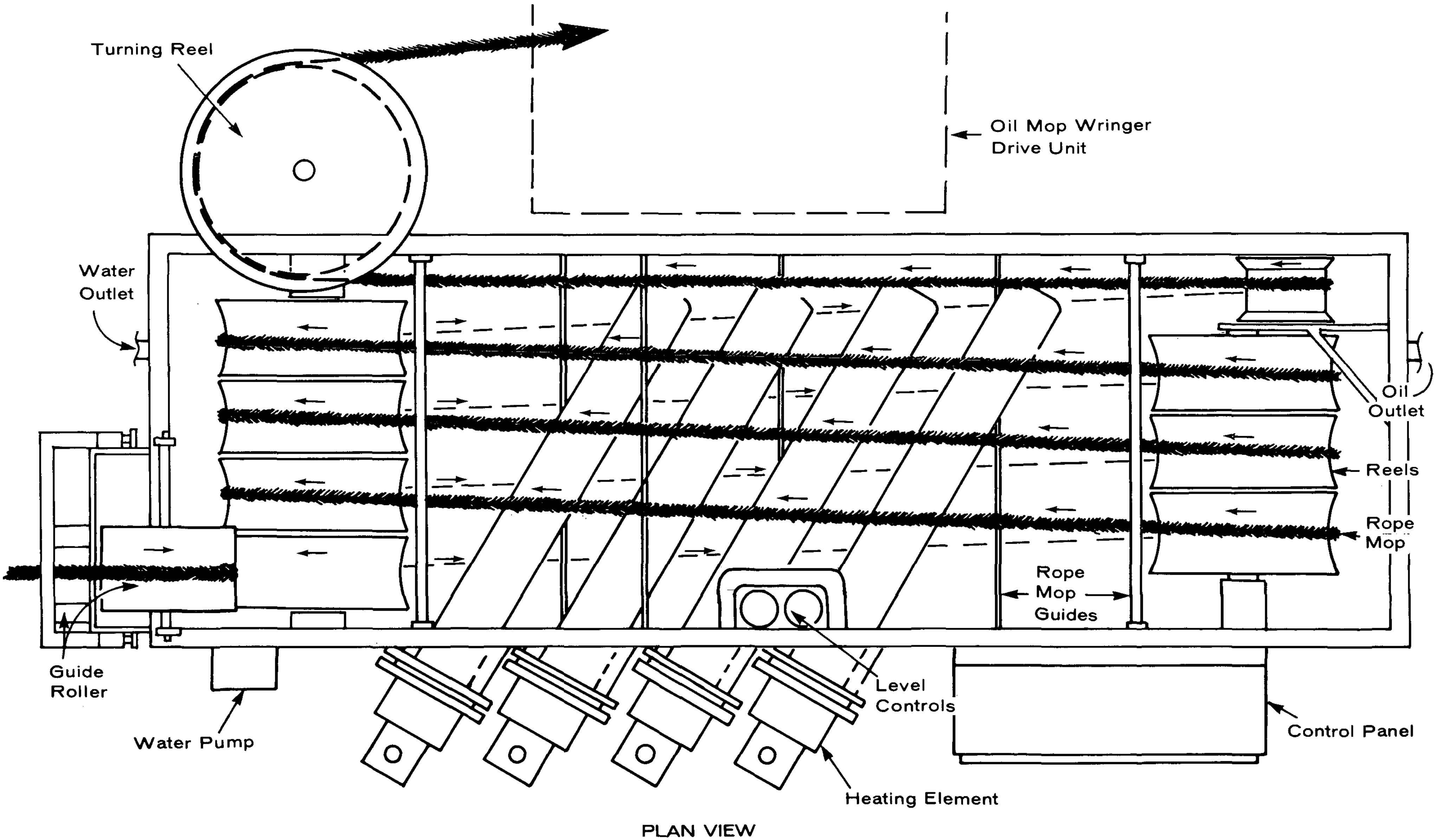


Fig.2 Preheat Unit Layout

Pump	-	Pump Type - double action diaphragm
	-	Make - SPATE
	-	Size - 3.8 cm
Drive Engine	-	Type - diesel
	-	Make - Hatz Wisconsin Type E79
	-	Size - 8 horsepower @ 3600 RPM
Rope Mop	-	Type - No. OCW4-9
	-	Maximum working length - 152 metres
	-	Nominal diameter - 22.9 cm
	-	Rope size - 1.3 cm
	-	Working strength - 1179 kg
	-	Nap weight - .496 kg/metre
	-	Mop weight - .566 kg/metre
Preheat Unit	-	Manufacturer - Oil Mop Pollution Control Ltd.
	-	Length - 3.58 m
	-	Width - 1.12 m
	-	Depth - 1.19 m
	-	Dry weight - 2700 kg
	-	Operating weight - 6363 kg
	-	Capacity - 3640 l
	-	Control panel - Custom Control Panels Ltd. rated 600 V, 200 A, 60 Hz, 3 ph, 200 kw
	-	Heaters - 4 Chromalox Type TM1-1850 rated 50 kw
	-	Temperature control - Fenwall Thermocouple
	-	Oil and water level control - Fenwall Limit Switch with solenoid controlled valves
	-	Water pump - small Moyno progressive cavity pump, electric drive

3.1.3 Deployment. For the Sorel trials, the Oil Mop drive unit and the preheat unit were mounted side by side on a trailer equipped with leveling jacks (see Figure 3). This configuration was developed to permit independent operation of the Oil Mop, yet minimize the reorganization required to bring the preheat unit on-line if and when required.

The combined preheat and Oil Mop drive units weigh about 7300 kg when in full operating condition.

3.2 Evaluation Data

3.2.1 Introduction. The preheat unit is a prototype device, thus testing personnel did not have the benefit of previous operating experience as a guide for assessing its performance or providing benchmark performance data. During the field trial period from April 19 to 26, the air temperature ranged from 13 1/2°C to 26°C and the water temperature in the harbour ranged from 6.5°C at the beginning of the trials to 12°C at the end. Although these are not "worst case" oil spill recovery conditions, the low ambient water temperatures served to indicate whether the preheat concept provided a workable answer to the problem of recovering heavy oils at temperatures below their pour point.

