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National Technical Information Service

AD-A035 137

ULTIMATE DISPOSAL OF OIL AND HAZARDOUS MATERIALS

COAST GUARD
WASHINGTON, D. C.

OCTOBER 1975

Report No. CG-D-36-76
Task No. 4103.10

ULTIMATE DISPOSAL OF OIL AND HAZARDOUS MATERIALS

John F. Leary

October 1975

FEASIBILITY STUDY

Document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

Prepared for

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD
Office of Research and Development
Washington, D.C. 20590

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
CG-D-36-76		

4. Title and Subtitle
ULTIMATE DISPOSAL OF OIL AND HAZARDOUS MATERIALS

5. Report Date
OCTOBER 1975

6. Performing Organization Code

7. Author(s)

8. Performing Organization Report No.

9. Performing Organization Name and Address
U.S. COAST GUARD (G-DET-1/62)
Officer of Research and Development
Washington, D. C. 20590

10. Work Unit No. (TRAIS)
4103.10

11. Contract or Grant No.

12. Sponsoring Agency Name and Address
U. S. Coast Guard (G-DET-1/62)
Officer of Research and Development
Washington, D. C. 20590

13. Type of Report and Period Covered
Final

14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This report covers an investigation of the state of the art of methods available to store and /or dispose of recovered oil and other hazardous chemicals which are the result of a discharge into United States inland and coastal waters. It includes the work accomplished by other organizations, both industry and government.

The report also describes the kinds of materials which likely will be recovered and discusses alternative techniques/systems for storage and disposal. Additionally, it discusses the areas of the Ultimate Disposal Problem which require research and development. It places particular emphasis on the need to establish the most cost effective and environmentally suitable Ultimate Disposal System to satisfy the Coast Guard's needs.

17. Key Words
Oil Pollution
Hazardous Chemicals
Ultimate Disposal

18. Distribution Statement

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	68	4.50/3.00

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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I SUMMARY

The purpose of this investigation was to establish the state of the art of methods available to store and/or dispose of recovered oil and hazardous substances which are the result of a discharge into the open sea. This effort included the review of work accomplished by other organizations both industry and government. The report also describes the kinds of material which might be recovered, and the alternative techniques for storage and disposal and further what elements must yet be developed or tested to satisfy Coast Guard needs.

A. STORAGE

Storage vessels do exist for oil; such as, tankers, tank trucks, barges, steel tanks, collapsible bags, lagoons rail car tanks, etc. Certain hazardous materials may also be stored in these devices.

B. DISPOSAL

Reprocessing or recycling of oil or hazardous materials is the best method of disposal but circumstances may not allow this to take place. Contamination of material and location are all factors which may rule out this method of disposal.

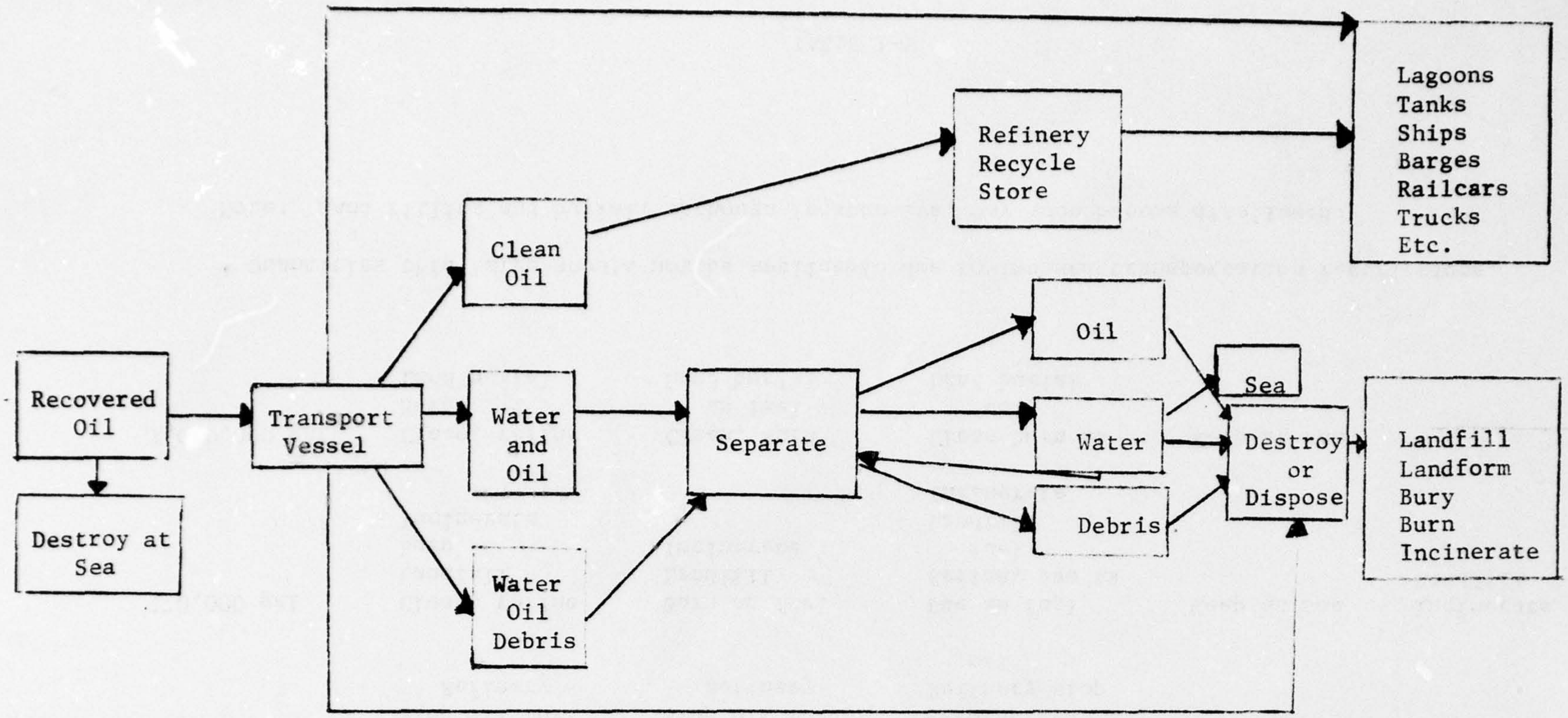
Land forming, land spreading, burning and incineration are all forms of destruction of oil or hazardous substances which may be acceptable (see Table 1-S). Incineration is a method which can be used but may be the most expensive. It will be most cost effective when the quantities are small (10,000 gallons or less in the case of oil). In the vast majority of cases incineration will be effective for hazardous materials, depending on the type, because these spills will be small. This comes about because of the restrictions placed on quantities which may be

