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SPILL TECHNOLOGY NEWSLETTER

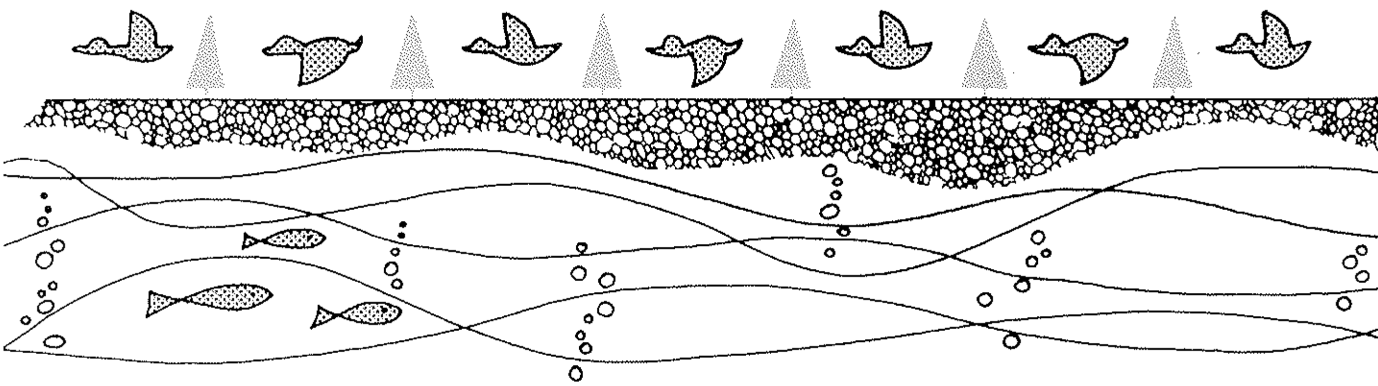

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Table of Contents

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The Spill Technology Newsletter was started with modest intentions in 1976 to provide a forum for the exchange of information on spill countermeasures and other related matters. We now have over 2000 subscribers in over 40 countries.

To broaden the scope of this newsletter, and to provide more information on industry and foreign activities in the field of spill control and prevention, readers are encouraged to submit articles on their work and views in this area.

INTRODUCTION

The first article of this issue is by Rick McKelvey of the Canadian Wildlife Service. Rick summarizes the oiled-bird problem and gives details on how to build a portable hot-water system for cleaning birds. The second article summarizes spill statistics for Atlantic Canada over the past fourteen years. The trends and significant occurrences are reviewed.

The third article is by Merv Fingas and Ed Tennyson who review their joint U.S. and Canadian project to evaluate Elastol and Demoussifier, two new spill treating agents. Both agents functioned well over a series of tests ranging from laboratory to large field scale.

UPCOMING CONFERENCES

DANGEROUS GOODS EMERGENCY RESPONSE '89

The Integration of Risk Assessment, Technology, People and Equipment into an Effective Transportation Emergency Response System for Dangerous Goods.

This international conference will be held in Halifax, Nova Scotia, Canada on May 16-18, 1989. The conference is being sponsored by Transport Canada in cooperation with Environment Canada, and is presented by the Canadian Chemical Producers' Association.

The world conference will provide opportunities to share information and gain insights into new methods and technological advances for effective transportation emergency response. These will include:

- new techniques and experience in emergency site management, including case studies, evacuation strategy, decontamination, and the use of computers in dispersion modelling, decision making and emergency site management;

- recent advances in emergency communications systems, equipment and procedures, both for responders and in communication with the public;

- latest developments in training requirements, programs and techniques;

- testing and evaluation of emergency response preparedness and capability for a response team, an organization and a municipality; this will include new standards and criteria and also how to get the most from test exercises;

- risk assessment and criteria, hazard analysis and municipal preparedness; and

- awareness, including risk communication and community right-to-know, outreach and community communication experiences.

This conference will be particularly informative and useful to managers involved in transportation emergency response on behalf of fire and police departments, various levels of government and industries shipping or handling dangerous goods. All managers with responsibilities or concerns in this area should attend this important international conference.

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INEXPENSIVE, PORTABLE EQUIPMENT TO AID IN CLEANING OILED BIRDS

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Introduction

The Canadian Wildlife Service (CWS) does not become directly involved in the cleaning of oiled birds unless an endangered species is involved (CWS Oil Spill Response Policy, 1987). In British Columbia the Canadian Wildlife Service does, however, maintain: expertise in techniques for cleaning oiled birds; a response capability through the Regional Environmental Emergency Team; emergency response equipment; and facilitates the coordination of non-government agencies and volunteer groups who are or would be involved in cleaning oiled birds.

The southwest coast of British Columbia is an important wintering area for migratory birds. This area also has the largest proportion of B.C.'s human population and, as a result, the focal point for both oil pollution and concern for the effects of oil pollution on birds. Fortunately major oil pollution incidents are relatively infrequent (McKelvey et al., 1980) and those involving small numbers of birds (50 to 75 retrievable) can be handled by existing non-government and volunteer organizations.

The existing oiled bird cleaning facilities, however, could be overwhelmed quickly in the event of any spill involving more than about 75 birds retrieved. Rather than maintain an expensive facility that could handle a large number of oiled birds, the Canadian Wildlife Service has developed some portable equipment that can be used to augment existing facilities or be deployed rapidly to an area with no facilities. The purpose of this article is to describe this equipment and to give the rationale behind its choice.

Rationale

The procedure believed to be the most effective for treating oiled birds was developed by the International Bird Rescue Research Centre in Berkley, California (Williams et al., 1978). This procedure involves washing the oiled birds with detergent, rinsing until feather water repellency is restored, holding the bird for about 24 hours to determine if the cleaning has been effective, and releasing the bird in a suitable environment well away from the spill site.