One of the difficulties encountered in the field evaluation program was obtaining an accurate definition of the oil/water interface in the recovery device, which is needed to determine the volume of oil collected and quantify oil recovery rates. Considerable error is encountered in any of a number of methods used to identify this interface. Hence, in the results presented in Tables 1 through 4, all measurements and calculations have been rounded off to the nearest whole number.

At the beginning of the program considerable difficulty was encountered in determining the oil/water interface in trials with crude oil and the first results obtained fluctuated substantially. Therefore, in computing the results for the different operating conditions, averages shown represent only the results collected after test number 7.

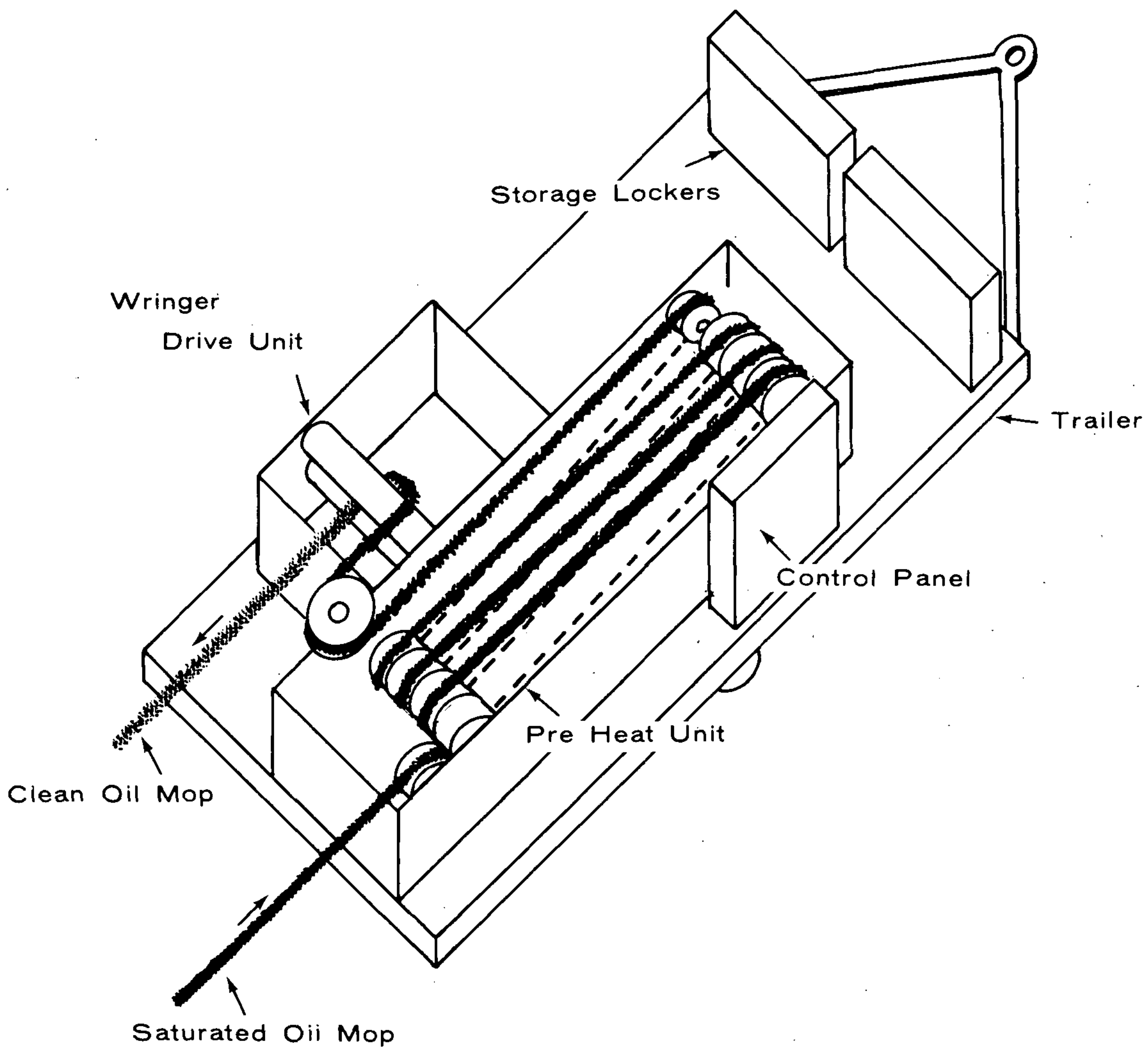


Fig.3—Oil Mop Unit Mounted on Trailer

Despite this inaccuracy, it is felt that the overall results of the evaluation program do serve to indicate the oil recovery capabilities of the Oil Mop with and without the preheat unit on-line.

3.2.2 **Test Results from Crude Oil Trials.** Results from the constant layer tests with and without the preheat unit on-line are presented in Tables 1 and 2 while those from the diminishing layer tests are presented in Table 3 and shown in Figure 4.

The data indicate that the highest oil recovery rates and oil content factors were recorded in the 5 mm constant layer trials. They also indicate that the oil recovery rates are comparable for both the Oil Mop by itself and with the preheat unit on-line, however, the overall efficiency is somewhat reduced when the preheat unit is used.

In the 1 mm trials, the oil recovery rates averaged 9 l/min under both operating conditions, but at least twice as much water was collected when the preheat unit was used. The average oil content factor was 69% when the Oil Mop was operated by itself, but this dropped to 49% when the preheating unit was integrated into the system. Although the average was higher, greater fluctuations in the oil content factor were found in the trials with the Oil Mop by itself. The emulsification factor was low in both operating modes, never exceeding 4% and generally less than 2%.

Results from the 5 mm test condition trials indicate that recovery rates were approximately twice those encountered in the 1 mm tests under both operating modes. The recovery rates with and without the preheat unit were 20 and 17 l/min, respectively. The Oil Content Factor again fluctuated more widely when the Oil Mop was tested by itself, but averaged 87% as opposed to 78% when the preheat unit was used. In both series of 5 mm tests, the emulsification factor generally remained less than 2%.

