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Selection Criteria and Laboratory Evaluation of Oil Spill Sorbents: An Update

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SELECTION CRITERIA AND LABORATORY EVALUATION OF OIL SPILL SORBENTS: AN UPDATE

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A Report Submitted To:

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ABSTRACT

Twenty-one oil spill sorbents were laboratory tested via immersion in three different petroleum products aged for one and seven days.

The synthetic sorbents generally exhibited higher initial and maximum capacities with the foam synthetics having the highest capacities. Potential reuse was also much greater for the synthetics than for the other sorbents.

During a 48-hour immersion test, the particulates and fibres exhibited the least change, the foams some structural weakening, and fibrous mats the most apparent alteration.

Several synthetic sorbents reacted with the diesel oil, changing from discrete particles to a homogeneous immiscible layer at the oil/water interface.

A statistical analysis shows that there is no significant difference between initial and maximum capacities for most sorbents. There is, however, a significant decrease in sorption capacity with the reduction of the oil layer thickness from 2.5 mm (diesel) and 5 mm (crude) to 0.1 mm for both oils, as well as a concurrent increase in water pickup.

RÉSUMÉ

Vingt et un types de produits absorbants et adsorbants pour nappes d'hydrocarbures ont été testés en laboratoire par immersion dans trois produits pétroliers différents déversés depuis un à sept jours.

En règle générale les produits synthétiques avaient une capacité d'absorption plus élevée, tant initiale que maximum, les mousses synthétiques se classant en tête. Les produits synthétiques présentaient également des possibilités de réutilisation meilleures que les autres produits.

Pendant le test d'immersion qui a duré 48 heures, les produits en particules et en fibres ne se sont guère altérés, tandis que la texture des mousses se modifiait quelque peu et que les nattes fibreuses présentaient les transformations les plus visibles.

Plusieurs produits synthétiques ont réagi avec l'huile diesel, passant de l'état de particules imperceptibles à celui d'une couche homogène immiscible à l'interface eau/hydrocarbures.

Une analyse statistique montre qu'il n'y a pas de différences sensibles entre les capacités d'absorption initiales et maxima pour la plupart des produits. Cependant, cette capacité diminue considérablement lorsque l'épaisseur de la nappe d'hydrocarbures passe de 2.5 mm dans le cas de l'huile diesel et de 5 mm dans le cas du pétrole brut à 0.1 mm, le volume d'eau absorbé augmentant en proportion.

FOREWORD

This report, designed to update previous sorbent work, results from work performed under contract to Fisheries and Environment Canada.

Mr. N. Vanderkooy of the Environmental Protection Service (EPS), Ontario Region, acted as scientific authority for this project, in cooperation with Mr. L.B. Solsberg, EPS, Ottawa.

The author is indebted to Mr. Scott Vader, who performed all laboratory work, as well as to the Canada Centre for Inland Waters in Burlington for the use of its laboratory facilities.

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1 INTRODUCTION

1.1 Background

In 1974 Fisheries and Environment Canada performed an evaluation of commercially available sorbents. The results of this evaluation were published in the report "Selection Criteria and Laboratory Evaluation of Oil Spill Sorbents" (Environmental Protection Service, Fisheries and Environment Canada, EPS 4-EC-76-5).

Since the completion of that study, several new sorbents have been introduced to the market. It was decided that evaluation of these new sorbents, together with those previously studied, would provide up-to-date information on sorbents presently available.

As a preliminary step to the study, a survey of sorbent manufacturers was conducted. The information received was compiled and sorbents were selected for testing. All new sorbents made known to the Department were evaluated, as well as the ten sorbents previously studied. The latter were included so that comparisons could be made with results obtained in the previous work.

The evaluations were carried out with three different oil products, at two different degrees of aging. During the testing procedures Lake Ontario water was used, on which different thicknesses of oil were layered.

A laboratory evaluation of sorbents does not provide all the answers regarding the performance of sorbents in the field but it does give a quantitative comparison of performance. When combined with practical field experience, this should result in the optimal and effective use of sorbents.

1.2 Introduction to Report

Sorbents, if categorized by material type, can be divided into three classes: natural products, modified natural products and synthetic products. A further distinction can be made by separating the organic and inorganic sorbents.

For the purposes of this study, it is sufficient to discuss sorbents under the following divisions: inorganic, natural organic and polymeric sorbents. A brief description of each category follows, including the names of the sorbents evaluated under each category. *An asterisk (*) denotes a sorbent not tested in the 1974 Environment Canada Study.*

1.2.1 Organic Sorbents. Organic sorbents consist of naturally occurring carbon compounds or materials derived from those substances, e.g. straw, peat moss and sawdust. These sorbents have been widely used in the recovery of spilled oil.

Organic products have distinct advantages over other sorbents in that they are readily available and relatively inexpensive, their oil-sorption capacity is higher than that of many inorganic sorbents, and their usage is less complex. If these materials are indiscriminately utilized, however, a sorbent retrieval problem may develop.

The organic sorbents tested were:

Conwed (modified organic)
Peat Moss
Rubbermaid Black (ground rubber)*
Slikwik
Straw

1.2.2 Inorganic Sorbents. This class of sorbents usually consists of naturally occurring material that has been mined or otherwise harvested. This material is often rendered more oleophilic and hydrophobic by treatment with silicones, etc.

Inorganic sorbents generally have low oil pickup capacities and are difficult to use. In addition, some types require protective wear for eyes and/or lungs, e.g. perlite, vermiculite, glass wool and volcanic rock.

The only inorganic sorbent tested was Zorbite*.

1.2.3 Mixed Sorbents (Organic/Inorganic Compounds). Several sorbents that are mixtures of the above material types are typically cellulose fibre-perlite mixtures. These are marketed under a variety of trade names and in several different physical configurations, e.g. granules, sheets and sausage booms.

In general, their sorption capacities and costs are comparable to the natural organic sorbents.

Sorbent C was the only mixed sorbent tested.

1.2.4 Synthetic Sorbents (Polymerics). Polyurethane, polyethylene, polypropylene and other organic polymers have been used to treat oil spills with varying success.

Most polymeric sorbents are highly oleophilic and hydrophobic, and have relatively high oil-sorption capacities. Unfortunately, however, past experience has shown that these sorbents are sparsely available and relatively expensive. Their application is greatly facilitated by the formats in which these materials are made available, i.e. bags, pads, sheets, booms, etc.

Synthetic sorbents show great promise in the future because their large sorption capacities and potential reuse offset the high initial costs.

The synthetic sorbents (polymerics) tested were:

Conwed Durable Pads*
Graboil
Imbiber Beads
Leomat*
Oil Snare
Qwik-Wick*
Spill Control FPD*
Spill Control PEP*

Tafmat*
3M Sheet
3M Fibre
Winkler Foam - 50-PS-PU*
Winkler Foam - 50-R-PS*
Winkler Foam - 80-R-PS*

1.2.5 Study Parameters. In the evaluation of sorbents as presented in this report, three quantitative aspects are highlighted: initial capacity, maximum capacity and water pickup.

Initial capacity is defined as the amount of oil that a particular sorbent is capable of picking up on its initial exposure to the oil/water testing system. This is expressed as grams of oil per gram of sorbent.

Maximum capacity is the maximum amount of oil recovered by a sorbent either on initial exposure to the oil/water test system or on subsequent exposures. This is expressed as grams of oil per gram of sorbent.

Water pickup is the weight of water pickup by a sorbent during testing, expressed as grams of water per gram of sorbent.

1.2.6 Report Contents. A brief summary of the study findings is presented in Section 2, "Principal Findings". Section 3 details the method used to evaluate the sorbents, and Section 4 presents the results obtained as well as a comprehensive discussion of these results.

Appendix I presents detailed data obtained during the testing program and comments on the characteristics and performance of each sorbent. Appendix II consists of a "Users' Guide to Sorbents", listing sorbents for which information was supplied by the manufacturer. Physical and chemical properties, sorption information, cost, and geometry of product are examples of parameters used to describe each sorbent.

2 PRINCIPAL FINDINGS

Experimental data collected during this laboratory study are summarized in Tables 1 to 4. Tables 1-3 show the initial and maximum capacities, water pickup, and number of reuses for each sorbent with one and seven-day aged diesel, 2.5 mm layer; crude, 5 mm layer; and Bunker C, 5 mm layer, respectively. Table 4 shows the initial capacity and water pickup for each sorbent with 0.1 mm layers of 1-day aged diesel and crude oils.

The synthetic sorbents generally exhibited higher initial and maximum capacities, with the foam synthetics (e.g. Graboil, Spill Control Co. PEP*) having the highest capacities. The potential reuse was much greater for the synthetics than for the other sorbents. A comparison of Tables 1 to 4 reveals that sorption capacity decreases with decreasing slick thickness while water pickup increases.

TABLE 1 SUMMARY OF INITIAL AND MAXIMUM CAPACITIES, WATER PICKUP AND NUMBER OF REUSES (DIESEL: 2.5 mm layer)

Sorbent	1-Day Aged				7-Day Aged			
	Initial Capacity	Maximum Capacity	Water Pickup	Reuse	Initial Capacity	Maximum Capacity	Water Pickup	Reuse
ORGANIC								
1. Conwed (modified organic)	11.74	11.74	0	1	13.54	13.54	0	1
2. Peat Moss	3.41	3.40	0	1	2.75	2.92	0.12	1
3. Rubbermaid Black (ground rubber)*	1.58	1.58	0.47	1	1.70	1.83	1.34	1
4. Slikwik	4.10	4.89	0	1	4.21	4.52	0.11	1
5. Straw	1.42	1.57	0.21	1	2.02	2.57	0.30	1
INORGANIC								
6. Zorbite*	4.52	4.52	0	1	5.27	7.26	0	1
MIXED (ORGANIC/INORGANIC)								
7. Sorbent C	5.39	5.39	0.97	1	6.82	6.82	0.31	1
SYNTHETIC (POLYMERIC)								
8. Conwed Durable Pads*	14.60	17.82	0.26	10	17.68	18.56	0	10
9. Graboil	24.73	30.65	0	10	27.21	28.82	1.92	10
10. Imbiber Beads	4.40	4.40	0	0	3.53	3.53	0	0
11. Leomat*	4.62	4.74	0	2	6.02	6.02	0	2
12. Oil Snare	1.15	1.36	0.15	1	1.35	1.45	0	1
13. Qwik-Wick*	10.60	10.60	0.40	10	10.21	10.21	0.04	7
14. Spill Control Co. FPD*	11.70	12.63	0	10	9.59	10.26	0.26	10
15. Spill Control Co. PEP*	37.48	41.18	0	10	25.45	27.37	0.28	10
16. Tafmat*	9.48	9.48	0	10	9.06	9.06	0	4
17. 3M Fibre	10.69	10.69	0	1	10.38	10.38	0	1
18. 3M Sheet	14.78	14.78	0	2	13.44	13.44	0	2
19. Winkler Foam 50-PS-PU*	9.78	11.36	0.48	1	14.90	14.90	3.08	1
20. Winkler Foam 50-R-PS*	3.09	3.76	0.48	1	1.44	1.59	1.62	1
21. Winkler Foam 80-R-PS*	1.45	1.63	0.35	1	2.58	2.85	0.28	1

Initial Capacity, Maximum Capacity and Water Pickup are expressed in grams of liquid/gram of sorbent

* Sorbent not tested in 1974 Environment Canada study

TABLE 2 SUMMARY OF INITIAL AND MAXIMUM CAPACITIES, WATER PICKUP AND NUMBER OF REUSES (CRUDE: 5 mm layer)

Sorbent	1-Day Aged				7-Day Aged			
	Initial Capacity	Maximum Capacity	Water Pickup	Reuse	Initial Capacity	Maximum Capacity	Water Pickup	Reuse
ORGANIC								
1. Conwed (modified organic)	12.0	12.0	0	2	13.62	14.24	0.99	7
2. Peat Moss	3.40	4.21	0.33	1	3.03	3.13	0.70	1
3. Rubbermaid Black (ground rubber)*	3.05	3.05	0	1	2.73	2.86	0.11	1
4. Slikwik	4.72	5.49	0	1	6.79	6.79	0	1
5. Straw	1.59	1.80	0.36	1	1.48	1.57	0.56	1
INORGANIC								
6. Zorbite*	3.90	4.22	4.10	1	1.63	1.81	4.02	1
MIXED (ORGANIC/INORGANIC)								
7. Sorbent C	8.62	8.62	2.09	1	16.65	16.65	7.75	1
SYNTHETIC (POLYMERIC)								
8. Conwed Durable Pads*	19.57	20.32	1.11	10	15.62	15.62	4.66	10
9. Graboil	22.84	41.29	0	10	44.92	47.0	0	10
10. Imbiber Beads	2.98	2.98	0	0	2.95	2.95	0	0
11. Leomat*	4.65	4.65	0.015	2	5.66	6.47	1.35	6
12. Oil Snare	0.98	1.07	1.47	1	1.66	1.66	0.94	1
13. Qwik-Wick*	11.20	11.20	0.19	10	4.07	4.35	9.35	10
14. Spill Control Co. FPD*	11.11	11.68	0	10	9.36	10.34	0	10
15. Spill Control Co. PEP*	40.25	46.90	0	10	40.35	45.96	0	10
16. Tafmat*	11.07	11.07	0	3	9.69	10.15	4.01	10
17. 3M Fibre	11.92	11.92	0.06	1	12.06	12.06	0.93	1
18. 3M Sheet	12.41	12.41	0.03	2	12.40	12.40	0	1
19. Winkler Foam 50-PS-PU*	24.94	32.39	6.0	10	31.27	31.65	2.61	1
20. Winkler Foam 50-R-PS*	9.68	12.97	3.42	2	24.31	24.31	23.84	1
21. Winkler Foam 80-R-PS*	5.27	7.03	4.01	3	21.01	21.01	14.74	2

Initial Capacity, Maximum Capacity and Water Pickup are expressed in grams of liquid/gram of sorbent

* Sorbent not tested in 1974 Environment Canada study

TABLE 3 SUMMARY OF INITIAL AND MAXIMUM CAPACITIES, WATER PICKUP AND NUMBER OF REUSES (BUNKER C: 5 mm layer)

Sorbent	1-Day Aged				7-Day Aged			
	Initial Capacity	Maximum Capacity	Water Pickup	Reuse	Initial Capacity	Maximum Capacity	Water Pickup	Reuse
ORGANIC								
1. Conwed (modified organic)	12.85	24.02	0	1	14.43	25.11	0	1
2. Peat Moss	2.15	3.59	0	1	3.18	3.18	0	1
3. Rubbermaid Black (ground rubber)*	2.58	3.42	0	1	1.78	2.98	0	1
4. Slikwik	9.60	9.60	0	1	6.07	6.19	0	1
5. Straw	4.26	4.75	0	1	3.78	3.83	0	1
INORGANIC								
6. Zorbite*	18.80	19.93	0	1	11.09	13.88	0	1
MIXED (ORGANIC/INORGANIC)								
7. Sorbent C	12.87	13.48	0	1	4.78	5.66	0	1
SYNTHETIC (POLYMERIC)								
8. Conwed Durable Pads*	22.49	23.03	0.28	1	22.62	22.98	0	1
9. Graboil	16.38	41.87	0	1	15.23	62.94	0	10
10. Imbiber Beads	5.05	5.05	0	0	6.41	6.41	0	0
11. Leomat*	6.27	9.55	0	1	6.53	10.12	0	1
12. Oil Snare	4.58	4.58	0	1	5.53	6.01	0	1
13. Qwik-Wick*	13.89	16.26	0	1	13.37	14.80	0	1
14. Spill Control Co. FPD*	11.77	14.52	0	1	10.02	14.04	0	1
15. Spill Control Co. PEP*	27.99	37.69	0	1	25.17	42.0	0	1
16. Tafmat*	13.23	14.68	0	1	13.42	14.75	0	1
17. 3M Fibre	11.81	12.23	0	1	6.79	9.16	0	1
18. 3M Sheet	4.38	6.75	0	1	5.91	10.02	0	1
19. Winkler Foam 50-PS-PU*	12.96	28.08	0	2	41.87	42.79	0	1
20. Winkler Foam 50-R-PS*	10.81	10.91	0	1	2.92	3.82	0	1
21. Winkler Foam 80-R-PS*	8.59	9.43	0	1	7.27	8.79	0	1

Initial Capacity, Maximum Capacity and Water Pickup are expressed in grams of liquid/gram of sorbent

* Sorbent not tested in 1974 Environment Canada study

TABLE 4 SUMMARY OF INITIAL CAPACITY AND WATER PICKUP WITH THIN OIL LAYER (DIESEL, CRUDE)

Sorbent	1-Day Aged			
	DIESEL (0.1 mm layer)		CRUDE (0.1 mm layer)	
	g oil/g sorbent	g water/g sorbent	g oil/g sorbent	g water/g sorbent
ORGANIC				
1. Conwed (modified organic)	0.08	1.6	0.49	0.32
2. Peat Moss	0.38	2.87	0.47	0.98
3. Rubbermaid Black (ground rubber)*	0.16	0.56	0.02	0.86
4. Slikwik	0.33	6.11	0.81	3.47
5. Straw	2.2	1.77	1.96	1.26
INORGANIC				
6. Zorbite*	0.01	3.80	0.02	3.26
MIXED (ORGANIC/INORGANIC)				
7. Sorbent C	1.09	4.04	0.84	1.10
SYNTHETIC (POLYMERIC)				
8. Conwed Durable Pads*	3.27	0.69	1.00	2.32
9. Graboil	2.92	2.13	0.36	0.36
10. Imbiber Beads	0.89	0	1.23	0
11. Leomat*	0.79	0.64	0.48	0.16
12. Oil Snare	1.46	0	2.39	1.72
13. Qwik-Wick*	0.19	14.14	0.39	12.29
14. Spill Control Co. FPD*	0.24	10.3	0.74	4.94
15. Spill Control Co. PEP*	0.79	3.44	1.05	2.12
16. Tafmat*	1.25	0.37	0.28	0.66
17. 3M Fibre	6.37	2.68	1.66	1.16
18. 3M Sheet	0.23	0.06	0.21	0.03
19. Winkler Foam 50-PS-PU*	2.66	5.68	3.29	5.13
20. Winkler Foam 50-R-PS*	1.20	1.09	6.59	5.84
21. Winkler Foam 80-R-PS*	0.85	0.79	1.33	1.75

* Sorbent not tested in 1974 Environment Canada study

During the 48-hour immersion test, the particulates and fibres exhibited the least change, the foams some structural weakening, and the fibrous mats the most apparent physical deformation.

Several synthetic sorbents reacted with the diesel oil, changing from discrete particles to a homogeneous immiscible layer at the oil/water interface.

The statistical analysis shows that there is no significant difference between initial and maximum capacities for most sorbents. There is, however, a significant decrease in sorption capacity with the reduction of the oil layer thickness from 2.5 mm (diesel) and 5 mm (crude) to 0.1 mm for both oils, and a concurrent increase in water pickup.

3 LABORATORY EVALUATION

The procedure used during this evaluation was similar to that outlined in the 1974 Environment Canada study (EPS 4-EC-76-5), but was modified slightly and expanded to include more test oils.

It must be stressed that the results of these tests serve only as a guide to sorbent selection and application. Actual field use involves varying weather conditions, sea state, water conditions and oil characteristics, which would in turn alter the capacities of the sorbents as determined in this study.

3.1 Experimental Method

3.1.1 Materials and Apparatus.

Carver Laboratory Press (0 - 100 psig Model "C")

Haake Temperature Control Unit, Model KT33

Normal laboratory apparatus

Various sorbents

Test Oils: Diesel
Crude (high sulphur)
Bunker C
Natural Water (lake water)

3.1.2 Procedure. Test oils were aged by continuous mixing in the presence of air; the volatiles were vented via a fume hood. The oils were aged for periods of 24 hours (1 day) and 168 hours (7 days).

A bath, with depth of natural water at 10-15 cm, was maintained at 10°C. Each oil was layered on the water (diesel 2.5 mm thick; crude and Bunker C, 5 mm thick). The 1-day weathered diesel and crude oils were also used at a layer thickness of 0.1 mm.

Figure 1 shows the laboratory setup as used during this evaluation.

