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A Review of Oil Slick Combustion Promoters

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Environmental Impact Control Directorate
November 1979

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A REVIEW OF OIL SLICK COMBUSTION PROMOTERS

Research and Development Division
Environmental Emergency Branch
Environmental Impact Control Directorate
Environmental Protection Service
Department of the Environment

EPS 3-EC-79-8
November 1979

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ABSTRACT

This report describes the use and effectiveness of combustion promoters as applied to in-situ burning of oil slicks. The materials described are classified into four groups in accordance with their effects upon the oil layer.

Several of the materials are no longer commercially produced. Some materials originally classified as oil sorbents have been listed as combustion promoters. Each of the materials listed can be air-dropped onto oil slicks should circumstances warrant this method. Detailed information concerning properties, cost, and availability is given.

The present data concerning the effectiveness and limitations of combustion promoters are insufficient for thorough conclusions to be made. It is recommended that controlled tests to obtain more quantitative results be performed. Further, it is recommended that other materials be investigated.

RÉSUMÉ

Le présent rapport décrit les caractéristiques, les antécédents et l'efficacité des agents de la combustion sur place des nappes d'hydrocarbures. Ces agents se répartissent en quatre groupes, selon leurs effets sur la couche d'hydrocarbures.

Plusieurs des produits classés comme agents de combustion ne sont plus fabriqués industriellement. De plus, certains d'entre eux étaient considérés à l'origine comme des absorbants. Nous pensons que tous les produits mentionnés peuvent s'appliquer par la voie des airs, à condition, bien sûr, que cette méthode s'avère la meilleure. Ce rapport donne des renseignements détaillés sur les caractéristiques (propriétés, coûts, disponibilité) des produits.

En règle générale, l'insuffisance des données actuelles sur l'efficacité et les limites des agents de combustion ne permet pas d'avancer de conclusions approfondies. Nous recommandons que les produits énumérés subissent des essais surveillés, afin d'obtenir de plus amples données quantitatives. Nous recommandons aussi d'envisager l'application d'autres produits.

FOREWORD

The information in this report was gathered by Energetex Engineering under contract to the Environmental Emergency Branch, Department of the Environment.

Mr. J. de Gonzague, Environmental Impact Control Directorate, Ottawa, and Mrs. J. Moore, Ottawa, edited this report while Dr. D.E. Thornton, Environmental Emergency Branch, Edmonton, acted as scientific authority.

TABLE OF CONTENTS

		Page
ABSTRACT		i
RÉSUMÉ		ii
FOREWORD		iii
LIST OF TABLES		vi
1	INTRODUCTION	1
2	FUNCTION AND CLASSIFICATION OF COMBUSTION PROMOTERS	2
3	LITERATURE REVIEW	5
3.1	Oil Spill Incidents Involving Combustion Promoters	5
3.2	Oil Spill Tests Involving Combustion Promoters	11
3.2.1	Guardian Chemical Corp.: PYRAXON	11
3.2.2	U.S. Environmental Protection Agency: PYRAXON, CAB-0-SIL ST-2-0, SEABEADS, EKOPERL, Straw	12
3.2.3	U.S. Navy: SEABEADS, CAB-0-SIL ST-2-0	12
3.2.4	U.S. Environmental Protection Agency: SEABEADS	12
3.2.5	Glaeser/Vance: Silica Beads, Glass Beads, Straw	13
3.2.6	Coupal: Peat Moss	13
3.2.7	McGuire: Expanded Vermiculite, SEABEADS Coated with Dicyclopentadienyliron	13
4	SUMMARY	14
5	FUTURE RESEARCH	15
6	PROPERTIES, AVAILABILITY, AND ECONOMIC ASPECTS OF COMBUSTION PROMOTERS	16
6.1	Group A: Summary Sheets	17
6.2	Group B: Summary Sheets	24
6.3	Group C: Summary Sheets	33
6.4	Group D: Summary Sheet	44
7	REFERENCES	46
8	BIBLIOGRAPHY: IN-SITU COMBUSTION OF OIL SLICKS	48

LIST OF TABLES

Table		Page
1	APPLICATION AND TESTS INVOLVING COMBUSTION PROMOTERS	6

1 INTRODUCTION

Elimination of oil spilled on water has been attempted by several methods. The most notable methods involve mechanical recovery, oil sorbents, sinking agents, chemicals (gelling agents, dispersants, and emulsifiers), and in-situ combustion techniques.

Major oil spills have increased in size and frequency over the last few years. The AMOCO CADIZ created the largest oil spill in history, and revealed the inadequacy of present technology to perform large-scale cleanup operations. In the Canadian Arctic, where remoteness and vastness create spill recovery problems more complex than usual, quick and inexpensive techniques are required.

In-situ burning shows promise as a possible cleanup method; this is especially true in the Arctic, where oil slicks will tend to be thicker than those in more temperate and ice-free environments, and hence more combustible. Moreover, this method is essentially independent of spill size and poses fewer logistical problems than other recovery methods. Under certain conditions, however, combustion promoters must be added to oil slicks for effective cleanup.

Interest in this field was originally sparked by the TORREY CANYON disaster. Most of the literature concerning the use of combustion promoters for in-situ burning covers their use in the late 1960's and early 1970's.

According to the literature, research and development on combustion promoters has diminished in recent years. An incomplete understanding of oil slick combustion and concern over the resulting air pollution effects are responsible for the declining interest in the development and application of combustion promoters.

If the appropriate oil slick and weather conditions are present, in-situ combustion with combustion promoters may be the quickest and most economical technique for the elimination of large and remote oil slicks.

2 FUNCTION AND CLASSIFICATION OF COMBUSTION PROMOTERS

There is confusion regarding the definition of a "combustion promoter" in the oil spill literature. Ignition devices, highly flammable chemicals, and numerous natural and processed materials have been referred to as combustion promoters, depending upon a particular author's viewpoint. The terms "burning agents", "wicking agents", and "combustion promoters" have been used interchangeably in the literature examined.

Direct burning of the oil layer on water is never complete, as a residue always remains. A minimum oil layer thickness is required, which is dependent upon oil type, the degree of weathering, and the extent of oil emulsification. During burning tests carried out with slicks consisting of Norman Wells crude oil, it was noted that residues ranging between 0.5 and 1.2 mm in thickness were left on the water surface (Energetex Engineering, 1978).

For this report, combustion promoters are defined as any substance that will decrease the amount of residue remaining, or allow oil burning to take place below the minimum ignitable thickness for direct in-situ burning.

Igniters (e.g. Kontax) and primers (e.g. gasoline, kerosene, lighter fluid, etc.) serve to make ignition of oil slicks easier to achieve. However, they were not considered as combustion promoters since they neither reduce the amount of residue remaining nor allow burning of an oil layer below the minimum ignitable thickness.

In general, the following parameters can be changed with respect to in-situ oil burning:

(1) surface tensions at the oil/water and oil/air interfaces;
(2) oil viscosity;
(3) thermal conductivity of the oil layer; and
(4) oil volatility.

Oil volatility can be increased by employing oil-cracking catalysts with the combustion promoter. Oil slick ignition can be improved by adding oxidizing agents to a combustion promoter, which would also intensify oil combustion. PYRAXON (Section 6.4) is the only reported combustion promoter that operates in this manner (Pastuhov, 1969; Sittig, 1974). However, such materials would be relatively expensive if large amounts of oxidizing agent and catalysts were required to drastically alter the volatility of the oil. Therefore, this discussion concentrates on the parameters of surface tensions, oil viscosity, and thermal conductivity of the oil layer.