The results from the diminishing layer tests show a definite trend toward reduced recovery rates and oil content factors as the thickness of the test oil layer is reduced. During the initial intervals, recovery rates exceeded 12 l/min but dropped to an average of 5 l/min during the last two intervals. Recovery rates were generally lower in the first trial (test no. 12) than the second, but in both cases, the average oil content factor was 63%. The emulsification factor in both tests was 2% or less in all test phases.

TABLE 1 OIL MOP CRUDE OIL TRIALS (CONSTANT LAYER)

Test No.	Oil Thickness (mm)	Run Time (min)	Machine Speed (m/sec)	Water Temp. (°C)	FLUID RECOVERY Oil Amt. (1)	%	Water Amt. (1)	%	Oil Recovery Rate (1/min)	Oil Content Factor (%)	Emulsification Factor (%)
1	1	3	0.4	6.5	75	42	102	58	25	42	0
2	1	3	0.4	6.5	0		27	100	0	-	0
3	1	3	0.4	6.5	64	89	8	11	21	89	0
4	5	3	0.4	8	28	44	36	56	9	44	0
5	5	3	0.4	8	23	85	4	15	8	85	5
6	5	3	0.4	8	70	62	44	38	23	62	-
7	5	3	0.4	8	51	63	30	37	17	63	4
8	5	3	0.4	8	57	97	2	3	19	97	1
9	5	3	0.4	8	53	93	4	7	18	93	1
10	5	3	0.4	8	46	75	15	26	15	75	-
13	1	3	0.4	9	23	61	15	39	8	61	4
14	1	3	0.4	9	30	79	8	21	10	79	2
15	1	3	0.4	9	32	71	13	29	11	71	1

TABLE 2 OIL MOP/PREHEAT UNIT CRUDE OIL TRIALS (CONSTANT LAYER)

Test No.	Oil Thickness (mm)	Run Time (min)	Machine Speed (m/sec)	Water Temp (°C)	Bath Temp. (°C)	FLUID RECOVERY Oil Amt. (l)	Oil %	Water Amt. (l)	Water %	Oil Recovery Rate (l/min)	Oil Content Factor (%)	Emulsification Factor (%)
17	1	3	0.4	9	100	21	47	30	53	9	47	<1
18	1	3	0.4	9	100	27	52	25	48	9	52	1
19	1	3	0.4	9	100	27	49	28	51	9	49	<1
21	5	3	0.4	9	100	59	82	13	18	20	82	<1
22	5	3	0.4	9	100	64	85	11	15	21	85	<1
23	5	3	0.4	9	100	53	74	19	26	18	74	2
24	5	3	0.4	9	100	61	73	23	27	20	73	<1

TABLE 3 OIL MOP CRUDE OIL TRIALS (DIMINISHING LAYER)

Test No.	Oil Thickness Start (mm)	Oil Thickness Finish (mm)	Run Time (min)	Machine Speed (m/sec)	Water Temp. (°C)		INTERVAL VOLUMES 5 Min. Amt. (l)	%	10 Min. Amt. (l)	%	15 Min. Amt. (l)	%	20 Min Amt. (l)	%
12	6	<1	20	0.4	8°	O	68	94	62	82	11	24	4	10
						W	4	6	15	18	37	76	34	90
13	9	1	20	0.4	8°	O	80	95	80	75	49	82	27	50
						W	4	5	27	25	11	18	27	50

Test No.	AVERAGE FLUID RECOVERY/PERIOD Oil Amt. (l)	%	Water Amt. (l)	%	Average Oil Recovery Rate (l/min)	Average Oil Content Factor (%)	Emulsification Factor (%)
12	38	63	22	37	8	63	2
13	59	63	35	37	12	63	<1

