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MESOSCALE APPLICATION AND TESTING OF AN OIL SPILL DEMULSIFYING AGENT AND ELASTOL

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ABSTRACT

Applicators suitable for mesoscale use were developed for the oil spill treating agents, Elastol and Brand M Demulsifier/ Demoussifier. The distribution characteristics of each applicator were tested and optimized. Experiments were conducted in the laboratory to determine the effectiveness of the treating agents when applied by these systems. The results are similar to those of previous studies and showed that the applicators could effectively distribute the agents on to oil spilled on water.

The applicators were used during four days of tests performed in a large scale wave basin. The results from these tests are discussed. Slicks treated with the demoussifier had lower water content. The application of Elastol rendered oil viscoelastic and thus enhanced oil recoverability by a skimmer.

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FOREWORD

This report is comprised of two parts. The first part describes the development and laboratory testing of mesoscale applicators for the oil spill products. The second part deals with mesoscale testing using these applicators. These tests were performed by M. Fingas, and his findings and observations are reported in Part 2.

Part 1 - Development and Testing of Mesoscale Applicators

1.1 INTRODUCTION

Recently, two promising oil spill treating agents have been developed. They are: Elastol, a viscoelastic enhancing agent which is manufactured in powder form by GTA Inc.; and Brand M, a liquid demulsifier/demoussifier formulated by Environment Canada. (Brand M is a reformulated version of an European developed emulsion breaker called Brand S.) Laboratory testing of Elastol and Brand S are well documented in Bobra et.al. (1987) and S.L.Ross (1987). Due to the favourable results obtained from these studies, testing of these two products on a larger scale has been planned. These planned tests include large-scale tank testing at the Esso Research Facility in Calgary and an offshore ocean trial.

This study was undertaken to develop and test methods of applying Elastol and Brand M for mesoscale applications. In particular, the objectives of the study are:

i. to develop applicators for dispensing Elastol and Brand M;

ii. to test and adjust these applicators to deliver the desired dose rates with a relatively uniform distribution pattern;

iii. to measure the effectiveness of Elastol and Brand M when applied by these systems.

1.2 APPLICATOR SYSTEMS

Selection Process

An extensive review of application systems used in previous field trials and of the products available from suppliers of counter-spill, agricultural and forestry equipment was conducted. These products were critically evaluated in terms of the following criteria:

i. distribution characteristics - the applicator should dispense the treating agent over a relatively large area with a uniform distribution pattern and deliver a flowrate that will dispense the treating agent in an acceptable period of time for the range of Elastol and Brand M doses proposed for the mesoscale trials (500 to 9000 ppm for Elastol and 250 to 4000 ppm for Brand M);

ii. portability and ruggedness - necessary for field use;

iii. safety - the equipment must be safe to use in the presence of flammable materials;

iv. simple to operate.

Applicator Apparatus

After careful evaluation, a Campbell-Hausfeld Power Blast Model AT1210 (more commonly known as a sandblaster) was chosen to dispense both spill treating agents. A schematic diagram of the system is illustrated in Figure 1.

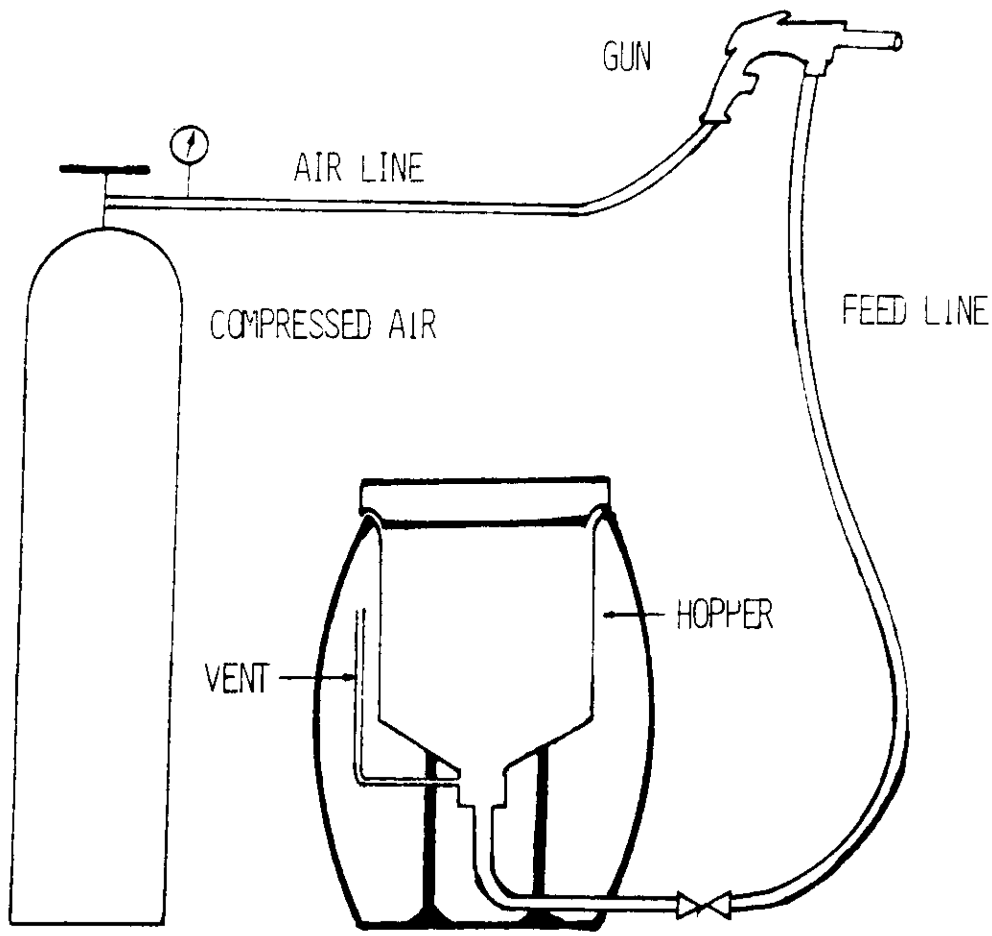


FIGURE 1 . SCHEMATIC DIAGRAM OF APPLICATOR.

The system has a 5 gallon (19L) capacity and uses compressed air to dispense its charge. A vented hopper was added to the blaster for the application of Elastol. This was necessary to ensure a continuous flow of Elastol and to ensure that all Elastol placed into the system is dispensed. No system modification was required for Brand M application.

The system offers several advantages:

- it gives good area coverage and discharges the agents at acceptable flowrates (this is discussed further in the experimental section)
- it is lightweight and portable
- it requires no external power source or fuel, therefore, it is not a potential source of ignition
- it is rugged and reliable; there are no mechanical parts to break or fail
- it is simple to use
- it is relatively cheap (blaster with gun costs approximately $140) and available.

Applicator Operation

During this work, the supply of compressed air came from the lightweight cylinders used for the Scott backpack breathing apparatus. These cylinders have a capacity of 45 ft^3 (1.3 m^3) at 2216 psi (15,280 kPa). The air pressure regulator was set at 40 psi (276 kPa) for the application of Elastol and at 20 psi (138 kPa) for the application of Brand M. These settings were determined to give the optimum spray patterns and dose rates. One air cylinder provided 7.5 minutes of air for the Elastol applicator and 12 minutes for the Brand M applicator. Two or more cylinders can be used in a cascade configuration for longer application times.

With the air and feed lines attached as shown in Figure 1, a pre-measured dose of treating agent is placed in the unit and the agent is discharged by squeezing the spray gun trigger.

In this study, the demulsifier was discharged as a 50% solution of Brand M in a commercial solvent Isopar M. This particular solvent was chosen because of its low volatility and toxicity. See Appendix II for properties of Isopar M. The reasons for mixing the demulisifier with solvent are:

i. to reduce its viscosity in order to improve flow characteristics (pure Brand M has a viscosity of 1200 cP at room temperature);

ii. to promote better diffusion and mixing of the demulsifier's active ingredients with the spilled oil;

iii. to increase the volume of the treating agent to be applied and thus the dispensing time, thereby allowing a more thorough and even application of Brand M to the oil slick, especially at the lower demulsifier-to-oil concentrations.

1.3 DISTRIBUTION EXPERIMENTS

Procedure

The flowrates and distribution patterns of Elastol and the Brand M solution were determined by conducting a set of indoor experiments in which the spill treating agents were dispensed from a stationary position onto a marked grid. For each applicator, two tests were performed: one with the spray gun positioned parallel to the ground and the other with the gun positioned 45 degrees downward. In both tests, the gun was fixed at a height of one metre above the ground.