In oil spill situations on the west coast the one commodity that is in shortest supply and of most critical need in a rehabilitation centre is hot water. The equipment the Canadian Wildlife Service has procured is designed to provide hot water immediately and continuously at any location.

Equipment

The equipment in the stockpile consists of the following items, most of which are in sufficient quantity to form two units. The purchase cost was approximately $4 000 in 1987.

Item		Number Required	Size
1.	1 1/2" (3.8 cm) single jacket fire hose equipped with quick-connect couplers	10	50' (15.24 m) lengths
2.	Standard garden hose	4	50' (15.24 m) lengths
3.	Palermo gas-fired hot water heaters	2	90 000 BTU (94 500 kJ)
4.	Threaded fire hydrant adapters	2	2 1/2" to 1 1/2" (6.4 to 3.8 cm)
5.	Threaded quick-connect coupler adapters	2	1 1/2" (3.8 cm)
6.	Reducers	2	1 1/2" to 5/8" (3.8 to 1.6 cm)
7.	Male/female garden hose adapters	2	5/8" (1.6 cm)
8.	Propane tanks with regulators and hoses	2	20 lb (9 kg)
9.	"Coleco" swimming pools	2	12' x 2' (3.7 x 0.6 m)
10.	Cases of "New Dawn" dish detergent	10	
11.	Plastic garbage pails	4	17 gal (77.3 L)
12.	Plastic wash trays	10	approximately 12" x 24" x 6" (30.5 x 61 x 15 cm)
13.	Miscellaneous parts:		
	washers		5/8" (1.6 cm)
	washers		1 1/2" (3.8 cm)
	pipe wrenches		14" (35.6 cm)
	crescent wrenches		10" (25.4 cm)
	water pump pliers		10" (25.4 cm)
	rubber gloves		
	disposable coveralls		
	tool boxes		

Water system. The water heater unit and plumbing arrangement are shown in Figures 1 and 2. The inlet side can be connected to any of the following:

i) a standard garden hose type connection on a domestic water service;
ii) a 1 1/2" (3.8 cm) domestic or municipal water service;
iii) a 2 1/2" (6.4 cm) fire hydrant or standpipe; or
iv) a 1 1/2" (3.8 cm) centrifugal pump if no domestic or municipal water service is easily accessible.

The water heater boiler is protected by a standard 3/4" (1.9 cm) pressure reducing valve (PRV), set at 80 psi (552 kPa), should a high pressure municipal service be the water source. Two bypasses are provided on the inlet side of the PRV. One allows mixing of cold inlet water with the hot outlet water. The ideal outlet temperature is 40°C which usually can be obtained by the appropriate setting of the temperature control on the heater. The other bypass allows water flow to be maintained if a centrifugal pump is the chosen supply. These pumps will usually not maintain a prime if flow is reduced from 1 1/2" to 3/4" (3.8 to 1.9 cm). However, by providing the 3/4" (1.9 cm) bypass the effective reduction is to about 1" (2.5 cm) which does not affect the prime.

The outlet side is fitted with a thermometer to check outlet temperature, and a standard 3/4" (1.9 cm) pipe thread, to which any 5/8" (1.6 cm) garden hose can be connected. The thermometer is somewhat slow to respond to temperature changes because of the mass of the temperature probe. Once the system is operating, a few minutes are required to obtain the correct temperature. If the outlet flow is shut off, for example by closing a nozzle, the heater unit will shut off automatically, and restart once there is a demand placed on the outlet flow.

The heater units are equipped with a standard female and 1/2" (1.3 cm) gas fitting which will accept a standard 1/2" (1.3 cm) propane fitting. The immediate fuel supply is one 20 lb (9 kg) propane tank per heater, which will provide about four hours of continuous service. The boiler flame is activated by a pilot light which in turn is piezo started.

Other equipment. The other equipment in the stockpile is standard bird cleaning equipment. The dish washing detergent is the brand recommended by the International Bird Rescue Research Centre. It is not generally available in Canada, although other brands that are may suffice. The garbage pails, plastic pans and swimming pools are generally readily available in an emergency but are provided with the kit so that bird cleaning can begin immediately.

Conclusion

In the event of a large spill involving many retrievable birds, all of the necessary cleaning equipment and facilities can usually be obtained within three days. During that time, however, many of the birds that could have been rehabilitated will die. Although the overall impact of oil pollution on bird populations appears not to be significant (Bourne, 1983), there is a strong expectation by the public that oiled birds will be cared for. With relatively small investment of resources on the part of government, that expectation can be met by providing equipment and expertise to those who wish to clean oiled birds.