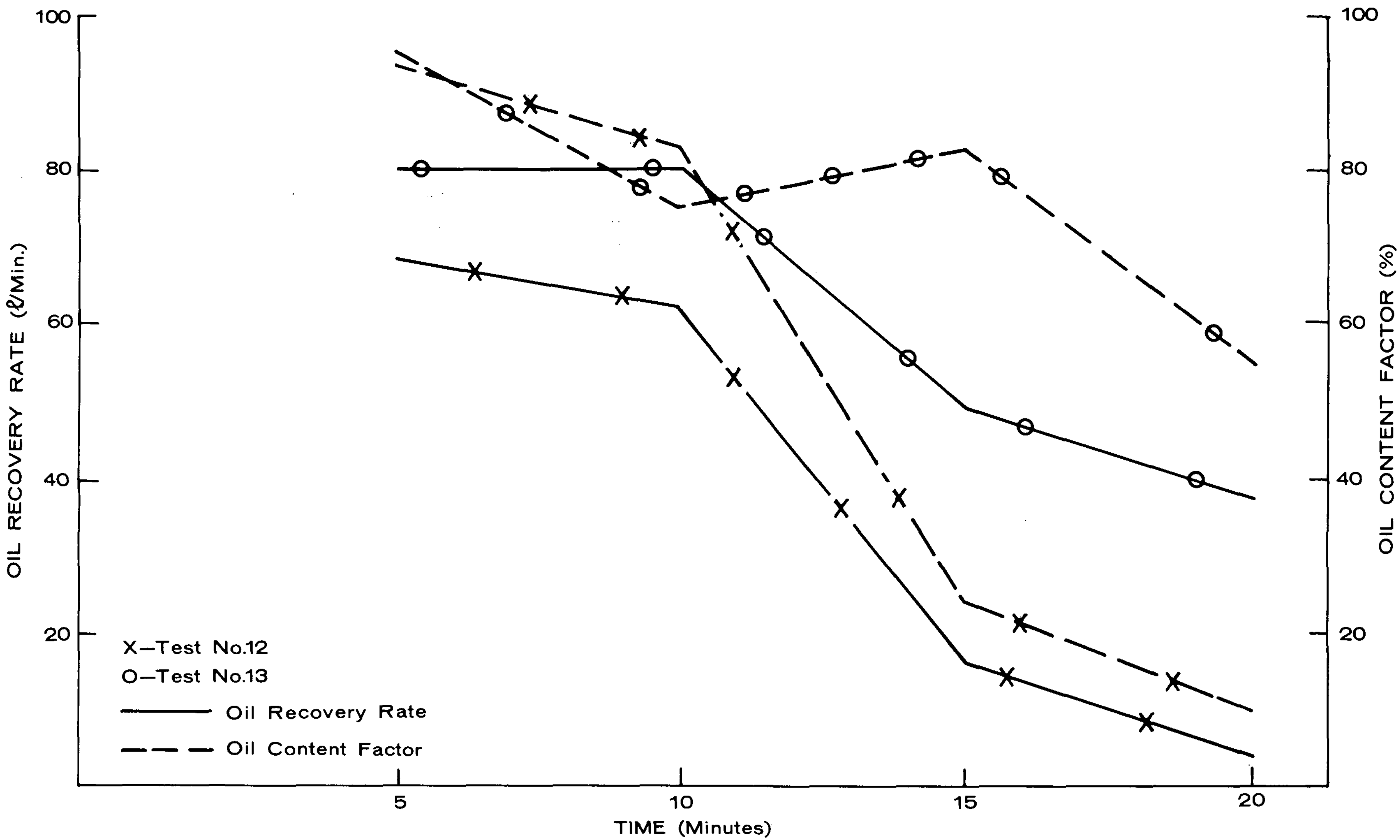


Fig.4 Diminishing Layer Test Results

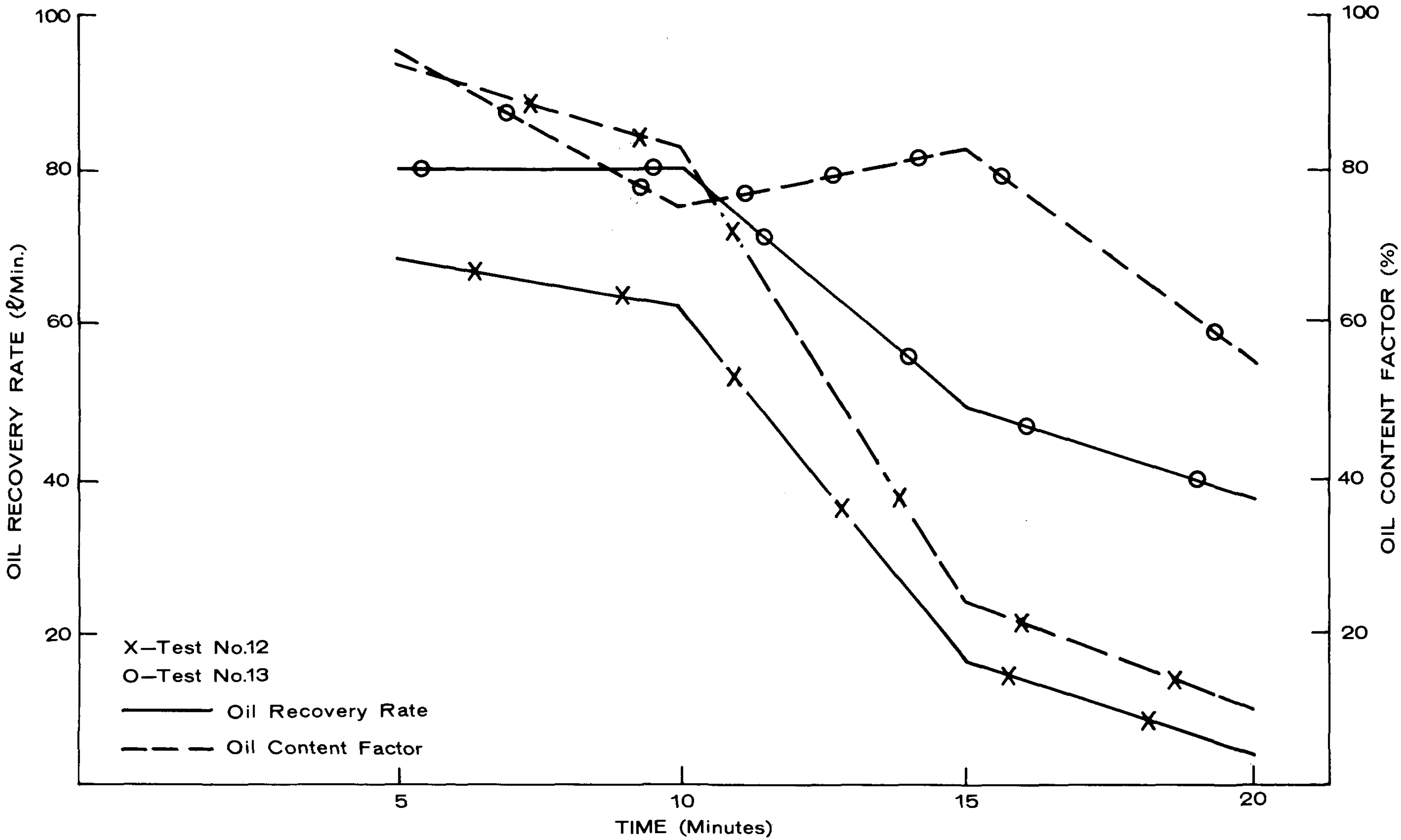


Fig.4 Diminishing Layer Test Results

3.2.3 Test Results from Bunker C Trials. Test results of the Bunker C trials with the preheat unit are shown in Table 4. No trials were carried out with the Oil Mop by itself because previous operating experience has shown that the unit will not strip Bunker C off the rope mop unless the temperature of the oil is above its pour point.

Data from the trials indicate that the recovery rates for equivalent thicknesses of oil were often only one-half to one-third of those recorded in crude oil trials. Overall, the average recovery rate recorded was about 6 l/min. With two exceptions, results indicate little, if any, variation in collection rates with the temperature of the preheat unit bath although when the bath temperature was set at 60°C, the oil apparently was not being adequately heated during the rope mop's transit through the tank and the material being wrung off the Mop was quite stiff. Oil recovery rates varied between 4 and 15 l/min and oil content factors averaged about 48%. With fresh bunker, the emulsification factor was low but with aged material it increased to as much as 13%.

Temperatures recorded during the tests show that the oil emerged from the preheat tank 12-18°C cooler than the operating bath temperatures.

The rope mop was immersed in the tank for about one minute at the speeds used for these trials (0.4 m/sec) and the temperature of the oil adsorbed on the rope mop increased 1°C per 1 to 2 second immersion interval.