transported. (see Fig. 1-S "Flow of Recovered Oil for Disposal). Landfilling, land burial, at sea burial and dumping normally will be the least expensive methods of disposal; however, they are becoming the least acceptable. The methods can allow contamination of surrounding soil or water and therefore, are environmentally less desirable methods. Hardware development will be needed if incineration is chosen as an alternative to be used for disposal of oil and hazardous substances. Burning devices can be used for destruction of large quantities of oil; however, these systems have not been sufficiently evaluated by the Coast Guard.

In the arctic, it is most desirable to dispose of oil or hazardous substances immediately rather than store and confront the possibility of a secondary spill. However, if storage vessels are required it is doubtful whether existing portable containers can withstand the arctic environment. In the case of certain active hazardous substances, present containers and handling equipment may not be adequate. Proper materials for handling these substances must be determined.

C. KNOWN RESEARCH & DEVELOPMENT ELEMENTS

So called portable incinerators for use on shipboard and on a barge which can also be trailer mounted, presently do not meet the Coast Guard 1000 gallon per hour rate requirement except for possibly a barge or ship mounted incinerator. (see Reference 24 "vulcanus") The EPA requirements for a portable incinerator appear to match, the Coast Guard's except for flow rate. EPA will be developing a portable incinerator. The Coast Guard may benefit from this effort. To date, EPA's requirement is for an incinerator, trailer mounted which can handle 100 gallons of oil or Hazardous



FLOW OF RECOVERED OIL
FOR DISPOSAL

Figure 1 - S

PRIORITY FOR DISPOSAL METHODS
FOR CERTAIN SPILL MATERIALS

QUANTITY RECOVERED	CRUDE OIL	RESIDUAL OIL	DISTIALLATE OIL	GASOLINE	HAZARDOUS SUBSTANCES
0-2,700 gal	Landfill Incinerate Slop oil for Refinery	Landfill Incinerate Slop oil for Refinery	Landfill Incinerate Keep at sea Refinery slop oil	Keep at sea	Incinerate
270,000 gal	Clean, refine Landfill Burn Incinerate	Burn as fuel Landfill Incinerate	Use as fuel Refine, use as fuel Landfill Incinerate	Keep at sea	Incinerate Landfill
7,000,000 gal	Clean, refine Burn Land burial	Clean, Burn as fuel Land burial	Clean burn as fuel Land burial	Keep at sea	*________

* Quantities this large should not be applicable due to imposed transportation restrictions.

Note: Land filling and burial, although inexpensive, may soon become disallowed.

TABLE 1-S

material per hour in addition.

Continued research and development of oil/water separators is required to insure sea water will not be brought to land in large quantities.

Materials investigation to insure that storage and other handling equipment will be constructed of substances which will be compatible with hazardous substances is definitely in order.

D. CONCLUSIONS/RECOMMENDATIONS

Further detailed study is required to determine which disposal technique or system, is the most effective to use in a given spill situation, considering overall cost and environmental impact. This is true for oil as well as other hazardous substances but more so for the later substances since little is known about the behavior of many of these chemicals.

For each alternate/system chosen, a program plan is required which will outline the work units, cost and time schedule necessary to arrive at the desired finished system. This will include any research and development found necessary for elements of the systems chosen. See Coast Guard proposed ultimate disposal program plan, Table 2-S.