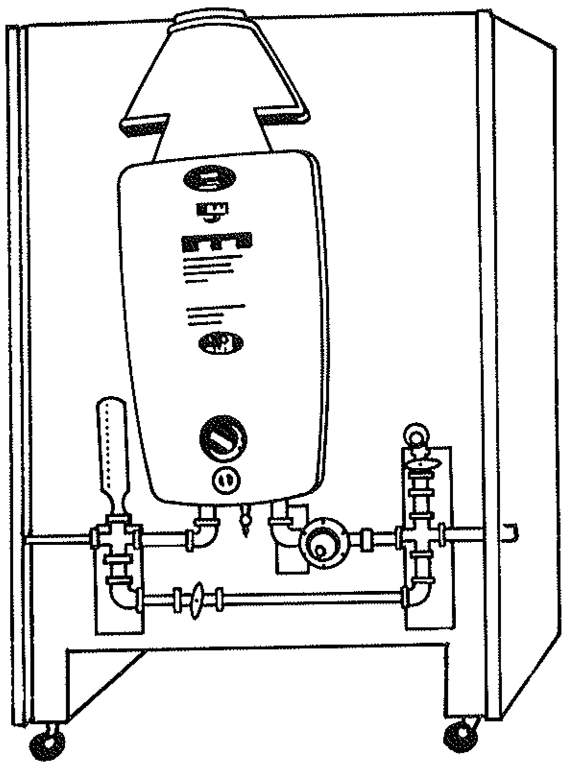

FIGURE 1 WATER HEATER FOR BIRD REHABILITATION

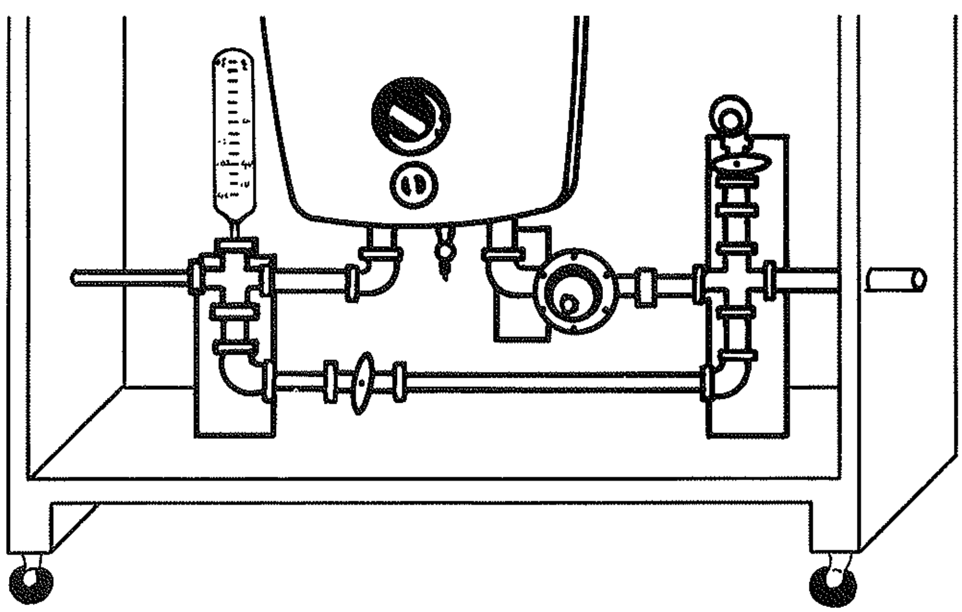

FIGURE 2 PLUMBING DETAIL ON WATER HEATER

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SPILL TRENDS - AN ATLANTIC REGION PERSPECTIVE

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Introduction

A call is received on the Environmental Emergencies Division's (EED) 24-hour emergency line. A private citizen is reporting a spill of 400 litres of furnace oil from a tank outside his home. The caller is concerned that the oil may seep into his basement and also contaminate his well. The phone rings again. A large diesel slick from an unknown source is spreading acoss a sheltered harbour, endangering nearby seabirds and a lobster pound...

These are examples of the types of spill reports routinely received by EED in the Atlantic Region. In conjunction with other agencies, EED devotes a large part of its resources to response, ensuring that spills are properly cleaned up and damage to the environment is minimized. To focus these efforts there is a continuing need to identify problem areas and develop appropriate prevention programs.

An important tool in this identification process is determining what recurring problems are experienced in the region. What or who is responsible for these reported spills? What are the primary causes of the spills? Are there any discernable trends in the number of spills over time? What major users of oil and hazardous materials are having particular problems?

Since 1981, many of these questions have been answered in a series of four reports entitled "A Summary of Trends Relating to Spills of Oil and Hazardous Materials in the Atlantic Region". Oil and hazardous material spill data from 1974 to 1985 inclusive are examined in these reports. Data for 1986 are currently being compiled for a fifth report. Information contained in these reports has been consolidated in a regional computerized Trends Data Base, which is based on spill reports usually received by telephone from other government agencies, industry and the general public.

In addition to allowing EED officials to define problem areas, focussing the development of spill prevention programs, these reports have several other important uses. Industrial sectors can observe their performance in reporting spills and identify whether or not spill prevention mechanisms are being effectively employed. These reports also offer valuable data to the interested public.

The major results and conclusions of the 1985 Trends Report are summarized in this article. The reader is directed to the four reports cited in the references for more detailed analyses of oil and hazardous material spills in the Atlantic Region.

A Regional Summary - More Spills, Better Reporting?

An increasing trend in the number of oil and hazardous material spills reported each year in the Atlantic Region is illustrated in Figure 1. A total of 3 364 spills released more than 44 000 tonnes of oil and hazardous materials into the environment during the 1974 to 1985 study period. The 746 spills reported in 1985 were the highest annual total on record, and initial analysis indicated that the 1986 count may be slightly higher.

The proportion of non-oil hazardous material spills also increased, and by 1985 represented 15% of all reported events. Twice as many different substances were spilled in 1985 than in 1984. Non-oil hazardous material spills are still more common in other parts of Canada, accounting for 32% of all spills recorded on the National Analysis of Trends in Emergencies System (NATES) data base in 1985 (Cloutier, 1987).

The increase in the number of oil and hazardous material spills over time is partly due to heightened public awareness after highly publicized incidents such as the Kenora, Ontario polychlorinated biphenyl (PCB) spill. Mandatory reporting provisions in New Brunswick and Newfoundland and under the federal Transport of Dangerous Goods Act have also improved the reporting of spills. In addition, a continuous increase in the number of hazardous products in use across Canada is likely contributing to the greater diversity of substances being spilled each year.

Fuel No. 2 was the most frequently spilled oil product over the 12-year period, accounting for 720 spills (25% of all oil spills), while Fuel No. 6 represented the largest volume, 12 944 tonnes (42% of the volume of oil spilled). Much of this volume can be attributed to the 10 127 tonne "Kurdistan" tanker spill of 1979. The random distribution of a small number of large spills has led to no discernible trends in total volumes spilled per year (Figure 2).