To test the capabilities of the preheat unit to sustain a bath temperature over an extended operating period, one trial was run for a period of 40 minutes during which the recovered oil was returned to the test enclosure. Results from those trials indicate that the recovery efficiency of the device is somewhat lower over an extended period than it is in five minute incremental trials. However, these could be attributed to the fact that the oil during this trial was more weathered than that used in the earlier trials with Bunker C. During this run, the bath temperature was sustained at a level comparable to those recorded during the earliest 5 minute trials. Despite the prolonged operation of the device, the recorded decreases in temperature were not significant. Throughout the trials, the temperature setting was from 2° - 5°C higher than the operating temperature of the bath.

TABLE 4 OIL MOP W/PREHEAT UNIT BUNKER C TRIALS (CONSTANT LAYER)

Test No.	Oil Thickness (mm)	Run Time (min)	Machine Speed (m/sec)	TEMPERATURE Ambient Water (°C)	Ambient Oil (°C)	Tank Start (°C)	Tank Finish (°C)	Treated Oil (°C)	Sump (°C)
50	Est. 5	5	0.4	10°	12°	70°	64°	46°	30°
51	Est. 5	5	0.4	10°	14°	70°	68°	50°	48°
52	Est. 5	5	0.4	10°	14°	70°	66°	56°	46°
53	Est. 5	5	0.4	10°	14°	70°	68°	54°	46°
54	Est. 5	40	0.4	10°	18-22°	70°	65°	52-54°	50°
55	Est. 10	5	0.4	10°	15°	80°	-	60°	-
56	Est. 10	5	0.4	10°	15°	80°	-	60°	-
60[2,4]	Est. 5	5	0.4	12°	20°	60°	-	38°	38°
61[4]	Est. 5	6	0.4	12°	17°	63°	-	55°	40°
62[3,4]	Est. 5	5	0.4	12°	19°	85°	-	57°	57°
63[3,4]	Est. 6	5	0.4	12°	15°	85°	-	70°	70°

TABLE 4 (Cont'd)

Test No.	FLUID RECOVERY Oil Amt. (l)	Oil %	Water Amt. (l)	Water %	Recovery Rate (l/min)	Oil Content Factor (%)	Emulsification Factor (%)
50	27	48	29	52	5	48	0
51	34	48	38	52	7	48	1
52	43	57	32	43	9	57	1
53	37	49	39	51	7	49	1
54	(51	38	83	62	10)	38	1
55	20	38	32	62	4	38	-
56	22	22	71	71	4	22	-
60[2,4]	74	81	19	19	15	81	5
61[4]	59	65	35	35	10	65	7
62[3,4]	108	100	-	-	22	100	13
63[3,4]	146	100	-	-	24	100	-

NOTE: All Figures and Calculations Rounded Off to Nearest Whole Number

[1]Extended Test ( ) Represents Results From Last Min. Increment

[2]Oil Lost in Preheat Tank

[3]Water Levels Not Measurable; Results Not Used in Calculations

[4]Test Medium was Combination of Weathered Bunker C and Crude Oil

3.2.4 Discussion of Test Results. The results from these trials confirm the capability of the Oil Mop unit to recover fresh crude oil from the water surface by itself and indicate that the Oil Mop Skimmer in conjunction with a preheat unit will recover Bunker C.

The data collected show, however, that significant water pickup occurs when the preheat unit is used. This is attributed to the fact that insufficient time exists for the water to run off the rope mop between the time it emerges from the bath in the preheat tank and the time it is wrung out in the wringer assembly. Interestingly, despite this increased water content, emulsification did not increase significantly. The presence of the preheat unit does not alter the oil recovery rate and oil does not tend to strip off the rope mop and accumulate on the surface of the bath.

The results indicate that lift time directly affects the oil content factor in the operation of the Oil Mop. At Sorel, where the unit was about 2.7 m above the water surface, the oil recovery rates were substantially lower than those recorded in the Halifax trials, but the oil content factors were considerably higher (See Table 5). The lift time was about 25 seconds whereas in Halifax it was less than 10 seconds; this difference accounts for the greater water pickup and higher degree of emulsification encountered in the Halifax trials. A factor that may influence the results from Sorel is that on occasion the rope mop rubbed on the front of the drip apron on the trailer and quantities of oil were seen to be flowing back down the main apron into the test enclosure.

In the diminishing layer trials, results show that the rope mop has the ability to draw low viscosity oil to itself. Recovery rates remain quite high until the test layer is less than 5 mm thick after which they are sharply reduced. Overall results from these trials indicate that the oil content is about two thirds of the total fluid recovered.

The results of these trials show that the Oil Mop in conjunction with the preheat unit can recover and handle Bunker C, although the recovery efficiency and rate are substantially lower than those recorded with crude oil. Recovery rates dropped as the Bunker C in the test enclosure weathered and cooled. The reduction in recovery efficiency was not attributable to the inability of the preheat unit to process the oil but rather to the rope mop not being able to hold the oil once recovery was achieved. Considerable shearing was evident in the floating bunker as the rope mop was drawn through the test enclosure. In the Sorel trials it was evident that the recovery rates were considerably enhanced by sinking the rope mop under the floating oil and allowing it to float up. Operated like this the rope mop adsorbed large volumes per unit length as it passed through the floating oil mat.

A comparison of the results obtained during the Halifax and Sorel field trials is shown in Table 5. These results indicate that, as a general rule, the recovery rates of the Oil Mop are dependent on the viscosity of the spilled oil; the heavier the oil being collected, the lower the recovery rate and the oil content factor for equivalent oil thicknesses. This is complicated, however, by the fact that recovery rates per unit time fluctuate dramatically when heavier or weathered oils are involved because they tend to form into clumps on the surface which (unless their movement is restricted) come in contact with and are adsorbed by the rope mop at random intervals.

The temperature of the bath appears to be critical when Bunker C is being processed. Although the critical recovery fluid temperature cannot be precisely defined from present results, observations suggest that 40°C is a cutoff point below which oil strips off the rope mop in the bath and does not readily flow off the wringers in the drive unit. At higher bath temperatures these problems were not encountered, even with aged oil.