ULTIMATE DISPOSAL PROGRAM PLAN

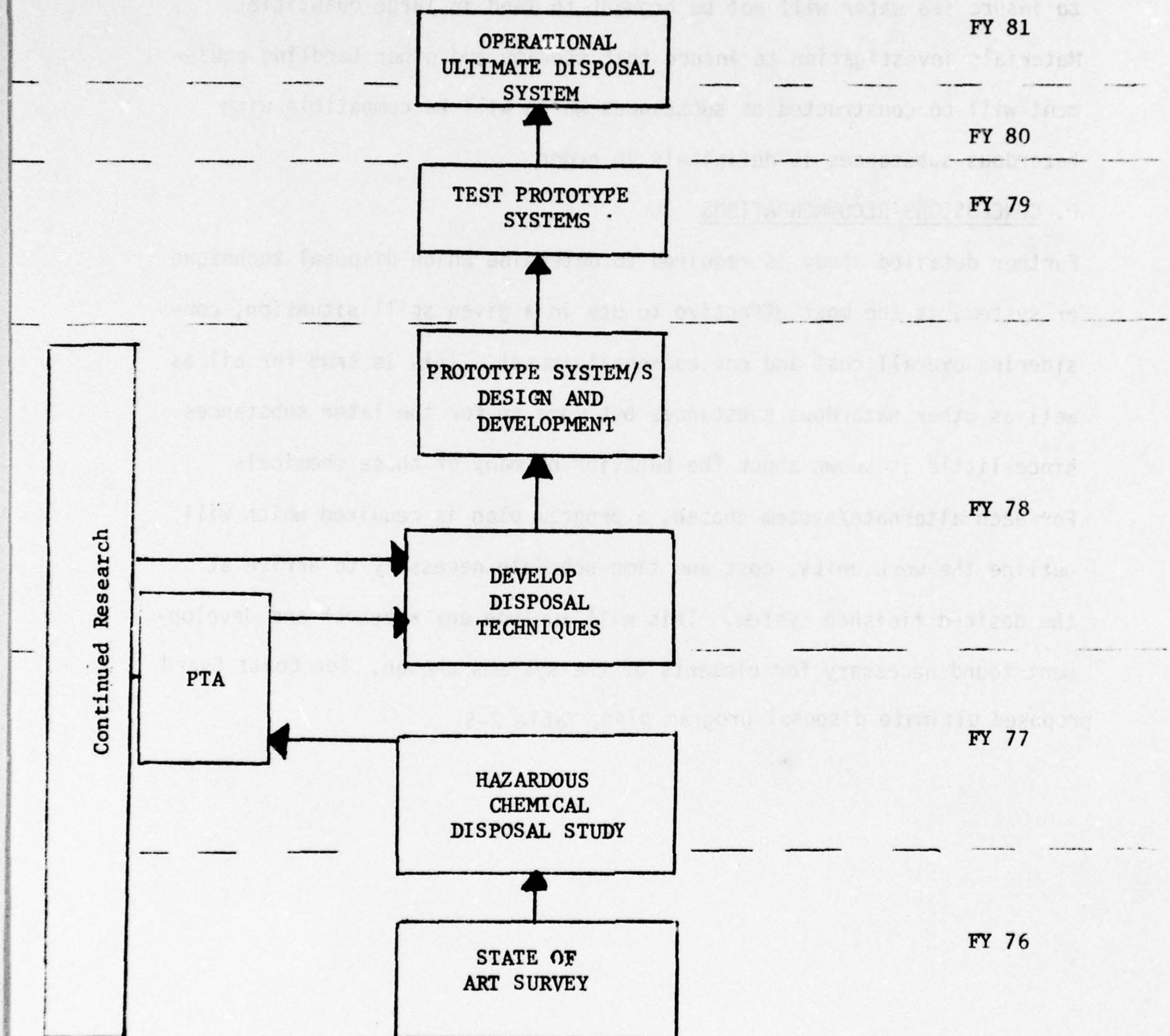


TABLE 2-S

II INTRODUCTION

The Coast Guard is developing Pollution Control devices for the containment and recovery of oil and hazardous materials from the High Seas. Equally important and yet to be developed are systems for the storage and/or ultimate disposal of recovered oil, oily debris, and hazardous substances. Section 311(c), Federal Water Pollution Control Act as implemented by E. O. 11735 and the National Contingency Plan requires the Coast Guard to remove oil spills from U. S. Coastal and Great Lakes waters and adjoining shorelines. Phase IV (cleanup, mitigation and disposal) of the National Contingency Plan requires the disposal of pollutants and contaminated materials that are recovered in cleanup operations in accordance with acceptable federal, state and local procedures.

Local Municipal trash disposal and burial facilities have consistently rejected requests to dispose of oil and oily debris and other hazardous substances.

Experience has shown that one of the most difficult problems on the scene of a spill is the disposal of the recovered materials. This includes, transport, storage, and ultimate disposal.

It is the intention of this report to summarize what already has been accomplished to solve the problem of disposal of pollutants and discuss the possible use of certain of these techniques. This, in effect, will establish the state of the art and from here we can plot our course for additional research and development, if necessary.

For this discussion hazardous substances considered will be those which can be treated as oil. There obviously will be certain materials which will require special treatment beyond that being employed for oil or "oil like" hazardous substances. These materials may require neutralization, long time storage and other measures for ultimate disposal. Present objectives are to be capable of storing 1 million gallons of oil, oily debris, or hazardous substances under temperate and arctic field conditions. It is also desired to be capable of disposing of 1000 gallons of oil, and oily debris, per hour while meeting all state and Federal Safety and pollution requirements. Disposal systems should be capable of field operation at or near the spill scene or point of storage. (see Table 1 Requirements)

TENTATIVE REQUIREMENTS

1. Store up to 1 million gallons of oil oily debris or hazardous substances under temperate and arctic conditions.

2. Dispose of 1000 gallons oil and oily debris per hour.

3. Operate disposal system in the field at or near spill site or spill storage.

4. Disposal system(s) should be portable and/or fixed in order to optimize cost effectiveness while also considering transportability and fast response.

5. Storage and disposal systems should be compatible with other pollution control equipment.

6. Airplane, motorvehicle, and waterborne ship are desirable vehicles to be considered for transporting the portable disposal system.

TABLE 1

III DISCUSSION

Recovered Material:

A high percentage of material to be stored or disposed of as a result of a discharge of oil or hazardous material will be floatable liquid material. It is this material which we will be mainly concerned with in this discussion although other types will be touched upon as well.