The surface tensions and oil viscosity are important parameters to consider in the burning of unconfined oil slicks. As the oil is heated to its ignition temperature, the surface tensions are altered, and oil viscosity decreases.

Connective flow caused by heat transfer from the flame is also created in the oil layer, which promotes the spreading of the burning oil layer. As a result, unconfined burning slicks tend to spread to thicknesses that do not support combustion. Thus, the main priority for the burning of unconfined slicks is alteration of the oil viscoisty and oil/water surface tensions so that oil spreading is minimal.

The combustion promoters used may be able to confine a slick if the constituents tend to cling together. Sawdust, vermiculite, and foam may serve this purpose. Also, gelling agents such as SPILL-AWAY and STRICKITE may be able to confine a slick if deployed with the combustion promoters (Stehle, 1970). However, no known tests have been performed to evaluate the above possibilities.

VISTANEX, a high molecular weight polymer, and M-4 THICKENER, the diacid aluminum soap of isootanoic acid, have been tested as viscosity index improvers for the burning of kerosene on water (Hillstrom, 1970). Although VISTANEX was effective in these tests, it is not known how effective either of these substances would be with slicks consisting of heavier hydrocarbons.

Chemical herding agents manufactured by Shell and Esso proved successful in reducing the surface area of fresh slicks consisting of Swan Hills and Norman Wells crude oil, but were unsuccessful with aged crude oil slicks (Energetex Engineering, 1977).

The ability of these chemical agents to confine oil slicks under high flame temperatures and for long periods of time is not presently known. Selected combustion promoters and chemical agents may be practical but probably in calm waters only.

Oil viscosity can also be altered by the combustion promoter. This occurs with materials that are hydrophobic (water-repelling). If these materials are added to the oil layer, oil viscosity increases; of course, this change in oil viscosity is a definite advantage. These materials could also serve as wicking agents, thus improving combustion by transporting oil away from the water underneath. The materials described in Section 6.3 serve this purpose.

The minimization of heat transfer from the flame to the water layer is extremely important. This can be effected by altering the thermal conductivity of the oil layer. The oil layer, if of sufficient thickness, serves as a thermal insulator, as the thermal conductivity of oil is approximately one fourth of that for water. However, with direct burning of oil over water, the oil layer eventually burns down to a thickness where an insufficient proportion of the flame energy is available for the continued vaporization of the oil. In general, the oil layer can be thermally insulated from the water layer by two artificial means, as follows:

(a) Alteration of the thermal conductivity of the oil layer by distributing materials of insulating value throughout the oil layer. For this purpose, most of the materials listed in Sections 6.2 and 6.3 are appropriate.

(b) Placement of an insulating layer between the oil and water layers. The generation of CAPILLARDIAMIN foam near the water layer by depositing a mixture of two aqueous solutions under the oil surface may serve to create such a layer. This method has not been evaluated. However, the location of this or other similar material at the oil/water interface would be difficult to achieve due to the small differences in density between crude oil and water.

In open waters, waves cause increased heat transfer to the water layer. Although no data have been reported to this effect, many failures with the combustion of oils slicks at sea may have been caused by wave action.

Materials noted in Section 6.1 are natural organic fibres that have little thermal insulating value. The thermal conductivity of a slick would not be greatly altered when seeded with these materials. Their oleophilic (oil-attracting) nature allows them to wick oil to the flame during combustion. Despite their combustibility and the fact that they do absorb water as well as oil, they are very inexpensive combustion promoters to employ.

Materials in Section 6.2 are processed minerals and chemicals that have considerable thermal insulating value, and therefore decrease the thermal conductivity of the oil layer when added to an oil slick. However, these materials are more expensive than those of Section 6.1, and are not necessarily oleophilic.

Materials in Section 6.3 are substances that are treated to be hydrophobic. Most of these materials have thermal insulating values that decrease the thermal conductivity of the oil layer; also, by their hydrophobic properties, they increase oil viscosity when applied to the slick.

Section 6.4 includes only one material, PYRAXON, which is available in either a powder or a liquid form. It alters oil volatility while functioning as a combustion promoter.

3 LITERATURE REVIEW

The performance of combustion promoters is discussed based on data from cleanup operations after oil spill incidents (Section 3.1) and from various tests carried out on oil spills (Section 3.2). The information in both sections is summarized in Table 1.

In general, the literature includes only qualitative information. Very little quantitative information is included concerning initial slick thickness, slick area, the quantity of combustion promoter material used, the extent of oil weathering or emulsification, and the amount of residue remaining.

The distribution of combustion promoters over oil slicks (in past applications and tests) has been achieved by manual labour, sprayers, and blowers. The last two methods were feasible only when the materials applied were granular or loose fibres. Although relatively time-consuming techniques, these methods allow for uniform distribution or thorough seeding of the materials throughout the oil slick.

Air deployment of combustion promoters has been given cursory consideration previously (Little, 1970), although the strategy has never been given a detailed evaluation. It is clear, however, that aircraft would have to travel at low air speeds quite close to the slick surface for effective deployment.

If extensive oil absorption is desired with combustion promoters, some materials (e.g. MISTRON ZSC, and WONDERPERL 1640) may have to be applied in large quantities.

3.1 Oil Spill Incidents Involving Combustion Promoters. On March 18, 1967, the tanker TORREY CANYON ran aground off Land's End, Great Britain, spilling approximately 100,000 t of Kuwait crude oil. The committee of scientists concerned with the cleanup reported that direct burning of the weathered and emulsified crude oil slicks would be pointless and that combustion promoters should be investigated (Byers/Freiberger, 1971).

On December 15, 1969, the tanker RAPHAEL ran aground near Emasalo, Finland, spilling approximately 54 t of crude oil. Peat moss, aided by fuel and petrol, was used as a combustion promoter to clean up the resulting slick. Despite adverse weather conditions created by snowfall, 90 percent of the spilled oil was removed by this method (Coupal, 1972; McLeod, 1972).

On February 4, 1970, the tanker ARROW ran aground near Chedabucto Bay, Nova Scotia, spilling most of the 14,500 t of Bunker C fuel oil that it carried. Several of

TABLE 1 APPLICATIONS AND TESTS INVOLVING COMBUSTION PROMOTERS

Material	Test or Incident	Oil Type and Quantity	Oil Slick Dimensions	Water Layer Conditions	Amount of Material Supplied	Application Rate	% of Oil burned, or Residue Left.
EKOPERL	EPA Tests, 1969.	No. 6 fuel oil; quantity not reported.	38.1 cm diameter; 1.9 cm thick.	Between 5-7°C.	Not reported.	Not reported.	33% oil burned; residue thickness not reported.
PEAT MOSS	RAPHAEL oil spill incident, Emasalo, Finland.	Crude oil; 54 t.	Not reported.	Not reported.	Not reported.	Not reported.	90% oil in the resulting slick burned.
	Burning tests, near Rimouski, Quebec, (Coupal, 1972).	Bunker C oil slicks; 9 l.	Not reported.	Between -2 and 4°C tested over water, ice and snow.	1.8 kg	Not reported.	Between 70-80% oil burned.
		Crude oil slicks; 9 l.	Not reported.	Between 8-24°C.	Minimum of 1.8 kg between 2.7-3.6 kg were also tested.	Not reported.	Between 70-95% oil burned, depending upon the amount of material.