A sample of the sorbent was weighed, placed in the test system (oil/water at 10 C) and left for 1 hour without mechanical agitation. The sample was then drained for 5 minutes and weighed. Oil (or oil and water) was removed from the sorbent using the press (maximum pressure of 2.82 kg/cm^2). The sorbent was then reweighed.

The liquid recovered was tested for water content (ASTM D95 or centrifuging). To ascertain the reusability of the sorbent, this procedure was repeated until the sorbent disintegrated or the recovered oil fell below 50 percent of the initial capacity (to a maximum of 10 repetitions). The oil was replenished after each test to maintain a constant oil layer thickness.

Each sorbent was tested in triplicate. The results obtained were used to calculate initial capacity, maximum capacity and water pickup. The results of the three samples were averaged to produce one number.

The calculations used were:

$$\text{Initial Capacity} = \frac{(\text{weight of oil, water and sorbent after initial exposure}) - (\text{weight water recovered}) - (\text{initial sorbent weight})}{\text{initial weight of sorbent}}$$

$$\text{Maximum Capacity} = \frac{(\text{maximum weight of oil, water and sorbent}) - (\text{weight water recovered}) - (\text{initial sorbent weight})}{\text{initial weight of sorbent}}$$

$$\text{Water Pickup} = \frac{\text{weight water recovered}}{\text{initial weight of sorbent}}$$

For "reuse" calculations of capacity, the weight of the sorbent plus oil remaining after pressing was subtracted, rather than the initial weight of sorbent sample.

Duplicate samples of sorbent were subjected to a 48-hour immersion test in each of the oil/water combinations. Figure 2 shows an immersion test in progress.

Observations were made during and at the end of the 48-hour test. Parameters considered were the percentage of sorbent still afloat, physical characteristics and integrity of sorbent, strength compared to new sorbent, and any chemical reaction(s).

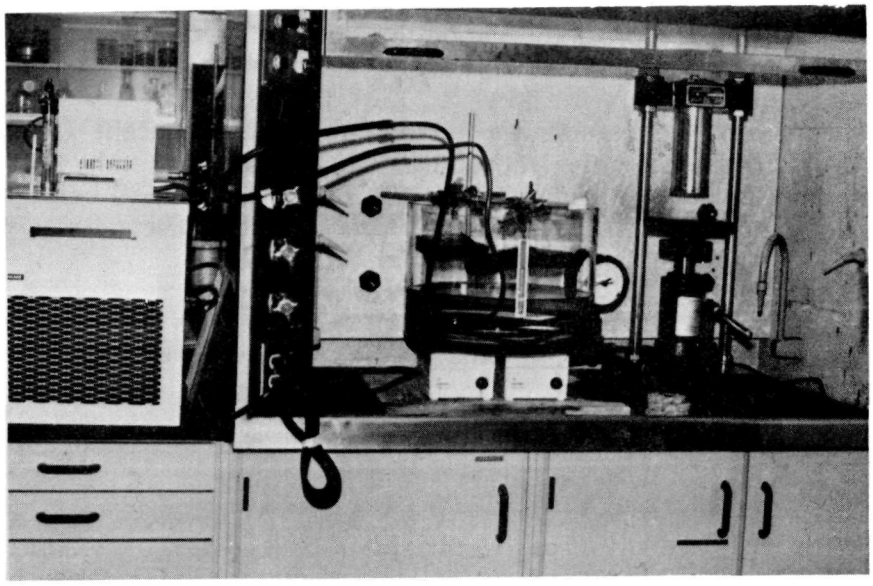


FIGURE 1 LABORATORY SETUP FOR SORBENT EVALUATION

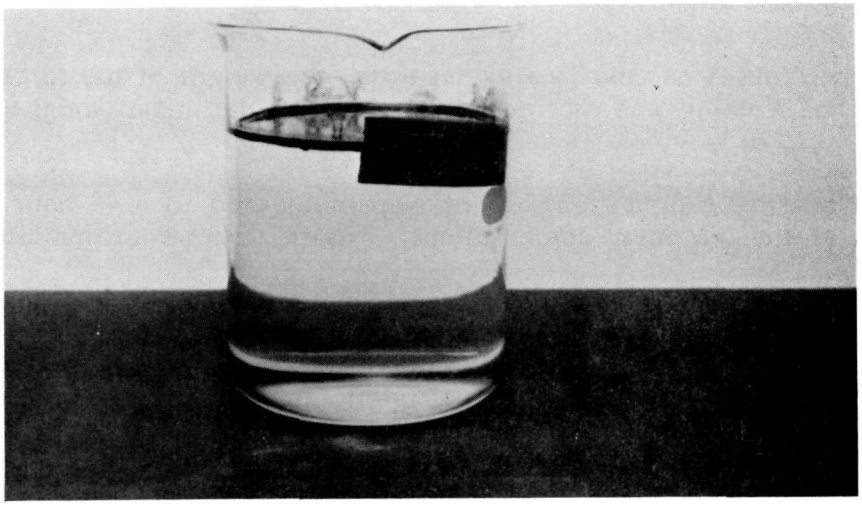


FIGURE 2 IMMERSION TESTING

4 RESULTS AND DISCUSSION

Figures 3 to 8 graphically present the results of the testing (more detailed data are available in Appendix A). The results are grouped by sorbent type for ease of comparison. The graphs show the initial weight of oil pickup, weight of water pickup, the weight of oil recovered and the number of reuses for each sample. Each sorbent was reused until the weight of oil recovered by pressing dropped below 50 percent of initial oil recovered, to a maximum of ten reuses.

The results of the 48-hour immersion test are given in Table 5. Immersion testing was performed without mechanical agitation, i.e. waves, so that test data may differ somewhat from actual field performance, during which energy is present.

Table 6 shows the specific gravities and viscosities of the test oils used. In general, the results of this test are comparable to those reported in the 1974 Environment Canada study (EPS 4-EC-76-5). As expected, the viscosities and specific gravities of the oils increased with aging. The Bunker C (not aged) had a pour point of 7.2 C. Since all testing was performed at 10 C, the Bunker C was very near its pour point. Most sorbents were so light (i.e. of low density) that they floated on top of this oil and did not contact water.

Sorbents recover oil by two mechanisms: absorption and adsorption. Absorbed oil penetrates into the sorbent structure and is very difficult to recover from the sorbent. Adsorbed oil is that which adheres to the sorbent surface. In general, the more surface area available to the oil, the more oil will be picked up. Similarly, an increase in viscosity is generally accompanied by an increase in pickup, to the point where oil can no longer penetrate into the sorbent, at which time pickup decreases.

With the Bunker C, many sorbents exhibited a higher capacity on reuse than on initial exposure. This can be explained by the fact that the initial pressing squeezed the oil through the sorbent, thus priming it. The sorbent was also heavier since very little oil was recovered during the pressing. These two factors increased oil pickup during the first reuse.

The first series of tests were performed on thicker layers of oil, i.e. 2.5 mm for diesel and 5 mm for crude and Bunker C. The oil layer thickness was then decreased to 0.1 mm for 1-day aged diesel and crude to determine the effectiveness of sorbents on very thin layers of oil.

The results obtained with the thicker layers of oil can be considered as optimum capacity for a given sorbent. The numbers are comparable to those obtained with pure oil (no water) tests in the 1974 Environment Canada study (EPS 4-EC-76-5).

For most sorbents, decreasing the oil layer thickness increased the quantity of water recovered by the sorbent.

For ease of comparison, the remainder of the results will be discussed in terms of the four sorbent types as defined in the "Introduction".

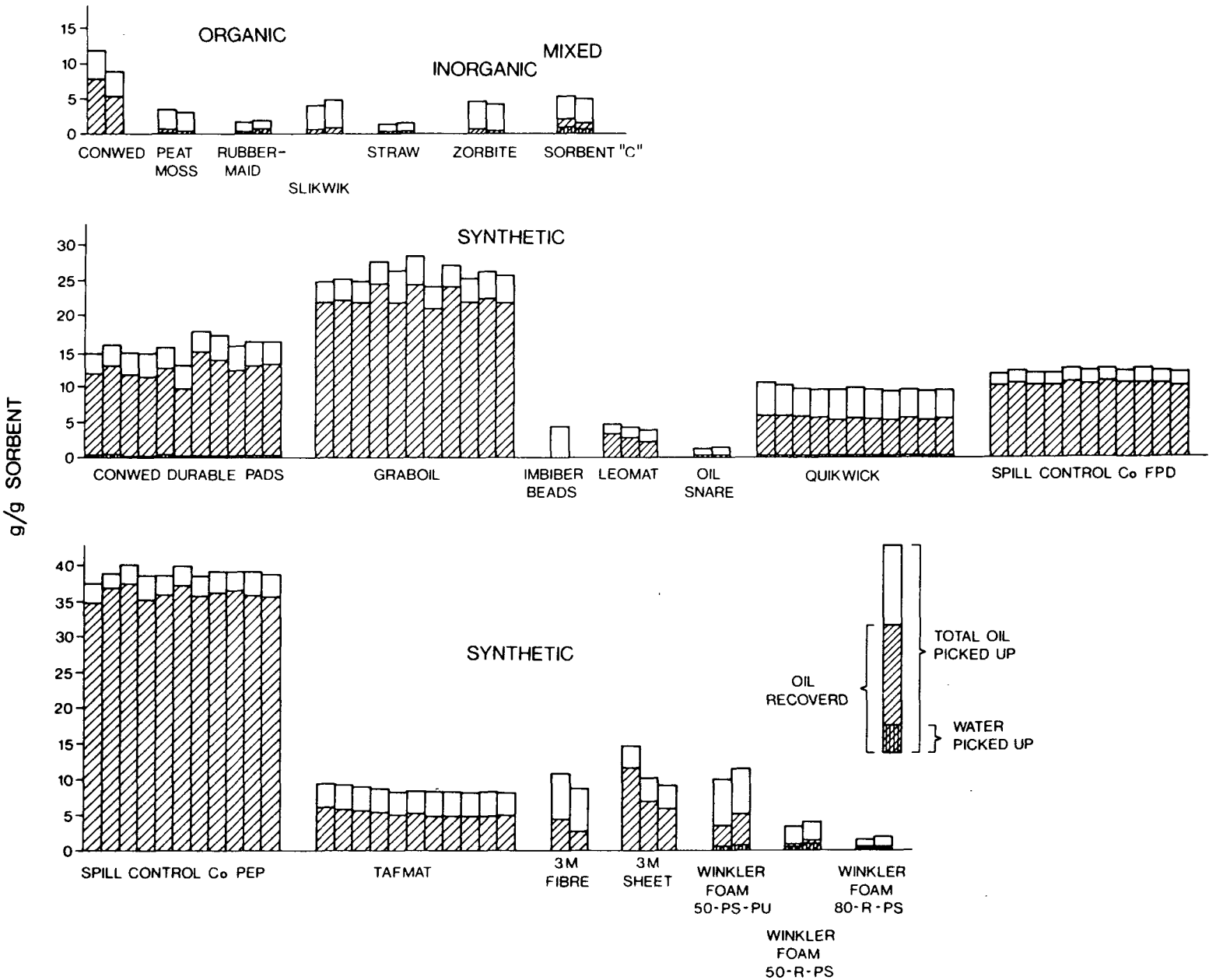


FIGURE 3 INITIAL WEIGHT OF OIL PICKUP, WEIGHT OF WATER PICKUP, WEIGHT OF OIL RECOVERED AND NUMBER OF REUSES (1-DAY AGED DIESEL)

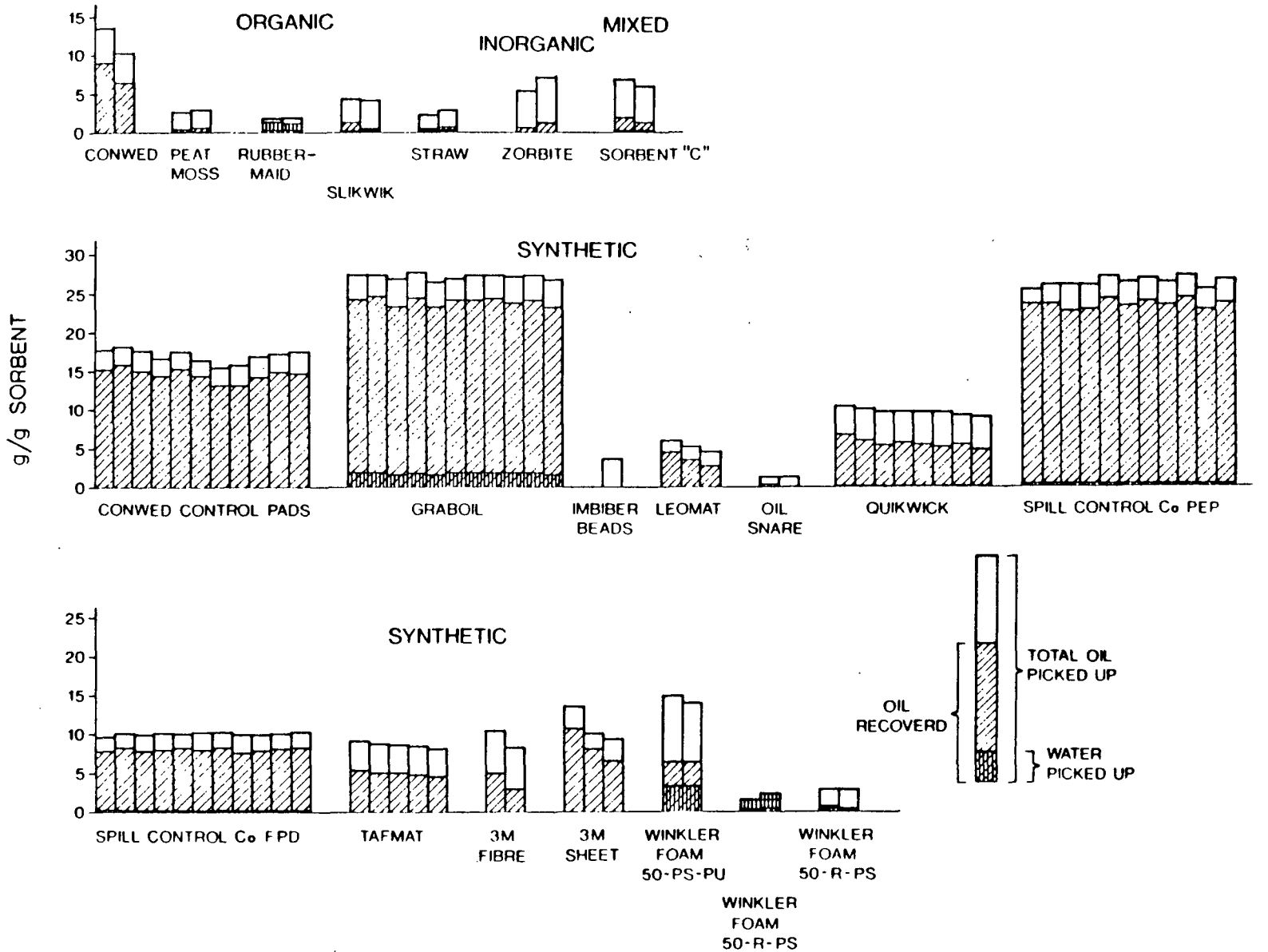


FIGURE 4 INITIAL WEIGHT OF OIL PICKUP, WEIGHT OF WATER PICKUP, WEIGHT OF OIL RECOVERED AND NUMBER OF REUSES (7-DAY AGED DIESEL)

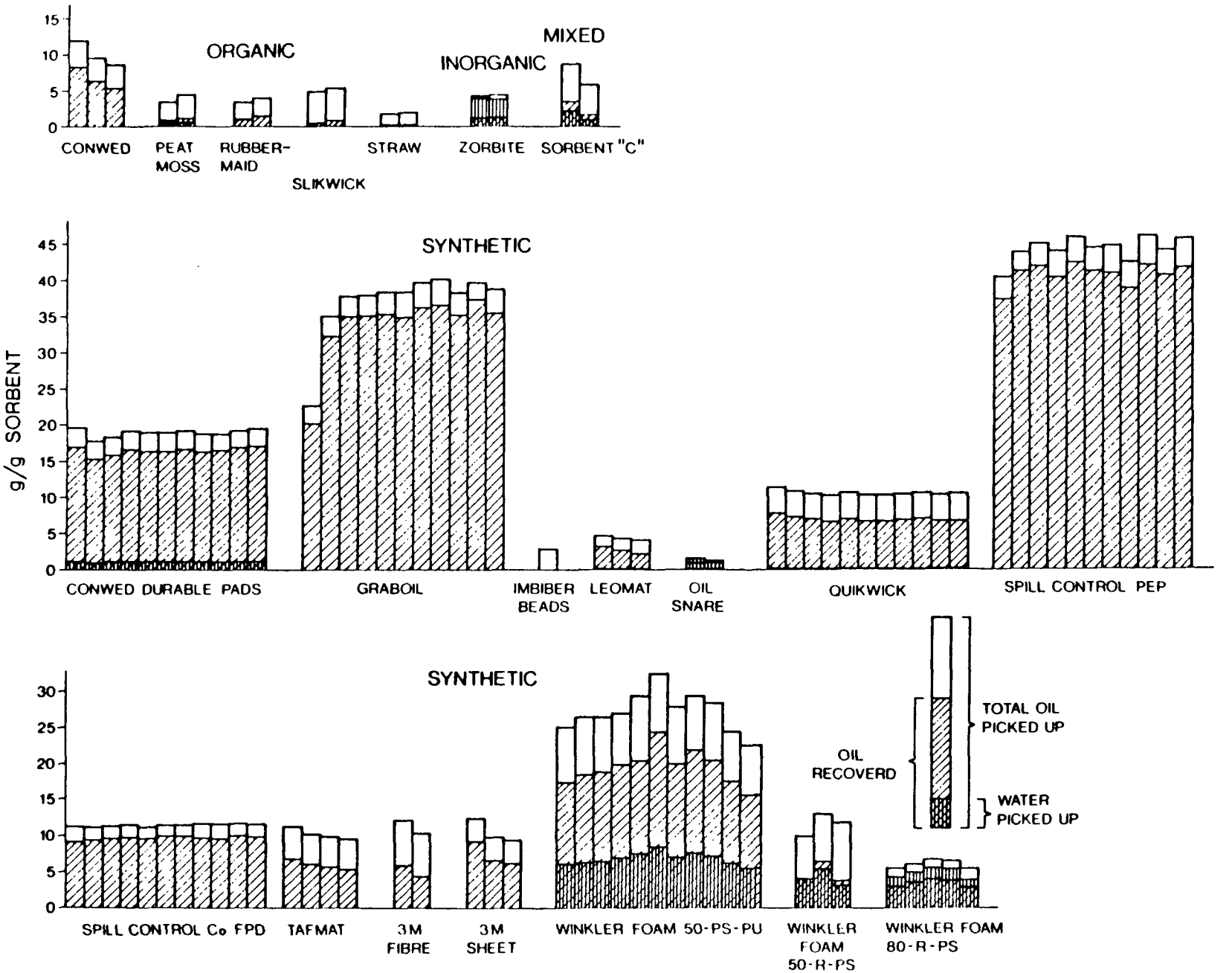


FIGURE 5 INITIAL WEIGHT OF OIL PICKUP, WEIGHT OF WATER PICKUP, WEIGHT OF OIL RECOVERED AND NUMBER OF REUSES (1-DAY AGED CRUDE)