In the Elastol tests, a preweighed dose of 100 grams was dispensed onto a floor marked off in a grid pattern of one by one metre squares. At the end of the experiment, the Elastol particles were collected from each square to determine the distribution pattern. The total dispensing time was also recorded and the average flowrate calculated.

A similar procedure was followed for the tests involving the Brand M solution, with the exception of the grid pattern which was marked every 1/2 meter. The total volume dispensed was 200 mL. The liquid was then collected from each square by individual sorbent pads to establish the distibution pattern. Finally, several tests were conducted outdoors to examine how the applicators would perform when subjected to the influence of wind.

Results

The distribution patterns for the sprayed Elastol and Brand M solution are presented in Figures 2 to 5. From the Figures, it can be seen that over 90% of the dispensed Elastol settled in an area 2 m wide by 4 m long. The area in which most of the Brand M settled was smaller, approximately 92% of the demulsifier solution was collected in an area 1 m wide by 3 m long. The total area covered was greater for Elastol when the gun was pointed horizontal to the ground (26 m^2), as opposed to 45 degrees downward ($20m^2$). The mass flux was calculated to be 0.14 g/m^2s and 0.18 g/m^2s, respectively. On the other hand, the direction of the gun did not affect the total area coverage (and flux) for the demulsifier. The respective values were determined to be 5.5 m^2 and 0.29 mL/m^2s.

The calculated flowrates were 3.6 g/s for Elastol and 1.6 mL/s for the demulsifier solution. The air pressure was set such that the lowest possible flowrates were obtained without compromising the smooth discharge of the treating agents. This was thought to give more flexibility to the operators at the field trial and would allow them to cover the oil slick more evenly, especially at low treatment levels. For example, treatment times for a 5 barrel oil spill (the proposed slick volume for the field trial) with Elastol would be approximately 3 minutes for a 1000 ppm dose, 9 minutes for 3000 ppm and 27 minutes for 9000 ppm. Similarly, application times for the Brand M solution would be 4 minutes for a 250 ppm dose, 16 minutes for 1000 ppm and 64 minutes for 4000 ppm. If some of these treatment durations are deemed excessive, two or more sprayers can be used simultaneously or in the case of Brand M, a more concentrated solution can be used to reduce the application time.

The performance of the applicators under calm outdoor conditions (wind speeds of up to 8 km/hr) was observed to be similar to that of the indoor tests. At higher wind speeds, the influence of the wind could be compensated for, in part, by directing the spray more towards the ground.

FIGURE 2 . Distribution Pattern of Sprayed Elastol

Conditions: -Flowrate: 3.6 ±0.4 g/s
-Sprayed Parallel to the Ground

		0.1 ±0.01 (0.004)	0.1 ±0.01 (0.004)			7m
	0.1 ±0.01 (0.004)	0.8 ±0.04 (0.029)	0.8 ±0.04 (0.029)	0.1 ±0.01 (0.004)		6m
0.1 ±0.01 (0.004)	0.8 ±0.23 (0.029)	2.6 ±0.4 (0.094)	2.6 ±0.4 (0.094)	0.8 ±0.23 (0.029)	0.1 ±0.01 (0.004)	5m
0.1 ±0.01 (0.004)	1.6 ±0.30 (0.058)	8.4 ±0.1 (0.302)	8.4 ±0.1 (0.302)	1.6 ±0.30 (0.058)	0.1 ±0.01 (0.004)	4m
	1.5 ±0.05 (0.054)	17.7 ±1.0 (0.637)	17.7 ±1.0 (0.637)	1.5 ±0.05 (0.054)		3m
	0.2 ±0.01 (0.007)	16.0 ±1.0 (0.576)	16.0 ±1.0 (0.576)	0.2 ±0.01 (0.007)		2m
						1m

3m 2m 1m ▲ 1m 2m 3m

Location of Gun

Values are in weight percent.
Values in Brackets are in g/m^2s.

FIGURE 3 . Distribution Pattern of Sprayed Elastol

Conditions: -Flowrate: 3.6 ±0.4 g/s

-Sprayed 45° Downwards.

	3m–2m	2m–1m	1m–0	0–1m	1m–2m	2m–3m
7m–6m			0.2 (0.007)	0.2 (0.007)		
6m–5m		0.2 (0.007)	1.9 (0.068)	1.9 (0.068)	0.2 (0.007)	
5m–4m		0.9 (0.032)	9.9 (0.356)	9.9 (0.356)	0.9 (0.032)	
4m–3m		1.6 (0.058)	13.8 (0.497)	13.8 (0.497)	1.6 (0.058)	
3m–2m		0.7 (0.025)	18.2 (0.655)	18.2 (0.655)	0.7 (0.025)	
2m–1m			2.6 (0.094)	2.6 (0.094)		
1m–0						

Location of Gun

Values are in weight percent.

Values in Brackets are in g/m^2s.

Figure 4. Distribution Pattern of Sprayed Brand 'M' Solution

Conditions: -Flowrate: 1.6 ±0.2 ml/s

-Solution: 50% Brand 'M' / 50% Isopar 'M'

-Sprayed Parallel to the Ground

	1m – 0.5m	0.5m – Gun	Gun – 0.5m	0.5m – 1m
Beyond 3m		3.8 ±1.0 (0.246 ±0.065)	3.8 ±1.0 (0.246 ±0.065)	
3m – 2.5m		2.7 ±0.6 (0.175 ±0.039)	2.7 ±0.6 (0.175 ±0.039)	
2.5m – 2m		6.6 ±0.9 (0.428 ±0.058)	6.6 ±0.9 (0.428 ±0.058)	
2m – 1.5m	0.1 (0.0016)	11.3 ±1.0 (0.732 ±0.065)	11.3 ±1.0 (0.732 ±0.065)	0.1 (0.0016)
1.5m – 1m	0.1 (0.0016)	11.9 ±0.9 (0.771 ±0.058)	11.9 ±0.9 (0.771 ±0.058)	0.1 (0.0016)
1m – 0.5m		10.3 ±0.3 (0.667 ±0.019)	10.3 ±0.3 (0.667 ±0.019)	
0.5m – 0		3.2 ±0.9 (0.207 ±0.058)	3.2 ±0.9 (0.207 ±0.058)	

1m 0.5m ▲ 0.5m 1m

Location of Gun

Values are in weight percent.

Values in Brackets are in ml/m^2s

FIGURE 5 . Distribution Pattern of Sprayed Brand 'M' Solution

Conditions: -Flowrate: 1.6 ±0.2 ml/s
-Solution: 50% Brand 'M' / 50% Isopar 'M'
-Sprayed 45^{o} Downwards

	1.5 (0.097)	1.5 (0.097)		Beyond 3m
0.6 (0.039)	1.6 (0.104)	1.6 (0.104)	0.6 (0.039)	3m
0.6 (0.039)	3.5 (0.227)	3.5 (0.227)	0.6 (0.039)	2.5m
0.3 (0.019)	14.0 (0.907)	14.0 (0.0907)	0.3 (0.019)	2m
0.3 (0.019)	14.4 (0.933)	14.4 (0.933)	0.3 (0.019)	1.5m
	9.4 (0.609)	9.4 (0.609)		1m
	3.8 (0.246)	3.8 (0.246)		0.5m
1m	0.5m	▲	0.5m	1m

Location of Gun

Values are in weight percent.
Values in Brackets are in ml/m^2s.

1.4 LABORATORY TANK TESTS

Procedure

Laboratory testing was conducted in an 89 cm diameter tank equipped with an adjustable speed oscillating hoop (85 cm in diameter) wave generator. The tank was filled with 336 L of 33 ppt salt water (water temperature: 15 +/- 2 deg C) and the wave generator was set at a speed of 46 RPM.

For the demulsifier tests, the Brand M solution was sprayed onto an 1 mm thick slick of "Emulsifying Mix oil" (50-50 mixture of Alberta Sweet Mix Blend crude and Bunker C) from a height of 1 m above the slick surface. Three separate experiments were performed in which the emulsion breaker was applied at Brand M-to-oil ratios of 1:500, 1:2000 and 1:4000. Oil samples were taken periodically over a 24 hour period to determine the water content of the oil slick and hence the effectiveness of Brand M in inhibiting emulsification.

An additional experiment was performed in which an 1:500 dose of the demulsifier was sprayed onto the oil slick after allowing it to emulsify for 3 hours. A second 1:500 dose was applied at the 4.5 hour mark. The water content was monitored at regular intervals.