TABLE 1 APPLICATIONS AND TESTS INVOLVING COMBUSTION PROMOTERS (Continued)

Material	Test or Incident	Oil Type and Quantity	Oil Slick Dimensions	Water Layer Conditions	Amount of Material Supplied	Application Rate	% of Oil Burned, or Residue Left.
PYRAXON (powder and liquid)	Guardian Chemical Corp. test, (Pastuhov 1969).	Crude oil; quantity not reported.	Confined to 18.2 m^2 thickness between 1.27-5 cm.	Near Freezing.	Powder: 0.453 kg /94.6 l Liquid 37.8 l /94.6 l.	5 g/l 0.48:1 liquid to oil by volume	Minimum 80% oil burned estimated; residue 0.32 cm thick.
	EPA tests, 1969.	No. 6 fuel oil; quantity not reported.	Surface 2.23 m^2	Not reported.	Not reported.	Not reported.	Material reported ineffective; residue thickness not reported.
SANERING-SULL	Oil discharge into the Ume River, Sweden.	Diesel fuel; 540 t	Not reported.	Air temperature between -25 and -35°C; slick was burned over ice and water.	Not reported.	Apply 1:8 material to oil by weight (lab tests, Robertson, 1976).	360 t oil burned over one month; residue thickness not reported.

TABLE 1 APPLICATIONS AND TESTS INVOLVING COMBUSTION PROMOTERS (Continued)

Material	Test or Incident	Oil Type and Quantity	Oil Slick Dimensions	Water Layer Conditions	Amount of Material Supplied	Application Rate	% of Oil Burned, or Residue Left.
SEABEADS	ARROW oil spill incident, Chedabucto Bay, Nova Scotia.	Bunker C; 14,000 t (only some resulting slicks were ignited).	Diameters to 4.6 m (15 ft)	Rough 28 km/h (15 knot) winds; water temperature near $1^{o}C$.	Not reported.	0.49 kg material/ m^2 oil, as a single layer.	50% oil from seeded slicks burned; residue thickness not reported.
	EPA tests, December, 1969.	No. 6 fuel oil; quantity not reported.	Thickness between 0.25 - 0.63 cm.	Not reported.	Not reported.	0.33-0.41 kg $/m^2$ thickness of spill can vary	complete oil combustion; residue thickness not reported.
	EPA tests, 1970.	Bunker C oil; quantity not reported.	Not reported.	Not reported.	Not reported.	Not reported.	Between 80-90% oil burned; residue thickness not reported.
	Burning tests (McGuire, 1972).	Kuwait crude oil; 110 ml.	Not reported.	Not applicable.	7 g (SEABEADS treated with Dicyclopentadienyliron coating).	Not reported.	98% oil was reported burned; residue thickness not reported.

TABLE 1 APPLICATIONS AND TESTS INVOLVING COMBUSTION PROMOTERS (Continued)

Material	Test or Incident	Oil Type and Quantity	Oil Slick Dimensions	Water Layer Conditions	Amount of Material Supplied	Application Rate	% of Oil Burned, or Residue Left.
SEABEADS and CAB-O-SIL ST-2-O	U.S. Navy sea trials (Stehle, 1970).	Bunker C (unconfined); 250 t.	Not specified for all tests; areas 1.2 m wide (4 ft) and 9.1 m long were seeded.	Water temperature 7°C water swells 2.44 - 3 m wind speeds 28-37 km/h	Not reported for either material.	CAB-O-SIL ST-2-O: 1:2 material to oil by weight; SEABEADS: 0.48 kg/m^2 as a single layer.	66% oil estimated burned; residue thickness not reported.
	Burning tests (Glaeser/ Vance, 1971).	Prudhoe Bay crude oil; 145-250 l.	Not reported.	Water and ice were incorporated under the oil layer.	Not reported for either material.	Not reported.	Between 2-10% oil by volume remained; no oil burning improvement claimed with either material.
STRAW	EPA tests, 1969.	No.6 fuel oil; volume not reported.	38.1 cm diameter; 1.9 cm thick.	Water temperature between 5-7°C.	80 g.	Not reported.	80% oil burned.
	Burning tests (Glaeser/ Vance, 1971).	Prudhoe Bay crude oil; 145-250 l.	Not reported.	Water and ice were incorporated under the oil layer.	Not reported.	Not reported.	Between 2-10% oil by volume remained; no oil burning improvement claimed.

TABLE 1 APPLICATIONS AND TESTS INVOLVING COMBUSTION PROMOTERS (Continued)

Material	Test or Incident	Oil Type and Quantity	Oil Slick Dimensions	Water Layer Conditions	Amount of Material Supplied	Application Rate	% of Oil Burned, or Residue Left.
VERMICULITE (expanded and coated with asphalt).	Burning tests (McGuire, 1972).	Kuwait crude oil; 110 ml.	0.32 cm thick.	Not reported.	Not reported.	Not reported.	98% oil burned with both expanded vermiculite and asphalt-coated vermiculite; residue thickness not reported.

the larger slicks (to 4.6 m in diameter) were coated with SEABEADS, ignited with varsol primer and marked with a flare (Byers/Freiberger, 1971; Coupal, 1972; and McLeod, 1972). The oil slicks had to be ignited several times; and the unconfined oil slicks tended to spread while burning (Byers/Freiberger, 1971). With rough wave conditions (28 km/h winds), and water temperatures near $1^{o}C$, 50 percent of the ignited oil was removed by this method. It is felt that better results would have been achieved if the slicks had been confined prior to combustion.

On March 30, 1970, the tanker OTHELLO collided with another tanker, the KATELYSIA, in Tralhavet Bay, Sweden, spilling 3,750 t of heavy fuel oil. Kerosene primer alone was not effective in the burning of the oil. However, the combustion promoter CAB-O-SIL ST-2-O was successfully used for several of the resulting slicks (Byers/Freiberger, 1971). The detailed effectiveness of this material and the weather conditions prevailing during this cleanup operation were not reported in the literature examined.

In February 1972, 540 t of diesel fuel oil were accidentally discharged into the Ume River in northern Sweden. The material SANERINGSULL was blown over the oil slick, which was confined by means of a boom. It was estimated that approximately 360 t of oil (over water and in ice) was burned with this material over a period of one month (Jerbo, 1972). It was reported that this material was functional in temperatures as low as $-35^{o}C$. On this basis, SANERINGSULL appears to have potential as a combustion promoter in Arctic conditions.

3.2 Oil Spill Tests Involving Combustion Promoters

3.2.1 Guardian Chemical Corp.: PYRAXON. Tests were performed by Guardian Chemical Corp. in order to evalute the effectiveness of PYRAXON as a combustion promoter for an oil slick contained in a 36.17 m^2 tank (Pastuhov, 1969). The initial slick ranged between 1.27 and 5.0 cm in thickness, with the water layer at near-freezing temperatures. PYRAXON powder and PYRAXON liquid were used to burn this slick. Guardian's recommended application rate for PYRAXON powder was 5 g/l of crude oil; for PYRAXON liquid, an application ratio of 1:25 by volume of liquid to crude oil was recommended. The residue was reported to be 0.32 cm thick. PYRAXON was not effective as a combustion promoter for emulsified oil ("chocolate mousse").

3.2.2 U.S. Environmental Protection Agency: PYRAXON, CAB-O-SIL ST-2-O, SEABEADS, EKOPERL, Straw. In December 1969, the U.S. Environmental Protection Agency evaluated the effectiveness of PYRAXON, CAB-O-SIL ST-2-O, SEABEADS, EKOPERL, and straw as combustion promoters for oil slicks consisting of No. 6 fuel oil (Byers/Freiberger, 1971).