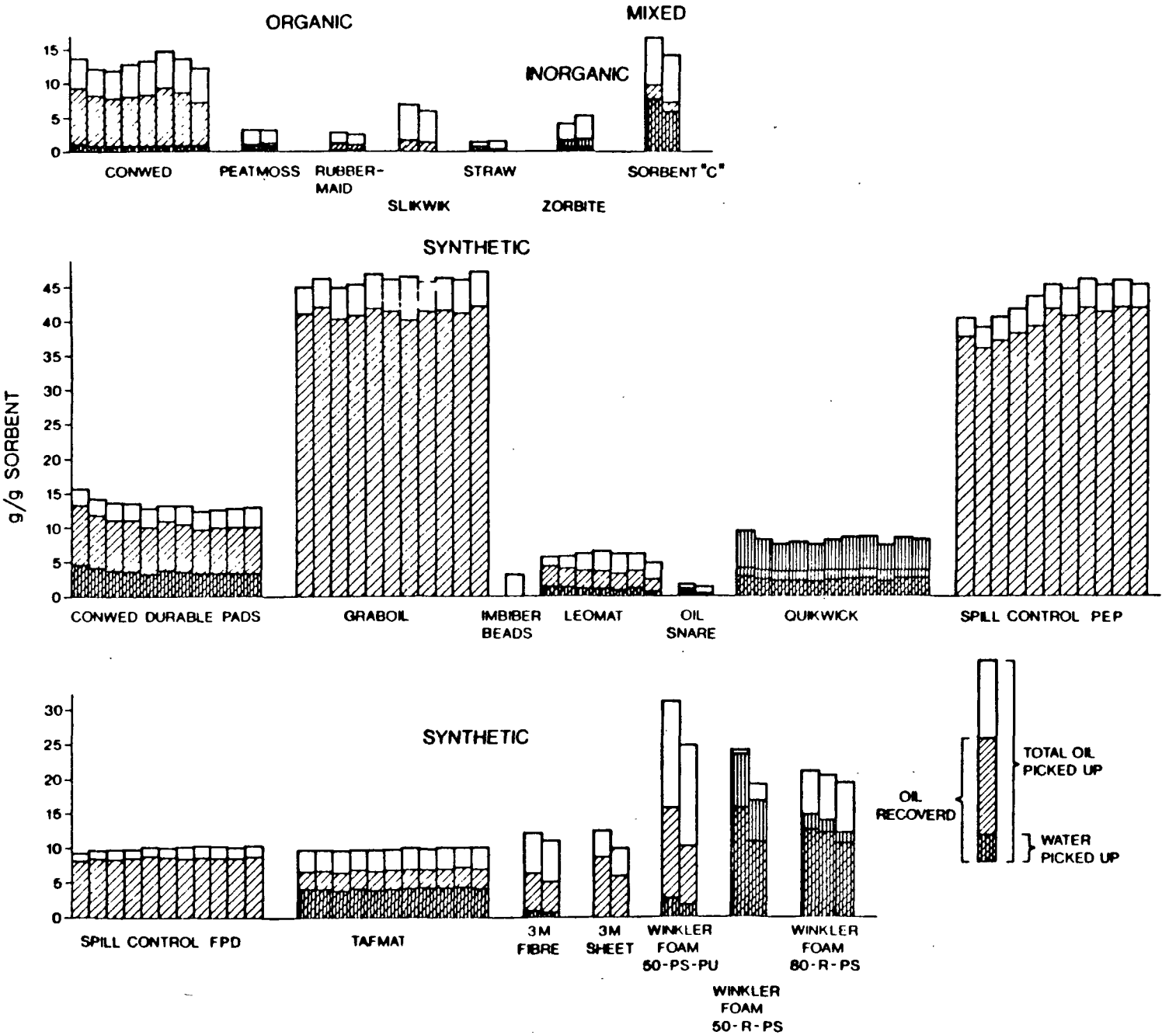


FIGURE 6 INITIAL WEIGHT OF OIL PICKUP, WEIGHT OF WATER PICKUP, WEIGHT OF OIL RECOVERED AND NUMBER OF REUSES (7-DAY AGED CRUDE)

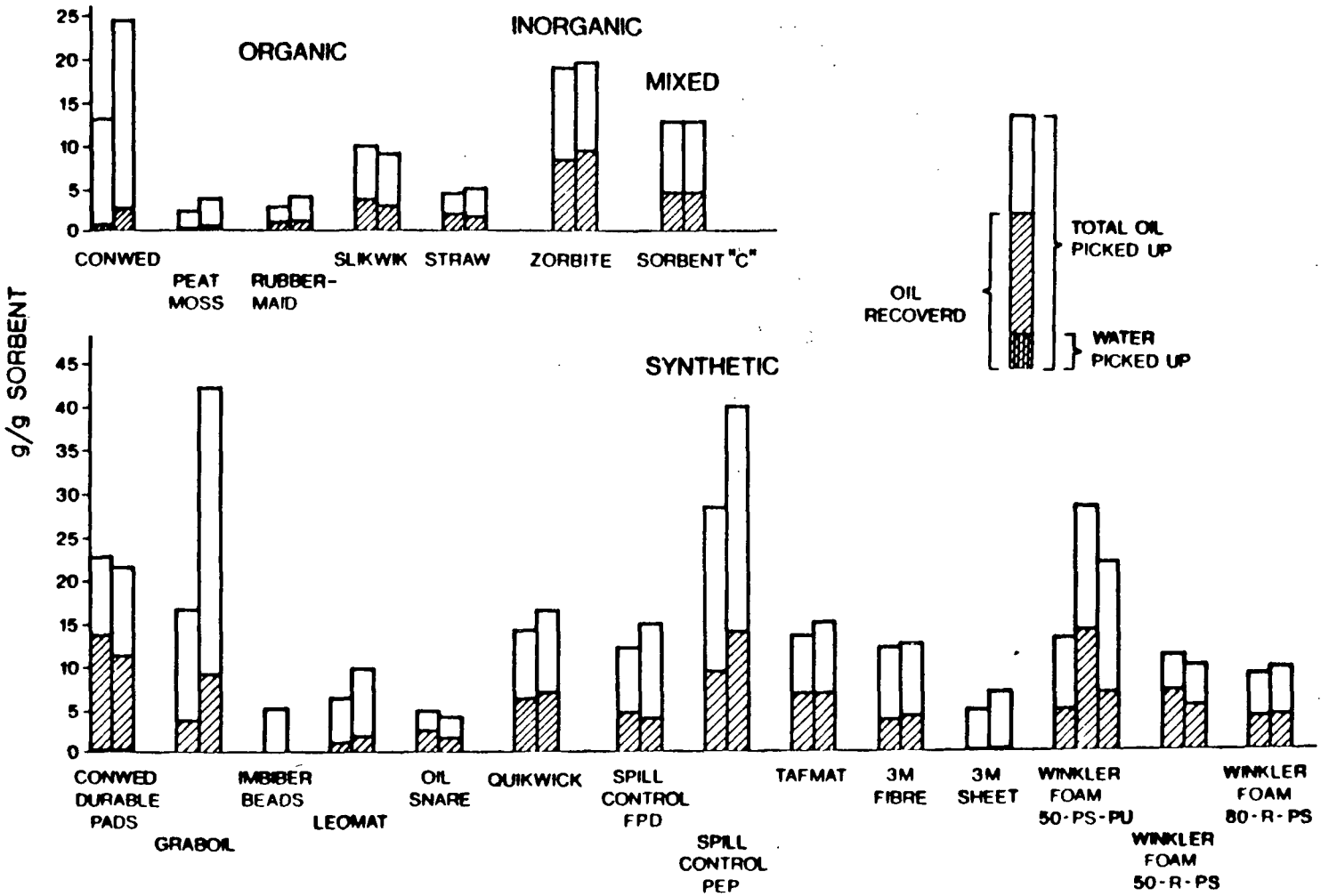


FIGURE 7 INITIAL WEIGHT OF OIL PICKUP, WEIGHT OF WATER PICKUP, WEIGHT OF OIL RECOVERED AND NUMBERS OF REUSES (1-DAY AGED BUNKER C)

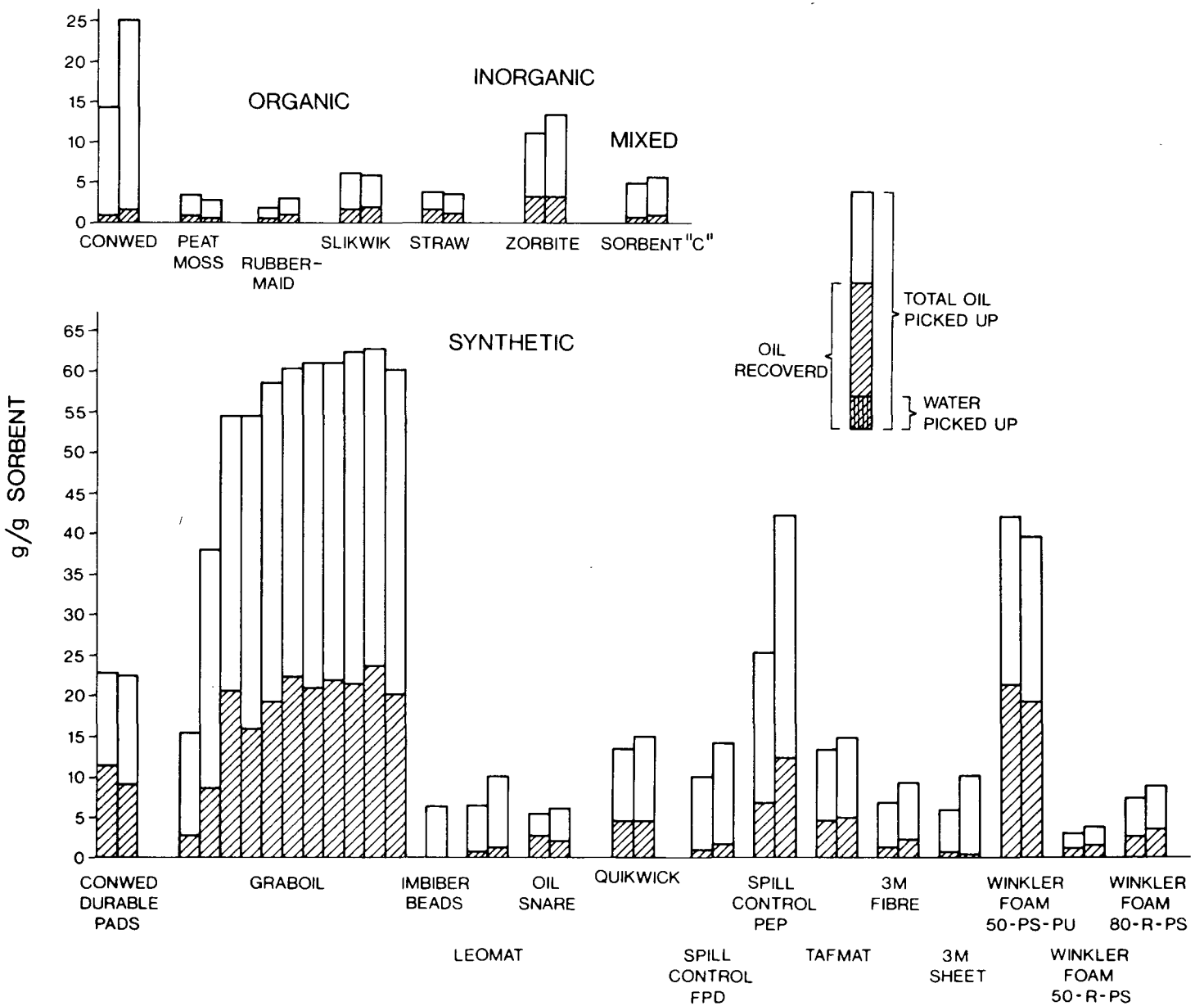


FIGURE 8 INITIAL WEIGHT OF OIL PICKUP, WEIGHT OF WATER PICKUP, WEIGHT OF OIL RECOVERED AND NUMBER OF REUSES (7-DAY AGED BUNKER C)

TABLE 5 48-HOUR IMMERSION TEST RESULTS

	DIESEL		CRUDE		BUNKER C	
	1-Day Aged	7-Day Aged	1-Day Aged	7-Day Aged	1-Day Aged	7-Day Aged
ORGANIC						
1. Conwed (modified organic)	Bonding of fibres weakened	Same as 1-day diesel	Fibres were readily pulled apart	Fibre strength even less than 1-day crude	Fibres became soft and mushy and fell from netting readily	Same as 1-day Bunker C
2. Peat Moss	-	-	-	-	Some sorbent sank to bottom taking oil with it	Same as 1-day Bunker C
3. Rubbermaid Rubber (ground rubber)*	No structural change; sank to bottom	Same as 1-day diesel	Sank, taking oil with it	Same as 1-day crude	No structural change; did not sink	Sank, taking oil with it
4. Slikwik	All sorbent at oil/water interface	Same as 1-day diesel	Same as 1-day diesel	Same as 1-day diesel	Sorbent clumped together	Sorbent clumped together
5. Straw	-	-	-	-	-	-
INORGANIC						
6. Zorbite*	-	25% sank to bottom	Same as 7-day diesel	-	Same as 7-day diesel	Same as 7-day diesel
MIXED						
7. Sorbent C	-	-	-	-	Sorbent appeared to have softened	Same as 1-day Bunker C

No change in sorbent during 48-hour immersion test

* Sorbent not tested in the 1974 Environment Canada study

TABLE 5 48-HOUR IMMERSION TEST RESULTS (Cont'd)

	DIESEL		CRUDE		BUNKER C	
	1-Day Aged	7-Day Aged	1-Day Aged	7-Day Aged	1-Day Aged	7-Day Aged
SYNTHETIC (POLYMERIC)						
8. Conwed Durable Pads*	-	-	-	-	-	-
9. Graboil	Slightly weakened	Same as 1-day diesel	Same as 1-day diesel	Same as 1-day diesel	Did not saturate fully; floated on oil surface	Same as 1-day Bunker C
10. Imbiber Beads	Swelled and became transparent	Same as 1-day diesel	-	-	-	-
11. Leomat*	Very weakened, fell apart readily shrank to one-half original thickness	Same as 1-day diesel	Same as 1-day diesel	Same as 1-day diesel	-	-
12. Oil Snare	-	-	-	-	-	-
13. Quik-Wick*	Stretched more readily but did not tear	Same as 1-day diesel	Same as 1-day diesel	Same as 1-day diesel	Same as 1-day diesel	Same as 1-day diesel
14. Spill Control Co. FPD*	Slightly weakened	Same as 1-day diesel	Same as 1-day diesel	Same as 1-day diesel	-	-
15. Spill Control Co. PEP*	Slightly weakened	Same as 1-day diesel	Same as 1-day diesel	Same as 1-day diesel	-	-

No change in sorbent during 48-hour immersion test

* Sorbent not tested in the 1974 Environment Canada study

TABLE 5 48-HOUR IMMERSION TEST RESULTS (Cont'd)

	DIESEL		CRUDE		BUNKER C	
	1-Day Aged	7-Day Aged	1-Day Aged	7-Day Aged	1-Day Aged	7-Day Aged
SYNTHETIC						
16. Tafmat*	Very weakened, fibres pulled apart readily	Same as 1-day diesel	Same as 1-day diesel	Same as 1-day diesel	-	-
17. 3M Fibre	-	-	-	-	-	-
18. 3M Sheet	Some weakening	Same as 1-day diesel	Some weakening; expanded to twice original thickness	Same as 1-day crude	Same as 1-day crude	Not fully saturated; no change
19. Winkler Foam 50-PS-PU*	Sorbent shrank and appeared to dissolve; formed rubberlike layer at oil/water interface	Same as 1-dav diesel	-	-	-	-
20. Winkler Foam 50-R-PS*	Same as 50-PS-PU in 1-day diesel	Same as 50-PS-PU in 1-day diesel; beads clumped together	-	-	-	-
21. Winkler Foam 80-P-PS*	Sorbent fused to form a rubberlike mat; formed layer at oil/water interface	Same as 1-day diesel	-	-	-	-

No change in sorbent during 48-hour immersion test

* Sorbent not tested in the 1974 Environment Canada study

TABLE 6 SPECIFIC GRAVITY AND VISCOSITY OF TEST OILS

Oil	No Aging		1-Day Aged		7-Day Aged	
	Specific Gravity	Viscosity (cps)	Specific Gravity	Viscosity (cps)	Specific Gravity	Viscosity (cps)
Diesel	0.840	5.0	0.841	5.3	0.848	6.0
Crude	0.827	7.6	0.846	22.8	0.880	20.9
Bunker C	0.970	47.90	0.972	65.20	0.972	86.10

4.1 Organic

Conwed, a modified organic, exhibited the highest maximum capacity with all test oils, ranging from 11.74 g oil/g sorbent with 1-day aged diesel to 25.11 g oil/g sorbent with 7-day aged Bunker C.

The remaining organic sorbents exhibited lower results, i.e. 1.57 g oil/g sorbent for straw with 1-day aged diesel, increasing to 4.75 g oil/g sorbent with 1-day aged Bunker C.

All organic sorbents tested exhibited severe limitations in terms of reuse.

During the 48-hour immersion test, Conwed, a "sheet" sorbent, weakened structurally. With the Bunker C oils, the Conwed cellulosic fibres softened, slurried, and subsequently detached from the netting.

The Rubbermaid Black (ground rubber)* product exhibited no physical change with the diesel and crude. With the 1-day aged Bunker C, it sank to the bottom of the tank, taking any adhering oil with it.

Peat Moss showed no deterioration with diesel or crude oils; but with the Bunker C, some of the sorbent sank to the bottom, again taking oil with it.

Slikwik sorbent remained at the oil/water interface in all cases; and with the Bunker C oils, it tended to form clumps.

Straw showed no change with all test oils.

4.2 Inorganic

The only inorganic tested was Zorbite*. Its maximum capacity ranged from 1.81 g oil/g sorbent with 7-day aged crude to 19.93 g oil/g sorbent with 1-day aged Bunker C. Zorbite exhibited its lowest sorption capacities with crude oils; i.e., it picked up water-intense test media only. When the oil layer thickness was reduced to 0.1 mm, the oil pickup decreased markedly to 0.01 g oil/g sorbent with 1-day aged diesel and 0.02 g oil/g sorbent with 1-day aged crude. The water pickup was 3.80 and 3.26 g/g sorbent with diesel and crude respectively.

Zorbite could not be reused after the first pressing. During the immersion test, no change was exhibited with 1-day aged diesel and 7-day aged crude. With the remaining four oils, however, approximately 25 percent of the product sank to the bottom of the test tank.

4.3 Mixed (Organic/Inorganic)

Sorbent C was the only product tested that fell into this category. Its maximum capacity increased with viscosity of oil, from 5.39 g oil/g sorbent with 1-day aged diesel to 16.65 g oil/g sorbent with 7-day aged crude. Maximum capacity decreased to 5.66 g oil/g sorbent with 7-day aged Bunker C. With decreasing oil layer thickness, the capacity lowered to 1.09 and 0.84 g oil/g sorbent with 1-day aged diesel and crude respectively. This sorbent, as well, could not be reused.

Sorbent C picked up water with all tests except the ones involving Bunker C oil. There was no apparent physical change with diesel or crude during the 48-hour immersion test, but the sorbent appeared to have softened with the Bunker C.

4.4 Synthetic (Polymeric)

This sorbent classification covers a wide range of products from the cross-linked polymer (Imbiber Beads) to polyethylene fibres (3M products) to the polyurethane foams (Graboil, Spill Control Co. products). Although these products are all polymers, their physical characteristics differ widely. For ease of discussion it is preferable to break them down into groups.

Of the 13 polymers tested, seven were foamlike in their physical appearance. Even within the general classification of foams, there was a great disparity in maximum capacity. With 1-day aged diesel, the maximum capacity ranged from 1.63 g oil/g sorbent for Winkler foam 80-R-PS*, to 41.18 g oil/g sorbent for Spill Control Co. PEP*. The highest maximum capacity for the foams, in fact for all sorbents tested, was 62.94 g oil/g sorbent on 7-day aged Bunker C for Graboil.

With the thin layer of oil, the foamlike polymeric having the highest sorption capacity was Conwed Durable Pads*, recovering 3.27 g oil/g sorbent with 1-day aged diesel. As in all previous cases, oil pickup with the thin layer of oil was greatly reduced from that with the thicker layers of oil.

Of the seven foams, four (Conwed Durable Pads*, Graboil, Spill Control Co. PEP* and Spill Control FPD*) were reused to the maximum of 10 times with both diesel and crude oils. The Winkler foams* showed multiple reuse with the 7-day aged crude before failing to meet the oil recovery limit of 50 percent of initial capacity.

The Winkler foams* also had the highest water pickup of all foams, reaching a maximum of 23.84 g water/g sorbent with 7-day aged crude, but recovering 24.31 g oil/g sorbent at the same time.

During the 48-hour immersion test, an interesting phenomenon was observed with respect to the three Winkler foams*. With 1-day and 7-day aged diesel, the sorbent changed from discrete particles to a rubberlike layer at the oil/water interface. No deterioration was observed with the crude and Bunker C oils.