The physical state of the materials to be stored or disposed of will be as fluids, solids, semi-solids, or debris or sorbents. The latter could be straw, cotton, or the synthetic sorbents such as polyurethane foam. (See Tables 2 & 3)

A. OIL

Oil spills on the sea will be of four general types: crude oil carried as cargo in tankers or other bulk cargo ships, refined petroleum products also carried as cargo, bunkering fuel, and oil in a bilge-water discharge. The composition of the spilled oil will change as it weathers on the sea surface. The characteristics of typical materials is shown in Figure 1. Although it is not the subject of this discussion to dwell on much of the auxiliary support equipment associated with the disposal of pollution materials it should be pointed out that viscosity of the fluids to be handled is undoubtedly one of the most important engineering parameters to be considered; transfer and handling of fluids can change drastically depending on viscosity. Of course, this will become most important in the arctic where low temperatures may prevail. The subject of transfer systems has been covered adequately by Battelle in both reference 1 and 2.

SORBENTS USED IN OIL-SPILL CLEANUP

Inorganic

Perlite, treated
Glass wool containing oleophilic additives
Vermiculite, expanded and treated
Volcanic ash, expanded and treated

Natural Organic

Corn cob, ground
Peanut hulls, ground
Redwood fiber, shredded
Sawdust, treated
Wheat straw
Wood cellulose fiber, treated
Cotton

Synethetic Organic

Polyurethane foams

A. Polyester type, shredded
B. Polyester type, reticulated
C. Polyester type, 1/2-inch cubes

Urea formaldehyde foam

Polyethylene fibers

A. Wool type
B. Sheet, matted
C. Continuous element, non-woven

Polyester plastic shavings

Polystyrene powder

Polytetrafluoroethylene (PTFE) shavings

See Reference 1

TABLE 2

PROPERTIES OF OIL SORBENTS

	Straw	Polyurethane Foam	Polyethylene Fibers	Corn Cobs	Vermi-culite	Cotton
Oil absorbed (dry) lb/lb	2-6	25-80	16-40	4-6	4	20-30
Water absorbed lb/lb	5	7.5-80	25	4	0.8	1.2-5
Oil Rentention percent	98	66-90	65	85	82	85%