The first three materials were tested with slicks having a surface area of 2.23 m^2. PYRAXON and CAB-O-SIL ST-2-O were not effective as combustion promoters. However, complete burning was obtained with SEABEADS, where thickness of the oil ranged between 0.25 and 0.63 cm. It was estimated that 0.33 - 0.41 kg of SEABEADS should be applied per square meter of slick to obtain effective burning (Dweling/Struzeski, 1969).

Straw and EKOPERL were evaluated with oil slicks 1.9 cm thick and 38.1 cm in diameter. The water temperatures were between 5 and 7^{o}C. With the application of straw (80 g applied to the slick), 80 percent of the oil was burned; with EKOPERL (0.11 kg applied to the slick), 33 percent of the oil was burned.

3.2.3 U.S. Navy: SEABEADS, CAB-O-SIL ST-2-O. In May 1970, sea trials were conducted by the U.S. Navy in the North Atlantic ocean. SEABEADS and CAB-O-SIL ST-2-O were evaluated as combustion promoters (Byers/Freiberger, 1971; Stehle, 1970). These tests were conducted in 28 to 37 km/h winds, with water swells between 2.44 and 3.05 m. The water temperature was approximately 7^{o}C.

Under these wind and wave conditions, proper seeding of the Bunker C oil slick with these materials, and successful oil ignition, were very difficult. However, with repeated ignition attempts, it was estimated that SEABEADS and CAB-O-SIL ST-2-O promoted the burning of 1,500 t of the 2,250 t spill.

As a result of the tests, it was suggested that containment of the oil by booms would be needed to prevent the breakup of a seeded oil spill.

3.2.4 U.S. Environmental Protection Agency: SEABEADS. During the summer of 1970, the U.S. Environmental Protection Agency conducted burning tests off the New Jersey coast with South Louisiana crude oil and Bunker C oil. It was found that 80 to 90 percent of Bunker C oil was burned when SEABEADS was used as a combution promoter. A priming fluid was also used.

The combustion of free-floating (uncontained) slicks was difficult if the slicks were less than 0.2 cm thick (Byers/Freiberger, 1971). For confined slicks of Louisiana crude oil, between 80 and 90 percent of the oil was burned without the use of combustion promoters.

3.2.5 Glaeser/Vance, 1971: Silica Beads, Glass Beads, Straw. In February 1971, Prudhoe Bay crude oil was used in the evaluation of silica beads, glass beads, and straw as combustion promoters. Tests volumes ranged between 145 and 250 l. Fresh and aged oil slicks on water and ice were burned, with and without the application of silica beads, glass beads, and straw.

The residue from all burns ranged between two and ten percent of the original oil volume. The ability of combustion promoters to reduce the amount of residue remaining was not clearly determined.

Glaeser and Vance claim that the use of combustion promoters did not noticeably increase the percentage of oil removed during combustion.

3.2.6 Coupal, 1972: Peat Moss. Peat moss was evaluated as a combustion promoter for Bunker C and crude oil during the spring and summer of 1972. With Bunker C oil, slicks having volumes of nine l were burned over water, ice, and snow. The water temperatures ranged between -2 and 4°C. With the aid of gasoline and diesel oil primers, between 70 and 80 percent of the oil was burned in the tests. With crude oil, the slicks had volumes of nine l and the water temperatures ranged between 8 and 24°C. In these tests, the percentage of oil burned generally ranged between 70 and 95 percent.

For both types of oil slicks, a minimum of 1.8 kg of peat moss was added to the slicks. A greater percentage of oil was burned when 2.7 to 36 kg of peat moss were applied to the slicks. The moisture content of the peat moss did not exceed 40 percent by weight.

3.2.7 McGuire, 1972: Expanded Vermiculite, SEABEADS Coated with Dicyclopentadienyliron. In tests carried out by McGuire et al, slicks of Kuwait crude oil were burned on salt water, with and without the presence of combustion promoters. When a slick of oil having a volume of 110 ml and a thickness of 0.32 cm was burned, only 50 percent of the oil was burned.

When expanded vermiculite was used as a combustion promoter, 98 percent of the oil was burned. When expanded vermiculite and SEABEADS coated with dicyclopentadienyliron (both applied in seven g portions) were used as combustion promoters, 98 percent of the oil was burned. In these tests, similar results were claimed with asphalt-coated vermiculite.

4 SUMMARY AND CONCLUSIONS

If appropriate weather and slick conditions exist, burning of large oil slicks serves as a rapid cleanup technique and requires a minimum of manpower and equipment.

Previous research suggests that air-deployable incendiary devices would be practical for igniting confined slicks in remote Arctic locations (Energetex Engineering, 1978).

Burning is suggested under calm weather conditions for slicks consisting of heavy or light crude oil, provided that they have a minimum thickness of 0.63 cm (Pastuhov, 1969). During recent burning tests performed with confined slicks of Norman Wells crude oil, the minimum ignitable thickness was approximately 1 mm for fresh slicks, and 3 mm for aged or weathered slicks (Energetex Engineering, 1978).

Confinement of the slick prior to burning is considered extremely important. Unconfined oil, when heated by the flame during combustion, decreases in viscosity and consequently spreads to a thickness that will not support combustion.

A uniform distribution of combustion promoters in confined oil slicks should allow a greater percentage of oil to be burned, thereby decreasing the amount of unburned residue remaining after combustion. For unconfined oil pools, some combustion promoters may serve as containing media and thus improve burning efficiency.

In-situ combustion, however, has several drawbacks and limitations. In rough waters, oil slicks require mechanical confinement in order to prevent them from breaking up during the burning process. Slick confinement by chemical or mechanical means is required to prevent the oil from spreading after it is ignited. An unburned residue always remains. This has to be cleaned up, along with the material serving as the combustion promoter. In-situ burning with or without combustion promoters is less effective with weathered or emulsified oil slicks. Potential fire hazards and air pollution would be created with this technique, which prohibits its application near populated areas.

Although several products either have been or are presently marketed as combustion promoters, considerable confusion exists regarding the effectiveness of these materials. Manufacturers state effectiveness in terms of percentage values of oil burned, but they do not mention how much oil would be burned in the absence of these materials.

None of the materials considered as combustion promoters in this report (Section 6) have been subjected to a sufficient number of controlled applications or tests for their effectiveness to be adequately judged.

5 FUTURE RESEARCH

In view of the qualitative and incomplete nature of the data available on the application and effectiveness of potential combustion promoters, it is desirable that more quantitative results be obtained. The following recommendations are made:

1. Controlled burning tests should determine optimal dosage rates of promising combustion promoters for confined slicks of heavy and light crude oil, Bunker C, and distillate fuels.
2. Gelling agents, substances that increase oil viscosity, and chemical herders should be tested in association with promising combustion promoters on unconfined slicks.
3. The effects of wave action, water temperature, oil weathering, and oil emulsification upon burning effectiveness, with and without the use of combustion promoters should be examined. This may eventually require experimental work on deliberately spilled oil to ensure realistic results.
4. The feasibility of seeding slicks by air deployment of combustion promoters should be evaluated. If the approach proves attractive, detailed investigations would eventually lead to experiments involving controlled oil discharges under calm and rough water conditions.