Although the Conwed Durable Pads* showed no deterioration throughout the immersion test, comparisons with the control samples showed that the remaining foams exhibited some structural weakening when tested with diesel and crude. Deterioration was not evident in the Bunker C tests.

Five of the remaining seven polymers were fibrous in nature, having been received as either fibres or sheets. Their maximum capacities ranged from 4.74 g oil/g sorbent for Leomat* to 14.78 g oil/g sorbent for 3M sheet, with 1-day aged diesel. As in all previous cases, the capacities decreased with decreasing oil layer thickness.

The fibrous materials achieved some multiple reuse. Qwik-Wick* underwent 10 reuses with diesel and crude; Tafmat*, as well, had 10 reuses on 1-day aged diesel and 7-day aged crude.

The water pickup for these products was relatively low, and remained low even with the 0.1 mm layer of oil. The 3M Fibre exhibited no change during the 48-hour immersion test. The remaining four products, which were in sheet format, weakened structurally when exposed to diesel and crude. The 3M Sheet and Qwik-Wick* also weakened; i.e., they were easier to pull apart when exposed to Bunker C oils. Tafmat* and Leomat*, however, did not structurally alter.

Imbiber Beads, a cross-linked polymer which absorbs oils, was one of the two remaining polymers tested. Its maximum capacity decreased with increasing viscosity, except with Bunker C oils. In the latter case, the mechanism of pickup was assumed to be adsorption, i.e. coating of the particles. The maximum capacity ranged from 2.95 g oil/g sorbent with 7-day aged crude to 6.41 g oil/g sorbent with 7-day aged Bunker C.

Because of the mechanism of oil recovery, the Imbiber Beads were not reuseable; they neither picked up water nor exhibited any deterioration during the 48-hour immersion test.

Oil Snare, the final polymer to be discussed, is a polyolefin yarn and could be called synthetic straw. Oil Snare adsorbs oil; its maximum capacity increased with increasing viscosity. The capacities ranged from 1.07 g oil/g sorbent with 1-day aged crude to 6.01 g oil/g sorbent with 7-day aged Bunker C.

The Oil Snare polymer did not pass the criteria established for reuse during the first pressing. Although it recovered some water during testing with diesel and crude oils, it did not do so with Bunker C. Deterioration was not evident during the 48-hour immersion test.

4.5 Statistical Analysis of Data

As indicated previously, triplicate determinations of initial and maximum capacities were made for each sorbent with three oils, each oil being aged for 1 day and 7 days. Mean values were calculated and are presented in Tables 1 to 4.

Without subjecting these data to a statistical analysis, one might conclude that significant differences exist between the initial and maximum capacities of each sorbent, between capacities of one sorbent for different oils, and between capacities of one sorbent for different ages of the same oil. Furthermore, it would also appear that oil film thickness significantly affects the initial sorption capacity of sorbents.

To confirm these observations statistically, two-way analysis of variance calculations were undertaken. Two-way analysis of variance (with replicates) is used to evaluate the significance of variations in a set of observations as a result of changes in two factors and to determine whether the two factors have a synergistic or antagonistic effect. For example, initial capacity may be a function not only of sorbent type, but also of oil type. Two-way analysis of variance is used to determine simultaneously whether different sorbents and different oils significantly affect the observed initial capacity, and whether a specific sorbent exhibits a marked preference for a specific oil.

Using maximum capacity data as the basis of comparison, the analysis of variance confirmed that there were indeed significant differences in the ability of the different sorbents to pick up any given oil (diesel, bunker or crude), regardless of age. It was further demonstrated that the type of oil significantly affected the maximum capacity of any given sorbent. The calculations also showed that some sorbents have an unexpected preference for either one or two of the three oils.

By performing the two-way analysis of variance for each sorbent and each oil, it was possible to demonstrate that oil age was a significant factor in the ability of some sorbents to pick up oil. Most sorbents, however, showed no significant differences between initial and maximum capacity for a given oil. Significant interactions between age of oil and capacity were noted for some sorbents, which indicated that some sorbents have an unexpected preference for a specific oil of a given age.

Based on experiments in which the initial capacities of sorbents for 1-day aged diesel and crude oils were measured, it was found that oil film thickness had a very significant effect on the initial capacity of sorbents. In general, a thinner layer of oil resulted in a decrease of initial capacity. In practical terms, this would result in a much higher requirement for sorbents in the field than that which would be calculated from the capacities reported here. Also, water pickup tended to be enhanced with thinner oil layers.

APPENDIX I

SUMMARY DATA

APPENDIX I - SUMMARY DATA

1 Introduction

Tables 7 to 9 provide the data for maximum of oil and water pickup with all oils.

Following these tables are summary sheets for each sorbent tested. These sheets include a photograph of each sorbent; a brief description of each sorbent's physical appearance and test results; any specific manufacturers' recommendations for use; and data from testing with 0.1 mm layer, 1-day aged diesel and crude, 2.5 mm layer of diesel, and 5.0 mm layers of crude and Bunker C. The data for the thicker oil layers include initial and maximum capacity, water pickup and weight of oil recovered on each reuse.

TABLE 7 MAXIMUM OIL AND WATER PICKUP (DIESEL)

Sorbent	1-Day Aged								7-Day Aged							
	g oil/g sorbent				g water/g sorbent				g oil/g sorbent				g water/g sorbent			
	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Organic																
1. Conwed (modified)	12.26	11.17	11.8	11.74	0	0	0	0	13.49	12.92	14.20	13.54	0	0	0	0
2. Peat Moss	3.48	4.01	2.74	3.41	0	0	0	0	2.62	2.82	3.32	2.92	0.11	0.11	0.12	0.12
3. Rubbermaid Black*	1.35	1.84	1.54	1.58	0.55	0.67	0.20	0.47	1.61	1.58	2.31	1.83	1.27	1.25	1.49	1.34
4. Slikwik	4.80	4.65	5.22	4.89	0	0	0	0	4.76	4.10	4.69	4.52	0.13	0.08	0.12	0.11
5. Straw	1.36	1.60	1.74	1.57	0.16	0.31	0.16	0.21	2.37	2.58	2.77	2.57	0.25	0.33	0.32	0.30
Inorganic																
6. Zorbite*	5.50	3.85	4.20	4.52	0	0	0	0	5.77	11.14	4.89	7.26	0	0	0	0
Mixed (Organic/ Inorganic)																
7. Sorbent C	5.74	5.62	4.82	5.39	0.94	0.98	0.99	0.97	6.98	7.21	6.29	6.82	0.71	0	0.22	0.31
Synthetic (Polymeric)																
8. Conwed Durable Pads*	17.62	19.12	16.71	17.82	0	0	0.72	0.26	19.48	18.28	17.91	18.56	0	0	0	0
9. Graboil	30.38	32.19	29.39	30.65	0	0	0	0	27.75	29.05	20.67	28.82	4.26	0	1.49	1.92
10. Imbiber Beads	4.88	4.16	4.15	4.40	0	0	0	0	3.30	3.81	3.48	3.53	0	0	0	0
11. Leomat*	4.84	5.59	3.80	4.74	0	0	0	0	5.74	6.30	6.03	6.02	0	0	0	0
12. Oil Snare	1.52	1.46	1.10	1.36	0	0	0.45	0.15	1.35	1.63	1.38	1.45	0	0	0	0
13. Qwik-Wick	10.05	9.97	11.8	10.60	0	0.38	0.83	0.40	9.78	10.78	10.06	10.21	0	0	0.13	0.04
14. Spill Control Co. FPD*	12.90	12.82	12.18	12.63	0	0	0	0	10.15	10.41	10.21	10.26	0.26	0.29	0.24	0.26
15. Spill Control Co. PEP*	40.86	40.73	41.94	41.18	0	0	0	0	26.90	25.70	29.50	27.37	0.34	0.23	0.26	0.28
16. Tafmat*	9.24	9.72	9.49	9.48	0	0	0	0	8.94	9.37	8.88	9.06	0	0	0	0
17. 3M Fibre	10.33	10.82	10.92	10.69	0	0	0	0	10.44	10.44	10.27	10.38	0	0	0	0
18. 3M Sheet	14.96	15.20	14.18	14.78	0	0	0	0	14.24	13.79	12.29	13.44	0	0	0	0
19. Winkler Foam 50-PS-RU*	11.29	8.40	14.40	11.36	0.47	0.36	0.60	0.48	11.66	17.34	15.69	14.90	2.29	0.77	6.19	3.08
20. Winkler Foam 50-R-PS*	4.15	3.06	4.08	3.76	0.45	0.41	0.59	0.48	1.74	1.71	1.31	1.59	1.98	1.58	1.31	1.62
21. Winkler Foam 80-R-PS*	1.59	1.91	1.38	1.63	0.38	0.42	0.24	0.35	2.33	2.53	3.69	2.85	0.25	0.19	0.39	0.28

* Sorbent not tested in the 1974 Environment Canada study

TABLE 8 MAXIMUM OIL AND WATER PICKUP (CRUDE)

	1-Day Aged								7-Day Aged							
	g oil/g sorbent				g water/g sorbent				g oil/g sorbent				g water/g sorbent			
Sorbent	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Organic																
1. Conwed (modified)	11.80	11.90	12.29	12.0	0	0	0	0	14.26	13.31	15.15	14.24	0.91	1.98	0	0.99
2. Peat Moss	2.24	4.37	6.02	4.21	1.01	0	0	0.33	3.11	3.36	2.92	3.13	0.79	0.92	0.39	0.70
3. Rubbermaid Black*	4.51	2.06	2.59	3.05	0	0	0	0	3.42	2.47	2.70	2.86	0	0.23	0.11	0.11
4. Slikwik	6.48	3.81	6.19	5.49	0	0	0	0	7.18	6.24	6.96	6.79	0	0	0	0
5. Straw	1.81	1.73	1.87	1.80	0.26	0.37	0.44	0.36	1.76	1.46	1.49	1.57	0.67	0.50	0.52	0.56
Inorganic																
6. Zorbite*	3.70	8.82	0.13	4.22	3.26	0	9.05	4.10	1.60	1.53	2.30	1.81	4.09	4.07	3.91	4.02
Mixed (Organic/ Inorganic)																
7. Sorbent C	8.38	8.19	9.30	8.62	1.7	3.22	1.37	2.09	11.09	20.53	18.33	16.65	12.61	6.25	4.39	7.75
Synthetic (Polymeric)																
8. Conwed Durable Pads*	20.01	20.47	20.47	20.32	0.66	2.06	0.60	1.11	16.43	14.27	16.17	15.52	5.61	3.48	4.90	4.66
9. Graboil	41.72	43.56	38.58	41.29	0	0	0	0	48.60	46.45	46.41	47.0	0	0	0	0
10. Imbiber Beads	3.36	2.62	2.95	2.98	0	0	0	0	2.10	3.21	3.54	2.95	0	0	0	0
11. Leomat*	5.10	4.75	4.10	4.65	0	0	0.047	0.015	6.24	6.28	6.88	6.47	1.27	1.62	1.15	1.35
12. Oil Snare	0.94	1.21	1.05	1.07	1.41	1.68	1.32	1.47	1.44	1.72	1.82	1.66	0.82	0.97	1.04	0.94
13. Qwik-Wick*	10.94	11.47	11.20	11.20	0.56	0	0	0.19	2.51	4.36	6.17	4.35	11.41	8.85	7.78	9.35
14. Spill Control Co. FPD*	12.85	10.49	11.70	11.68	0	0	0	0	11.37	7.76	11.88	10.34	0	0	0	0
15. Spill Control Co. PEP*	44.35	48.24	48.10	46.90	0	0	0	0	47.68	44.59	45.62	45.96	0	0	0	0
16. Tafmat*	10.67	11.84	10.70	11.07	0	0	0	0	8.35	11.13	10.96	10.15	5.57	2.83	3.64	4.01
17. 3M Fibre	12.20	11.48	12.08	11.92	0	0	0.17	0.06	11.23	13.04	11.91	12.06	1.07	1.14	0.57	0.93
18. 3M Sheet	13.54	12.33	11.35	12.41	0	0	0.09	0.03	12.97	12.22	12.0	12.40	0	0	0	0
19. Winkler Foam 50-PS-RU*	35.81	30.95	30.41	32.39	5.72	4.03	8.25	6.0	41.74	21.41	31.80	31.65	0	6.58	1.25	2.61
20. Winkler Foam 50-R-PS*	9.47	12.72	16.73	12.97	4.86	2.64	2.76	3.42	30.54	26.34	16.05	24.31	27.0	29.93	14.60	23.84
21. Winkler Foam 80-R-PS*	6.35	8.71	6.04	7.03	4.40	2.75	4.88	4.01	27.48	17.84	17.70	21.01	21.49	18.02	4.70	14.74

* Sorbent not tested in the 1974 Environment Canada study

TABLE 9 MAXIMUM OIL AND WATER PICKUP (BUNKER C)

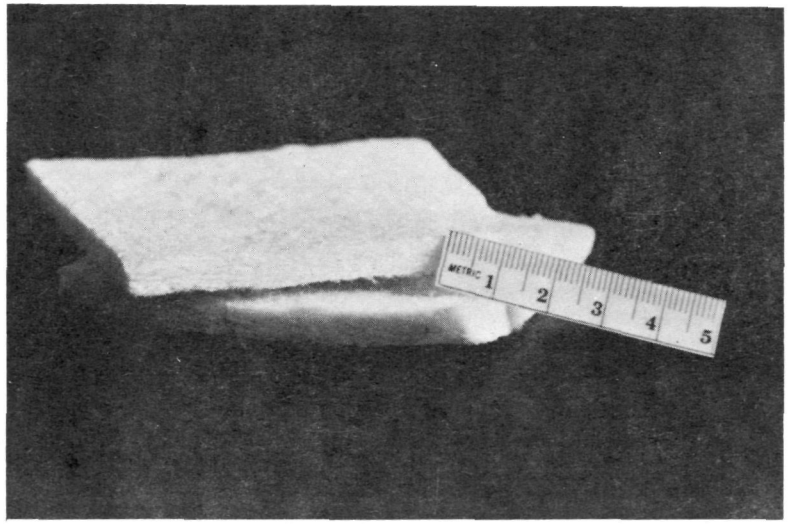
Sorbent	1-Day Aged								7-Day Aged							
	g oil/g sorbent				g water/g sorbent				g oil/g sorbent				g water/g sorbent			
	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Organic																
1. Conwed (modified)	22.46	25.94	23.67	24.02	0	0	0	0	21.17	27.63	26.53	25.11	0	0	0	0
2. Peat Moss	5.04	3.33	2.41	3.59	0	0	0	0	4.07	2.95	2.53	3.18	0	0	0	0
3. Rubbermaid Black*	3.41	3.50	3.35	3.42	0	0	0	0	2.75	4.08	2.10	2.98	0	0	0	0
4. Slikwik	8.67	10.21	9.93	9.60	0	0	0	0	5.76	6.74	6.08	6.19	0	0	0	0
5. Straw	4.76	4.55	4.94	4.75	0	0	0	0	3.70	3.82	3.97	3.83	0	0	0	0
Inorganic																
6. Zorbite*	19.43	23.85	16.51	19.93	0	0	0	0	16.86	9.45	15.34	13.88	0	0	0	0
Mixed (Organic/ Inorganic)																
7. Sorbent C	13.07	13.88	13.5	13.48	0	0	0	0	6.84	6.23	3.91	5.66	0	0	0	0
Synthetic (Polymeric)																
8. Conwed Durable Pads*	22.34	22.5	24.25	23.03	0.85	0	0	0.28	23.52	22.54	22.89	22.98	0	0	0	0
9. Graboil	46.64	36.38	42.59	41.87	0	0	0	0	66.61	62.74	59.47	62.94	0	0	0	0
10. Imbiber Beads	6.32	4.06	4.78	5.05	0	0	0	0	8.37	3.14	7.72	6.41	0	0	0	0
11. Leomat*	10.49	9.30	8.87	9.55	0	0	0	0	11.20	10.06	9.11	10.12	0	0	0	0
12. Oil Snare	4.13	4.45	5.15	4.58	0	0	0	0	7.0	5.19	5.83	6.01	0	0	0	0
13. Qwik-Wick*	15.95	15.59	17.24	16.26	0	0	0	0	15.53	12.97	15.90	14.80	0	0	0	0
14. Spill Control Co. FPD*	14.48	14.83	14.39	14.57	0	0	0	0	14.63	15.82	11.67	14.04	0	0	0	0
15. Spill Control Co. PEP*	37.65	43.91	37.46	39.67	0	0	0	0	46.88	34.03	45.08	42.0	0	0	0	0
16. Tafmat*	14.94	15.97	13.13	14.68	0	0	0	0	13.98	15.16	15.10	14.75	0	0	0	0
17. 3M Fibre	11.39	12.46	12.83	12.23	0	0	0	0	8.65	8.52	10.31	9.16	0	0	0	0
18. 3M Sheet	8.05	6.19	6.00	6.75	0	0	0	0	12.55	9.65	7.87	10.02	0	0	0	0
19. Winkler Foam 50-PS-RU*	29.76	28.98	25.51	28.08	0	0	0	0	46.83	40.36	41.18	42.79	0	0	0	0
20. Winkler Foam 50-R-PS*	10.37	8.29	14.08	10.91	0	0	0	0	4.0	3.24	4.23	3.82	0	0	0	0
21. Winkler Foam 80-R-PS*	7.78	8.04	12.46	9.43	0	0	0	0	10.53	7.62	8.23	8.79	0	0	0	0

* Sorbent not tested in the 1974 Environment Canada study

1.1 Organic

Conwed (modified organic)

- fibre pads with nylon netting in middle
- weakened during 48-hour immersion test; fibres separated from netting during tests with Bunker C; remained floating
- during reuse, sorbent tended to disintegrate, especially with heavier oils, i.e. 7-day crude, Bunker C
- could not be tested for reuse more than seven times with 7-day crude since sorbent disintegrated completely

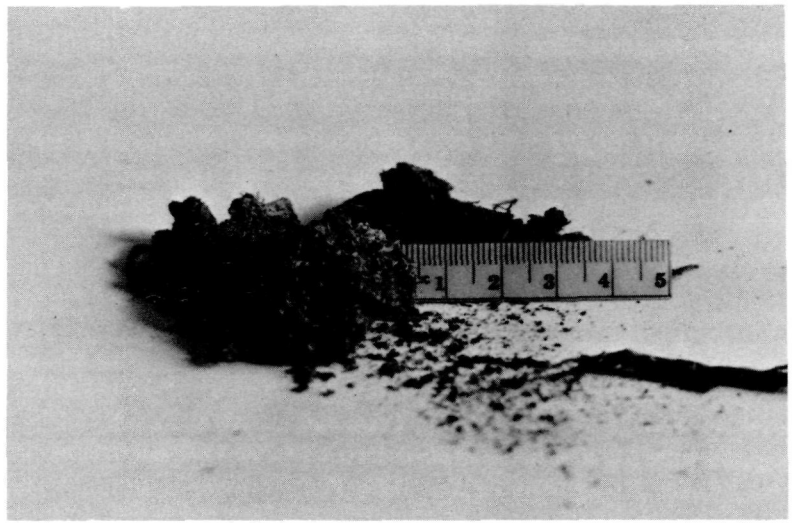


	1-Day Aged/0.1 mm Layer of Oil	
	g oil/g sorbent	g water/g sorbent
Diesel	0.08	1.6
Crude	0.49	0.32

Diesel 2.5 mm Crude 5.0 mm Bunker C 5.0 mm	Av. Int'l. Pickup (g/g)	Av. Max. Pickup (g/g)	Av. Water Pickup (g/g)	Initial Use	Reuses (Weight Oil Recovered g oil/g sorbent)									
					1	2	3	4	5	6	7	8	9	10
Diesel (1 day)	11.74	11.74	0	7.75	5.3									
Diesel (7 day)	13.54	13.54	0	8.85	6.26									
Crude (1 day)	12.0	12.0	0	8.24	7.27	5.35								
Crude (7 day)	13.62	14.24	0.96	9.30	8.17	7.74	7.99	8.15	9.32	8.64	7.15			
Bunker C (1 day)	12.85	24.02	0	0.7	2.52									
Bunker C (7 day)	14.43	25.11	0	0.93	1.69									