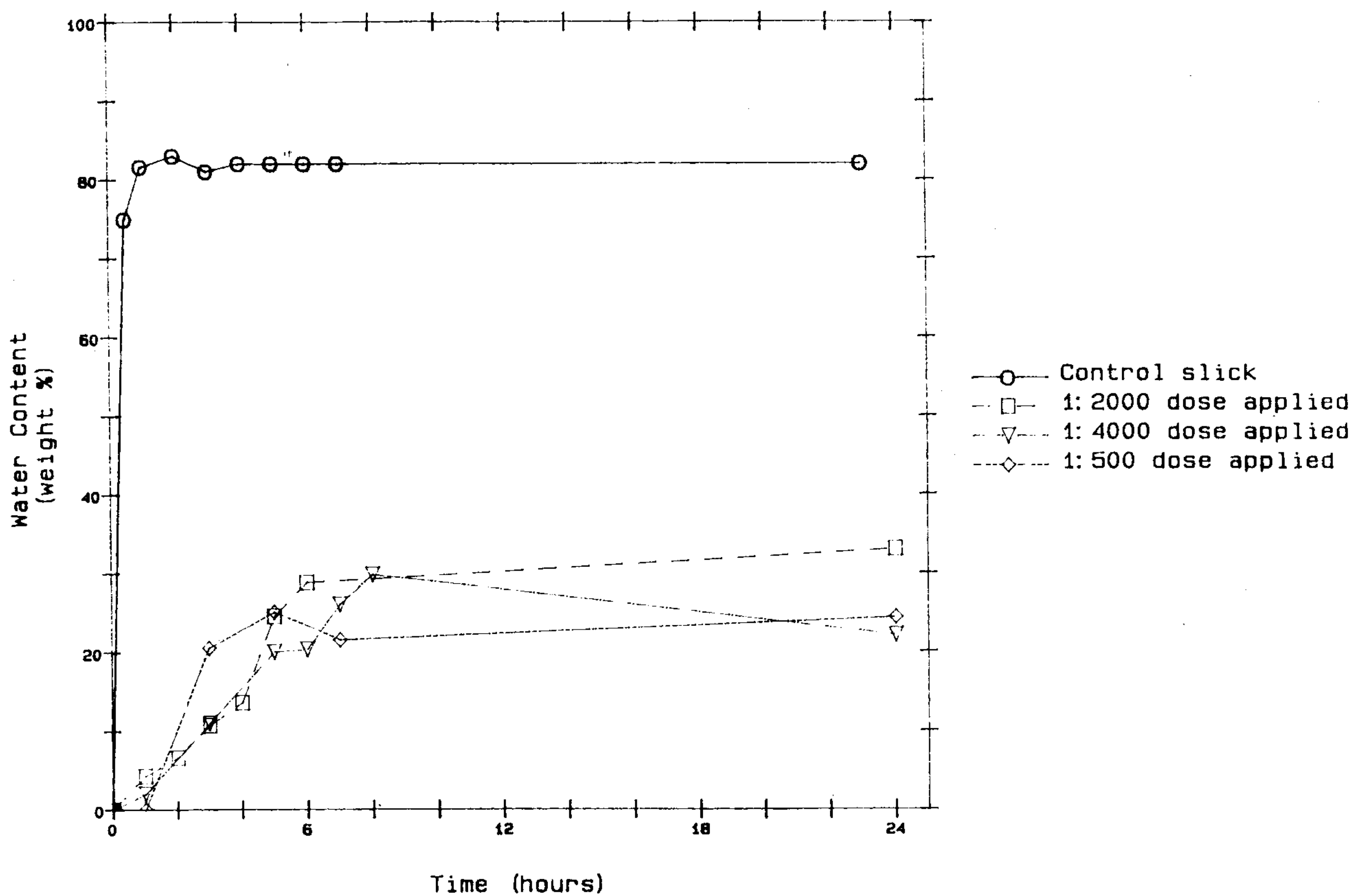
For the Elastol tests, the Elastol applicator was used to dispense the treating agent at doses of 1500 and 3000 ppm onto a 1 mm thick slick of fresh Alberta Sweet Mix Blend crude oil. Oil samples were taken hourly to determine the elasticity using the die swell procedure as outlined in Bobra et.al. (1987). The Elastol used was the latest version formulated by GTA, "80/20 Elastol", and has a different composition than the Elastol used in the previous laboratory study.

Results

i. Brand M

The results of the demulsifier application tests in the large oscillating hoop tank are presented as a plot of water content of surface oil versus time in Figure 6. It is clear that in the control slick to which no demulsifier was applied, the oil emulsified to a stable water content of 80% within the first hour. The other curves show that the addition of the demulsifier in the dose range from 1:4000 to 1:500 reduces the degree of emulsification and the rate of water uptake. Approximately 6 hours were required for treated slicks to attain a constant water content.

FIGURE 6 . Water Content of Slick as a Function of Time



It is peculiar to note that considering the large difference in treatment doses, there was little difference in the water content values of the three treated slicks. These results are similar to those found in the wind/wave tank tests of Brand S emulsion inhibitor (S.L. Ross, 1987). In an attempt to further examine this behaviour, oil/seawater interfacial tension was measured as a function of Brand M concentration. These measurements are plotted in Figure 7. Pure oil and seawater has an interfacial tension of 26 dynes/cm. Figure 7 shows that the addition of Brand M (at Brand M-to-oil ratios of 1:10,000 to 1:500) significantly reduces the interfacial tension, but that there is only a slight drop in the interfacial tension from about 15 to 14 dynes/cm with a 20 factor increase in Brand M concentation. This may, in part, account for the results obtained in Figure 6. Nevertheless, these results seem to indicate that only a small dose of demulsifier may be required to effectively prevent extensive emulsion formation.

Figure 8 shows the results of the test in which the demulsifier was applied to emulsified oil. A 10% drop in the water content was observed after the first application and a further 15% decrease was obtained following the second addition. This indicates that the demulsifier is also effective in reducing the water content of emulsified oil.

The test results show that the applicator was successful in effectively delivering the demulsifier to oil spilled on water.