See Reference 1

TABLE 3

MATERIAL VISCOSITIES VERSUS TEMPERATURE

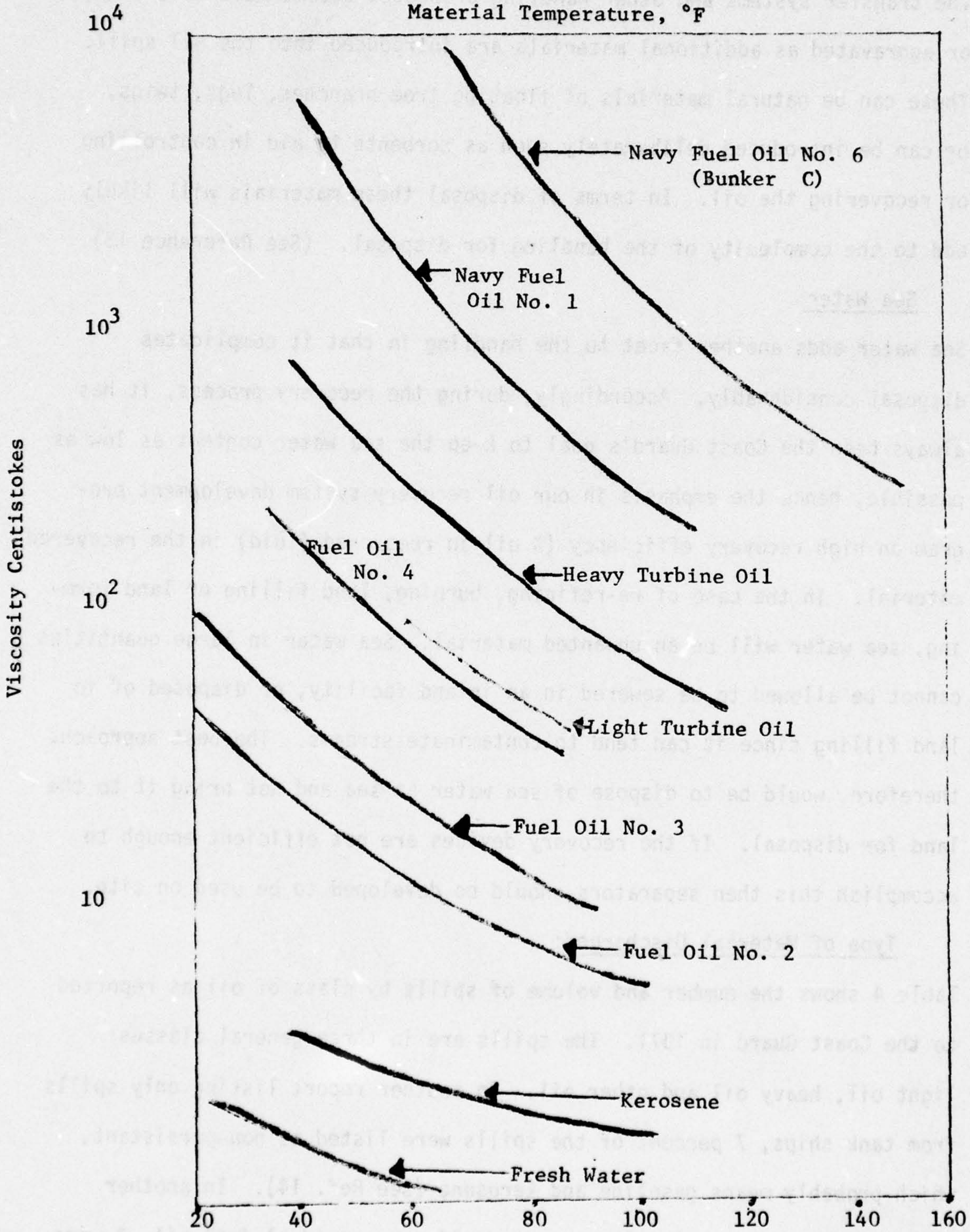


FIGURE 1

See Reference 1

Debris

The transfer systems and other handling processes become much more complex or aggravated as additional materials are introduced into the oil spill. These can be natural materials of floating tree branches, logs, twigs, or can be introduced deliberately such as sorbents to aid in controlling or recovering the oil. In terms of disposal these materials will likely add to the complexity of the handling for disposal. (See Reference 13)

Sea Water

Sea water adds another facet to the handling in that it complicates disposal considerably. Accordingly, during the recovery process, it has always been the Coast Guard's goal to keep the sea water content as low as possible, hence the emphasis in our oil recovery system development program on high recovery efficiency (% oil in recovered fluid) in the recovered material. In the case of re-refining, burning, land filling or land forming, sea water will be an unwanted material. Sea water in large quantities cannot be allowed to be sewered in an inland facility, or disposed of in land filling since it can tend to contaminate streams. The best approach, therefore, would be to dispose of sea water at sea and not bring it to the land for disposal. If the recovery devices are not efficient enough to accomplish this then separators should be developed to be used on site.

Type of Material Discharged:

Table 4 shows the number and volume of spills by class of oil as reported to the Coast Guard in 1971. The spills are in three general classes: light oil, heavy oil and other oil. In another report listing only spills from tank ships, 7 percent of the spills were listed as non-persistant, which probably means gasoline and kerosene (see Ref. 14). In another report listing 38 spills, 18 were crude 15 were residual fuel oil, 3 were

TYPE OF MATERIAL DISCHARGED

	Number of Incidents	% of Total	Gallons	% of Total
Light Oil (Gasoline, Light Fuel Oil, Kerosene, Light Crude)	4,320	49.5	2,822,463	31.9
Heavy Oil (Diesel Oil, Heating Oil, Heavy Fuel Oil, Heavy Crude, Asphalt)	1,603	18.4	2,934,181	33.2
Lubricating Oil	168	1.9	22,365	0.3
Animal or Vegetable Oil	39	0.4	18,957	0.2
Waste Oil	930	10.6	164,352	1.9
Other Oil	462	5.3	2,673,077	30.2
Sewage	24	0.3	2,509	0.0
Refuse and Garbage	56	0.6	336	0.0
Dredge Spoil	15	0.2	168	0.0
Other Material	174	2.0	112,030	1.3
Unknown	945	10.8	89,085	1.0
Total	8,736	100.0	8,839,523	100.0

TABLE 4

distillate fuel oil. Table 5 reported in 1974 shows 26% of the spills were crude oil and of the greatest total volume. From these data, the largest spills will probably be crude oil. Residual and distillate fuel oils will probably be spilled in about equal amounts and volumes. The residual and distillate fuel oils together are spilled about as often as crude, but in much smaller volumes. Spills of gasoline and more volatile materials will probably be small and infrequent and in any case cannot be recovered.

Behavior of Oil at Sea

The characteristics of oil change after spreading at sea as a function of time. Evaporation, oxidation, emulsification, dissolution in the water and biodegradation will cause the oil to disappear in time (See Ref 15). Many oils which are spilled will cause emulsions to form (See Ref 16) which can be found to contain high percentage of water, sometimes as high as 76%. These emulsions containing such large amounts of water approach the density of sea water. Oil is also slightly soluble in water and various components of oil dissolve in the 1 to 100-ppm range. The medium-boiling hydrocarbons which boil at about 500°F dissolve the most. The more volatile fractions are lost by evaporation before they have time to dissolve and the higher boiling fractions are less soluble. (See Ref 17)

Biodegration

The oil which remains in the sea is eventually removed by biodegradation or bio-oxidation. Micro-organisms change the oil which is dissolved in the water, some perform at the oil water interface, and some actually live in the oil. (See Ref. 18) Biodegradation is a long term destruction process and does not lend itself to the large spill. Work is being done by General Electric's Research and Development Organization, as well as in

TYPE OF MATERIAL DISCHARGED

	Number of Incidents	% of Total	Volume of Gallons	% of Total
Crude Oil	3,639	26.0	9,028,262	53.0
Gasoline	545	4.0	1,045,603	6.0
Other distillate fuel oil	322	2.0	1,824,130	11.0
Solvent	44	0.0	13,114	0.0
Diesel Oil	1,833	13.0	1,120,862	7.0
Asphalt or residual fuel oil	1,127	8.0	1,908,752	11.0
Animal or vegetable oil	57	0.0	27,316	0.0
Waste Oil	1,094	8.0	111,900	1.0
Other Oil	2,774	21.0	728,497	4.0
Liquid Chemical	222	2.0	913,027	5.0
Other Pollutant (Sewage, dredge, spoil, chemical wastes, etc.)	162	1.0	31,792	0.0
Natural Substance	105	1.0	1,528	0.0
Other Material	199	1.0	104,709	1.0
Unknown Material	1,843	13.0	56,816	0.0
Total	13,966	100.0	16,916,308	100.0

1974 Report by U. S. Coast Guard
(Reference 30)

TABLE 5

others, in examining suitable microrganisms for oil destruction; however, much is yet to be accomplished before this technique could ever by itself, be considered for Coast Guard use as a disposal method. It could possibly satisfy the final cleanup requirements in the shorter run.