3.3 Field Trail Observations

3.3.1 Equipment Reliability. During the pre-trial familiarization periods and the trials themselves the Oil Mop and preheat unit worked extremely well. Only minor mechanical problems were encountered and these were quickly rectified. The torque-limiting clutch on the wringer-drive assembly became disengaged and had to be reset, and a set screw in the clutch driving the Spate pump vibrated loose, which necessitated removal and servicing of the unit. The stripping of polypropylene fibres off the rope mop noted in the Halifax trials was not encountered at Sorel. This may be a function of oil temperature but can also be related to the use of the machine whereby the wringers were disengaged every evening after trial completion so as to eliminate the tendency of the rope mop to freeze to the rollers.

TABLE 5 OIL MOP AND OIL MOP/PREHEAT UNIT FIELD TRIAL RESULTS COMPARISON AND SUMMARY

OIL			AVERAGE RECOVERY RATE									AVERAGE OIL CONTENT FACTOR		
			HALIFAX			SOREL						HALIFAX	SOREL	
						OM			OMH					
Type	Thickness (mm)	Machine Speed (l/sec)	Total (l/min)	Oil (l/min)	%[1]	Total (l/min)	Oil (l/min)	%	Total (l/min)	Oil (l/min)	%	(%)	OM[2] (%)	OMH[3] (%)
CRUDE	1	0.3-0.4	19.5	9.8	50	13.4	9.8	70	18.2	9	49	50	70	49
CRUDE	5	0.3-0.4	40 7	34.3	84	21.5	17.3	80	25.4	19.8	78	84	80	78
EMULSION	Est 5	0.3	24.4	17.2	82	-	-	-	-	-	-	82	-	
BUNKER C[4]	Est 5	0.4	-	-	-	-	-	-	14.1	6.0	43	-	-	43

1 - Percentages Adjusted to Nearest Whole Number

2 - Oil Mop Unit

3 - Oil Mop Preheat Unit

4 - Data from Tests 50-56

Several major modifications had been made to the Oil Mop unit tested as compared to the one used in the Halifax trials. These were:

- a torque- limiting clutch had been added to the chain drive assembly on the mop wringer drive to prevent damage to the engine and tearing of the mop should the wringers jam,
- a clutch had been added to the pump-out unit on the Oil Mop to replace the sliding platform and pulley tension device used previously, and
- a positive displacment Spate pump had replaced the centrifugal pump.

All modifications have improved the overall performance of the machine, however, a continuing difficulty with the Spate pump is the type of hose connectors which can be affixed to the unit. The suction and discharge manifold castings are not threaded which means that hoses must be clamped on and considerable difficulty was encountered keeping these tight, particularly when pressures built up. It was found that during these trials the suction on the Spate had to be throttled down to 1 1/2 inch to match the discharge lines available.

The Hatz diesel on the Oil Mop provided adequate power under all oil recovery operating conditions with and without the preheat unit but did not have adequate power or pump-off operations while continuing to drive the rope mop. During this operation, the engine would stall unless the throttle was advanced to full power. Because more power would be required if a longer length of rope mop were used, or large quantities of oil were being recovered, a larger engine is needed so that oil recovery operations can continue while pumping-off is taking place. This is particularly true where Bunker C is involved because it cannot be allowed to sit in the collection sump and cool off.

The preheat unit operated without fault throughout the trial program. Its operation with and without the insulated covers had no apparent effect on overall performance. Any extra loading on the Oil Mop engine as a result of extra friction resulting from pulling the rope mop through the bath did not measurably affect the speed of the rope mop.

The ten-step temperature controller kept the bath temperature within 1°C and the maximum temperature drop recorded over a forty minute trial was only 5°C. During start up operations, the bath temperature can be raised to the selected operating temperature from ambient temperature at a rate of about 1°C per minute. It was not possible to measure the power requirements to maintain bath temperatures because the ten-step controller cut in very infrequently.

The oil level control valve is not needed as oil accumulation on the tank surface is minimal and the makeup water pump and level control maintained stable levels.

A problem noted in this program which had been discussed in the report on the Halifax trials (EPS 4-EC-76-3) is the difficulty encountered with the plastic screw connections on the transfer hoses. These connections are fragile, difficult to work with, and tend to leak. It is suggested that quick couplings become standard on hoses used for oil spill countermeasures work.

3.3.2 Personnel Safety. The Oil Mop and preheat unit package tested presented few safety hazards for operating personnel or bystanders under the existing test conditions. There is, however, the possibility that, if the preheat unit is used to collect fresh crude oil, an explosive atmosphere could build up in the preheat tank if the covers are in place during recovery operations. The high bath temperatures could drive off many of the lighter distillate fractions which could accumulate in the air space under the covers. This state apparently did not develop during the Sorel trials because covers were not used (the bath was kept at a relatively low temperature).

The hot water bath does not present any hazard during operations. Because of the high freeboard on the tank, hot water cannot slop out of the tank and scald bystanders, and any runoff from the rope mop returns to the bath or drains into the Oil Mop sump. Warning signs and locking control levers have been incorporated into the control panel to prevent the accidental start up of the heaters when the tank is dry. Although not completely foolproof, it is felt that sufficient safeguards have been built in to prevent accidental start up when the tank is dry. All the control components are explosion proof.

As with any device of this type, common sense is the key to safe operation of this unit.

The one immediate hazard that exists on the Oil Mop unit itself is the operation of the clutch driving the Spate pump. Although the drive belts and clutch itself have a protective shield, the handle on the clutch is an exposed bar lever. When engaging the clutch, the lever is drawn up and back and requires a strong pull to engage. If the operator's hand should slip off the bar during the engaging process, it might get caught in the clutch assembly. To alleviate this hazard, it is suggested that a simple bail grip be welded to the handle.

3.3.3 Debris Sensitivity. Little or no debris was present in the test enclosure during the test period so it is not possible to say how the test package would react to the presence of large amounts of floatsam or jetsam under the different operating modes. An observation made during the Bunker C trials suggests that the bail of the idler pulley is not large enough to allow free passage of large clumps of material entrained in the rope mop to pass around the pulley. It was noted that the large quantities of cold bunker tended to accumulate by the idler pulley but could not get pulled around by the rope mop because the bail constricted the passage of material and effectively acted as a barrier. This observation is discussed more fully in Part 3.5.1 of this report.