FIGURE 7 . Interfacial Tension of Oil/Seawater as a Function of Brand M Dose

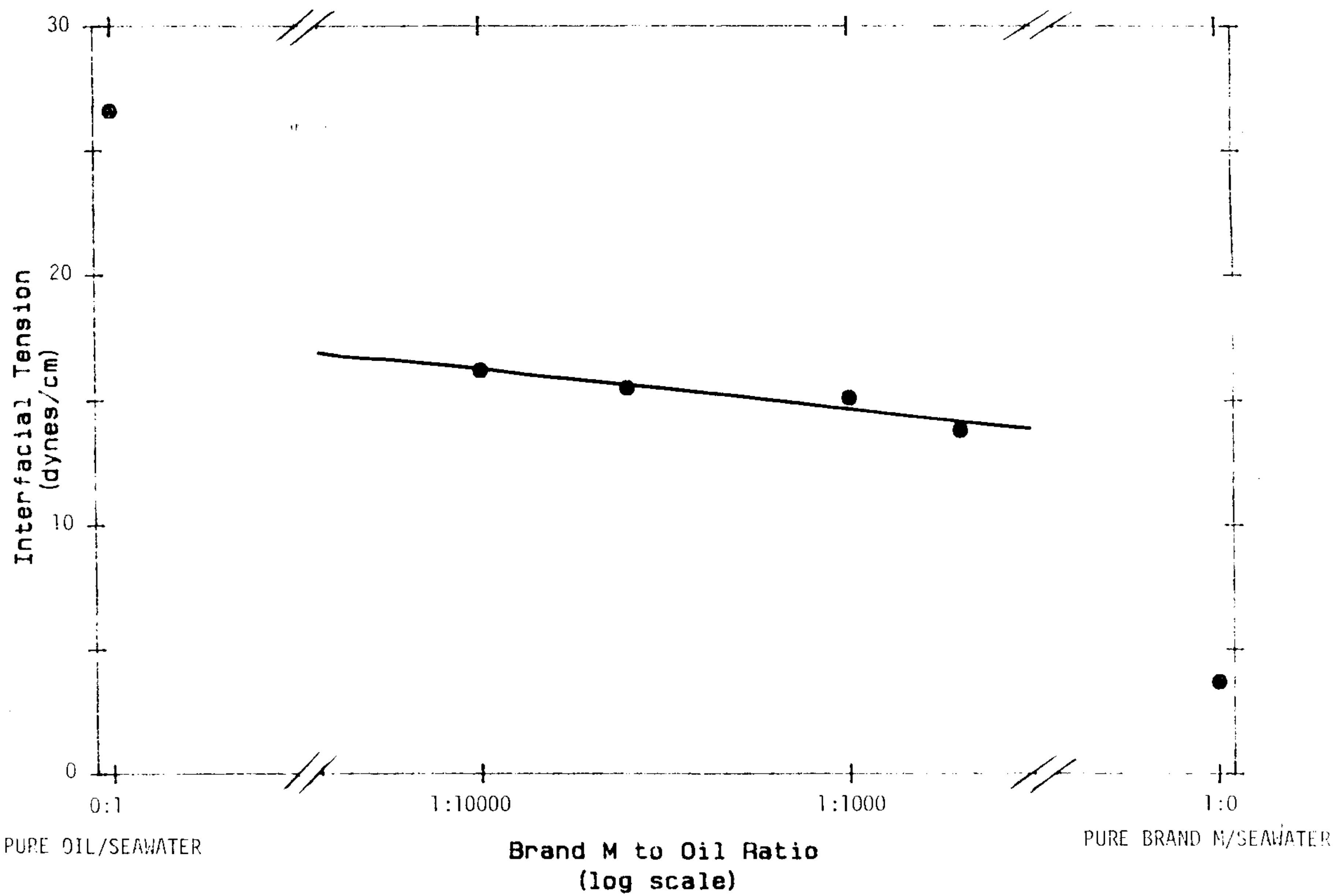
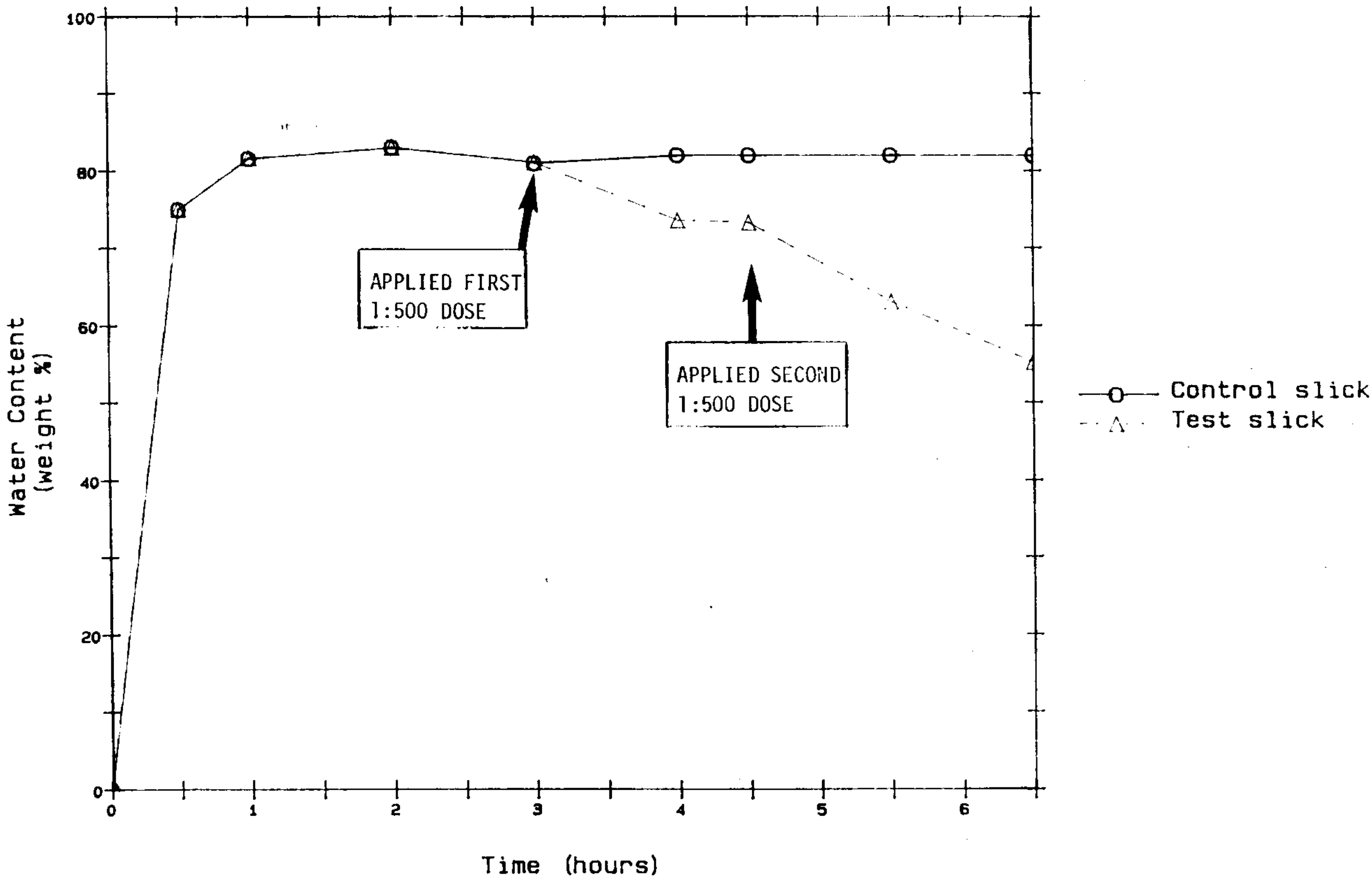


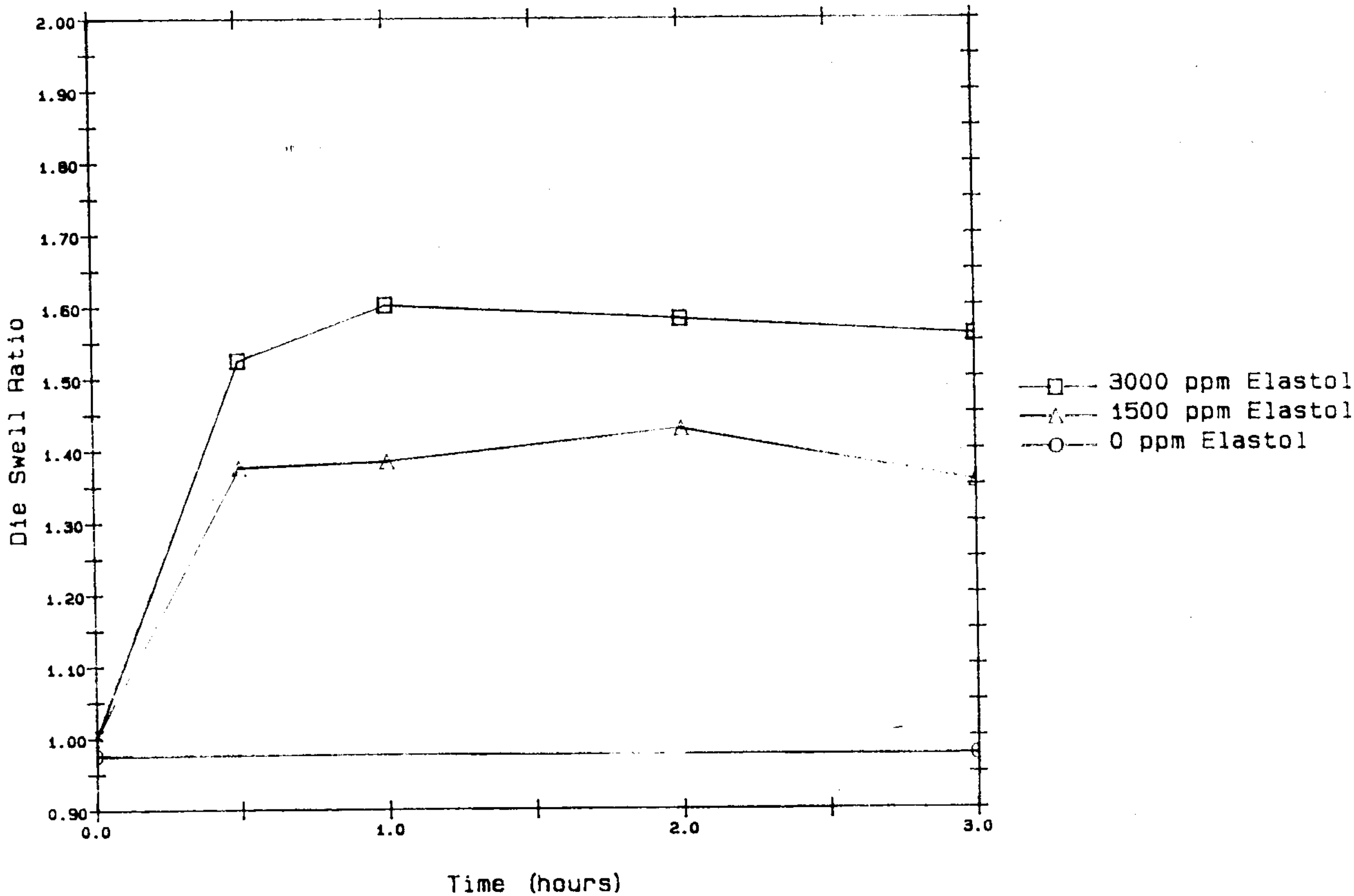
FIGURE 8 . Water Content of Slick as a Function of Time When Treated with Brand "M" Demulsifier