Industrial chemicals (including PCBs, acids and caustics) were the most frequently spilled hazardous materials with 219 spills, or 49% of all non-oil hazardous material spills. Industrial wastes accounted for 6 166 tonnes, or 47% of the total volume of hazardous material spilled. This category includes large effluent spills such as liquor spills from pulp mills.

The major causes of spills in the Atlantic Region are identified in Table 1. The most significant over the 12-year period were land transport accidents (19%), tank leaks (15%), sea transport accidents (13%) and equipment malfunctions (12%). These were also the major causes of spills in 1985, although pipe breaks were also significant.

Spills by Major Users of Oil and Hazardous Materials

In 1985, although spills tended to be distributed over a wide range of industrial sectors, refineries and power plants accounted for a total of 31% of reported incidents (Figure 3). Many spills were classified as "miscellaneous", a category which includes small industries, commercial enterprises, institutions, private citizens and spills where the source could not be identified.

With the exception of a pronounced decline in 1980, the number of spills reported by oil companies tended to increase from close to 65 per year between 1975 and

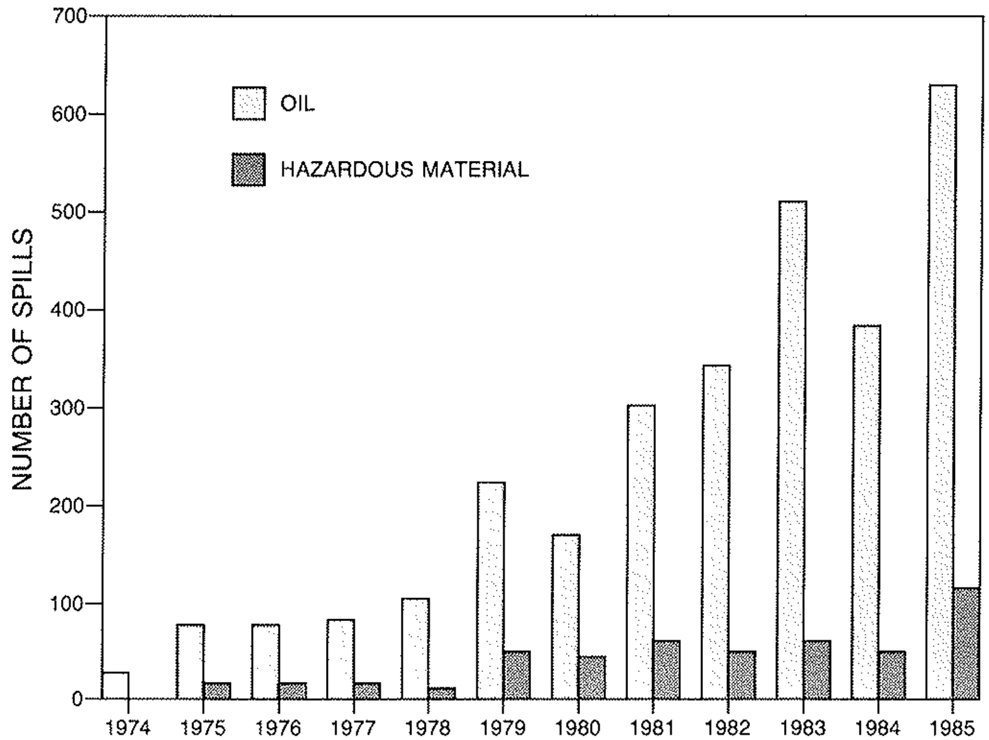

FIGURE 1 OIL AND HAZARDOUS MATERIALS SPILLS (Atlantic Region - 1974 to 1985)

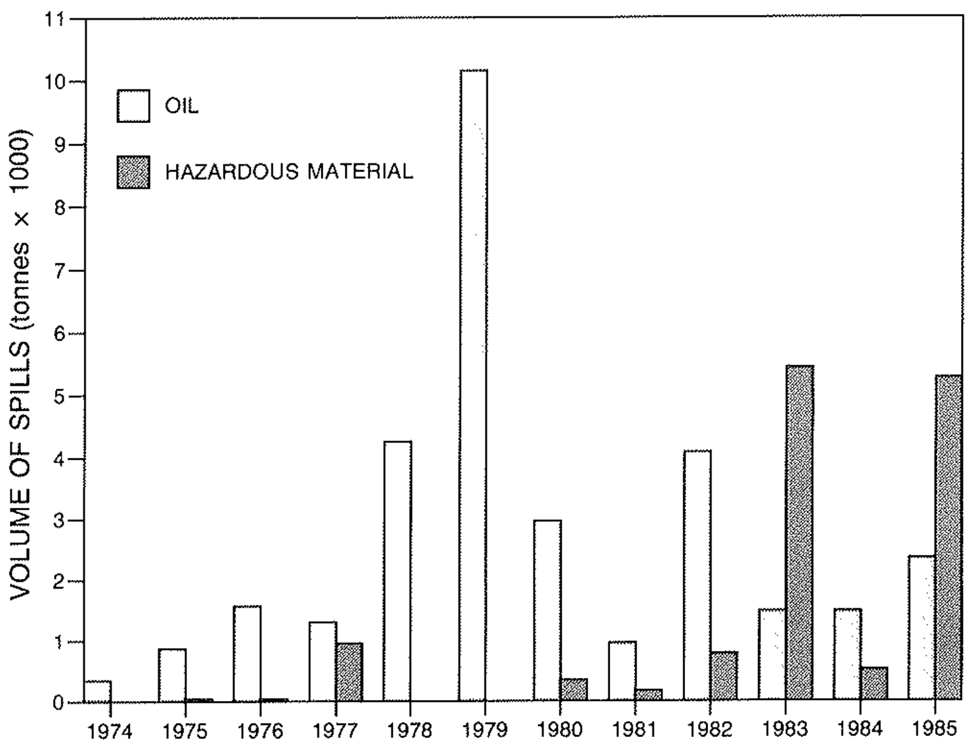

FIGURE 2 VOLUME OF OIL AND HAZARDOUS SPILLS (Atlantic Region)