6 PROPERTIES, AVAILABILITY, AND ECONOMIC ASPECTS OF COMBUSTION PROMOTERS

The majority of the information presented in Sections 6.1 to 6.4 is based upon two reference articles (Battelle, 1972 and Robertson, 1976). The following articles have supplied additional data concerning oil spill cleanup and test results:

Byers/Freiberger, 1971
Coupal, 1972
Glaeser/Vance, 1971
Jerbo, 1972
McLeod, 1972
Pastuhov, 1969
Schatzberg, 1971
Stehle, 1970.

Verbal communications, correspondence and brochures from the commercial organizations concerned have supplied information concerning the current prices and minimum order sizes for the materials.

Many of the materials listed were originally considered as oil sorbents, and are only suggested as potential combustion promoters in this report.

6.1 Group A

These are natural organic fibres, which have no thermal insulating value, and are combustible when exposed to flame. They are oleophilic (oil-attracting), but do absorb water to some degree.

6.1 Group A: Summary Sheets

NAME: *CANSORB A*

COMPOSITION:	sphagnum peat moss, subjected to heat treatment
DISTRIBUTOR:	Annapolis Valley Peat Moss Company, Ltd. Berwick, Nova Scotia Canada B0P 1E0
MINIMUM ORDER SIZE:	one bale (0.112 m^3; 14 kg)
COST:	$4.25/bale
BULK DENSITY:	120 kg/m^3
COMBUSTIBILITY:	combustible
SHELF LIFE:	indefinite if shielded from direct sunlight
TOXICITY:	non-toxic to humans or marine organisms; after burning, ashes sink below water, posing no pollution hazard
APPLICATION METHOD:	manual; blower; air-drop (suggested).
OIL SPILL EXPERIENCE/TESTS:	- manufacturer's data; - no test data or oil spill cleanup experience reported.

Additional information on this material when used as a sorbent:

APPLICATION RATE:	material to oil 1:1.25-1.41 by volume

6.1 Group A: Summary Sheets (continued)

NAME: *PEAT MOSS*

COMPOSITION:	natural organic fibre
DISTRIBUTOR:	local nurseries and garden centres
MINIMUM ORDER SIZE:	4 kg (estimate, Roberston et al, 1976)
COST:	$0.63/kg (4 kg min.) (estimate, Roberston et al, 1976)
BULK DENSITY:	82 to 171 kg/m^3
COMBUSTIBILITY:	combustible
SHELF LIFE:	indefinite if stored in cold, dry location
TOXICITY:	non-toxic to humans or marine organisms
APPLICATION METHOD:	manual; blower; air-drop (suggested)
OIL SPILL EXPERIENCE/TESTS:	- combustion promoter use, RAPHAEL (Emasalo, Finland) oil spill cleanup (Coupal, 1972 and McLeod, 1972); - absorbs eight times its weight in oil (Laboratory test, Robertston et al, 1976).

Additional information on this material when used as a sorbent:

APPLICATION RATE:	material to oil 1:8-12 by weight
EFFECTIVENESS:	the moisture content of dry material should be less than 15%; material sinks when wet.
OIL SPILL EXPERIENCE/TESTS:	- limited-scale use, ARROW (Nova Scotia) oil spill cleanup.

6.1 Group A: Summary Sheets (continued)

NAME: *SAWDUST*

COMPOSITION:	natural organic fibre
DISTRIBUTOR:	local sawmills and lumber suppliers
MINIMUM SIZE:	inapplicable
COST:	negligible, exclusive of the costs for shipping, handling, packaging, etc.
SPECIFIC GRAVITY:	unknown
COMBUSTIBILITY:	combustible
SHELF LIFE:	indefinite if kept dry
APPLICATION METHOD:	manual; blower (suggested); air-drop (suggested).
OIL SPILL EXPERIENCE/TESTS:	- no oil spill cleanup experience reported

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Additional information on this material when used as a sorbent:

APPLICATION RATE:	material to oil 1:3-4 by weight (Schatzberg, 1971)
EFFECTIVENESS:	recommended for Bunker C, heavy crude, light crude, and No. 2 fuel oils

6.1 Group A: Summary Sheets (continued)

NAME: *SLICKWIK*

COMPOSITION:	natural organic fibre (ground corn cobs)
DISTRIBUTOR:	Ashwell Feeds, Ltd. 139 Millwide Drive Toronto, Ontario
MINIMUM SIZE:	one bag (17 kg)
COST:	$4.50/bag
BULK DENSITY:	141 kg/m^3
COMBUSTIBILITY:	combustible
SHELF LIFE:	indefinite if stored in plastic bags
TOXICITY:	non-toxic to humans or marine organisms; may cause eye irritation
APPLICATION METHOD:	manual; blower; air-drop (suggested).
EFFECTIVENESS:	recommended for fresh crude oils and distillate fuels
OIL SPILL EXPERIENCE/TESTS:	- no oil spill cleanup experience reported;

Additional information on this material when used as a sorbent:

APPLICATION RATE:	unknown material to oil 1:4-5 by weight (Schatzberg, 1971 and Robertson et al, 1976).

6.1 Group A: Summary Sheets (continued)

NAME: *SORB-OIL*

COMPOSITION:	natural organic fibre (recycled fibre board)
DISTRIBUTOR:	McArthur Chemical Company, Ltd. 62 Arrow Road Weston, Ontario Canada M9M 2L9
MINIMUM SIZE:	one carton
COST:	$30/carton
SPECIFIC GRAVITY:	unknown
COMBUSTIBILITY:	combustible
SHELF LIFE:	indefinite if stored in dry location
TOXICITY:	non-toxic to humans or marine organisms
APPLICATION METHOD:	manual; blower (suggested for chips); air-drop (suggested for chips).
OIL SPILL EXPERIENCE/TESTS:	- no oil spill cleanup experience reported

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Additional information on this material when used as a sorbent:

APPLICATION RATE:	material to light crude oil 1:10 by weight; material to heavy crude oil 1:18 by weight; material to Bunker C oil 1:21 by weight (Schatzberg, 1971).
EFFECTIVENESS:	recommended for Bunker C, heavy crude, and light crude oils

6.1 Group A: Summary Sheets (continued)

NAME: *STRAW*

COMPOSITION:	natural organic fibre
DISTRIBUTOR:	local agricultural outlets
MINIMUM SIZE:	unknown
COST:	($0.26 to $0.037/kg) (Robertson et al, 1976)
BULK DENSITY:	less than 993 kg/m^3
COMBUSTIBILITY:	combustible
SHELF LIFE:	indefinite if protected from moisture, heat and bacteria
TOXICITY:	non-toxic to humans or marine organisms
APPLICATION METHOD:	manual; mulcher; air-drop (suggested).
OIL SPILL EXPERIENCE/TESTS:	- test as a combustion promoter, U.S. Environmental Protection Agency - 80% effective in elimination of two litres No. 6 fuel oil (Byers/Freiberger, 1971); - tested as a combustion promoter with Prudhoe Bay crude oil (Glaeser/Vance, 1971).

Additional information on this material when used as a sorbent:

APPLICATION RATE:	material to oil 1:5 by weight (Robertson et al, 1976)
EFFECTIVENESS:	recommended for fresh and weathered crude oil, Bunker C, and distillate fuels; sinks if saturated with light distillate fuels.
OIL SPILL EXPERIENCE/TESTS:	- used extensively as a sorbent at Santa Barbara oil spill cleanup (Stehle, 1970); - absorbs two to six times its weight in oil (laboratory test, Schatzberg, 1971).

6.2 Group B

These are processed minerals and chemicals into which oil is absorbed. These materials have a definite thermal insulating value but do not necessarily exhibit selective oil absorption. Once distributed within the oils layer, the thermal insulating value of the oil layer is increased.