ii. Elastol

The results of the Elastol application tests are presented in Figure 9 which plots the die swell ratios as a function of time. The results show that Elastol applied in this manner was effective in imparting elastic behaviour to the oil slicks within one-half hour after application as indicated by the greater-than-one die swell ratios, and that increasing the Elastol concentration resulted in greater elasticity. Furthermore, observation of the slicks showed a fairly even elasticity development throughout the oil, indicating a relatively even distribution of the treating agent during the application procedure.

FIGURE 9 . Die Swell Ratio versus Time



1.5 CONCLUSIONS

Mesoscale application systems have been developed for the two new oil spill treating agents, Elastol and Brand M. The main components of both applicators are a commercially available sandblaster and portable air cylinders. These systems were chosen over other designs because they encompass all the features deemed necessary for field use. Namely, these features are: good spray charcteristics (area covered and dose rate delivered); portability; ruggedness; safe to use in the presence of flammable materials; and simple to operate.

Tests conducted during this study showed that from a fixed position, the Elastol applicator could distribute the treating agent up to a distance of 7 m and cover an area of 26 m^2. Similarily, the Brand M applicator could spray up to 4 m and cover an area of 5.5 m^2. A solvent, Isopar M, was chosen as a carrier/solvent for Brand M application in order to improve its spray characteristics and to promote better mixing with oil.

Finally, tests were conducted in a large laboratory wave-generating tank to measure the effectiveness of the treating agents when applied from these systems. The results obtained from these tests were similar to those of previous laboratory studies; they showed that Brand M demoussifier can effectively reduce the degree to which oil emulsifies and that Elastol renders oil viscoelastic. The applicators developed as a result of this work proved to work well during all tests conducted and therefore, it is expected that they will perform with equal reliablity during the proposed mesoscale and ocean testing of these agents.

PART 2 Report on Mesoscale Testing of Brand M Demulsifier and Elastol

2.1 Introduction

M. Fingas conducted four days of testing in the outdoor test basin at the Esso Research Facility in Calgary. The specially designed applicators described in Part 1 of this report were used for applying the treating agents. The purpose of the testing was:

i. to examine the performance of the applicators under conditions that loosely resemble those found at environmental spill situations;

ii. to determine the effectiveness of the agents when applied in this manner and under these conditions;

iii. to compare the behaviour of treated slicks to slicks left untreated.

2.2 EXPERIMENTAL

A schematic of the basin is shown in Figure 10. The dimensions of the basin are 15 m x 19 m with a maximum depth of 2 m. For these tests, the basin was filled with fresh water. Two circular boom configurations of 5m in diameter were positioned side by side and parallel to the wave generating flap. With the booms placed in such a configuration, slicks can be placed in each of the boomed areas and then subjected to identical wave conditions. For each day of testing, one slick was treated with an agent and the other slick was left untreated to serve as a control.

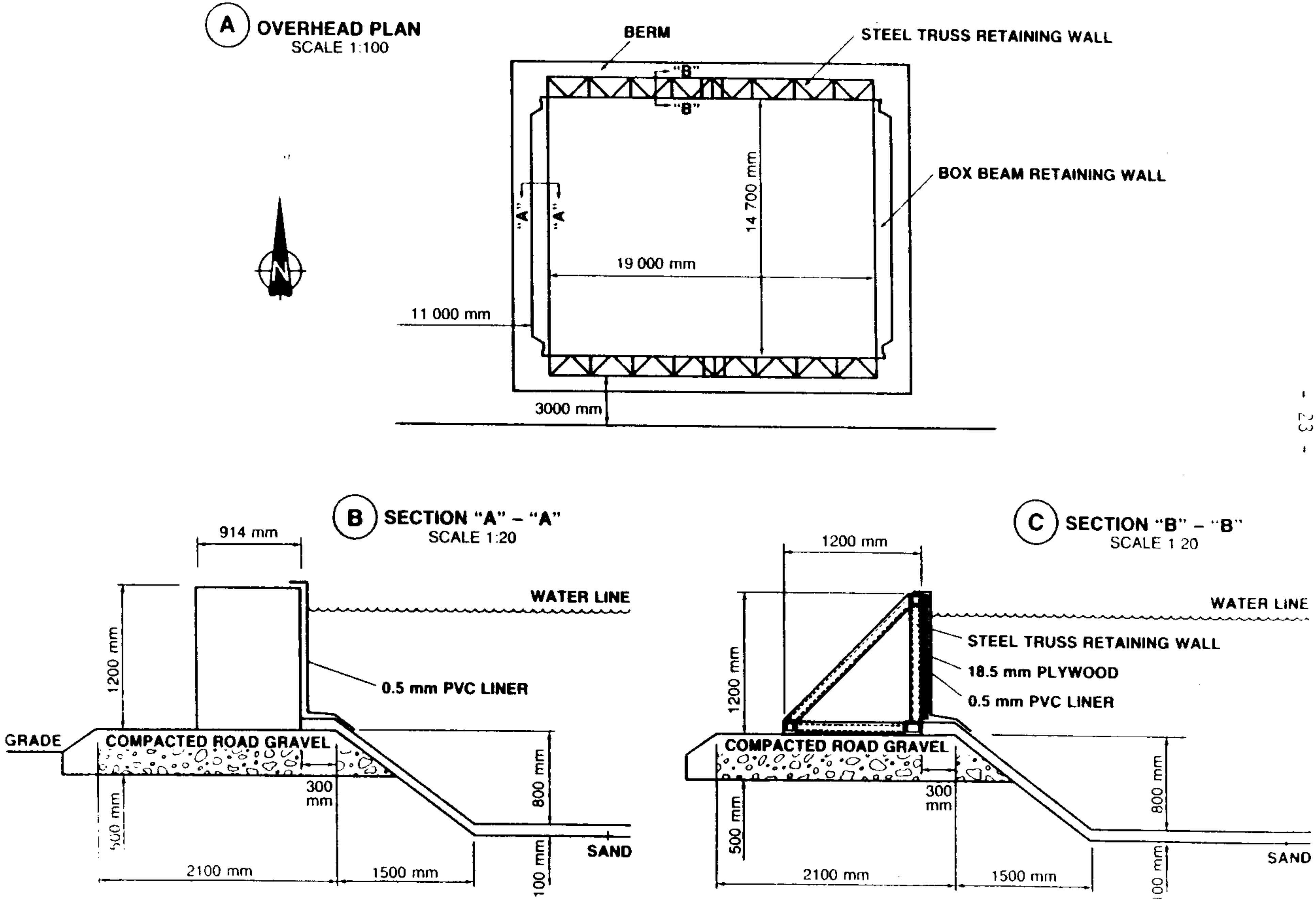
After applying the treating agent, the wave generators were turned on to produce waves 10 cm in height. The wave generators were turned off during sample taking and during oil recovery with the skimmer.

Samples were taken from both slicks at approximately logarithmic intervals and dynamic viscosities were measured using a Fann viscometer.

At the end of each test day, the oil contained in the booms was recovered by a Morris MI-2C skimmer. The recovered oil was allowed to settle overnight in order to separate the oil and water. Recovery rates were calculated from the volume of oil recovered and the skimmer's operating time.

Figure 10

Schematic Plans of Test Basin



2.3 RESULTS

DAY 1 - Application of 2000 ppm Brand M Demoussifier

The test oil used was a half-half mixture of Federated crude oil and tar. This mixture was used because preliminary tests showed it had a strong tendency to form stable emulsions. Some diesel fuel was inadvertently added to the test oil thus producing a mixture slightly different than that used on Day 2.