TABLE 1 SUMMARY OF CAUSE OF REGIONAL SPILLS (1974 to 1985)

Spill Cause	Total Number	%
Storage		
- defective valve	105	3
- tank leak	491	15
- pipeline break	255	8
Transportation		
- land	645	19
- sea	418	12
Plant Operations		
- tank overfill	325	10
- equipment malfunction	414	12
- human error	259	8
Unknown Cause	353	11
Airplane Crash	77	2
Flood	2	0
TOTALS	3 344	100

1977 to over 120 reported per year from 1982 to 1985. Land transport accidents, tank leaks and equipment malfunctions caused a total of 65% of reported oil company spills in 1985.

A total of 73 spills was reported for power plants in 1985, well above the average of 29 spills per year reported during the period from 1979 to 1984. PCB spills increased from nine in 1984 to 15 in 1985, because of better reporting and a large number of small spills at a single power sub-station in New Brunswick. Most power plant spills were caused by leaking transformers and capacitors.

More than 50% of all reported spills in 1985 were categorized as miscellaneous. Many of these spills were furnace oil leaks from private storage tanks, or small spills whose source could not be identified. The four largest spills recorded during the year were from ship accidents (two events) and overflows of manure from pig farms in the Annapolis Valley of Nova Scotia (two events).

The major causes of miscellaneous spills in 1985 were tank leaks, equipment malfunctions and sea transport incidents. Land transport accidents, the major cause of miscellaneous spills in 1984, were only responsible for 11% of these spills in 1985. More

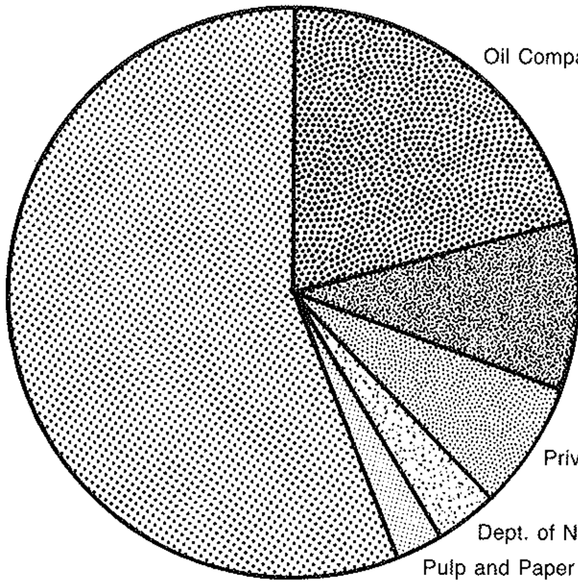

FIGURE 3 DISTRIBUTION OF SPILLS BY USER SECTOR (Atlantic Region - 1985)

miscellaneous spills were reported in Nova Scotia (184 events) and Newfoundland (137 events) than in New Brunswick (53 events) and Prince Edward Island (18 events).

Conclusions

The number of reported spills in the region continues to increase each year, a trend which has also been noted across Canada (Beach and Cloutier, 1987). The variety of materials spilled also has increased substantially in the Atlantic Region, but is still well below the variety of substances spilled in other regions of Canada.

Although oil refineries and power plants combined for over 30% of all reported spills, most spills were classified as miscellaneous. This can be a problem, as unlike refineries and power companies which employ experienced spill response personnel, most miscellaneous spills originate from organizations or individuals with no training or equipment for dealing with spills.

Because of this, normally routine incidents can become serious pollution problems. Training, media presentations and involvement in high profile public information sessions (such as Environment Week) are three methods Environment Canada uses to increase public awareness and promote more effective spill response.

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EVALUATION OF TWO NEW OIL SPILL CHEMICAL ADDITIVES: ELASTOL AND DEMOUSSIFIER

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Introduction

A new oil spill treating agent, Elastol, has been developed for enhancing the recovery potential of oil. When added to oil, the powder renders oil visco-elastic making it adhesive to oil spill recovery equipment. Elastol is composed of a non-toxic polymer, polyisobutylene and is hydrophobic and not water soluble. A major study was undertaken jointly by the U.S. Minerals Management Service and Environment Canada to evaluate this new spill additive. Laboratory testing was done and studies were conducted in large-scale test tanks and in a major field exercise off Canada's east coast.

At the same time, another new spill treating agent, demoussifier, was tested in large outdoor tanks and at sea. This product, which also consists of a mixture of long-chain polymers which have no measurable toxicity to humans or to aquatic life, was developed at Environment Canada's River Road Labs. The product breaks up water-in-oil emulsions and prevents their formation.

Laboratory Testing of Elastol

The laboratory work on Elastol involved several different tests. The effect on a suite of different oils was determined by measuring the time to initiate change and the degree of elasticity formed. These oils included: Prudhoe Bay, Alberta Sweet Mix Blend, Norman Wells, Bent Horn, Hibernia, Tarsiut, Atkinson, Amauligak crudes, diesel fuel and a Bunker C mix. All oils displayed viscoeleastic properties when treated with doses of 600 to 6000 ppm Elastol. In general, more viscous oils tended to attain a higher degree of elasticity than non-viscous oils, but did so over a longer period of time. No simple correlation could be established between an oil property and Elastol effectiveness. Elastol effectiveness is enhanced by mixing and by higher temperatures, although the latter may be the effect of decreasing oil viscosity.