Storage of Oil

Upon recovery of spilled oil some kind of storage device will be required. If the oil is not destroyed immediately at the spill scene but transported to another location, storage will also be required on that end of the operation.

The location of the spill may dictate the kind of storage device used. At sea a transport vessel will normally be required depending on the size of the spill. Collapsible bags can also be used as well as storage barges. The draft of the device and also the depth of the body of water will be a determining factor. Inland sites can use steel tanks, collapsible bags, railtank cars, gondola cars, tank trucks, and dump trucks depending on the particular situation. Table 6 shows the type of storage facilities available through sizes, limitations and kinds of material which can be stored. With regard to lagoons they would require a lining in order that the oil would not leak out to the surrounding soil. Table 7 shows a list of the type materials which could possibly be used and some of their physical and chemical characteristics. (Ref. 1)

Water Removal

Depending on the disposal method used, removal of water may or may not be required. Most refineries have some requirement for maximum water content of oil. Any disposal procedure which would allow large quantities of sea water to be deposited inland would certainly be prohibited. Sea water should be left at sea if at all possible.

STORAGE FACILITIES

Type	Smallest Size, gal	Largest Size, gal	Limitations
Tankship	50,000	25,000,000	Liquid only
Barge	5,000	250,000	
Steel Tank	No limit	11,000,000	Liquid only
Collapsable bag	No limit	210,000	Liquid only
Lagoon	No limit	No limit	
Pit	No limit	No limit	Dry solids only
On ground	No limit	No limit	Dry solids only
Rail tank car	5,000	15,000	Liquid only
Rail gondola car	5,000	15,000	Dry solids only
Tank truck	500	5,000	Liquid only
Dump truck	500	9,000	Dry solids only

See Reference 1

TABLE 6

PROPERTIES OF COMMONLY USED LINING MATERIALS

Property	Polyethylene Low Density	Polyethylene High Density	Polyvinyl Chloride	Chlorinated Polyethylene	Polypropylene	Nylon	Butyl Rubber	Natural Rubber	Hypalon
Specific gravity	0.92-0.94	0.94-0.96	1.20-1.5	1.35-1.39	0.9-0.91	1.08-1.4	0.92-1.25	0.91-1.25	
Tensile strength, psi	1,300-2,500	2,400-4,800	3,500-10,000	1,800 min.	4,000-32,000	9,000-11,000	1,000-4,000	1,000-3,500	1,000-2
Elongation, %	200-800	10-650	60-200	375-575	40-400	250-550			
Shore "A" hardness							15-90	20-100	55-95
Operating Temperature range, F	-70 to 180	-70 to 240	-60 to 200	-40 to 200	-60 to 220	-60 to 380	-50 to 325	-70 to 250	-45 to
Resistance to acids	P-G	G	G-E	G-E	G-E	P			G
Resistance to bases	G-E	G-E	G-E	G-E	G-E	E			G-E
Resistance to oxygenated solvents	P-G	P-G	G	P					G
Resistance to aromatic and halogenated solvents	F	F	G	P	G	G	P	P	F
Resistance to aliphatic (petroleum) solvents	P-F	F-G	G	G	G	E	P	P	G
Water vapor permeability, perm mils	3-14	1.8-2.2	3-18	0.040-0.048	0.25-1	0.09-1.0	0.15		2.0

TABLE 7

PROPERTIES OF COMMONLY USED LINING MATERIALS

Property	Polyethylene Low Density	Polyethylene High Density	Polyvinyl Chloride	Chlorinated Polyethylene	Polypropylene	Nylon	Butyl Rubber	Natural Rubber	Hypalon
Weatherability	P	P	G	E	P	F	G	F	E
Time to crack, hr	900	300	No crack till 2,500 hr	No effect to 4,000 hr	100	1,200			
Time to chalk, hr	No effect till 2,500 hr	600	300	Ditto	600	No effect till 2,500 hr			
Time to fade, hr	300	300	100	Ditto	900	200			

NOTE: Data not shown were unavailable. P = Poor, F = Fair, G = Good, E = Excellent.

TABLE 7 CONT'D

Separation, therefore, can be accomplished in may ways; gravity, by centrifuge or by Electrostatic Coalescers. Reference 1 explains all of these techniques and when a specific technique might be most profitably used.

Disposal Methods

The methods of disposal of oil are:

(a) Recycling

(b) Complete destruction

(c) Landfilling

(d) Degradation by the sea

What to do with recovered material from the sea will depend on many conditions, such as:

(a) Proximity to shore line.

(b) Size of spill

(c) Conditions of material recovered

(d) Remoteness of spill, such as the arctic area

(e) Other environmental, physical and economic considerations (See Table 8)

Reprocessing

Using the retrieved oil as a saleable product directly is the simplest method of disposal. Recycling or reprocessing is also one of the best methods of disposal for reasons of economy of resources and monetary value. Recovered oil, since it has lost much of the low boiling fractions, would be best mixed with fresh crude.