The measured viscosities are given in Table 1 and Figure 11. The higher viscosity values recorded for the control slick indicate that the untreated oil was forming an emulsion more readily than the treated oil. This was also supported by the physical appearance of the slicks. The control slick had reddish-brown streaks in it, indicating formation of "chocolate mousse". On the other hand, the treated slick remained black in colour and the slick surface was distinctly smooth and glossy.

The slicks also showed a marked difference in their recoverability by the skimmer. The untreated oil was recovered at more than twice the rate of the treated oil. It is suspected that this is due to the lower interfacial tension of the treated oil caused by the demoussifier.

Day 2 - Application of 2000 ppm Brand M Demoussifier

The test oil was a half-half mixture of Federated crude oil and tar. The viscosity results are presented in Table 2 and Figure 11, and as in Day 1, the viscosity of the control slick was higher than the treated slick. The difference in oil recoverability was less dramatic than in Day 1, but the untreated oil had a recovery rate of about 37% higher than the treated oil.

During the course of the day, another quick test of opportunity was performed. A small mat of oil which had escaped from the boom of the control slick on the previous day was floating at one end of the tank. This oil was highly emulsified and had the typical "chocolate mousse" appearance. A small amount of demoussifier was poured directly onto the oil mat and observations were taken. Over a period of minutes, the oil's colour turned to black and then the oil formed a thinner, shiny slick.

Day 3 - Application of 4000 ppm Elastol

The test oil used was Federated crude oil. The numerical viscosity results, given in Table 3 and Figure 12, show the dramatic increase in viscosity caused by the addition of Elastol.

At the end of the day, it was decided that a quick burning experiment be conducted prior to recovering the oil. With the wave generator turned off, the treated slick (viscosity of 4825 cP) was released from the boom. A simple ignition device consisting of cubes of solidified barbecue lighter fuel on a piece of styrofoam was placed in the thickest portion of the slick. The flame did not propagate but oil in the immediate vicinity of the device burned with the characteristic popping sound of a burning slick. The flame was sustained for 35 minutes. Examination of the device showed that most of its components remained intact indicating that oil had sustained the burn. The oil slick was thin and by visual estimation was not of sufficient thickness to permit flame propagation. It is estimated that a viscosity of 50,000 cP would be required to render the oil of sufficient thickness to burn. The oil remaining after the burn experiment was recovered by the skimmer. The recovery rate was not recorded but it was observed that the skimmer was collecting oil at maximum capacity as indicated by oil overflowing the skimmer.

Day 4 - Application of 2000 ppm Elastol

The test oil was Norman Wells crude oil. Figure 12 and Table 4 show the Elastol treated slick had a higher viscosity than the control.

During the course of the test, the control slick was observed to be taking up water and the characteristic reddish-brown appearance of mousse was spreading throughout the slick. At 140 minutes, a 500 ppm dose of Brand M was added to the control slick to prevent further emulsification. The demoussifier was poured directly onto the slick and in a non-uniform manner. Despite this, the entire slick surface gradually turned black and took on the distinctive glossy shine. The same 500 ppm demoussifier treatment was applied to the Elastol-treated oil to ensure no experimental bias.

The recovery rates are shown in Table 4; the Elastol treated oil was recovered at more than twice the the rate of the untreated oil. Indeed, the treated oil resulted in flooding of the skimmer indicating that the skimmer was operating at capacity. Therefore, the recoverability of the oil may be more than that indicated by the capacity of the Morris MI-2c skimmer. This also shows that the decrease in recoverability caused by the demoussifier can be remedied by the addition of Elastol, and it confirms previous laboratory tests that show Elastol and Brand M can be employed together.

TABLE 1: NUMERICAL RESULTS FROM THE ESSO TANK TESTS

Day 1: 2000 PPM DEMOUSSIFIER TRIAL

Oil: 70L half Federated crude oil and half tar (approx.) (contaminated with small amount of diesel fuel)

Viscosity [illegible]

time (min)	0	40	95
test slick	64(±2)	113(±7)	190(±42)
control	64(±2)	169(±1)	324(±25)

Recovery by Skimmer

	Volume (L)	Rate (L/min.)
test slick	46	0.93
control	32	2.1

Overall Conditions:

Wave Height: 10 cm
Water temperature: 19 deg C
Air temperature: 20 to 28 deg C, depending on time of day
Wind speed: 0 to 5 km/hr, direction and speed variable

TABLE 2: NUMERICAL RESULTS FROM THE ESSO TANK TESTS

Day 2: 2000 PPM DEMOUSSIFIER TRIAL

Oil: 70L half Federated crude oil and half tar

Viscosity [illegible]

time (min)	0	20	90	210
test slick	176(±3)	176(±5)	200(±9)	350(±160)
control	176(±3)		383(±20)	668(±32)

Recovery by Skimmer

	Volume (L)	Rate (L/min.)
test slick	57	0.95
control	60	1.3

Overall Conditions:
Wave Height: 10 cm
Water temperature: 19 deg C
Air temperature: 20 to 28 deg C, depending on time of day
Wind speed: 0 to 5 km/hr, direction and speed variable

Figure 11. RESULTS OF THE DEMOUSSIFIER TANK TESTS

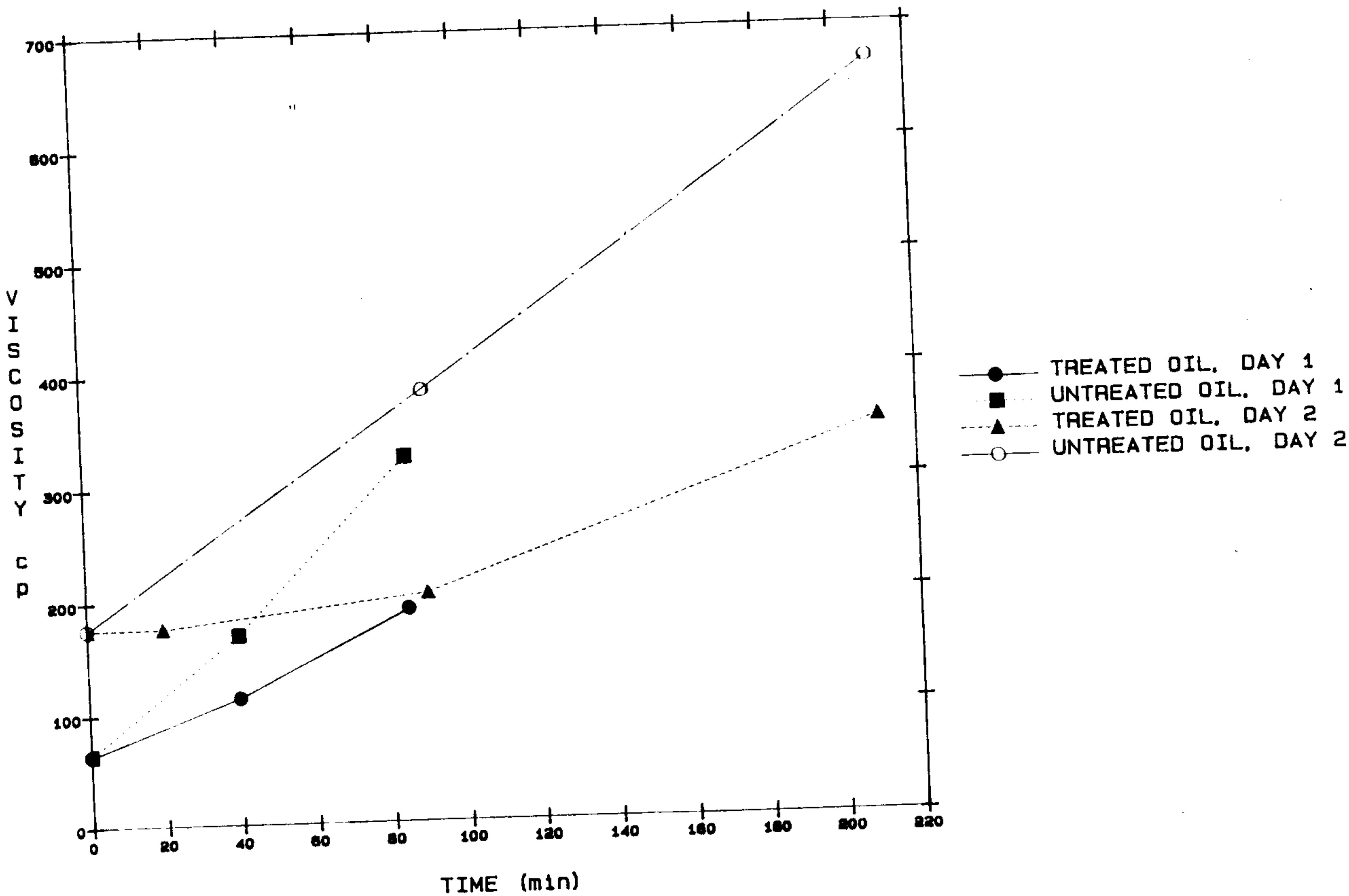


TABLE 3: NUMERICAL RESULTS FROM THE ESSO TANK TESTS

Day 3: 4000 PPM ELASTOL TRIAL

Oil: 75L of Federated crude

Viscosity [illegible]

time (min)	0	25	110	270
test slick	5(±0.5)	22(±3)	128(±18)	4825(±75)
control	5(±0.5)	12(±0.5)	28(±5)	229(±25)