Peat Moss

- fibrous material of varying particle size
- when dry, tends to be oleophilic and hydrophobic
- showed no change during 48-hour immersion and remained floating for all tests except Bunker C, with which some sorbent sank to bottom, taking oil with it



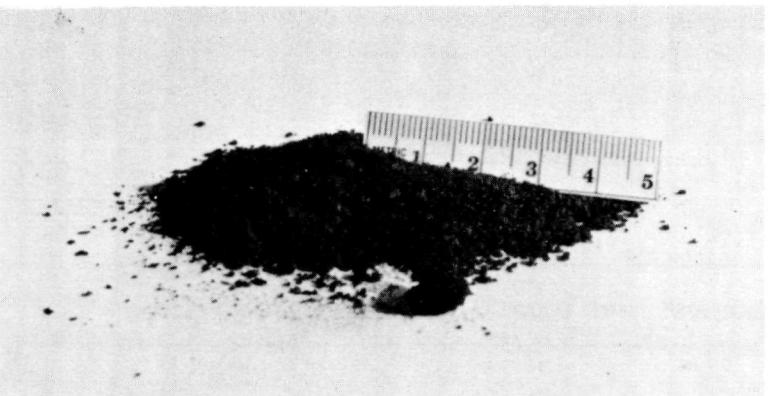
	1-Day Aged/0.1 mm Layer of Oil	
	g oil/g sorbent	g water/g sorbent
Diesel	0.38	2.87
Crude	0.47	0.98

Diesel 2.5 mm Crude 5.0 mm Bunker C 5.0 mm	Av. Int'l. Pickup (g/g)	Av. Max. Pickup (g/g)	Av. Water Pickup (g/g)	Initial Use	Reuses (Weight Oil Recovered g oil/g sorbent)									
					1	2	3	4	5	6	7	8	9	10
Diesel (1 day)	3.41	3.41	0	0.63	0.28									
Diesel (7 day)	2.75	2.92	0.12	0.42	0.65									
Crude (1 day)	3.40	4.21	0.33	0.80	1.07									
Crude (7 day)	3.03	3.13	0.70	0.93	1.06									
Bunker C (1 day)	2.15	3.59	0	0.15	0.49									
Bunker C (7 day)	3.18	3.18	0	0.80	0.45									

Rubbermaid Black (ground rubber)*

- ground rubber: fine black powderlike material
- during 48-hour immersion material sank to bottom taking oil with it for all tests except 1-day Bunker C; in this case, it remained in the oil phase

	1-Day Aged/0.1 mm Layer of Oil	
	g oil/g sorbent	g water/g sorbent
Diesel	0.16	0.56
Crude	0.02	0.86

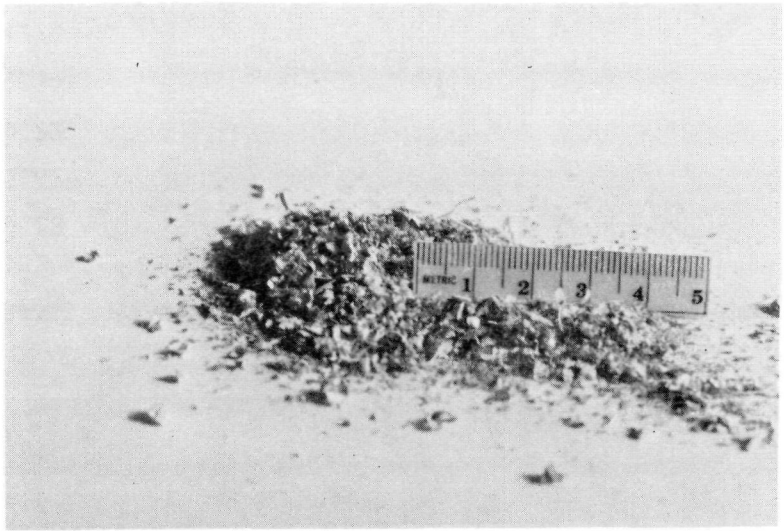


Diesel Crude Bunker C	2.5 mm 5.0 mm 5.0 mm	Av. Int'l. Pickup (g/g)	Av. Max. Pickup (g/g)	Av. Water Pickup (g/g)	Initial Use	Reuses (Weight Oil Recovered g oil/g sorbent)									
						1	2	3	4	5	6	7	8	9	10
Diesel (1 day)		1.58	1.58	0.47	0.48	0.78									
Diesel (7 day)		1.70	1.83	1.34	0.27	0.25									
Crude (1 day)		3.05	3.05	0	0.96	1.40									
Crude (7 day)		2.73	2.86	0.11	1.25	1.02									
Bunker C (1 day)		2.58	3.42	0	1.00	1.19									
Bunker C (7 day)		1.78	2.98	0	0.55	0.78									

* Sorbent not tested during the 1974 Environment Canada study

Slikwik

- ground corn cobs: fine particulate material, very light
- during 48-hour immersion test, sorbent was saturated and remained at the oil/water interface; with Bunker C, the sorbent particles tended to clump together
- marked increase in water pickup with thin layer of oil

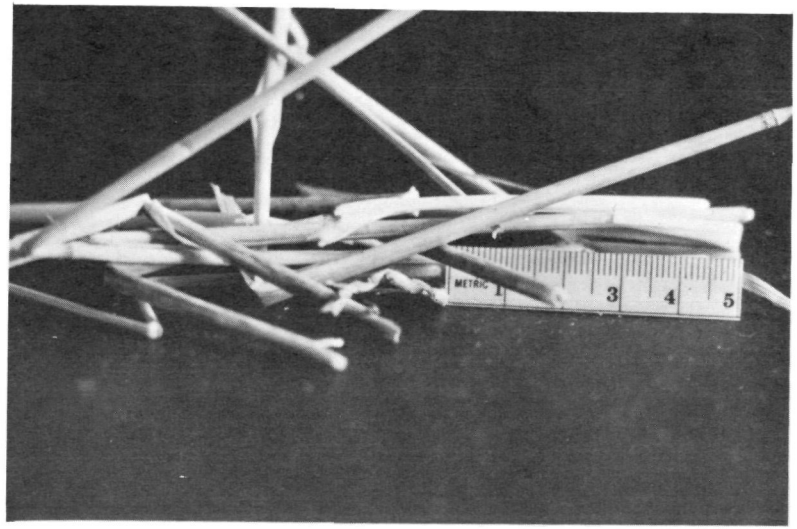


	1-Day Aged/0.1 mm Layer of Oil	
	g oil/g sorbent	g water/g sorbent
Diesel	0.33	6.11
Crude	0.81	3.47

Diesel Crude Bunker C	2.5 mm 5.0 mm 5.0 mm	Av. Int'l. Pickup (g/g)	Av. Max. Pickup (g/g)	Av. Water Pickup (g/g)	Initial Use	Reuses (Weight Oil Recovered g oil/g sorbent)									
						1	2	3	4	5	6	7	8	9	10
Diesel (1 day)		4.10	4.89	0	0.52	0.75									
Diesel (7 day)		4.21	4.52	0.11	1.44	0.41									
Crude (1 day)		4.72	5.49	0	0.40	0.81									
Crude (7 day)		6.79	6.79	0	1.80	1.68									
Bunker C (1 day)		9.60	9.60	0	3.67	2.74									
Bunker C (7 day)		6.07	6.19	0	1.67	1.73									

Straw

- consists of stalks of cellulose; readily available near farming areas
- showed no change during 48-hour immersion test; remained floating
- only one of two sorbents tested for which initial capacity did not significantly decrease with thinner layer of oil



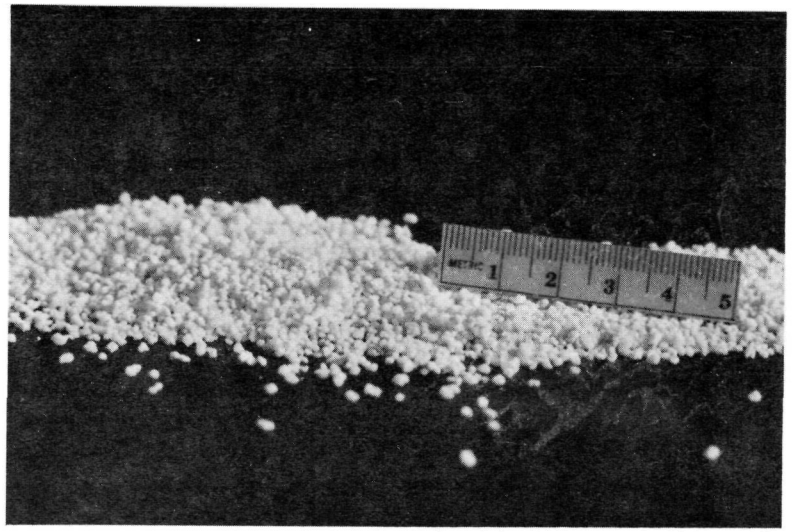
	1-Day Aged/0.1 mm Layer of Oil	
	g oil/g sorbent	g water/g sorbent
Diesel	2.2	1.77
Crude	1.96	1.26

Diesel 2.5 mm Crude 5.0 mm Bunker C 5.0 mm	Av. Int'l. Pickup (g/g)	Av. Max. Pickup (g/g)	Av. Water Pickup (g/g)	Initial Use	Reuses (Weight Oil Recovered g oil/g sorbent)									
					1	2	3	4	5	6	7	8	9	10
Diesel (1 day)	1.42	1.57	0.21	0.29	0.28									
Diesel (7 day)	2.02	2.57	0.30	0.41	0.62									
Crude (1 day)	1.59	1.80	0.36	0.38	0.22									
Crude (7 day)	1.48	1.57	0.56	0.41	0.34									
Bunker C (1 day)	4.26	4.75	0	1.96	1.73									
Bunker C (7 day)	3.78	3.83	0	1.61	1.18									

1.2 Inorganic

Zorbite*

- granular inorganic material
- distributor recommends use on land spills
- during 48-hour immersion test, about 25 percent of sorbent sank to bottom of tank for all tests except 1-day diesel and 7-day crude; no change was observed with these oils



	1-Day Aged/0.1 mm Layer of Oil	
	g oil/g sorbent	g water/g sorbent
Diesel	0.01	3.80
Crude	0.02	3.26

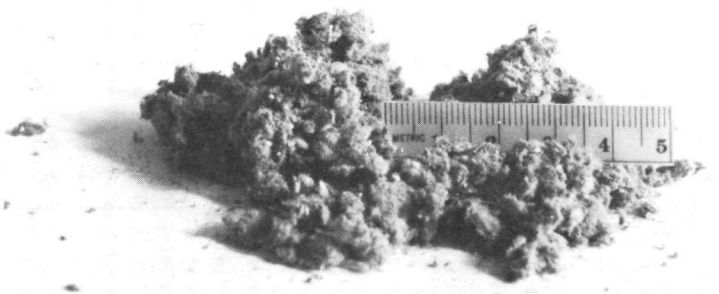
Diesel 2.5 mm Crude 5.0 mm Bunker C 5.0 mm	Av. Int'l. Pickup (g/g)	Av. Max. Pickup (g/g)	Av. Water Pickup (g/g)	Initial Use	Reuses (Weight Oil Recovered g oil/g sorbent)									
					1	2	3	4	5	6	7	8	9	10
Diesel (1 day)	4.52	4.52	0	0.63	0.44									
Diesel (7 day)	5.27	7.62	0	0.69	1.05									
Crude (1 day)	3.90	4.22	4.10	1.15	1.23									
Crude (7 day)	1.63	1.81	4.02	0.15	0.67									
Bunker C (1 day)	18.8	19.93	0	8.39	9.23									
Bunker C (7 day)	11.09	13.88	0	3.10	3.19									

* Sorbent not tested during the 1974 Environment Canada study

1.3 Mixed (Organic/Inorganic)

Sorbent C

- particulate sorbent composed of cellulose fibres and perlite
- during 48-hour immersion test there was no deterioration with diesel and crude; appeared to soften when tested with Bunker C; remained floating



	1-Day Aged/0.1 mm Layer of Oil	
	g oil/g sorbent	g water/g sorbent
Diesel	1.09	4.04
Crude	0.84	1.10

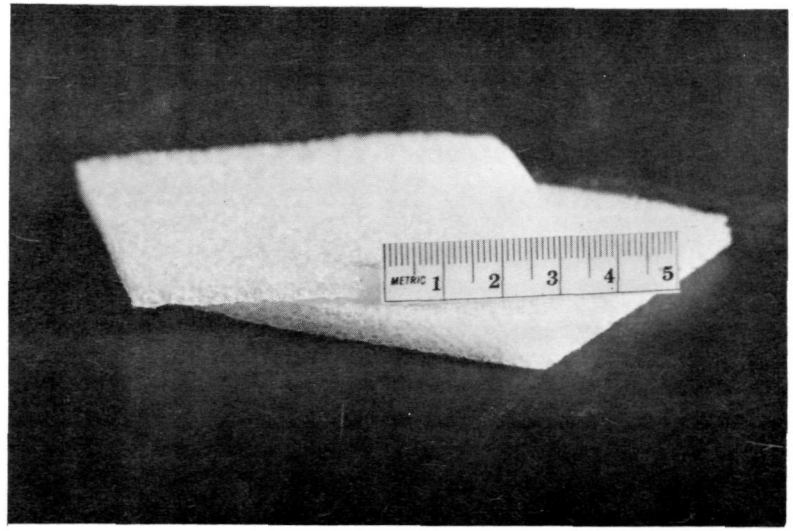
Diesel 2.5 mm Crude 5.0 mm Bunker C 5.0 mm	Av. Int'l. Pickup (g/g)	Av. Max. Pickup (g/g)	Av. Water Pickup (g/g)	Initial Use	Reuses (Weight Oil Recovered g oil/g sorbent)									
					1	2	3	4	5	6	7	8	9	10
Diesel (1 day)	5.39	5.39	0.97	20.7	1.46									
Diesel (7 day)	6.82	6.82	0.31	1.73	1.10									
Crude (1 day)	8.62	8.62	2.09	3.45	1.50									
Crude (7 day)	16.65	16.65	7.75	9.53	7.31									
Bunker C (1 day)	12.87	13.48	0	4.49	4.49									
Bunker C (7 day)	4.78	5.66	0	0.57	0.90									

1.4 Synthetic (Polymeric)

Durable Conwed Pads*

- modified, closed-cell polyethylene foam
- exhibited no change during 48-hour immersion test; remained floating
- with 1-day Bunker C, one sample did not saturate fully after 1-hour soaking time; it was also the only sample to pick up water with Bunker C oils

	1-Day Aged/0.1 mm Layer of Oil	
	g oil/g sorbent	g water/g sorbent
Diesel	3.27	0.69
Crude	1.00	2.32

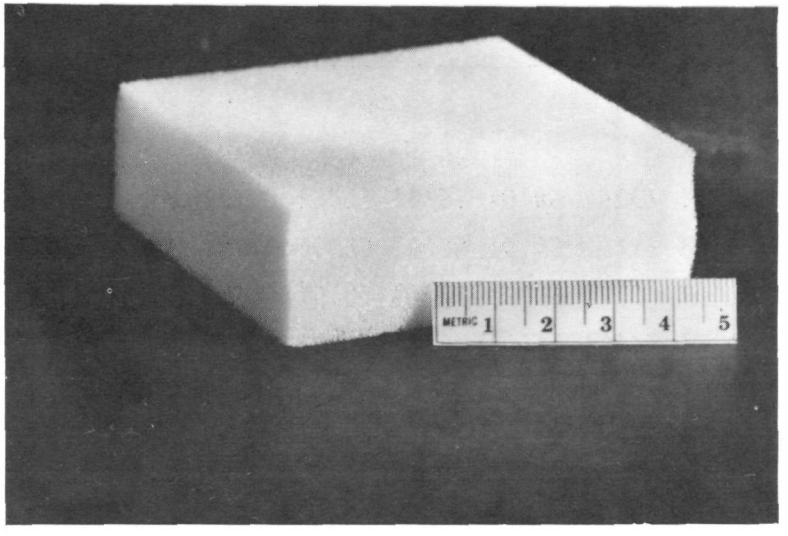


Diesel 2.5 mm Crude 5.0 mm Bunker C 5.0 mm	Av. Int'l. Pickup (g/g)	Av. Max. Pickup (g/g)	Av. Water Pickup (g/g)	Initial Use	Reuses (Weight Oil Recovered g oil/g sorbent)									
					1	2	3	4	5	6	7	8	9	10
Diesel (1 day)	14.60	17.82	0.26	11.69	12.89	11.58	11.44	12.55	9.54	14.92	13.72	12.41	12.92	13.10
Diesel (7 day)	17.68	17.68	0	15.15	15.79	14.92	14.23	15.07	14.41	13.09	13.0	14.23	14.78	14.71
Crude (1 day)	19.57	20.32	1.11	16.99	15.16	15.76	16.6	16.23	16.39	16.53	16.17	16.4	16.8	16.85
Crude (7 day)	15.62	15.62	4.66	13.41	11.94	11.08	11.10	10.01	10.91	10.49	9.67	9.80	9.96	9.84
Bunker C (1 day)	22.49	23.03	0.28	13.5	11.03									
Bunker C (7 day)	22.69	22.98	0	11.38	9.03									

* Not tested in 1974 Environment Canada study

Graboil

- polyurethane foam sheets
- slightly structurally weakened after 48-hour immersion test with diesel and crude; did not saturate fully and floated on surface of Bunker C



	1-Day Aged/0.1 mm Layer of Oil	
	g oil/g sorbent	g water/g sorbent
Diesel	2.92	2.13
Crude	0.36	0.36

Diesel 2.5 mm Crude 5.0 mm Bunker C 5.0 mm	Av. Int'l. Pickup (g/g)	Av. Max. Pickup (g/g)	Av. Water Pickup (g/g)	Initial Use	Reuses (Weight Oil Recovered g oil/g sorbent)									
					1	2	3	4	5	6	7	8	9	10
Diesel (1 day)	24.73	30.65	0	21.98	22.31	21.86	24.63	21.86	24.47	21.09	24.05	21.94	22.53	21.92
Diesel (7 day)	27.21	28.82	1.92	24.18	24.53	23.37	24.36	23.18	24.03	24.12	24.21	23.73	24.08	23.12
Crude (1 day)	22.84	41.29	0	20.20	32.31	34.92	35.16	35.25	34.91	36.13	36.48	35.28	37.41	35.45
Crude (7 day)	44.92	47.0	0	40.97	41.9	40.04	40.54	41.69	41.27	39.96	41.17	41.40	41.01	41.92
Bunker C (1 day)	16.38	41.87	0	3.51	8.77									
Bunker C (7 day)	15.23	62.94	0	2.87	8.62	20.34	15.93	19.24	22.34	20.83	21.91	21.41	23.56	20.18

Imbiber Beads

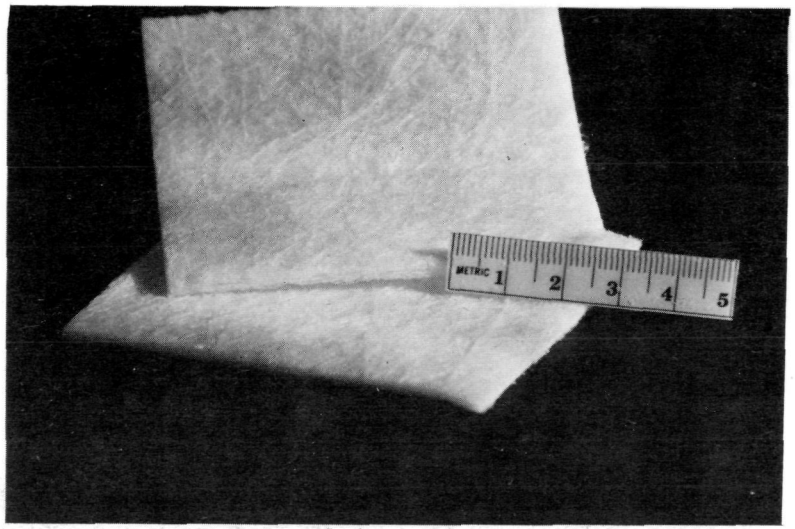
- cross-linked polymer beads; very fine particle size
- manufacturer recommends use on very light products, i.e. gasoline, hexane
- no change during 48-hour immersion for all tests except diesel, with which sorbent swelled and became transparent