Under low mixing energy conditions, oils exhibited some degree of elasticity within 15 minutes of Elastol application. A high degree of elasticity was not observed until after one hour. Less viscous oils took less time to reach maximum elasticity and viscous oils more time. If left to weather, Elastol-treated oil became more elastic with the increasing viscosity of the oil. In fact, some samples left for 30-day periods became elastic as rubber bands sold for stationery purposes. This effect has been ascribed to the effect of the increasing viscosity of the oil with weathering (evaporation) and not the progressive reaction of the Elastol.

Elastol causes a minor reduction in the rate of oil evaporation, but not significant enough to reduce its flash point. Elastol reduces slick spreading to a limited degree, especially at high concentrations. This effect, about 20%, is not believed to have a significant useful benefit by itself in real applications. When Elastol is applied in very large doses, >1%, the slick would actually contract somewhat, but again, the effect would not be beneficial in a field situation.

The addition of Elastol either had no effect or an inhibiting effect on the formation of water-in-oil emulsions, except in the case of the Amauligak and Tarsiut oils from the Beaufort Sea region. In two cases, the application of Elastol to emulsified oil actually led to measurable de-emulsification. Application of Elastol to stable water-in-oil emulsions sometimes had little effect. Testing with commercial de-emulsifiers and the Environment Canada "demoussifier", showed that Elastol had no effect on the operation of these chemicals and that they could be used together.

Elastol reduces chemical dispersant effectiveness by as much as one order of magnitude. Elastol also reduces natural dispersion of oil into water by as much as three orders of magnitude. This property, while superficially appearing negative, is actually quite useful. If Elastol was used in situations where the aquatic life is very sensitive and important, it could reduce water concentrations of the oil in the water to threshold levels.

Elasticity was measured using a die swell apparatus in which oil is pushed through a small opening and the fluid responds by swelling to a size corresponding to its elasticity. This is measured by photographing the swell, measuring it with a vernier caliper and comparing untreated versus treated oil to yield a ratio which is described as "elasticity" in this paper. The instrument displayed good sensitivity to polymer concentration and to the degree of observed elasticity. This instrument could also be used in field conditions and is relatively insensitive to debris and water in the oil.

Tank Scale Testing of Elastol and Demoussifier

An application device was developed for each of the two products, as commercial devices do not exist for delivering treatments at the low ratios required. Elastol would be tested at 500 to 5000 ppm and demoussifier would be tested at 150 to 2000 ppm. A search of commercial devices revealed that nothing suitable was available off-the-shelf but that sandblaster-type equipment could be satisfactorily modified. A commercial blaster (Sears) was modified so that it could spray low quantities. One modification was necessary for the solid Elastol, and another for the liquid demoussifier. The modified applicator was tested on each product to ensure that uniform spacial distribution was achieved and that application rates could be controlled over the necessary range by adjusting the air pressure when applying the product from a boat travelling at approximately 3 knots. A series of test tank runs were performed to ensure that results obtained previously with hand distribution techniques and with pre-mixing were duplicated with the new applicators. Success was achieved in all cases, and no detrimental effects were observed during application of either product, such as herding and other phenomena that have decreased the field effectiveness of dispersants so dramatically (Bobra et al., 1988).

Part of this study involved large-scale tank testing of both products using the Esso tank in Calgary, Alberta. The tank measures 15 x 19 m with a depth of 0.8 to 2 m. Two test days were devoted to demoussifier and two to Elastol. Testing was performed in two boomed areas inside the tank. This permitted the simultaneous testing of a control and a treated slick under identical conditions. The demoussifier prevented the formation of water-in-oil emulsions on both test days and did so at ratios as low as 1:2000 (500 ppm).

Elastol was added to a test crude oil at 4000 ppm and the test slick was released several hours later when the oil was highly elastic. Despite this high elasticity, the oil was not thick enough to burn. The oil was recovered by a rotating disk skimmer and the effect of Elastol was to increase the recovery rate of this unit significantly. In fact, the pump could not keep pace with all the oil being recovered. On the fourth day of testing, crude oil was treated with 2000 ppm of Elastol and recovered with a skimmer. The recovery rate was again high and exceeded the capacity of the pump to remove it. On this particular day, the oil in the untreated boom had formed an emulsion. This was treated with demoussifier as was the Elastol-treated slick. The demoussifier broke the emulsion in the untreated slick and no emulsion formed in the treated slick, nor were any other effects noted. During the first two trial days, the use of demoussifier reduced the effectiveness of the recovery operation significantly. It was concluded, therefore, that on a preliminary basis, demoussifier and Elastol could be used together to enhance recovery and eliminate emulsion.

The tank scale tests showed that there were no scaling effects for either the Elastol or the demoussifier. Both products worked well for the intended purpose. Elastol increased the visco-elasticity of the oil and greatly increased the recovery by the oil skimmer. Elastol, however, did not reduce the spreading or increase the thickness of the slick sufficiently to allow in-situ burning. Demoussifier prevented the formation of water-in-oil emulsion and also broke emulsion already formed. Although demoussifier causes the oil to be less adhesive and lowers the recovery rate of skimmers, the two products can be applied together to achieve positive results.

Large-scale Field Testing

The tests conducted in the tank were repeated on five-barrel slicks during a field trial 50 miles offshore of Nova Scotia (Seakem, 1988). Five slicks were laid for each of the products and each product was tested both premixed and by application-at-sea, to confirm that application effects were not a factor. The treatments and results of the trial are summarized in Table 1.

The demoussifier trials were performed by laying down a five-barrel oil slick, treating it with the product at the specified ratio, taking samples at subsequent intervals and measuring the water content and the viscosity. One slick was left untreated throughout as a control and another slick was left to form mousse (water-in-oil emulsion) and then treated at the 240-minute interval to test the demoussifier's ability to break emulsion at sea. As can be seen by dramatic reduction in viscosity (105 000 to 22 600 cSt; 1050 to 226 cm^2/s) over the 30-minute period between samples, the product worked well in breaking up the emulsion.