Recovery by Skimmer

	Volume (L)	Rate (L/min.)
test slick	burn attempt -- did not propagate	
control	100 (much H2O)	2.9

Overall Conditions:
Wave Height: 10 cm
Water temperature: 19 deg C
Air temperature: 20 to 28 deg C, depending on time of day
Wind speed: 0 to 5 km/hr, direction and speed variable

TABLE 4: NUMERICAL RESULTS FROM THE ESSO TANK TESTS

Day 4: 2000 PPM ELASTOL TRIAL

Oil: 75L Norman Wells Crude

Viscosity (cP or mPa.s)

time (min)	0	40	120	270
test slick	6.7(±0.2)	41(±5)	172(±28)	356(±21)
control	6.7(±0.2)	19(±1)	75(±28)	136(±14)

Recovery by Skimmer

	Volume (L)	Rate (L/min.)
test slick	90	5.0
control	46	2.0

Overall Conditions:

Wave Height: 10 cm

Water temperature: 19 deg C

Air temperature: 20 to 30 deg C, depending on time of day

Wind speed: 0 to 5 km/hr, direction and speed variable

Figure 12. RESULTS OF THE ELASTOL TANK TESTS

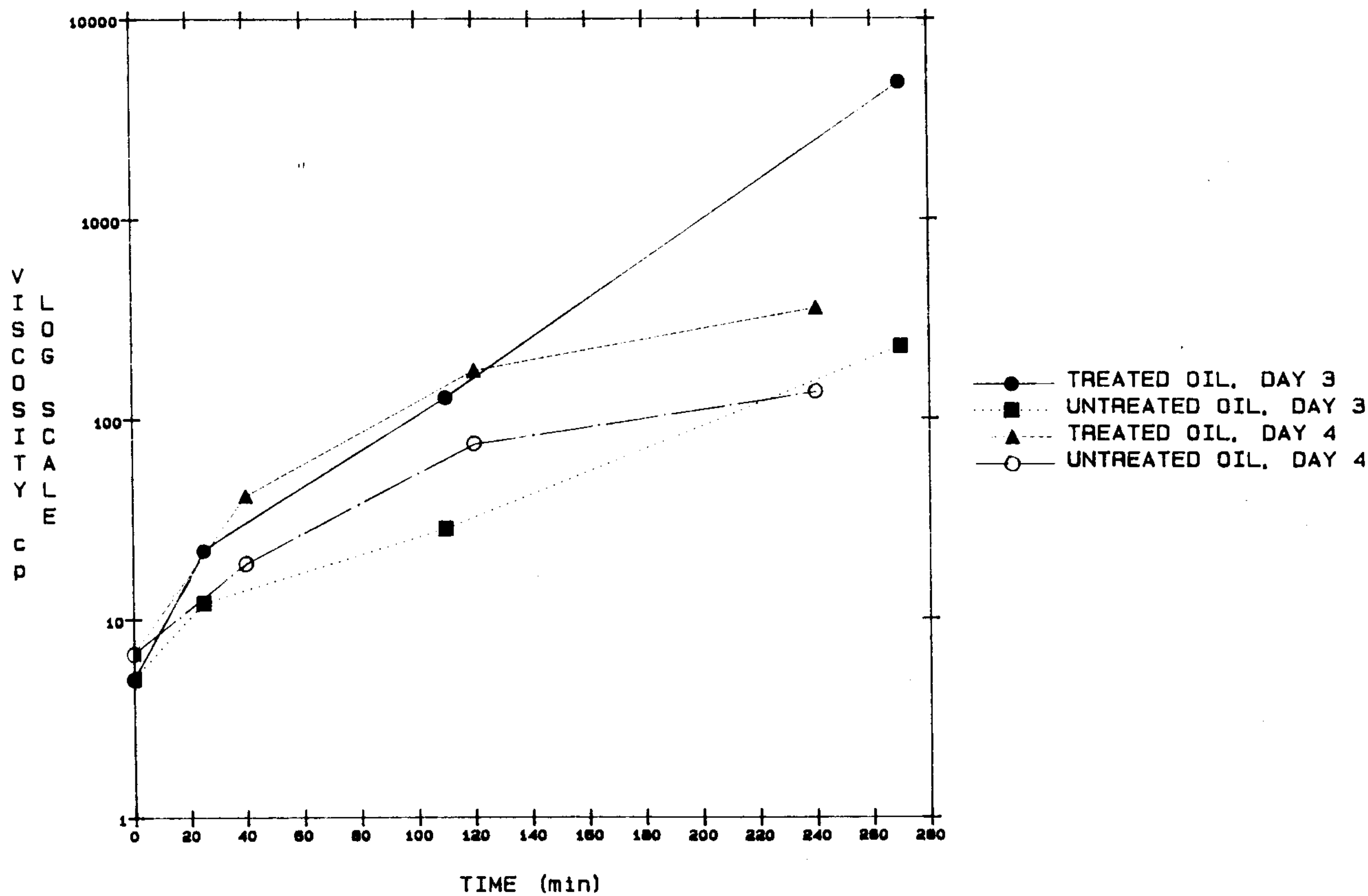
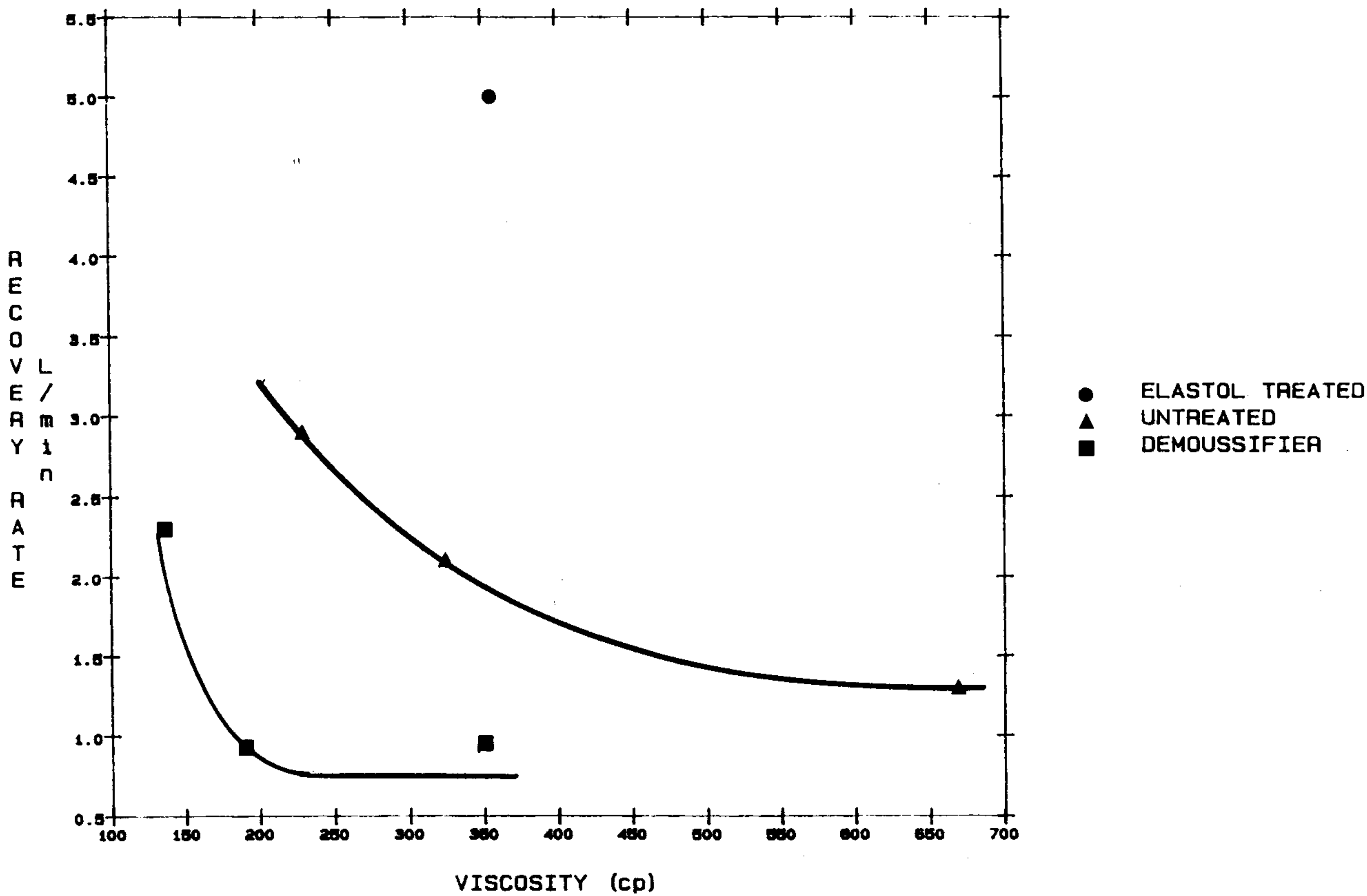