Recovered oil (See Figure 2) would undoubtedly require some sort of screening to eliminate the debris collected in the recovery process, sea water separation would also be required. There is a high probability,

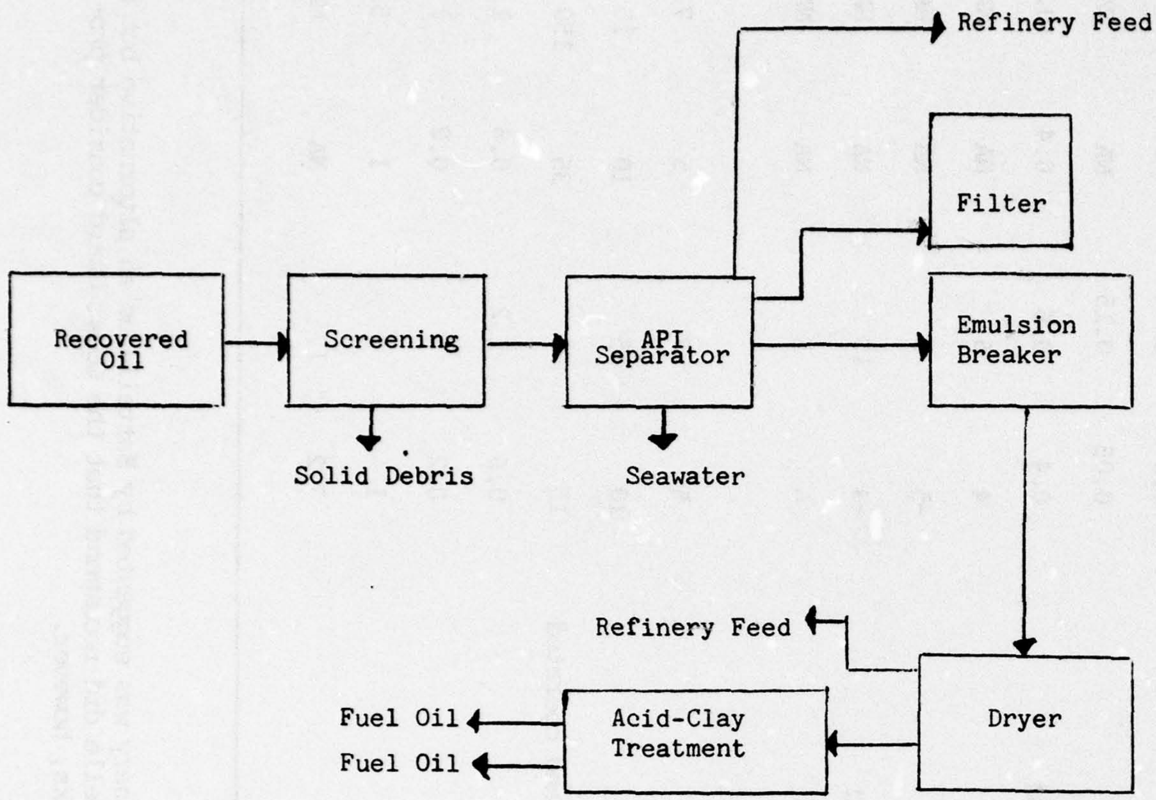
COSTS FOR STORAGE, DEWATERING,
SHIPPING, AND ULTIMATE DISPOSAL

	Liquid Range of Costs, cents/gal		Solids Range of Costs, cents/gal	
	Low	High	Low	High
Lagoon Storage	0.5	3	0.5	3
Dewatering	0.05	0.15	NA	NA
Truck Shipping (local)	0.4	0.6	0.4	0.6
Re-refinery	4	6	NA	NA
Refinery	-5	5	NA	NA
*Refinery, Coast Guard	-4	13	NA	NA
Road Oiling	0	5	NA	NA
Incineration				
Municipal	5	7	5	7
Waste Disposal Co.	10	15	10	15
Coast Guard owned and operated	15	50	35	150
Sanitary Landfill	0.6	1.2	0.6	1.2
Uncontrolled Dump	0.2	1	0.2	1
Land Burial	1	5	1	5
Land Spreading	7.2	17	NA	NA

NA - Not Applicable

* A Coast Guard refinery was suggested by Battelle as an alternative but not recommended. Battelle did recommend that the Coast Guard consider providing storage tanks, however.

TABLE 8



FLOW DIAGRAM FOR REPROCESSING OF RECOVERED SPILLED OIL

See Reference 1

Figure 2

in the case of many of the crude oils, that an emulsion breaker will be required. After the emulsion is removed the oil is then dried (drying means water is then removed completely). It can be used at this point for a refinery feed or further processed through an acid clay treatment to be used as a fuel oil or a road oil. (Ref. 7)

Land forming

One oil company is developing a land forming technique (Ref 12) for the Environmental Protection Agency in which oily sludges are spread over soil, cultivated, and decomposed by bacteria. It has been demonstrated that about 3,000 gals/acre-month can be decomposed during the summer. When the temperature drops below 50°F decomposition stops. The oil is applied to a soil layer 6 inches deep at a rate of about 1 gal/ft3 or 20,000 gal/acre. This is still an experimental approach.

Land spreading can also be used and that is to spread oil on the surface of a farmland area and not use it for one year and allow the oil to decompose then farm the following year. Rates of disposal are estimated to be 70 bbls/acre/mo. at costs ranging from $3.00/barrel to $7.00/barrel depending on the type oil.

Activated-Sludge Treatment

This is essentially a sewage treatment process. The oily sludge can be injected with oil-decomposing bacteria. Both the activated-sludge and the land spreading techniques are in the experimental stages and require further research. (Ref. 1 and Ref. 12)

Landfilling

Recovered oil can also be disposed of by landfilling, land burial or dumping. Landfilling is a so-called "sanitary land filling" process whereby the material is carefully covered with soil within a short period of time as is all refuse. Land burial is essentially the same except that the burial place is dedicated only for oil or oily debris. Dumping is the old fashioned method of disposing in some remote area where refuse is disposed. This later disposal method is becoming less popular with all types of refuse, because of the unsanitary aspects of the process. In spite of this fact, dumping is the main method of disposal in many parts of the United States.