The product also worked well over the five-hour test period to prevent the formation of emulsions. This is illustrated in Figure 1 which also shows that there is a

TABLE 1 TREATMENTS AND RESULTS OF TRIALS

			Sample 1					Sample 2				
Trials	Slick	Treatment (ppm)	Time (min.)	Viscosity (cSt)*	Water Content	Elasticity	Comments	Time (min.)	Viscosity (cSt)*	Water Content	Elasticity	Comments
Demoussifier	1	1000	60	10 000	84%		No mousse formed	300	84 250	90%		No mousse noted
	2	250	60	2 700	54%		No mousse formed	300	62 250	93%		No mousse noted
	3	control	60	6 350	88%		Heavy mousse	270	320 000	95%		Heavy mousse
	4	post-4000	60	2 200	72%		Moderate mousse	pre-240	105 000	90%		Heavy mousse
								post-270	22 600	78%		Treatment broke mousse
	5	pre-1000	15	970	32%		No mousse formed	280	38 500	80%		No mousse formed
Elastol	6	3000	130	29 300		1.33	Moderately elastic	280	300 000		1.35	Highly elastic
	7	1000	145	32 250		1.28	Low elasticity	280	228 000		1.33	Moderately elastic
	8	control	135	187 000		0.99	No elasticity, widespread	290	242 000		0.99	No elasticity, widespread
	9	9000	120	93 000		1.99	High elasticity	330	696 000		2.63	Super elastic
	10	pre-3000	115	170 500		1.35	Moderate elasticity	315	156 000		1.57	Highly elastic

* 1 cSt = 1 x 10^{-2} cm^2/s

strong correlation between the viscosity and the amount of treatment. The greater the treatment, the less the viscosity, because of the lesser water content. The water content was universally high, even in those slicks that visibly did not form water-in-oil emulsions. Although water content is indicative of the formation of water-in-oil emulsification, the stability of the emulsion would have to be determined because the unstable emulsions lost water slowly. The water content of the slicks is interesting in that all the slicks laid over the two day test period rapidly took up water, including those slicks that were treated with Elastol. This was noted despite the fact that the oil viscosity was higher, although not as high as that expected from an emulsion, and the oil did not have the appearance of an emulsion. The appearance of the unemulsified oil is also significant, the water droplets were often of sufficient size to be seen. An emulsion is reddish-brown in colour, has a high viscosity and the water droplets are too small to be seen.

The Elastol tests were performed in an analogous manner, with one control slick laid and one slick being pretreated to test the effect of at-sea treatment. The slicks were sampled periodically, and both viscosity and elasticity were measured immediately on board the ship.

The high elasticity of the treated slicks was significantly higher than that of the untreated slicks and corresponded to that experienced in the laboratory, in fact, as shown in Figure 2, it actually exceeded laboratory results at the higher doses. This unexpected result is probably due to the better mixing achieved in the field situation. Interestingly, the dose and elasticity in the field appear to be linear, a phenomenon that had not been noted previously.

The elasticity of the oil was sufficient to cause stringing of the product when samples were recovered. This is indicative of a very high state of elasticity and would result in high oil recovery rates if a skimmer was used. The elasticity appeared to be uniform throughout the slicks despite the typical uneven distribution of treating agent at sea.