6.2 Group B: Summary Sheets

NAME: *CAPILLARDIAMIN*

COMPOSITION:	urea formaldehyde foam produced from the combination of two aqueous solutions
DISTRIBUTOR:	U.F. Chemical Corporation 37-20 58 Street Woodside, N.Y. U.S.A. 11377
BULK DENSITY:	11 kg/m^3
COMBUSTIBILITY:	combustible
MELTING POINT:	220°C
SHELF LIFE:	aqueous solutions: approx. six weeks
TOXICITY:	highly toxic vapours released during combustion; non-toxic to humans and marine organism as a foam
APPLICATION METHOD:	mix the two aqueous solutions near oil spill site, and place the mixture under the oil slick: foam sets between 15 minutes and two hours after mixing (suggested); manual: foam chips 1.27 to 2.54 cm in diameter; air deployment of chips (suggested).
OIL SPILL EXPERIENCE/TESTS:	- pilot operation at Santa Barbara (Battelle, 1972); - absorbs 30 to 50 times its weight in oil (Battelle, 1972 and Robertson et al, 1976).

Additional information on this material when used as a sorbent:

APPLICATION RATE:	481 to 641 kg/m^3
EFFECTIVENESS:	recommended for Bunker C and fresh crude oil, and distillate fuels; ineffective as a sorbent for oils having high viscosities.

6.2 Group B: Summary Sheets (continued)

NAME: *FIBREPERL*

COMPOSITION:	expanded perlite (aluminium silicate) and cellulosic fibre
MANUFACTURER:	DISTRIBUTOR
Brefco, Inc. Control Products Unit 3450 Wilshire Blvd. Los Angeles, Calif. U.S.A. 90010	John Misener Marine Equipment Ltd. P.O. Box 278 Marina Road Port Colbourne, Ontario Canada L3K 5W1
MINIMUM SIZE:	one bag (0.112 m^3; 8 kg)
COST:	\$9-\$10/bag depending upon order size
BULK DENSITY:	72 kg/m^3
COMBUSTIBILITY:	perlite is incombustibe; cellulose is combustible
SHELF LIFE:	indefinite
TOXICITY:	toxic if inhaled; dust is an irritant
APPLICATION METHOD:	manual; spreader; air-drop (suggested).
OIL SPILL EXPERIENCE/TESTS:	absorbs six to nine times its weight in oil (laboratory test, Schatzberg, 1971)

Additional information on this material when used as a sorbent:

APPLICATION RATE:	material to oil 1:5-7 by weight (Robertson et al, 1976)
EFFECTIVENESS:	recommended for fresh crude oil and distillate fuels; ineffective as a sorbent for emulsified oils; one bag (0.112 m^3; 8 kg) absorbs 34-57 l oil.

6.2 Group B: Summary Sheets (continued)

NAME: *IMBIBER BEADS*

COMPOSITION:	beads composed of cross-linked alkylstyrene polymer
DISTRIBUTOR:	Dow Chemical of Canada, Ltd. Specialty Chemicals P.O. Box 1012 Modeland Road Sarnia, Ontario Canada N7T 7K7
MINIMUM SIZE:	one fibre drum (18 kg)
COST:	\$7.26 to \$10.78/kg depending upon order size
BULK DENSITY:	unknown
COMBUSTIBILITY:	unknown
MELTING POINT:	240°C (Styrene polymers)
SOLVENT COMPATIBILITY:	does not dissolve in organic solvents
SHELF LIFE:	assumed to be indefinite
TOXICITY:	moderately toxic fumes released when burning takes place; non-toxic to humans and marine organisms.
APPLICATION METHOD:	manual; blower (suggested); air-drop (suggested).
OIL SPILL EXPERIENCE/TESTS:	- data supplied by manufacturer - no test data or oil spill cleanup experience reported.

Additional information on this material when used as a sorbent:

EFFECTIVENESS:	absorb up to 27 times their volume in solvents; effective with gasoline, diesel and jet fuels, No. 1, 2 and 3 fuels, oils, chlorinated solvents, and light hydrocarbons; ineffective with highly viscous oils

6.2 Group B: Summary Sheets (continued)

NAME: *SEABEADS*

COMPOSITION: cellated glass beads, 3 to 6 mm in diameter

MANUFACTURER: Pittsburgh-Corning Corporation
Department TR
One Gateway Center
Pittsburgh, PA
U.S.A. 15222
(N.B. Commercial production of this material has ceased.)

BULK DENSITY: 128 kg/m^3

COMBUSTIBILITY: incombustible

SHELF LIFE: indefinite

TOXICITY: non-toxic to humans and marine organisms

APPLICATION METHOD: blower;
air-drop (suggested).

APPLICATION RATE: 0.43 kg/m^2

EFFECTIVENESS: recommended for all oil types having slick thickness of 0.76 mm or greater;
effective wicking action up to -6^{o}C.

OIL SPILL EXPERIENCE/TESTS:

- cleanup of Bunker C slicks following ARROW incident, Nova Scotia: only limited success with unconfined slicks (Byers/Freiberger, 1971 and Batelle, 1972);
- U.S. Navy sea trials (in conjunction with CAB-O-SIL ST-2-O) for Bunker C Oil (Stehle, 1970);
- fumed silica beads used for Prudhoe Bay crude oil (Glaeser/Vance, 1971);
- EPA field tests (1969 and 1970) for No. 6 (Bunker C) fuel oil (Byers/Freiberger, 1971);
- based upon laboratory tests carried out in a 10 ft diameter tank, manufacturer claimed an effectiveness near 100% (Battelle, 1972);
- small-scale tests with crude oil (McGuire, 1972).

6.2 Group B: Summary Sheets (continued)

NAME: *SOL-SPEEDI-DRI*

COMPOSITION:	attapulgite (hydrated magnesium aluminum silicate)
DISTRIBUTOR:	Engelhard Minerals and Chemicals Corporation Menlo Park Edison, N.J. U.S.A. 08817
MINIMUM SIZE:	one bag (23 kg)
COST:	$1.70/bag
SPECIFIC GRAVITY:	2.45
COMBUSTIBILITY:	incombustible
SOLVENT COMPATIBILITY:	inapplicable; it is, however, miscible with all liquids
SHELF LIFE:	indefinite
TOXICITY:	non-toxic to humans or marine organisms
APPLICATION METHOD:	blower (suggested); air-drop (suggested).

Additional information on this material when used as a sorbent:

EFFECTIVENESS:	manufacturer claims Westinghouse Absorption values of 100 for Oil, and 120 for water; has been reported to sink after absorbing petroleum products; has been reported as difficult to apply in windy conditions.
OIL SPILL EXPERIENCE/TESTS:	- limited-scale cleanup of small oil spills by Keystone Shipping Co. (Battelle, 1972); - no test data reported.

6.2 Group B: Summary Sheets (continued)

NAME: *SORBENT C*

COMPOSITION:	Expanded perlite (aluminum silicate), and fibrous wood material (cellulose)
MANUFACTURER:	Clean Water, Inc. P.O. Box 1002 Toms River, N.J. U.S.A. 08753
DISTRIBUTOR:	Hayes, Stewart and Co., Ltd. 100 Dixie Plaza 1250 South Service Rd. Mississauga, Ontario Canada L5E 1V4 Hayes, Stewart and Co., Ltd. 297 Duke Street Montreal, Quebec Canada H3C 2M2
MINIMUM ORDER SIZE:	one bag (0.112 m^3)
COST:	$10.43/bag
BULK DENSITY:	72 kg/m^3
COMBUSTIBILITY:	incombustible
SHELF LIFE:	indefinite
TOXICITY:	non-toxic to humans or marine organisms
APPLICATION METHOD:	manual; mechanical broadcaster; air-drop (suggested).