3.4 Summary of the Evaluation Program

The results of this field evaluation program indicate the Oil Mop/preheat unit is a versatile combination that could be used in a variety of spill conditions. The general test findings, in relation to the broad evaluation criteria defined in Part 1.4, are outlined below.

3.4.1 Oil Collection Performance. The oil collection performance as measured by the oil recovery rate, the oil content factor, and the emulsification factor indicate that the Oil Mop with and without the preheat unit has reasonable recovery rates and shows only a slight tendency to emulsify the recovered product. The water pickup is, however, substantially greater when the preheat unit is used. The recovery rates are sensitive to the thickness of the slick and the viscosity of the oil.

Although debris sensitivity could not be adequately assessed, it was evident that the limited throat on the idler pulley bail restricted the passage of collected Bunker C and could collect debris.

3.4.2 Operational Capabilities. It is apparent that the rope mop/heater could be used under a variety of spill conditions from either the shore or a barge. This is particularly true of the test package which is mounted on a trailer. Both units are straight-forward and simple to use, and with one modification, do not present a serious operational hazard to personnel.

One person can very easily operate the unit(s). The preheat controls are all automatic and the Oil Mop unit will run from six to eight hours without refuelling.

3.4.3 Operational Availability. The preheat unit and Oil Mop are of rugged construction and made to stand up to the rigors of field operations. They appear to be very mechanically reliable and the difficulties encountered during the program were more than would be expected under normal operation conditions.

Both units are relatively easy to clean and service.

3.4.4 Support Requirements. The recovery unit can be deployed with relative ease at the spill site providing there is good road access. The power requirements of the preheat unit suggest, however, that the unit will have limited applicability to spill emergencies, particularly at more remote locations. Operation of four immersion heaters requires the usage of 250 kw and a 300-400 hp diesel generator would be needed to produce such power. Few of the vessels that would be involved in a spill cleanup have this generating capacity.

The operating weight of the unit (7.3 tons) would also preclude its use on many of the vessels, particularly SP (special purpose) barges that might be used on a spill site. Although it could be broken down into its individual component units for transport by air to a remote spill location, a minimum lift capacity of 2.7 tons would be required to move the preheat unit.

3.4.5 Conclusion. The results of this evaluation show that the Oil Mop and the preheat unit can recover heavy oils under cooler ambient water temperature conditions and that both machines have been well engineered and are mechanically reliable.

The power requirements and present supply strategy for the preheat unit appear, however, to present severe application constraints.

3.5 Recommendations

As a result of the field evaluation program at Sorel, a number of recommendations have been developed and are presented below. It must be recognized that the duration and environmental conditions encountered during this program did not present the "worst case" conditions which the combined units are designed to handle. The test results indicate that the Oil Mop and preheat unit combination are capable of recovering and processing Bunker C. Observations made during the trials did not indicate any major mechanical deficiencies but information on performance under more demanding environmental conditions is desirable.

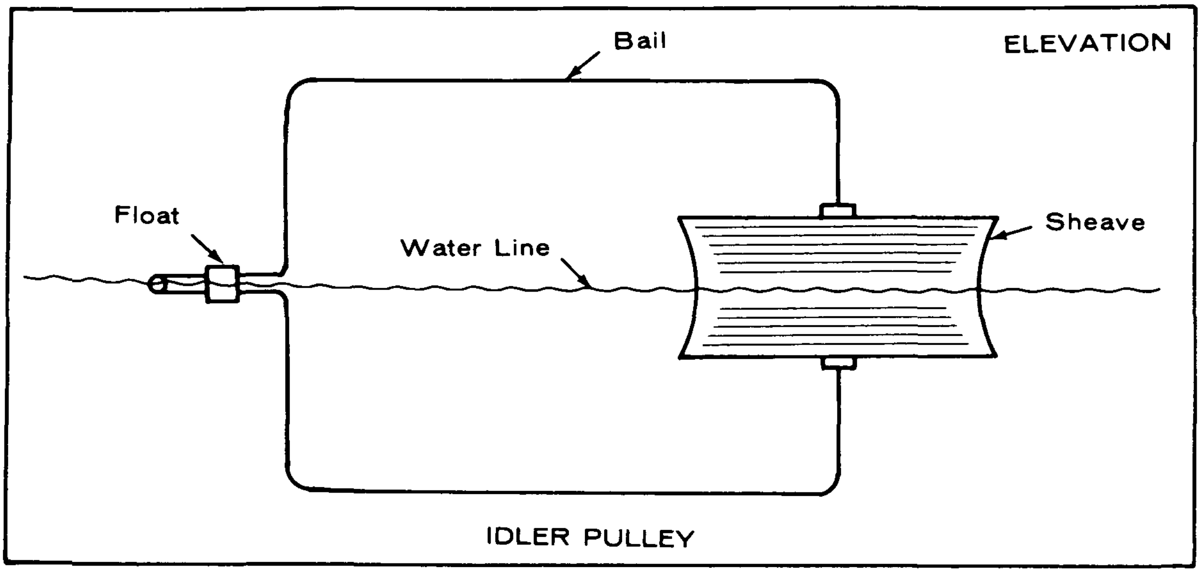
3.5.1 Equipment

a. Pulleys

As indicated in Section 3.3.3, some difficulty was encountered in recovering cold Bunker C because it tended to shear off the mop and collect at the tail pulley. A casual observation also showed that if the mop is depressed under clumps of cold Bunker C and allowed to float up through it, substantial quantities can be recovered in a very short time. A conceptual sketch of suggested modifications to the idler pulley and a concept for sinking the rope mop below the surface to improve collection performance with heavy oils are shown in Figure 5. Alternatively, for the latter, a conventional idler pulley anchored vertically to the bottom with a heavy weight might prove suitable although this would require constant adjustment in tidal areas.

b. Heater Tank

It would be desirable to have the immersion heaters surrounded by protective sleeves to prevent damage to the exposed coils when the water is drained out of the tank. It would also be desireable to have a "sniffer" integrated into the tank structure for