	1-Day Aged/0.1 mm Layer of Oil	
	g oil/g sorbent	g water/g sorbent
Diesel	0.89	0
Crude	1.23	0

Diesel Crude Bunker C	2.5 mm 5.0 mm 5.0 mm	Av. Int'l. Pickup (g/g)	Av. Max. Pickup (g/g)	Av. Water Pickup (g/g)	Initial Use	Reuses (Weight Oil Recovered g oil/g sorbent)									
						1	2	3	4	5	6	7	8	9	10
Diesel (1 day)		4.40	4.40	0											
Diesel (7 day)		3.53	3.53	0											
Crude (1 day)		2.98	2.98	0											
Crude (7 day)		2.95	2.95	0											
Bunker C (1 day)		5.05	5.05	0											
Bunker C (7 day)		6.41	6.41	0											

Leomat*

- fibrous resin mat
- very weakened, fell apart readily, shrank to one-half original thickness during 48-hour immersion test with diesel and crude oils; no change with Bunker C oil
- during reuse, started to disintegrate after first reuse with 7-day aged diesel and after second reuse with 1-day aged crude



	1-Day Aged/0.1 mm Layer of Oil	
	g oil/g sorbent	g water/g sorbent
Diesel	0.79	0.64
Crude	0.48	0.16

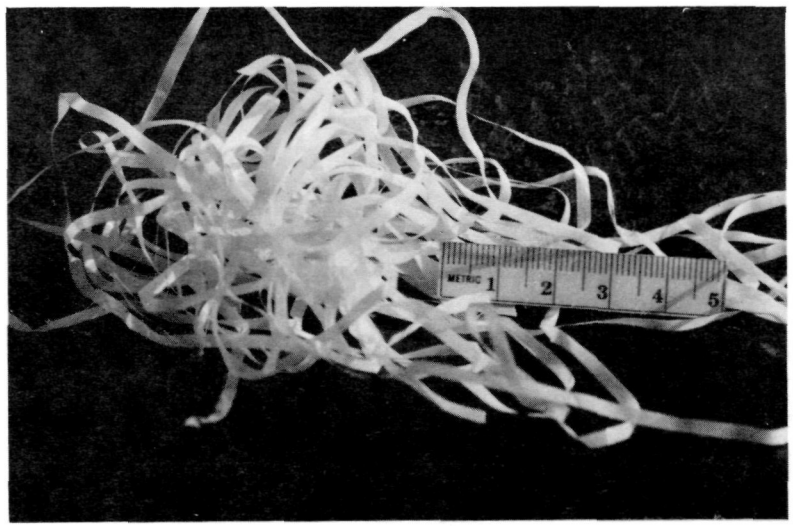
Diesel 2.5 mm Crude 5.0 mm Bunker C 5.0 mm	Av. Int'l. Pickup (g/g)	Av. Max. Pickup (g/g)	Av. Water Pickup (g/g)	Initial Use	Reuses (Weight Oil Recovered g oil/g sorbent)									
					1	2	3	4	5	6	7	8	9	10
Diesel (1 day)	4.62	4.74	0	3.32	2.84	2.06								
Diesel (7 day)	6.02	6.02	0	4.51	3.54	2.79								
Crude (1 day)	4.65	4.65	0.015	3.17	2.67	2.15								
Crude (7 day)	5.66	6.47	1.35	4.46	3.95	3.74	3.59	3.17	3.60	2.26				
Bunker C (1 day)	6.27	9.55	0	1.06	1.07									
Bunker C (7 day)	6.53	10.12	0	0.82	1.41									

* Sorbent not tested in the 1974 Environment Canada study

Oil Snare

- polyolefin strands
- manufacturer recommends use with very viscous oils
- showed no change during 48-hour immersion test

	1-Day Aged/0.1 mm Layer of Oil	
	g oil/g sorbent	g water/g sorbent
Diesel	1.46	0
Crude	2.39	1.72

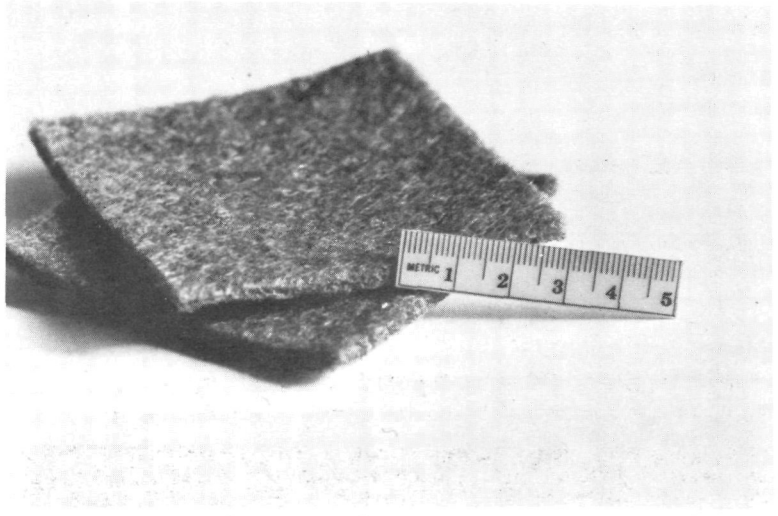


Diesel Crude Bunker C	2.5 mm 5.0 mm 5.0 mm	Av. Int'l. Pickup (g/g)	Av. Max. Pickup (g/g)	Av. Water Pickup (g/g)	Initial Use	Reuses (Weight Oil Recovered g oil/g sorbent)									
						1	2	3	4	5	6	7	8	9	10
Diesel (1 day)		1.15	1.36	0.15	0.22	0.33									
Diesel (7 day)		1.35	1.45	0	0.42	0.22									
Crude (1 day)		0.98	1.07	1.47	0.27	0.22									
Crude (7 day)		1.66	1.66	0.94	0.58	0.29									
Bunker C (1 day)		4.58	4.58	0	2.42	1.57									
Bunker C (7 day)		5.53	6.01	0	2.89	2.15									

Qwik-Wick*

- polypropylene fibre mat
- stretched more readily but did not tear after 48-hour immersion test; remained floating
- water pickup with thin layer of oil

	1-Day Aged/0.1 mm Layer of Oil	
	g oil/g sorbent	g water/g sorbent
Diesel	0.19	14.14
Crude	0.39	12.29



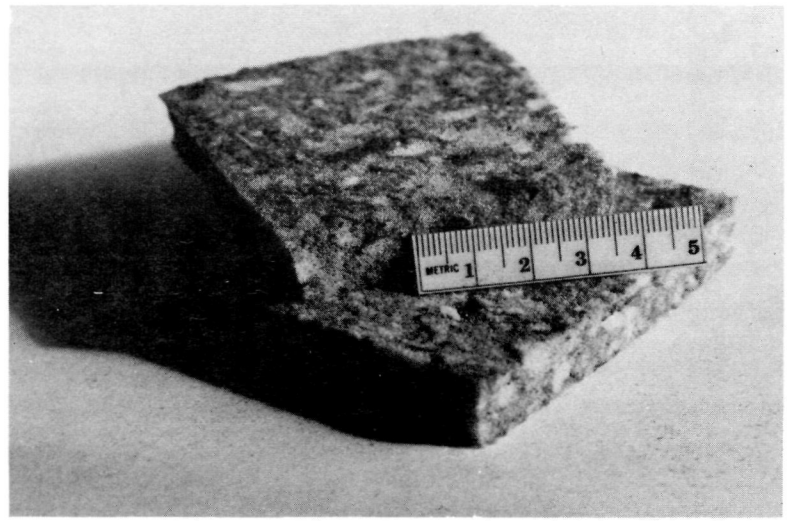
Diesel 2.5 mm Crude 5.0 mm Bunker C 5.0 mm	Av. Int'l. Pickup (g/g)	Av. Max. Pickup (g/g)	Av. Water Pickup (g/g)	Initial Use	Reuses (Weight Oil Recovered g oil/g sorbent)									
					1	2	3	4	5	6	7	8	9	10
Diesel (1 day)	10.60	10.60	0.40	5.91	5.99	5.70	5.64	5.47	5.61	5.58	5.42	5.56	5.27	5.57
Diesel (7 day)	10.21	20.21	0.04	6.71	6.04	5.46	5.55	5.33	5.25	5.34	4.74			
Crude (1 day)	11.20	11.20	0.19	7.64	7.22	6.90	6.70	6.97	6.62	6.83	6.82	6.89	6.64	6.66
Crude (7 day)	4.07	4.35	9.35	2.88	2.56	2.42	2.44	2.34	2.58	2.62	2.66	2.31	2.63	2.61
Bunker C (1 day)	13.89	16.26	0	6.15	6.85									
Bunker C (7 day)	13.37	14.8	0	4.47	4.42									

* Sorbent not tested in the 1974 Environment Canada study

Spill Control Co. FPD*

- chips of polyurethane foam bonded together more densely than sheets of polyurethane foam
- slightly weakened during 48-hour immersion test with diesel and crude; no change with Bunker C

	1-Day Aged/0.1 mm Layer of Oil	
	g oil/g sorbent	g water/g sorbent
Diesel	0.24	10.3
Crude	0.74	4.94

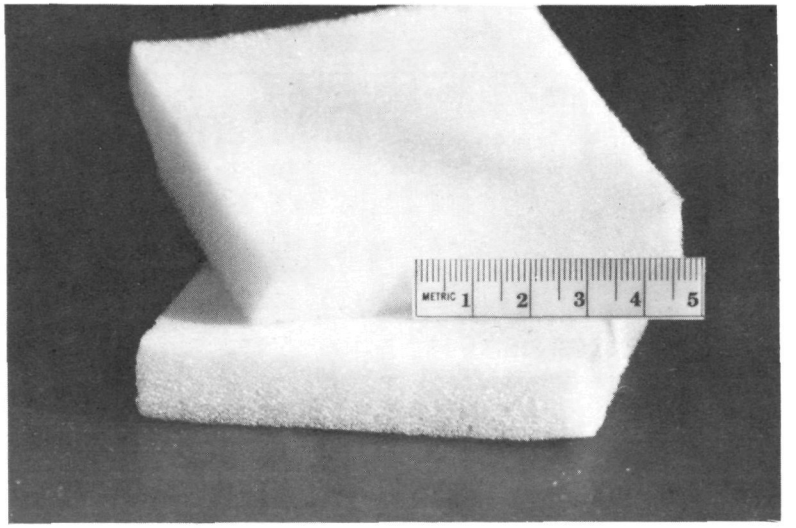


Diesel Crude Bunker C	2.5 mm 5.0 mm 5.0 mm	Av. Int'l. Pickup (g/g)	Av. Max. Pickup (g/g)	Av. Water Pickup (g/g)	Initial Use	Reuses (Weight Oil Recovered g oil/g sorbent)									
						1	2	3	4	5	6	7	8	9	10
Diesel (1 day)		11.70	12.63	0	10.0	10.31	10.08	10.12	10.51	10.38	10.73	10.24	10.38	10.32	9.84
Diesel (7 day)		9.59	10.26	0.26	7.89	8.28	7.89	8.08	8.15	7.99	8.18	7.73	7.90	8.15	8.19
Crude (1 day)		11.11	11.68	0	9.06	0.34	9.66	9.70	9.51	9.80	9.81	9.68	9.66	9.80	9.69
Crude (7 day)		9.36	10.34	0	8.19	8.43	8.42	8.63	8.74	8.58	8.51	8.55	8.54	8.48	8.73
Bunker C (1 day)		11.77	14.57	0	4.46	3.90									
Bunker C (7 day)		10.02	14.04	0	0.97	1.51									

* Sorbent not tested in the 1974 Environment Canada study

Spill Control Co. PEP*

- polyurethane foam sheets
- slightly weakened during 48-hour immersion test with diesel and crude; no apparent change with Bunker C



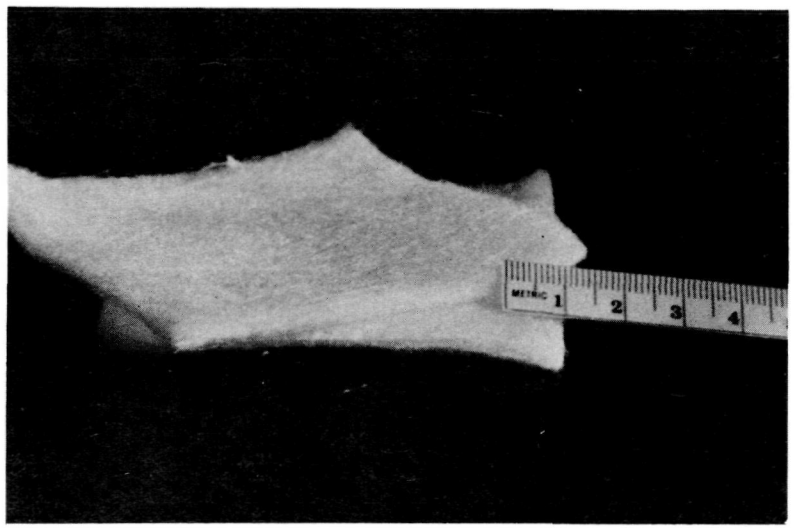
	1-Day Aged/0.1 mm Layer of Oil	
	g oil/g sorbent	g water/g sorbent
Diesel	0.79	3.44
Crude	1.05	2.12

Diesel 2.5 mm Crude 5.0 mm Bunker C 5.0 mm	Av. Int'l. Pickup (g/g)	Av. Max. Pickup (g/g)	Av. Water Pickup (g/g)	Initial Use	Reuses (Weight Oil Recovered g oil/g sorbent)									
					1	2	3	4	5	6	7	8	9	10
Diesel (1 day)	37.48	41.18	0	34.89	36.85	37.36	35.37	35.90	37.32	35.93	36.25	32.52	35.84	35.72
Diesel (7 day)	25.45	27.37	0.28	23.72	23.65	22.61	22.84	24.17	23.13	23.88	23.32	24.33	22.73	23.64
Crude (1 day)	40.25	46.90	0	37.01	41.03	41.84	40.19	42.19	41.01	40.80	38.77	41.99	40.59	41.60
Crude (7 day)	40.35	45.96	0	37.58	36.02	37.09	38.07	39.16	41.71	40.86	41.95	41.32	41.88	41.79
Bunker C (1 day)	27.99	39.67	0	9.3	13.87									
Bunker C (7 day)	25.17	42.0	0	6.79	12.38									

* Sorbent not tested in the 1974 Environment Canada study

Tafmat*

- fibrous resin mat
- very weakened, fibres pulled apart readily during 48-hour immersion test with diesel and crude oils; no change with Bunker C



	1-Day Aged/0.1 mm Layer of Oil	
	g oil/g sorbent	g water/g sorbent
Diesel	1.25	0.37
Crude	0.28	0.66

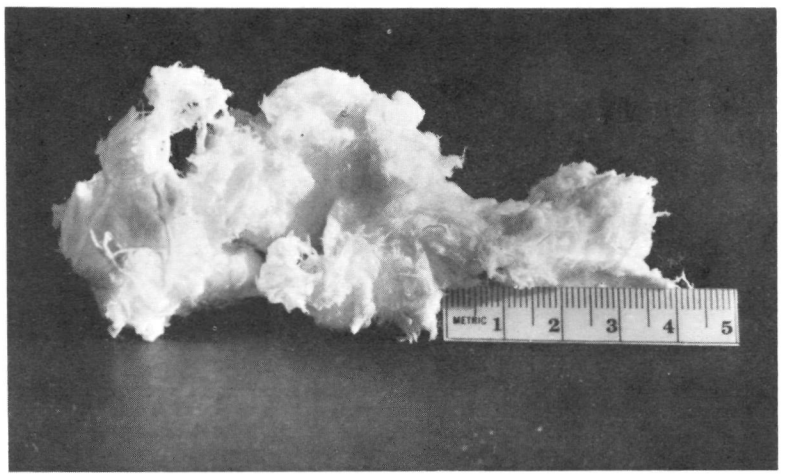
Diesel 2.5 mm Crude 5.0 mm Bunker C 5.0 mm	Av. Int'l. Pickup (g/g)	Av. Max. Pickup (g/g)	Av. Water Pickup (g/g)	Initial Use	Reuses (Weight Oil Recovered g oil/g sorbent)									
					1	2	3	4	5	6	7	8	9	10
Diesel (1 day)	9.48	9.48	0	6.09	5.74	5.55	5.36	4.91	5.11	4.88	4.94	4.84	4.90	4.89
Diesel (7 day)	9.06	9.06	0	5.24	4.95	4.82	4.67	4.50						
Crude (1 day)	11.07	11.07	0	6.62	5.91	5.60	5.27							
Crude (7 day)	9.69	10.15	4.01	6.65	6.64	6.47	6.80	6.59	6.73	6.84	6.89	6.90	7.01	6.69
Bunker C (1 day)	13.23	14.68	0	6.66	6.56									
Bunker C (7 day)	13.42	14.75	0	4.52	4.93									

*Sorbent not tested in the 1974 Environment Canada study

3M Fibre

- polyethylene fibres
- no change during 48-hour immersion test

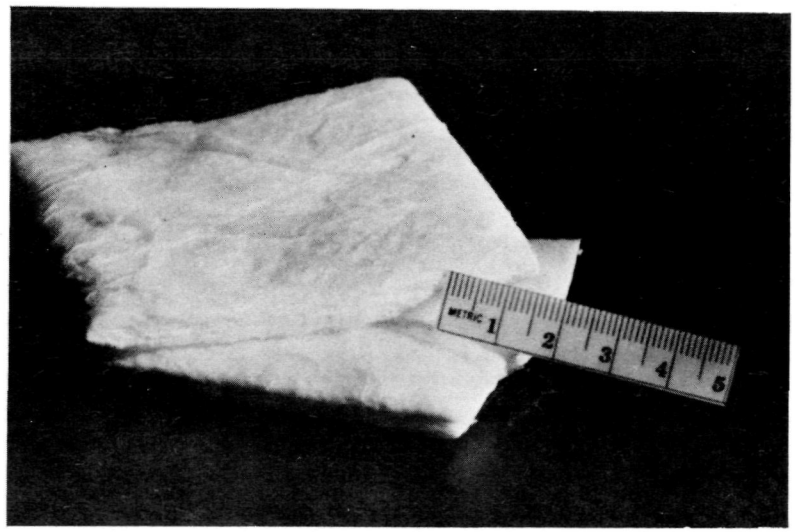
	1-Day Aged/0.1 mm Layer of Oil	
	g oil/g sorbent	g water/g sorbent
Diesel	6.37	2.68
Crude	1.66	1.16



Diesel Crude Bunker C	2.5 mm 5.0 mm 5.0 mm	Av. Int'l. Pickup (g/g)	Av. Max. Pickup (g/g)	Av. Water Pickup (g/g)	Initial Use	Reuses (Weight Oil Recovered g oil/g sorbent)									
						1	2	3	4	5	6	7	8	9	10
Diesel (1 day)		10.69	10.69	0	4.48	2.60									
Diesel (7 day)		10.38	10.38	0	4.98	2.97									
Crude (1 day)		11.92	11.92	0.06	5.89	4.39									
Crude (7 day)		12.06	12.06	0.93	6.40	5.02									
Bunker C (1 day)		11.89	12.23	0	3.61	3.95									
Bunker C (7 day)		6.79	9.16	0	1.11	2.05									

3M Sheet

- polyethylene fibre mat
- some weakening during 48-hour immersion test with diesel, 7-day crude and 1-day Bunker C; some weakening and expansion to twice original thickness with 1-day crude; not fully saturated, no change with 7-day Bunker C