6.2 Group B: Summary Sheets (continued)

OIL SPILL EXPERIENCE/TESTS:

- oil spill cleanup at Port Reading, N.J. (Battelle, 1972);
- limited-basis use by Keystone Shipping Co. for cleanup of refined petroleums and petrochemicals (Battelle, 1972);
- absorbs approximately nine to the times its weight in oil (laboratory tests, Schatzberg, 1971 and Robertson et al, 1976).

Additional information on this material when used as a sorbent:

APPLICATION RATE: material to No. 2 fuel oil or light crude oil 1:0.61 by volume;
material to heavy fuel oil 1:0.40-0.56 by volume.

EFFECTIVENESS: recommended by manufacturer for Bunker C, fresh and weathered crude oils, and distillate fuels, at temperatures above -23°C.

OIL SPILL EXPERIENCE/TESTS:

- cleanup of three pipeline spills (Battelle, 1972)

6.2 Group B: Summary Sheets (continued)

NAME: *WONDERPERL 1640 (N.B. Information on this material is incomplete.)*

COMPOSITION:	aluminum silicate (perlite)
DISTRIBUTOR:	Perlite Popped Products 12655 E. Imperial Hwy. Santa Fe Springs, California U.S.A. 90670
SPECIFIC GRAVITY:	unknown
COMBUSTIBILITY:	incombustible
SHELF LIFE:	indefinite
TOXICITY:	considered non-toxic to humans or marine organisms
APPLICATION METHOD:	underwater blower; air-drop (suggested).
OIL SPILL EXPERIENCE/TESTS:	- absorbs three to four times its weight in oil (laboratory test, Schatzberg, 1971).

Additional information on this material when used as a sorbent:

APPLICATION RATE:	material to oil 1.5:1 by volume
EFFECTIVENESS:	best results obtained with low-viscosity oils
OIL SPILL EXPERIENCE/TESTS:	- Perlite used for cleanup of oil spills at Santa Barbara and off the French coast following TORREY CANYON disaster (Battelle, 1972).

6.3 Group C

These materials are processed minerals and chemicals treated to be hydrophobic (water-repelling). They are thermal insulators; when inserted in the oil layer, they decrease its thermal conductivity. They also alter the viscosity of the oil if applied in sufficient amounts.

6.3 Group C: Summary Sheets

NAME: *ABSORBENT 1012 (N.B. Information on this material is incomplete.)*

COMPOSITION:	expanded pumice (treated)
DISTRIBUTOR:	Colloid Spilldam, Inc. P.O. Box 861 Brockton, Mass. U.S.A. 02403
BULK DENSITY:	104 kg/m^3
COMBUSTIBILITY:	incombustible
SHELF LIFE:	indefinite
TOXICITY:	non-toxic
APPLICATION METHOD:	manual; spreader; air-drop (suggested).
OIL SPILL EXPERIENCE/TESTS:	- no oil spill cleanup experience reported; - absorbs 4.5 times its weight in oil (laboratory test, Robertson et al, 1976).

Additional information on this material when used as a sorbent:

EFFECTIVENESS:	recommended for Bunker C and crude oils, and distillate fuels.
APPLICATION RATE:	material to oil 2:1 by weight

6.3 Group C: Summary Sheets (continued)

NAME: *AEROSIL R-972*

COMPOSITION:	silicon dioxide, surface-treated with silane
MANUFACTURER:	Degussa, Inc. U.S. Highway 46 Hollister Road Teterboro, N.J. U.S.A.
DISTRIBUTOR:	Philipp Brothers (Canada), Ltd. 1165 Standard Life Bldg. Sherbrooke St., West Montreal, Quebec Canada H3G 1G9
MINIMUM ORDER SIZE:	23 kg
COST:	$2.30 to 3.45/0.454 kg, depending upon order size
SPECIFIC GRAVITY:	not reported
COMBUSTIBILITY:	incombustible
SHELF LIFE:	indefinite
TOXICITY:	not reported
APPLICATION METHOD:	sprayer (suggested); air-drop (suggested).
EFFECTIVENESS:	assumed to function in the same manner as CAB-O-SIL ST-2-O (Byers/Freiberger, 1971)
OIL SPILL EXPERIENCE/TESTS:	not reported

6.3 Group C: Summary Sheets (continued)

NAME: *BIO-SORB*

COMPOSITION:	vermiculite (treated)	
DISTRIBUTOR:	John Dunn and Company, Ltd. 1847 West Georgia Street Vancouver, B.C. (last known address)	Vermiculite is available from local outlets
MINIMUM ORDER SIZE:	not reported	
COST:	not reported	
BULK DENSITY:	80 kg/m^3	
COMBUSTIBILITY:	incombustible	
SHELF LIFE:	indefinite	
TOXICITY:	non-toxic to humans or marine organisms	
APPLICATION METHOD:	blower (suggested) air-drop (suggested).	

Additional information on this material when used as a sorbent:

APPLICATION RATE: material to oil 1:3.5 by weight (Robertson et al, 1976)

6.3 Group C: Summary Sheets (continued)

NAME: *CAB-O-SIL ST-2-0*

COMPOSITION:	silicon dioxide, surface-treated with silane
MANUFACTURER:	Cabot Corporation 125 High Street Boston, Mass. U.S.A. 02110 *(N.B. Commercial production of this material has ceased.)*
BULK DENSITY:	48 kg/m^3
COMBUSTIBILITY:	incombustible
SOLVENT COMPATIBILITY:	dispersible in organic solvents
SHELF LIFE:	indefinite if stored at temperatures less than 199^{o}C
TOXICITY:	unknown for humans or marine organisms
APPLICATION METHOD:	sprayer (through hoses); air-drop (suggested).
APPLICATION RATE:	material to oil 1:10 by weight; smaller ratios for slicks greater than 1 cm thick
EFFECTIVENESS:	recommended for Bunker C, fresh crude, and aged crude oils; minimum oil film thickness between 1.5 and 2 mm for effective combustion; manufacturer claims 98% burning effectiveness with thick oil slicks.
OIL SPILL EXPERIENCE/TESTS:	- oil spill cleanup near Tralhavet Bay, Sweden (Byers/Freiberger, 1971); - U.S. Navy sea trials (with SEABEADS) for Bunker C oil (Stehle, 1970); - burning tests for Prudhoe Bay crude oil (Glaeser-/Vance, 1971); - sea trials carried out at Heard Pond, Wayland, Massachusetts: 15,140 l of No. 5 and No. 6 oils were burned (Battelle, 1972); - test near Boston harbour, Massachusetts: 757 l of No. 2 and Bunker C oils were burned (Battelle, 1972)

6.3 Group C: Summary Sheets (continued)

NAME:	*CALIDRIA ASBESTOS*
COMPOSITION:	chrysotile asbestos, surface-treated
MANUFACTURER:	Union Carbide Corporation Chemicals and Plastics Division 270 Park Avenue New York, N.Y. U.S.A. 10017
DISTRIBUTOR:	Harrisons and Crossfield (Canada) Ltd. 63 Medulla Avenue Toronto, Ontario Canada M8Z 5L6
MINIMUM ORDER SIZE:	one bag (4.5 kg)
COST:	$21/bag
BULK DENSITY:	304 kg/m^3
COMBUSTIBILITY:	incombustible
SHELF LIFE:	indefinite
TOXICITY:	slight irritant; highly toxic if inhaled by humans; possible danger to marine organisms.
APPLICATION METHOD:	scoop; blower; air-drop (suggested).
APPLICATION RATE:	6 - 15 percent material to oil by weight

6.3 Group C: Summary Sheets (continued)

EFFECTIVENESS:

recommended for Bunker C oil, fresh crude, aged crude, and distillate fuels;
ineffective with emulsified oil spills;
absorbs up to 21 times its weight with Bunker C oil, and up to 15 times its weight with heavy crude oil (Schatzberg, 1971);
absorbs three times its weight with light crude and No. 2 fuel oils (laboratory test, Schatzberg, 1971).