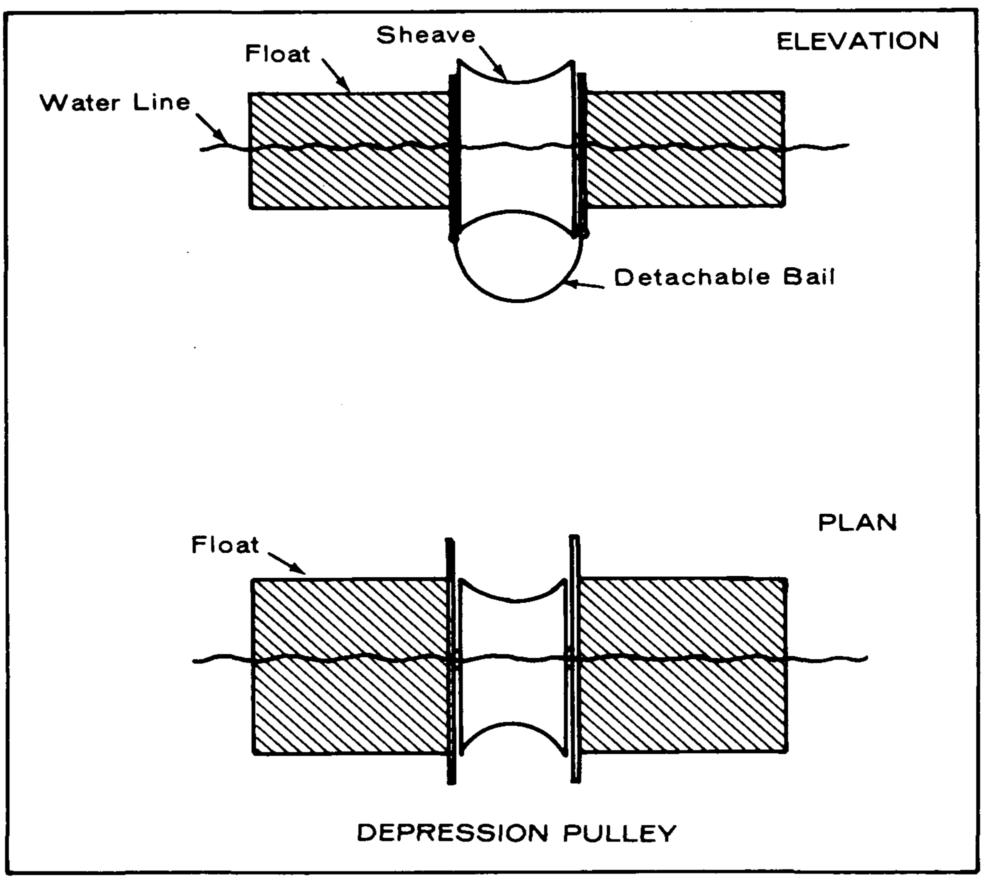


Fig.5

Alternative Pulley Concepts

detection of explosive atmospheres if the preheat unit is being used to collect a product with a large percentage of volatiles still present.

c. Logistical Requirements

Travelling and operating weights of the complete equipment package should be recorded and placed on a builder's plate on the unit and in an operating manual so that suitability of available barges and cranes for moving the units can be quickly and accurately identified.

d. Pumps

A pressure relief valve on the Spate pump should be supplied to prevent damage to discharge lines and avoid accidental release of the discharge connection.

3.5.2 Testing

a. Test Conditions

The Sorel field trials, while a reasonable test of the unit's capability to collect heavy oil, did not present "worst case" conditions for which the preheat unit is designed. The maximum air temperature was 26°C which is near or above the pour point of Bunker C and the maximum water temperature encountered was 12°C. The oil was not as stiff, nor was it as weathered, as would be encountered in near-freezing conditions, and the heating element was not forced to heat continuously to maintain the temperature of the bath. A 24 to 36 hour continuous operation test of the device is required when air and water temperatures are at or near the freezing point. It is impractical to consider such a test anywhere but in a slop pit at a refinery where a layer of bunker could be poured on the water and continuously recycled during the test period. The combination of cool temperatures and weathered oil would be a real test of the device's capabilities.

b. Electrical Requirements

The electrical requirements of the preheat unit have never been practically defined. Although it has a capability of producing heat from four 250 kw Chromalox heaters, the actual electrical requirement to keep the tank up to operating temperatures was not defined during these trials. Although an ammeter was available, it was not possible to define the variation in power required because the ten-step control unit kept cutting in and out. Therefore, during any future field evaluations of the unit, it is recommended that a large recording ammeter be incorporated into the control panel in order to measure the total and average power requirements over the test period. This would permit complete records of electrical requirements and better define how much power is necessary to meet the operational requirements of the unit.

Until the power requirement is properly determined, it is difficult to say whether the electrical heating concept should be modified or some other form of heating considered, particularly if the unit is to be used in remote areas such as the Arctic where large generators are difficult to obtain and even more difficult to transport.

APPENDIX A - FIELD TEST PROCEDURES

APPENDIX A - FIELD TEST PROCEDURES

This field evaluation program was carried out at the Canadian Coast Guard Base at Sorel, Quebec. The general layout of the test area is shown in Figure 6 and a list of the major equipment is given in Table 6.

The oils used for the trials were:

- western Canadian crude oil with an API gravity of 30-45 and residuum 30% at 370°C, and
- fresh number 6 fuel oil (Bunker C) with a specific gravity between .86 and .98, and a boiling point between 230°C and 650°C.

The two types of tests conducted to test the oil recovery capabilities of the Oil Mop with and without the preheat unit on-line were:

- constant layer tests where the oil quantities in the test enclosures remain constant, and
- diminishing layer trials where a predetermined volume of oil is poured into the enclosure and the equipment run for an extended period.

The test program can be broken down as follows:

	CONSTANT LAYER TRIALS				DIMINISHING LAYER TRIALS	
	1mm		5mm		5mm	
	OM	OMH	OM	OMH	OM	OMH
Crude Oil	x	x	x	x	x	
Bunker C				x		x

OM - Oil Mop Unit Only

OMH - Oil Mop Unit with Preheat Device

x - represents one test run

Trials with the preheat unit were conducted at the following bath temperatures:

Crude Oil - 40°C

Bunker C - 60°C, 70°C, 80°C, 85°C