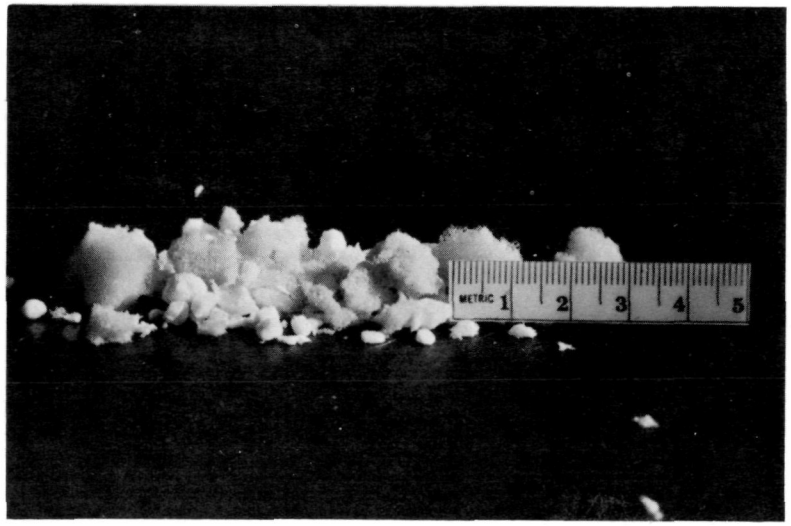


	1-Day Aged/0.1 mm Layer of Oil	
	g oil/g sorbent	g water/g sorbent
Diesel	0.23	0.06
Crude	0.21	0.03

Diesel 2.5 mm Crude 5.0 mm Bunker C 5.0 mm	Av. Int'l. Pickup (g/g)	Av. Max. Pickup (g/g)	Av. Water Pickup (g/g)	Initial Use	Reuses (Weight Oil Recovered g oil/g sorbent)									
					1	2	3	4	5	6	7	8	9	10
Diesel (1 day)	14.78	14.78	0	11.49	6.97	5.91								
Diesel (7 day)	13.44	13.44	0	10.51	6.99	6.48								
Crude (1 day)	12.41	12.41	0.03	9.01	6.49	6.07								
Crude (7 day)	12.40	12.40	0	8.69	5.89									
Bunker C (1 day)	4.83	6.75	0	0.17	0.19									
Bunker C (7 day)	5.91	10.02	0	0.57	0.47									

Winkler Foam 50-PS-PU*

- polyurethane chips and polystyrene beads
- during 48-hour immersion test with diesel, sorbent shrank and appeared to dissolve, formed a rubberlike layer at the oil/water interface; no change with crude and Bunker C oils



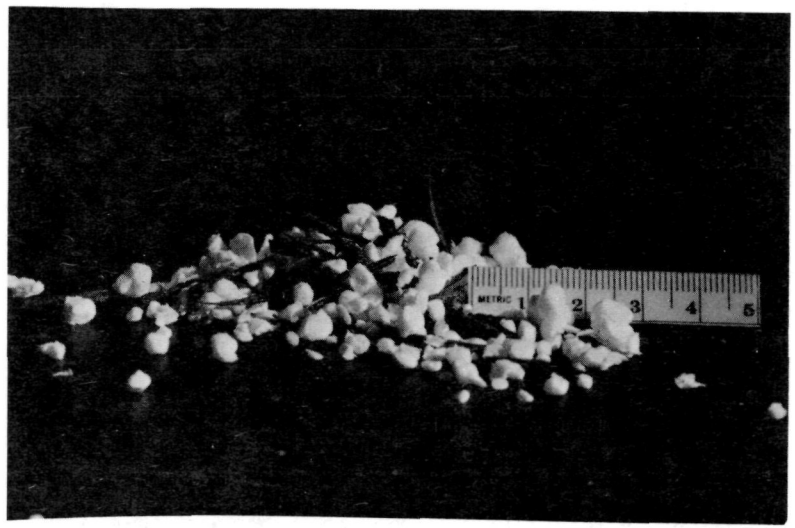
	1-Day Aged/0.1 mm Layer of Oil	
	g oil/g sorbent	g water/g sorbent
Diesel	2.66	5.68
Crude	3.29	5.13

Diesel Crude Bunker C	2.5 mm 5.0 mm 5.0 mm	Av. Int'l. Pickup (g/g)	Av. Max. Pickup (g/g)	Av. Water Pickup (g/g)	Initial Use	Reuses (Weight Oil Recovered g oil/g sorbent)									
						1	2	3	4	5	6	7	8	9	10
Diesel (1 day)		9.87	11.36	0.48	3.47	4.81									
Diesel (7 day)		14.90	14.83	3.08	6.26	6.25									
Crude (1 day)		24.94	32.39	6.0	17.46	18.35	18.67	19.67	21.04	24.07	19.82	21.65	20.33	17.4	15.37
Crude (7 day)		31.27	31.65	2.61	15.7	10.21									
Bunker C (1 day)		12.96	28.08	0	4.53	13.71	6.59								
Bunker C (7 day)		41.87	42.79	0	21.03	19.11									

* Sorbent not tested in the 1974 Environment Canada study

Winkler Foam 50-R-PS*

- polystyrene beads and rubber fibres
- during the 48-hour immersion test with diesel, sorbent shrank and appeared to dissolve, formed a rubberlike layer at oil/water interface; additionally, with 7-day diesel, beads clumped together; no change with crude and Bunker C oils



	1-Day Aged/0.1 mm Layer of Oil	
	g oil/g sorbent	g water/g sorbent
Diesel	1.20	1.09
Crude	6.59	5.84

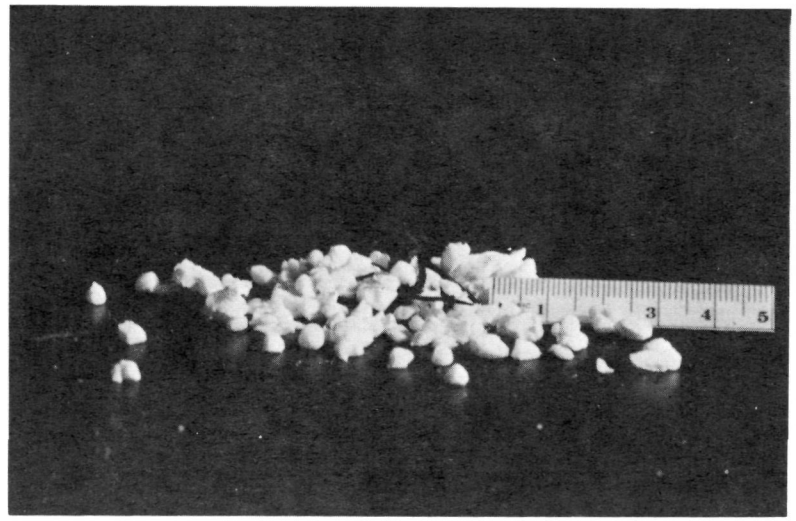
Diesel 2.5 mm Crude 5.0 mm Bunker C 5.0 mm	Av. Int'l. Pickup (g/g)	Av. Max. Pickup (g/g)	Av. Water Pickup (g/g)	Initial Use	Reuses (Weight Oil Recovered g oil/g sorbent)									
					1	2	3	4	5	6	7	8	9	10
Diesel (1 day)	3.09	3.76	0.48	0.73	1.26									
Diesel (7 day)	1.44	1.59	1.62	0.27	0.37									
Crude (1 day)	9.68	12.97	3.42	3.90	6.07	3.51								
Crude (7 day)	24.31	24.31	23.84	15.37	10.87									
Bunker C (1 day)	10.91	10.91	0	6.89	5.0									
Bunker C (7 day)	2.92	3.82	0	1.10	1.49									

* Sorbent not tested in the 1974 Environment Canada study

Winkler Foam 80-R-PS*

- polystyrene beads and rubber fibres
- during the 48-hour immersion test with diesel, sorbent fused together to form a rubberlike mat at oil/water interface; no change with crude and Bunker C oils

	1-Day Aged/ 0.1 mm Layer of Oil	
	g oil/g sorbent	g water/g sorbent
Diesel	0.85	0.79
Crude	1.33	1.75



Diesel Crude Bunker C	2.5 mm 5.0 mm 5.0 mm	Av. Int'l. Pickup (g/g)	Av. Max. Pickup (g/g)	Av. Water Pickup (g/g)	Initial Use	Reuses (Weight Oil Recovered g oil/g sorbent)									
						1	2	3	4	5	6	7	8	9	10
Diesel (1 day)		1.45	1.63	0.35	0.08	0.12									
Diesel (7 day)		2.58	2.85	0.28	0.54	0.34									
Crude (1 day)		5.27	7.03	4.01	2.89	3.41	3.86	2.55							
Crude (7 day)		21.01	21.01	14.74	12.75	12.08	10.55								
Bunker C (1 day)		8.59	9.43	0	3.71	3.96									
Bunker C (7 day)		7.27	8.79	0	2.52	3.40									

* Sorbent not tested in the 1974 Environment Canada study

APPENDIX II

USERS' GUIDE TO SORBENTS

APPENDIX II - USERS' GUIDE TO SORBENTS

1 Introduction

If used judiciously, sorbents can be a useful tool in the recovery of spilled oil. They are primarily intended for use on small spills, on thin layers of oil, or after mechanical equipment has been used to pick up most of the oil. Sorbents can also be used effectively to remove oil from land; the particulate sorbents, especially the granular ones, perform best under these circumstances.

Sorbents can also be used for shoreline protection and cleanup and as backup to conventional booms. A system has been developed to broadcast, recover, and reuse sorbents on open seas.

Before a sorbent is acquired, consideration should be given to its intended use. The following section describes other parameters to be taken into account when selecting a sorbent.

Finally, there is a summary of sorbents available on the market. The summary includes pertinent physical and operational characteristics. Sorbents marked with an asterisk (*) were tested for the first time during this study. Prices indicated were quoted in September, 1977.

2 Sorbent Selection Criteria

A sorbent should fulfill certain basic performance and operational criteria to be acceptable for use in the event of an oil spill. Firstly, the sorbent must readily be able to pick up and retain oil; secondly, the sorbent must lend itself well to the seven basic operations involved in sorbent use: supply, storage, transportation, application, sorption, harvesting and disposal.

In terms of performance, an ideal sorbent should also be:

1. oleophilic: have greater attraction for oil than water;
2. hydrophobic: repel water;
3. capable of a high sorption capacity: possess a high ratio of weight of oil absorbed or adsorbed to the weight of the substance itself;
4. retentive: retain oil indefinitely;
5. buoyant when saturated;
6. fast acting;
7. self-acting: require little or no mixing energy to sorb oil;

8. non-toxic; and

9. reusable: will not deteriorate upon reapplication in a water environment.

3 Operational Considerations

3.1 Supply. Quick countermeasure action is desirable in the event of an oil spill. It is therefore necessary that sorbents, to be used in cleanup are readily available in sufficient quantities from a nearby source. It is for this reason that natural organic sorbents have been used in the past; more efficient polymeric sorbents were not readily available in large quantities.

3.2 Storage. In order to stockpile sorbents for certain areas, storage requirements must be considered. Often valuable warehouse space is not available and consequently, the sorbent must be stored outdoors. In situations of this type, the sorbent must be able to either withstand weathering (e.g. ultraviolet rays, freezing) or be packaged in a weatherproof container. Materials such as peat and straw may be subject to microbial attack. The potential fire hazard of stored sorbents must also be taken into account.

Natural organic sorbents do not lend themselves well to outdoor storage due to their degradability, sensitivity to moisture, and bulk. Because of their higher sorption capacity, synthetic sorbents are required in smaller volumes. Some are vacuum packed, thus further reducing the necessity for storage space.

3.3 Transportation. In the movement of the sorbents from the supply site to the spill site, packaging is an important consideration. The package should be easily handled by one necessitating a small, light package. A well-packaged synthetic of high capacity would be preferable to large, heavy bales of straw if the spill site is any distance either from the point of supply or the transportation vehicle.

3.4 Application. The method of application of sorbents depends on the weather conditions, the type of sorbent, and the shoreline configuration. Some sorbents can be applied manually, whereas others require machinery. Straw, for example, could be readily applied by hand or pitchfork; however, for large, flat intertidal areas a mulcher-blower would be preferable. Additionally, sorbent application may depend on its packaging format.

3.5 Sorption. Various environmental and climatic conditions at a spill site will strongly influence sorption. These factors, in addition to the test data and performance criteria included herein, should be taken into account when selecting a product.

3.6 Harvesting. A sorbent, once it has been applied, must eventually be removed. Certain formats, e.g. pads, pillows, or sheets, lend themselves very well to manual retrieval with or without the aid of tools such as hooks or forks. Other formats, including fibres or granules, require pickup equipment in the form of nets

or skimmers. The additional equipment required for such formats may well influence decisions regarding their use. It may be deemed undesirable to broadcast loose sorbents on areas where containment is not possible, and yet desirable to do so in large, contained intertidal zones, e.g. mud flats.

3.7 **Disposal.** The oil/sorbent mixture must be disposed of in a clean, safe, and efficient manner. One method of disposal consists of depositing the collected material either in an approved landfill site or in an abandoned mine, if so authorized. In using this method of disposal, however, one must bear in mind the possibility of contaminating underground waters; the oil retention properties of the sorbent should be considered.

Another method of disposal is incineration, either in situ or in an enclosed device. Here, consideration should be given to the toxicity of gases produced during the burning of the sorbents. The development of smokeless incinerators might render this method of disposal more feasible in the future. Synthetic and organic sorbents usually lend themselves well to incineration.

At present, the most promising and efficient method of disposal is to separate the oil from the sorbent; in this regard, wringing and centrifuging techniques have been tested. The recovered oil could possibly be returned to a refinery and the sorbent reused. This method applies very well to the new polymeric sorbents, with which separation of the oil is accomplished by applying pressure; usually the sorbent is designed for reuse.

4 SUMMARY SHEETS FOR COMMERCIALLY AVAILABLE SORBENTS

NAME:	Absorbent 1012
TYPE:	Treated, expanded pumice
AVAILABLE GEOMETRY:	Granules, packaged in .11 m^3 bags (11 kg); 4 cu. ft. bags (25 lb.)
DISTRIBUTOR:	Colloid Chemicals Co. P. O. Box 861 Brockton, Mass. U.S.A. 02403
COST:	---

PHYSICAL PROPERTIES

BULK DENSITY:	104 kg/m^3 (6.5 lb./cu. ft.)
SHELF LIFE:	Indefinite
STORAGE REQUIREMENTS:	None

PERFORMANCE

OIL PICKUP RATIO:	---
REUSABILITY:	Not reusable

APPLICATION

TYPE OF SPILL:	Petroleum products
RECOMMENDED DOSAGE:	Sorbent to oil 2:1 by volume
EQUIPMENT REQUIRED:	Manual labour, spreader
REACTION TIME:	15 minutes to 1 hour
RETRIEVAL METHOD:	Manual labour, vacuum equipment
DISPOSAL:	Burial
TOXICITY:	Non-toxic

4 SUMMARY SHEETS FOR COMMERCIALLY AVAILABLE SORBENTS (Cont'd)

NAME:	Conwed*
TYPE:	Surface-treated cellulose
AVAILABLE GEOMETRY:	Pads, booms, blankets, strips, pillows packaged in cardboard boxes
DISTRIBUTOR:	1) Sigma International 58 Davisbrook Blvd. Agincourt, Ontario M1T 2J1 (416) 498-1230 2) C.I.L. P.O. Box 200, Station A Willowdale, Ontario (416) 226-6110
COST:	---

PHYSICAL PROPERTIES

BULK DENSITY:	51 kg/m^3 (3.2 lb./cu. ft.)
SHELF LIFE:	Indefinite
STORAGE REQUIREMENTS:	Below 107° C (225° F); away from ultraviolet light

PERFORMANCE

OIL PICKUP RATIO:	---
REUSABILITY:	Reusable

APPLICATION

TYPE OF SPILL:	Fresh crude, bunker fuels, distillate fuels
RECOMMENDED DOSAGE:	Sorbent to oil 1:16 to 1:20 by weight
EQUIPMENT REQUIRED:	Manual labour
REACTION TIME:	8 to 30 seconds
RETRIEVAL METHOD:	Manual labour
DISPOSAL:	Burial, incineration
TOXICITY:	Non-toxic
COMMENTS:	Sinks when wet; however, displays better buoyancy when oil-soaked; structurally weakens upon prolonged contact with water

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*Not tested in the 1974 Environment Canada study

4 SUMMARY SHEETS FOR COMMERCIALLY AVAILABLE SORBENTS (Cont'd)

NAME:	Conwed D Sorbent (Durable Pads*)
TYPE:	Modified, closed-cell, polyethylene foam
AVAILABLE GEOMETRY:	53 x 53 cm pads 6 mm thick; 80 pcs. per 56 cm x 50 cm corrugated cont. (21 x 21" pads 1/4" thick; 80 pcs. per 22 x 19.5" corrugated cont.)
DISTRIBUTOR:	1) Sigma International 58 Davisbrook Blvd. Agincourt, Ontario M1T 2J1 (416) 498-1230
	2) C.I.L. P.O. Box 200, Station A Willowdale, Ontario (416) 226-6110
COST:	---

PHYSICAL PROPERTIES

BULK DENSITY:	37 kg/m^3 (2.3 lb./cu. ft.)
SHELF LIFE:	Indefinite
STORAGE REQUIREMENTS:	Temperature no higher than 77° C (170° F)

PERFORMANCE

OIL PICKUP RATIO:	---
REUSABILITY:	25 times wrung out by hand

APPLICATION

TYPE OF SPILL:	Petroleum products and certain non-miscible chemicals
RECOMMENDED DOSAGE:	Sorbent to oil 1:15 to 1:20 by weight
EQUIPMENT REQUIRED:	Manual labour
REACTION TIME:	Immediate increases with increasing viscosity
RETRIEVAL METHOD:	Manual labour
DISPOSAL:	Burial, incineration
TOXICITY:	Non-toxic

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*Not tested in the 1974 Environment Canada study

4 SUMMARY SHEETS FOR COMMERCIALLY AVAILABLE SORBENTS (Cont'd)

NAME:	Fibreperl
TYPE:	Expanded perlite and cellulosic fibre
AVAILABLE GEOMETRY:	Fibres
DISTRIBUTOR:	John Misener Marine Equipment Ltd. Box 278, Marina Road Port Colborne, Ontario L3K 5W1
COST:	$0.47 per .45 kg ($0.47 per lb.)

PHYSICAL PROPERTIES

BULK DENSITY:	72 kg/m^3 (4.5 lb./cu. ft.)
SHELF LIFE:	Indefinite
STORAGE REQUIREMENTS:	None

PERFORMANCE

OIL PICKUP RATIO:	---
REUSABILITY:	---

APPLICATION

TYPE OF SPILL:	Fresh crude or distillate fuels on open sea, bay, harbour, shore or estuary
RECOMMENDED DOSAGE:	Sorbent to oil 1:5 to 1:7 by weight
EQUIPMENT REQUIRED:	Manual labour, spreader, respiratory protection
REACTION TIME:	Minutes to hours
RETRIEVAL METHOD:	Manual labour, boom, skimmer
DISPOSAL:	Burial, incineration
TOXICITY:	Dust is an irritant
COMMENTS:	Care must be exercised in the application of this sorbent to avoid inhalation of fine particulate matter

4 SUMMARY SHEETS FOR COMMERCIALLY AVAILABLE SORBENTS (Cont'd)

NAME:	Graboil*
TYPE:	Foam
AVAILABLE GEOMETRY:	Batts, rolls, booms packaged in plastic bags
DISTRIBUTOR:	RBH Cybernetics (1970) Ltd. P.O. Box 4205, Station A Victoria, B.C. V8X 3X8
COST:	Batts: $67.50 per 100 bd. ft. package

PHYSICAL PROPERTIES

BULK DENSITY:	19 kg/m^3 (1.2 lb./cu. ft.)
SHELF LIFE:	Indefinite
STORAGE REQUIREMENTS:	---

PERFORMANCE

OIL PICKUP RATIO:	---
REUSABILITY:	Reusable

APPLICATION

TYPE OF SPILL:	Light and heavy fuels
RECOMMENDED DOSAGE:	Sorbent to oil 1:35 by weight
EQUIPMENT REQUIRED:	Manual labour, air deployable
REACTION TIME:	Rapid
RETRIEVAL METHOD:	Manual labour
DISPOSAL:	Burial, incineration
TOXICITY:	Non-toxic
COMMENTS:	For heavier oils, must be forced into oil initially; on reuses, sorbs oil rapidly

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*Not tested in the 1974 Environment Canada study

4 SUMMARY SHEETS FOR COMMERCIALLY AVAILABLE SORBENTS (Cont'd)

NAME:	Ground, Cured, Scrap-Rubber Compound*
TYPE:	Ground rubber
AVAILABLE GEOMETRY:	Fine particles
DISTRIBUTOR:	Rubbermaid Canada Ltd. 2562 Stanfield Road Mississauga, Ontario
COST:	$0.15/.45 kg ($0.15/lb.)