OIL SPILL EXPERIENCE/TESTS:

- tested on the Buffalo River;
- application rates for Bunker C, heavy crude, light crude and No. 2 fuel oils stated above (laboratory test, Schatzberg, 1971);
- absorbs three times its weight with light crude and No. 2 fuel oils (laboratory test, Schatzberg, 1971).

6.3 Group C: Summary Sheets (continued)

NAME: *EKOPERL (N.B. Information on this material is incomplete).*

COMPOSITION:	aluminium silicate (perlite), treated to be water-repellent
DISTRIBUTOR:	Grefo, Inc. Control Products Unit 3450 Wilshire Blvd. Los angeles, California U.S.A. 90100
BULK DENSITY:	as low as 96 kg/m^3
COMBUSTIBILITY:	incombustible
SHELF LIFE:	indefinite if kept dry
TOXICITY:	moderately toxic if inhaled (dusty); non-toxic to marine organisms.
APPLICATION METHOD:	manual; sprayer; air-drop (suggested).
APPLICATION RATE:	material to oil 1:5 by weight
EFFEECTIVENESS:	recomended for Bunker C, fresh crude and weathered crude oils, and distillate fuels; manufacturer claims 100% effectiveness.
OIL SPILL EXPERIENCE/TESTS:	- EPA field tests with No. 6 fuel oil (Byers/-Freiberger, 1971); - absorbs three to five times its weight in crude oil (test data by Shell Pipeline Corp., Batelle, 1972).

Additional information on this material when used as a sorbent:

OIL SPILL EXPERIENCE/TESTS:	- cleanup as a sorbent off the French Coast following the TORREY CANYON incident; - oil spill cleanup as a sorbent after the OCEAN EAGLE spill off Puerto Rico (Batelle, 1972); - oil spill cleanup as a sorbent at W. Falmouth, Massachusetts, and Camden, New Jersey (Batelle, 1972).

6.3 Group C: Summary Sheets (continued)

NAME: *MISTRON ZSC*

COMPOSITION:	talc (magnesium silicate) powder, coated with zinc stearate
MANUFACTURER:	Cyprus Mines Corporation United Sierra Division P.P. Box 1201 Trenton, N.J. U.S.A. 08606
DISTRIBUTOR:	Bate Chemical Company, Ltd. 160 Lesmills Road Don Mills, Ontario
MINIMUM ORDER SIZE:	one bag (23 kg)
COST:	$25/bag
SPECIFIC GRAVITY:	2.75 (however, this material floats on water when treated)
COMBUSTIBILITY:	incombustible
SHELF LIFE:	indefinite
TOXICITY:	non-toxic to humans or marine organisms
APPLICATION METOD:	manual; broadcast blower; air-drop (suggested).

Additional information on this material when used as a sorbent:

APPLICATION RATE:	material to oil 2-3:1 by weight (estimated)
EFFECTIVENESS:	recommended for fresh crude oil and distillate fuels; ineffective with heavy fractions or Bunker C oils.
OIL SPILL EXPERIENCE/TESTS:	- oil slick cleanup after the OCEAN EAGLE spill near Puerto Rico (Batelle, 1972)

6.3 Group C: Summary Sheets (continued)

NAME: *PERLITE KING SRD-32*

COMPOSITION:	aluminum silicate (perlite), treated with silicone
DISTRIBUTOR:	Filter Media Company P.O. Box 19156 Houston, Texas U.S.A 77024
MINIMUM ORDER SIZE:	one bag (0.112 m^3; 13 kg)
COST:	$7/bag
BULK DENSITY:	116 kg/m^3
COMBUSTIBILITY:	incombustible
SHELF LIFE:	indefinite
TOXICITY:	non-toxic to humans or marine organisms
APPLICATION METHOD:	insulation blower; broadcast spreader; air-drop (suggested);
OIL SPILL EXPERIENCE/TESTS:	- perlite (not Perlite King SRD-32) used for the cleanup of oil spills at Santa Barbara, and off the French Coast following the TORREY CANYON incident; - no test data reported for this material.

Additional information on this material when used as a sorbent:

EFFECTIVENESS:	manufacturer claims 50 percent oil absorption by weight; recommended for fresh crude oil; lighter oils may not be absorbed as well.

6.3 Group C: Summary Sheets (continued)

NAME: *SANERINGSULL (N.B. Information on this material is incomplete.)*

COMPOSITION:	rockwool, impregnated with phenol formaldehyde resin
MANUFACTURER:	No current manufacturer reported.
SPECIFIC GRAVITY:	not reported
COMBUSTIBILITY:	not reported
SHELF LIFE:	assumed as indefinite
TOXICITY:	not reported
APPLICATION METHOD:	manual; blower; air-drop (suggested).
OIL SPILL EXPERIENCE/TESTS:	oil spill cleanup on the Ume River (Jerbo, 1972)

Additional information on this material when used as a sorbent:

APPLICATION RATE:	material to oil 1:8 by weight (laboratory test, Robertson et al, 1976)

6.4 Group D

These materials are those which alter oil volatility while functionning as combustion promoters. There is only one material presently classified in this group.

6.4 Group D: Summary Sheet

NAME: *PYRAXON*

COMPOSITION:	specific composition unknown; a powder containing an oil-cracking catalyst, plus small amounts of oxidizing agent; Pyraxon liquid is employed as the priming agent (starting fluid).
MANUFACTURER:	Guardian Chemical Corporation 41-45 Crescent St. Long Island City, N.Y. U.S.A. 11101
BULK DENSITY:	1201 kg/m^3
COMBUSTIBILITY:	incombustible
SHELF LIFE:	indefinite if stored below 270°C
TOXICITY:	non-toxic to humans; toxic to marine organisms at concentrations above 1000 ppm
APPLICATION METHOD:	blower; air-drop (suggested).
APPLICATION RATE:	2.4 g/l
EFFECTIVENESS:	- recommended for Bunker C, heavy crude, weathered crude, and heavy residual oils; - ineffective on emulsified or light oils; - oil slicks must be 3 mm or thicker for effective burning; - manufacturer claims 80 to 90 percent burning effectiveness; - ineffective in heavy waves (Battelle, 1972).
OIL SPILL EXPERIENCE/TESTS:	- manufacturer's test with crude oil (Pastuhov, 1969); - EPA field tests with No. 6 fuel oil (Byers/-Freiberger, 1971).

7 REFERENCES

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2. Byers, J., and A. Freiberger, "Burning Agents for Oil Spill Cleanup" Proceedings of Joint Conference on Prevention and Control of Oil Spills, Washington, D.C. pp. 245-51 (June 1971).

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