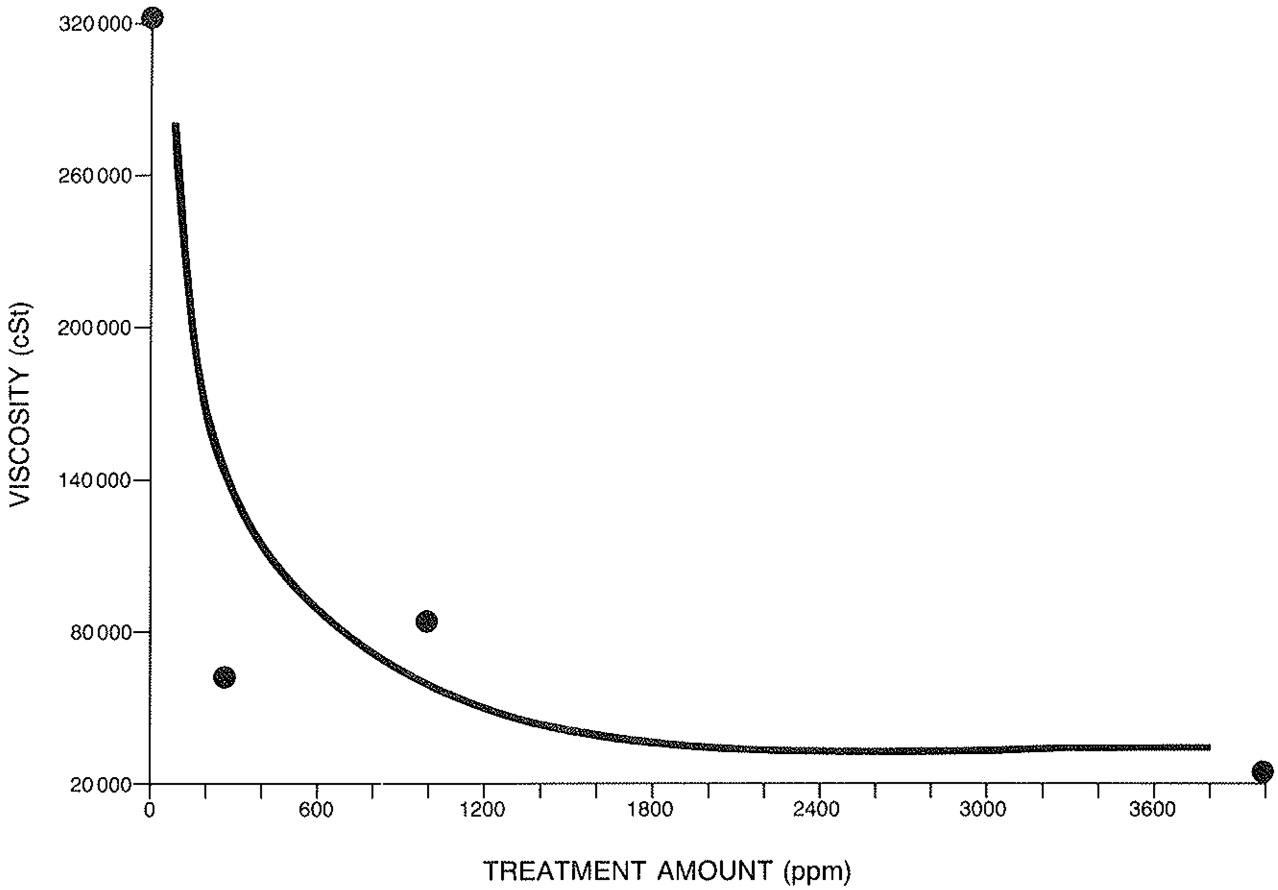

FIGURE 1 THE EFFECT OF DEMOUSSIFIER APPLICATION ON VISCOSITY

The slicks were monitored by a remote sensing aircraft, but the analysis of slick areas was not complete at the time of writing. Slicks treated with Elastol, however, appeared to be smaller to shipboard observers and the size of the slick appeared to correlate well with the amount of Elastol. In fact, one was able to distinguish slicks by their size, with the 9 000-ppm-treated slick being the smallest.

Summary and Conclusions

1. Elastol functioned well in the laboratory, test tank and in field situations; it caused oil to become viscoelastic in all applications.

2. Elastol is able to float with and mix with oil so that application is not critical as it is with dispersants.

3. Demoussifier has the same application insensitivity as Elastol.

4. The effects of Elastol improves oil skimmer recovery.

5. Elastol retards slick spreading; however, this effect, for physical reasons, is not sufficient for countermeasures purposes such as in-situ burning of oil on water.

6. The demoussifier prevented emulsion in the test slicks over the five-hour test period.

7. The demoussifier broke water-in-oil emulsions in 10 to 15 seconds after application.

8. Results of field application such as herding and loss of effectiveness, seen with dispersants, were not noted at all with either product.

9. Water content is not a good indicator of mousse formation as all slicks at the offshore trial accumulated a large amount of water. Stable mousse formation is indicated by a stable water content, small water droplet size, red colouring and a very high viscosity.

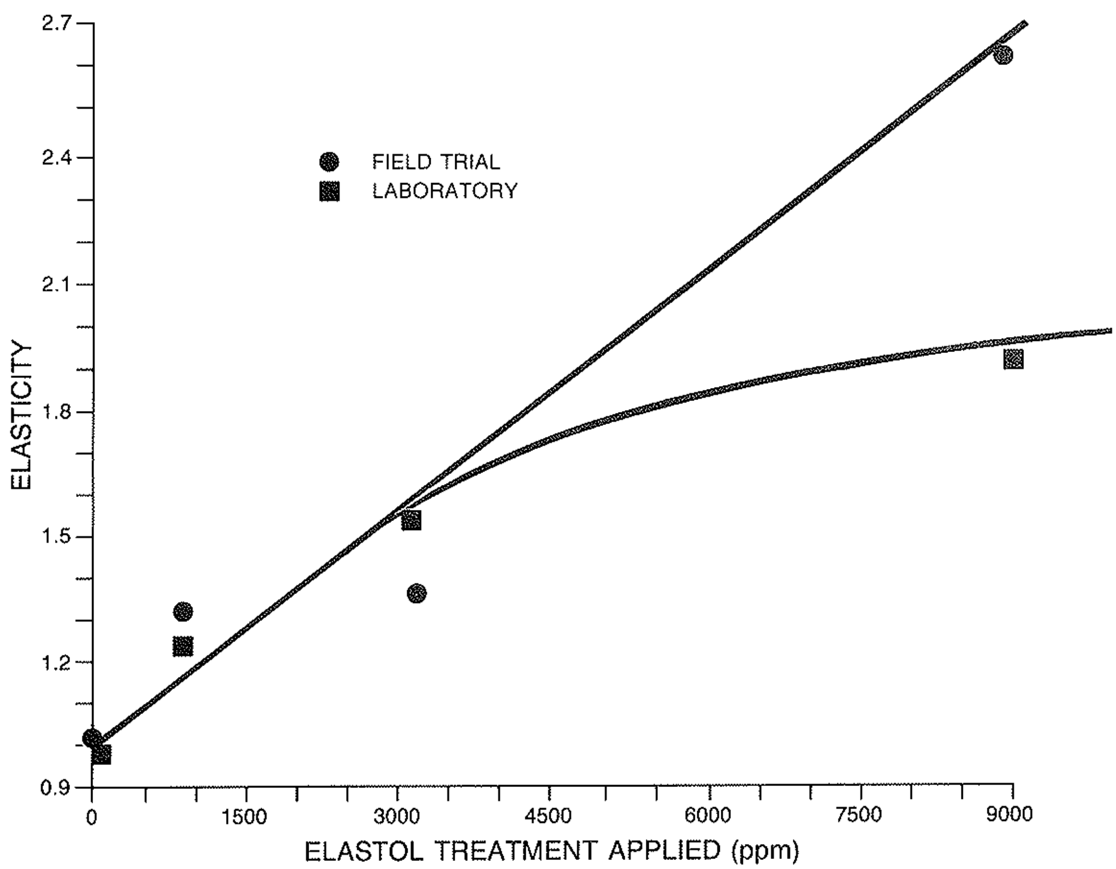

FIGURE 2 ELASTICITY OF OILS AFTER ELASTOL TREATMENT

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