Figure 13. EFFECT OF TREATMENT ON RECOVERY RATES



2.4 CONCLUSIONS

The applicators specially designed for the mesoscale application of Brand M demoussifier and Elastol proved to work well during the four days of basin tests.

Slicks treated with Brand M had lower water content than untreated control slicks subjected to the same conditions. As Figure 13 shows oil recoverability (as determined by a skimmer) was decreased by the demoussifier treatment but this could be remedied by adding Elastol.

Testing done with Elastol showed that its application resulted in a dramatic increase in viscosity and in recoverability. A slick treated with 2000 ppm was of sufficient viscoelasticity that its recoverability exceeded the capacity recovery rate of a Morris MI-2C skimmer. A slick treated with 4000 ppm of Elastol proved to be insufficiently thick to propagate burning.

REFERENCES

Bobra, M., Kawamura, P., Fingas, M., and Velicogna, D., Laboratory and Tank Test Evaluation of Elastol. Environmental Emergencies Technology Division, Environmental Protection Service, Environment Canada. EE-report (in publication), 1987.

S.L.Ross Environmental Research Limited, An Experimental Study of Oil Spill Treating Agents that Inhibit Emulsification and Promote Dispersion. Environmental Emergencies Technology Division, Environmental Protection Service, Environment Canada. EE-87, 1986.

APPENDIX I
Modified Die Swell Apparatus

During the preliminary laboratory study (Bobra et al. 1987), die swell ratios were measured using a simple die swell apparatus which utilized pneumatic force to induce oil flow. This design worked well for non-emulsified oils but failed to produce smooth uniform flow for the more viscous "mousse". It was felt that replacing the pneumatic piston with a motorized constant speed plunger would eliminate the dependence of flowrate on viscosity and thus improve the sensitivity of the apparatus to changes in elasticity.

A high pressure syringe pump (Harvard Apparatus Model 909) was obtained and used in place of the pneumatic piston system. The oil sample was contained in a 50 mL disposable syringe and the motor drive system of the pump was set to induce a constant flowrate of 38.2 mL per minute. The needle, microscope/camera system, and general procedure previously described remained unchanged. In order to test the sensitivity of this setup to Elastol concentration, die swell measurements were taken for a series of oil samples treated with 600 to 9000 ppm. The oil tested was Alberta Sweet Mix Blend crude and the oils were mixed for 48 hours at 15 deg C and at 80 RPM in a shaker/incubator. The results for die swell ratio versus concentration are shown in Figure 14.

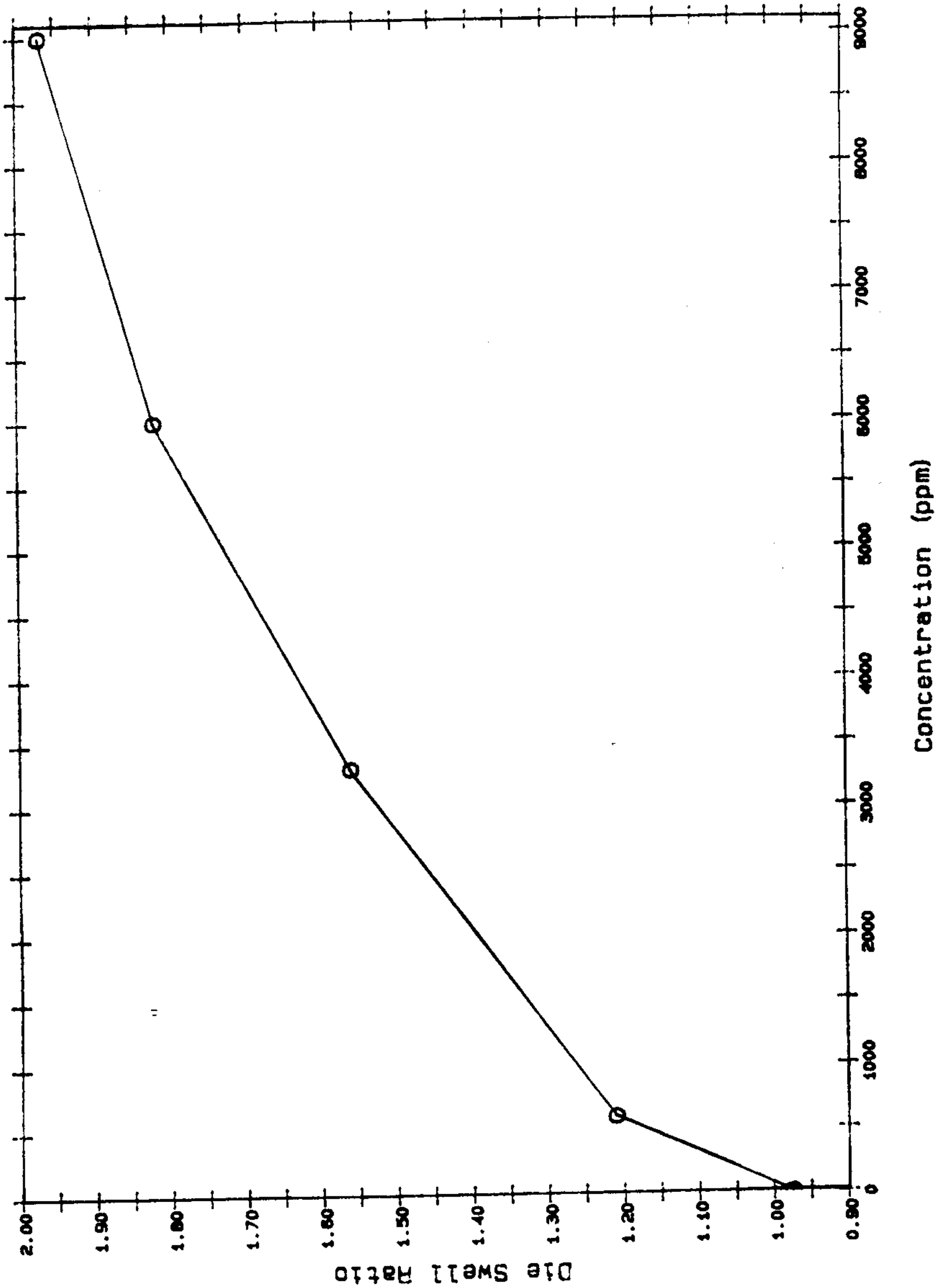


Figure 14. Die Swell Ratio versus Elastol Concentration

APPENDIX II
Properties of Isopar M

Properties	GRADE ISOPAR M
Volatility	
Flash Point, deg C, (TCC)	78
Distillation, deg C	
IBP	207
50%	223
Dry Point	251
Vapour Pressure, psia @ 38 degC	<0.1
Solvency	
Aniline Point, deg C	88
Solubility, Parameter	7.3
Kauri Butanol Value	27
General	
Specific Gravity @ 15.6 deg C	0.782
Colour, Saybolt	+30
Viscosity, cSt @ 25 deg C	3.14
Auto-ignition Temp., deg C	388
Composition, %	
Paraffins	79.4
Naphthenes	19.6
Aromatics	0.9