PHYSICAL PROPERTIES

BULK DENSITY:	Less than 993 kg/m^3 (less than 62 lb./cu. ft.)
SHELF LIFE:	Indefinite
STORAGE REQUIREMENTS:	None

PERFORMANCE

OIL PICKUP RATIO:	---
REUSABILITY:	---

APPLICATION

TYPE OF SPILL:	Petroleum products
RECOMMENDED DOSAGE:	Sorbent to oil 1:1 to 1:2 by weight
EQUIPMENT REQUIRED:	Manual labour, blower
REACTION TIME:	---
RETRIEVAL METHOD:	Manual labour, skimmer
DISPOSAL:	Burial
TOXICITY:	Non-toxic
COMMENTS:	Manufacturer recommends use on land

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*Not tested in the 1974 Environment Canada study

4 SUMMARY SHEETS FOR COMMERCIALLY AVAILABLE SORBENTS (Cont'd)

NAME:	Imbiber Beads*
TYPE:	Cross-linked polymer beads
AVAILABLE GEOMETRY:	Packets, blankets, valves, beads
DISTRIBUTOR:	Dow Chemical of Canada, Ltd. Modeland Rd., P.O. Box 1012 Sarnia, Ontario N7T 7K7
COST:	$2.65/.45 kg; ($2.65/lb.; $0.95/packet; $6.00/valve; $6.30 - $19.00/blanket)

PHYSICAL PROPERTIES

BULK DENSITY:	982 kg/m^3 (61.3 lb./cu. ft.)
SHELF LIFE:	Indefinite
STORAGE REQUIREMENTS:	None

PERFORMANCE

OIL PICKUP RATIO:	To 1:27 (manufacturer)
REUSABILITY:	Not reusable

APPLICATION

TYPE OF SPILL:	Best with solvents or No. 1, 2 or 3 fuel oils
RECOMMENDED DOSAGE:	Sorbent to oil: to 1:27 by volume
EQUIPMENT REQUIRED:	Manual labour
REACTION TIME:	Immediate for light solvents
RETRIEVAL METHOD:	Manual labour
DISPOSAL:	Burial, incineration
TOXICITY:	Non-toxic
COMMENTS:	Absorbed material will not leach from beads

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*Not tested in the 1974 Environment Canada study

4 SUMMARY SHEETS FOR COMMERCIALLY AVAILABLE SORBENTS (Cont'd)

NAME:	Leomat*
TYPE:	Synthetic fibre
AVAILABLE GEOMETRY:	Mats, rolls
DISTRIBUTOR:	E.W. Seward Ltd. P.O. Box 225, Station A Willowdale, Ontario M2N 5S8
COST:	$87.50/25 kg ($87.50/55 lb.)

PHYSICAL PROPERTIES

BULK DENSITY:	Less than 993 kg/m^3 (less than 62 lb./cu. ft.)
SHELF LIFE:	Indefinite
STORAGE REQUIREMENTS:	None

PERFORMANCE

OIL PICKUP RATIO:	---
REUSABILITY:	Reusable

APPLICATION

TYPE OF SPILL:	Any oil, solvents
RECOMMENDED DOSAGE:	---
EQUIPMENT REQUIRED:	Manual labour
REACTION TIME:	Rapid
RETRIEVAL METHOD:	Manual labour
DISPOSAL:	Incineration
TOXICITY:	---

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*Not tested in the 1974 Environment Canada study

4 SUMMARY SHEETS FOR COMMERCIALLY AVAILABLE SORBENTS (Cont'd)

NAME:	Oil Snare*
TYPE:	Polyolefin yarn
AVAILABLE GEOMETRY:	Bundles of yarn boxed
DISTRIBUTOR:	John Misener Marine Equipment Ltd. Box 278, Marina Road Port Colborne, Ontario L3K 5W1
COST:	$37.50/7 kg; ($37.50/15 lb. carton; 30 snares)

PHYSICAL PROPERTIES

BULK DENSITY:	142.6 kg/m^3 (9 lb./cu. ft.)
SHELF LIFE:	Indefinite
STORAGE REQUIREMENTS:	Dryness for packaging

PERFORMANCE

OIL PICKUP RATIO:	---
REUSABILITY:	---

APPLICATION

TYPE OF SPILL:	Preferably a viscous oil on open sea, bay, harbour, estuary or shore
RECOMMENDED DOSAGE:	Sorbent to oil 1:3 to 1:64 by weight
EQUIPMENT REQUIRED:	Manual labour
REACTION TIME:	Immediate
RETRIEVAL METHOD:	Manual labour, some types of skimmers
DISPOSAL:	Burial, incineration
TOXICITY:	Non-toxic
COMMENTS:	Recommended for use with heavy oils, i.e. Bunker C

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*Not tested in the 1974 Environment Canada study

4 SUMMARY SHEETS FOR COMMERCIALLY AVAILABLE SORBENTS (Cont'd)

NAME:	Peat Moss*
TYPE:	Organic fibre
AVAILABLE GEOMETRY:	Loose fibres bagged
DISTRIBUTOR:	Local distributor
COST:	---

PHYSICAL PROPERTIES

BULK DENSITY:	82 to 171 kg/m^3 (5.1 to 10.7 lb./cu. ft.) depending on particle size and moisture content
SHELF LIFE:	---
STORAGE REQUIREMENTS:	Dryness

PERFORMANCE

OIL PICKUP RATIO:	---
REUSABILITY:	Not reusable

APPLICATION

TYPE OF SPILL:	---
RECOMMENDED DOSAGE:	Sorbent to oil 1:8 to 1:12 by weight
EQUIPMENT REQUIRED:	Manual labour, blower, mulcher
REACTION TIME:	---
RETRIEVAL METHOD:	Manual labour, skimmer
DISPOSAL:	Burial, incineration
TOXICITY:	Non-toxic
COMMENTS:	Sinks when wet; can be used as a combustion promoter; drying may be necessary to reduce moisture content below 35 percent for improved performance

*Not tested in the 1974 Environment Canada study

4 SUMMARY SHEETS FOR COMMERCIALLY AVAILABLE SORBENTS (Cont'd)

NAME:	Petro-pak, Bilge Buddies
TYPE:	Vermiculite
AVAILABLE GEOMETRY:	Bags, pillows
DISTRIBUTOR:	Grace Construction Materials 1234 Glen Drive Vancouver, B.C. V6A 3M9
COST:	---

PHYSICAL PROPERTIES

BULK DENSITY:	72 kg/m^3 (4.5 lb./cu. ft.)
SHELF LIFE:	Indefinite
STORAGE REQUIREMENTS:	None

PERFORMANCE

OIL PICKUP RATIO:	---
REUSABILITY:	---

APPLICATION

TYPE OF SPILL:	Petroleum products
RECOMMENDED DOSAGE:	---
EQUIPMENT REQUIRED:	Manual labour
REACTION TIME:	Rapid
RETRIEVAL METHOD:	Manual labour
DISPOSAL:	Burial
TOXICITY:	Non-toxic
COMMENTS:	Manufacturer recommends use to soak up oil in holds of boats

4 SUMMARY SHEETS FOR COMMERCIALLY AVAILABLE SORBENTS (Cont'd)

NAME:	Qwik-Wick*
TYPE:	Polypropylene (treated)
AVAILABLE GEOMETRY:	Sheets, rolls, pillows
DISTRIBUTOR:	Clark-Cutler-McDermott Co. 1 Fisher Street Franklin, Mass. 02038 U.S.A.
COST:	$79.00/roll (91 cm x 46 m); $79.00/roll (36" x 50 yards)

PHYSICAL PROPERTIES

BULK DENSITY:	Approx. 45 kg/m^3 (Approx. 2.8 lb./cu. ft.)
SHELF LIFE:	Indefinite
STORAGE REQUIREMENTS:	None

PERFORMANCE

OIL PICKUP RATIO:	---
REUSABILITY:	Reusable

APPLICATION

TYPE OF SPILL:	Petroleum products
RECOMMENDED DOSAGE:	Sorbent to oil 1:16 by weight
EQUIPMENT REQUIRED:	Manual labour
REACTION TIME:	Immediate
RETRIEVAL METHOD:	Manual labour
DISPOSAL:	Recycling, burial, incineration
TOXICITY:	---

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*Not tested in the 1974 Environment Canada study

4 SUMMARY SHEETS FOR COMMERCIALLY AVAILABLE SORBENTS (Cont'd)

NAME:	Slikwik*
TYPE:	Ground corn cobs
AVAILABLE GEOMETRY:	Loose particles in 3 cu. ft. (37 lb.) plastic bags
DISTRIBUTOR:	Ashwell Feeds Ltd. 139 Millwick Drive Weston, Ontario M9L 1Y7
COST:	$0.11/.45 kg ($4.25/17 kg bag); $0.11/lb. ($4.25/37 lb. bag)

PHYSICAL PROPERTIES

BULK DENSITY:	141 kg/m^3 (8.8 lb./cu. ft.)
SHELF LIFE:	Indefinite
STORAGE REQUIREMENTS:	None if in plastic bags

PERFORMANCE

OIL PICKUP RATIO:	---
REUSABILITY:	Not reusable

APPLICATION

TYPE OF SPILL:	Fresh crude distillate fuels in bay, harbour, shore and estuary
RECOMMENDED DOSAGE:	Sorbent to oil 1:5 by weight
EQUIPMENT REQUIRED:	Manual labour, blower
REACTION TIME:	Immediate
RETRIEVAL METHOD:	Manual labour, skimmer
DISPOSAL:	Burial, incineration
TOXICITY:	Non-toxic; may cause eye irritation

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*Not tested in the 1974 Environment Canada study

4 SUMMARY SHEETS FOR COMMERCIALLY AVAILABLE SORBENTS (Cont'd)

NAME:	Sorbent C*
TYPE:	Expanded perlite and fibrous wood material
AVAILABLE GEOMETRY:	Fibre in 4 cu. ft. bags
DISTRIBUTOR:	Clean Water Inc. P.O. Box 1002 Toms River, New Jersey U.S.A. 08753
COST:	---

PHYSICAL PROPERTIES

BULK DENSITY:	72 kg/m^3 (4.5 lb./cu. ft.)
SHELF LIFE:	Indefinite
STORAGE REQUIREMENTS:	None

PERFORMANCE

OIL PICKUP RATIO:	---
REUSABILITY:	Not reusable

APPLICATION

TYPE OF SPILL:	Fresh and weathered crude, distillate fuels
RECOMMENDED DOSAGE:	Sorbent to oil 1:7 by weight
EQUIPMENT REQUIRED:	Manual labour
REACTION TIME:	Immediate
RETRIEVAL METHOD:	Manual labour, skimmer
DISPOSAL:	Burial, incineration
TOXICITY:	Non-toxic; may cause eye, nose, throat irritation

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*Not tested in the 1974 Environment Canada study

4 SUMMARY SHEETS FOR COMMERCIALLY AVAILABLE SORBENTS (Cont'd)

NAME:	Sorb-Oil
TYPE:	Recycled Fibreboard
AVAILABLE GEOMETRY:	Mats, chips, booms, swabs
DISTRIBUTOR:	McArthur Chemical Co. Ltd. 62 Arrow Road Weston, Ontario M9M 2L9
COST:	---

PHYSICAL PROPERTIES

BULK DENSITY:	---
SHELF LIFE:	Indefinite
STORAGE REQUIREMENTS:	---

PERFORMANCE

OIL PICKUP RATIO:	--
REUSABILITY:	---

APPLICATION

TYPE OF SPILL:	Petroleum products
RECOMMENDED DOSAGE:	Sorbent to oil 1:2.3 to 1:21 by wieght
EQUIPMENT REQUIRED:	Manual labour
REACTION TIME:	Rapid
RETRIEVAL METHOD:	Manual labour, skimmer can recover chips
DISPOSAL:	Burial, incineration
TOXICITY:	Non-toxic

4 SUMMARY SHEETS FOR COMMERCIALLY AVAILABLE SORBENTS (Cont'd)

NAME:	SOS sorbent boom particles
TYPE:	Polyurethane foam
AVAILABLE GEOMETRY:	Boom, particles
DISTRIBUTOR:	Scandinavian Oil Service Stora Badhusgatan 20 S-411 21 Gothenburg, Sweden
COST:	---

PHYSICAL PROPERTIES

BULK DENSITY:	10 kg/m^3
SHELF LIFE:	Indefinite
STORAGE REQUIREMENTS:	---

PERFORMANCE

OIL PICKUP RATIO:	---
REUSABILITY:	---

APPLICATION

TYPE OF SPILL:	Any oil
RECOMMENDED DOSAGE:	Sorbent to oil 1:50 by weight
EQUIPMENT REQUIRED:	Manual labour
REACTION TIME:	Rapid
RETRIEVAL METHOD:	Manual labour
DISPOSAL:	Burial, incineration
TOXICITY:	Non-toxic

4 SUMMARY SHEETS FOR COMMERCIALLY AVAILABLE SORBENTS (Cont'd)

NAME:	Spill Control Co. Sorbent (Types SS, FPD*, PEP*, SPD)
TYPE:	Polyurethane foams
AVAILABLE GEOMETRY:	Pads, sheets, booms, pillows, strips
DISTRIBUTOR:	Spill Control Co. 828 North Grand Avenue Covina, California U.S.A. 91724
COST:	$89.00/ctn. of sheets (30 x 4 x 168 cm sheet); $89.00/ctn. of sheets (12 x 1-1/2 x 66" sheet)

PHYSICAL PROPERTIES

BULK DENSITY:	---
SHELF LIFE:	Indefinite
STORAGE REQUIREMENTS:	None

PERFORMANCE

OIL PICKUP RATIO:	---
REUSABILITY:	Readily reusable

APPLICATION

TYPE OF SPILL:	All oils
RECOMMENDED DOSAGE:	Sorbent to oil 1:40 to 1:60 by weight
EQUIPMENT REQUIRED:	Manual labour
REACTION TIME:	Immediate
RETRIEVAL METHOD:	Manual labour
DISPOSAL:	Recycling, burial, incineration
TOXICITY:	Non-toxic

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*Not tested in the 1974 Environment Canada study

4 SUMMARY SHEETS FOR COMMERCIALLY AVAILABLE SORBENTS (Cont'd)

NAME:	Straw*
TYPE:	Natural fibre
AVAILABLE GEOMETRY:	Fibres in bales (50 to 100 lb.)
DISTRIBUTOR:	Local distributor
COST:	$0.01 to $0.02/.45 kg (per 45 kg bale); $0.01 to $0.02/lb. (per 100 lb. bale)

PHYSICAL PROPERTIES

BULK DENSITY:	Less than 993 kg/m^3 (less than 62 lb./cu. ft.)
SHELF LIFE:	Subject to microbial attack, spontaneous combustion
STORAGE REQUIREMENTS:	Away from moisture, heat

PERFORMANCE

OIL PICKUP RATIO:	---
REUSABILITY:	Not reusable

APPLICATION

TYPE OF SPILL:	Fresh and weathered crude, Bunker C, distillate fuels
RECOMMENDED DOSAGE:	Sorbent to oil 1:5 by weight
EQUIPMENT REQUIRED:	Manual labour, mulcher, blower
REACTION TIME:	Rapid
RETRIEVAL METHOD:	Manual labour, net, skimmer
DISPOSAL:	Burial, incineration
TOXICITY:	Non-toxic

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*Not tested in the 1974 Environmental Canada study

4 SUMMARY SHEETS FOR COMMERCIALLY AVAILABLE SORBENTS (Cont'd)

NAME:	Tafmat*
TYPE:	Polypropylene fibres
AVAILABLE GEOMETRY:	Sheets, custom designed, configurations
DISTRIBUTOR:	E.W. Seward Ltd. P.O. Box 225, Station A Willowdale, Ontario M2N 5S8
COST:	---

PHYSICAL PROPERTIES

BULK DENSITY:	10 kg/m^3
SHELF LIFE:	Indefinite
STORAGE REQUIREMENTS:	None

PERFORMANCE

OIL PICKUP RATIO:	---
REUSABILITY:	Reusable

APPLICATION

TYPE OF SPILL:	Any oil
RECOMMENDED DOSAGE:	Sorbent to oil 1:10 to 1:13 by weight
EQUIPMENT REQUIRED:	Manual labour
REACTION TIME:	Rapid
RETRIEVAL METHOD:	Manual labour
DISPOSAL:	Burial, incineration
TOXICITY:	Non-toxic

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*Not tested in the 1974 Environment Canada study

4 SUMMARY SHEETS FOR COMMERCIALLY AVAILABLE SORBENTS (Cont'd)

NAME:	3M Brand Oil Sorbent*
TYPE:	Polyethylene fibres
AVAILABLE GEOMETRY:	Fibres, pads, sheets, booms, swabs
DISTRIBUTOR:	Bennett Pollution Control 119 Charles Street North Vancouver, B.C.
	John Misener Marine Equipment Ltd. Box 278, Marina Road Port Colborne, Ontario L3K 5W1
	Saniva Inc. 1705 - 3 Avenue (Pointe-Aux-Trembles) Montreal, Quebec H1B 5G6
COST:	---

PHYSICAL PROPERTIES

BULK DENSITY:	48 - 64 kg/m^3 (3 - 4 lb./cu. ft.)
SHELF LIFE:	Indefinite
STORAGE REQUIREMENTS:	None

PERFORMANCE

OIL PICKUP RATIO:	---
REUSABILITY:	Reusable

APPLICATION

TYPE OF SPILL:	Crude, distillates, some bunker on open water
RECOMMENDED DOSAGE:	Sorbent to oil 1:10 to 1:20 by weight
EQUIPMENT REQUIRED:	Manual labour
REACTION TIME:	Seconds to minutes
RETRIEVAL METHOD:	Manual labour, fibres by skimmer
DISPOSAL:	Incineration, dissolution in hot oil
TOXICITY:	Non-toxic
COMMENTS:	Floats when wet or oil soaked

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*Not tested in the 1974 Environment Canada study

4 SUMMARY SHEETS FOR COMMERCIALLY AVAILABLE SORBENTS (Cont'd)

NAME:	Winkler Foam* (50-PS-PU)
TYPE:	Plastic foam chips
AVAILABLE GEOMETRY:	Loose chips
DISTRIBUTOR:	BNH Limited 971 West 1st Street North Vancouver, B.C.
COST:	$0.50 to $0.75/.45 kg ($0.50 to $0.75/lb.)

PHYSICAL PROPERTIES

BULK DENSITY:	25 kg/m^3
SHELF LIFE:	Indefinite
STORAGE REQUIREMENTS:	Below 93° C (200° F)

PERFORMANCE

OIL PICKUP RATIO:	---
REUSABILITY:	Not reusable

APPLICATION

TYPE OF SPILL:	Medium viscosity petroleum oil
RECOMMENDED DOSAGE:	Sorbent to oil 1:5 by weight
EQUIPMENT REQUIRED:	Manual labour, blower
REACTION TIME:	Immediate
RETRIEVAL METHOD:	Manual labour, skimmer
DISPOSAL:	Liquify; use as asphalt extender
TOXICITY:	---

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*Not tested in the 1974 Environment Canada study

4 SUMMARY SHEETS FOR COMMERCIALLY AVAILABLE SORBENTS (Cont'd)

NAME:	Zorbite*
TYPE:	Formulated perlite
AVAILABLE GEOMETRY:	Loose particles
DISTRIBUTOR:	Spill Control Co. 828 North Grand Avenue Covina, California U.S.A. 91724
COST:	---

PHYSICAL PROPERTIES

BULK DENSITY:	144 kg/m^3 (9 lb./cu. ft.)
SHELF LIFE:	Indefinite
STORAGE REQUIREMENTS:	None

PERFORMANCE

OIL PICKUP RATIO:	---
REUSABILITY:	Not reusable

APPLICATION

TYPE OF SPILL:	Any oil on land
RECOMMENDED DOSAGE:	---
EQUIPMENT REQUIRED:	Manual labour, with scoop, shovels
REACTION TIME:	Rapid
RETRIEVAL METHOD:	Manual labour, with boom, shovels
DISPOSAL:	Burial, flush down drain
TOXICITY:	
COMMENTS:	Not recommended for application in windy areas

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*Not tested in the 1974 Environment Canada study