Burning

Recovered oil, if properly handled, could also be disposed of by burning in high flow oil burners which are presently available and capable of burning over 250 gallons per minute which approaches our High Seas Oil Recovery Systems recovery rate. These devices can be barge mounted or ship mounted. (see Appx I and Ref. 28)

Incineration

Disposal by incineration is a method which could completely dispose of oil and oily debris from an oil spill. This method is final and is applicable to a wide range of waste oil types, compositions, and volumes, It can be used to dispose of oil and oily wastes which contain large amounts of water and solid debris. Municipal fixed installation incinerators can presently dispose of oil. Chemical waste disposal companies operate incinerators for the destruction of noxious chemicals. Some plants are available which have capacities up to 26,000 gallons per day. Sea water disposal would not be a problem in this type of facility and materials containing up to 50% sea water could be handled. These plants would charge 10-15 cents per gallon to incinerate. Some additional information on incineration concerning costs to handle liquid waste and solid waste can be found in Table 9.

SUMMARY OF FIXED INSTALLATION INCINERATOR COSTS

		Liquid Waste (100 gal/hr)	Solid Waste (325 lb/hr)
Equipment Cost (Installed)	$	76,000	105,000
Operating Cost [(a)]	cents/gal	47	400
	$/ton		550
Operating Costs [(b)]	cents/gal	16	140
	$/ton		185

(a) At 30 days per year operation

(b) At 300 days per year operation

See Reference 1

TABLE 9

These values might be adjusted slightly upward due to inflation, since these estimates are based on 1972-1973 time frame.

Municipal Incinerators (Fixed Installations)

These incinerators can be used to take oil and debris filled oil; however, they are not normally designed to handle the heat of combustion of oil since it is much higher than that of ordinary refuse which they handle. The sodium in oil can destroy the refractories and the chlorides can destroy the heat exchanger surfaces inside. The high heat problem can be alleviated by mixing with the refuse and the refractory and heat exchanger problem can solved by removing the salt before incineration. The capacity of present day municipal incinerators is in the range of 500 to 1000 tons of refuse per day. Approximately 5 to 10 percent additional could be handled on any given day. This would be 25 to 100 tons per day or 7000 to 27,000 gallons per day. (Ref. 1 also Ref. 23) Refuse incineration costs about five dollars per ton. Since incinerator capacity is limited by heat released and oil has about three times the heat content of refuse, an estimated cost for oil incineration is fifteen dollars per ton or 5 to 6 cents per gallon.

Portable Incinerators

These incinerators are available but not to handle very large quantities of oil. Presently, designs are available to handle in the neighborhood of 100 gallons per hour. This size unit can be transported with considerable ease. It is estimated that the cost of one of these devices, "Off-the-shelf" would be $75,000 or more. (See Appendix III for dimensions, weight etc., of such a device) (also Reference 29). To do an adequate job in a reasonable time at a large spill 20 or more of these units would be needed at the spill site. The Environmental Protection Agency has developed a request for proposal for a portable incinerator which will be trailer mounted and will be capable of detoxification and incineration of non-reusable or non-recoverable wastes during on-site cleanup of oil or hazardous materials. (Ref. 5) This effort was discontinued due in part to funding problems and also due to EPA's difficulty with procurement of a French design. The EPA, as previously mentioned, have reviewed the technology and found it necessary to consider a development program for the construction of a portable incinerator. A review of the U. S. industry and goverment and foreign technology by J. Leary, USCG Research and Development indicates that there is no system presently being considered which would satisfy the Coast Guards needs in the form of a portable incinerator. Several open pit type incinerators were built by both U. S. industry and the Canadians; however, these devices cannot meet the specifications pertaining to effluent, either gaseous or particulate; (Ref. 26, Ref. 27, Ref, 31, Ref. 32, Ref. 33, Ref 39) further, they could not be used safely aboard ship.

Certain improvements in the technology could be undertaken to increase the flow rate and safety and endurance of the devices. Cooling of the walls could be considered to reduce radiation, use of better materials to decrease destruction by sea water and erosion by other gases and salts. Development of scrubbers could be undertaken to reduce the size, if possible.

Capacities of disposal Techniques

Disposal operations have different minimum and maximum capacities that can be handled. They are not so well defined but depend largely upon the particular facility. Table 10 shows comparative ranges of capacity

CAPACITY OF AVAILABLE DISPOSAL METHODS

	Minimum Quantity, gal	Total Daily Capacity, gal	Storage Capacity, gal
Incinerator, Chemical	50	26,000	1,000,000
Incinerator, Municipal	N O N E	26,000	N O N E
Re-refinery	5,000	40,000	2,000,000
Sanitary Landfill	N O N E	50,000	N O N E
Uncontrolled Dump	N O N E	10,000	N O N E
Land Burial	1,000,000	No limit	N O N E
Refinery	40,000	5,000,000	40,000,000
Waste Oil Company	1,000	20,000	200,000
High Flow Oil Burners	--------	360,000	-------

TABLE 10

for handling oil. The minimum capacity shown for refineries and re-refineries are related by operators as a nuisance rather than a limitation to the method. Maximum capacities are not so clearly defined either, its a matter of what excess capacity is available in the particular process. Solid debris can be incinerated at about the same rate as liquid oil. Landfills can accept debris so long as the quantity does not interfere with normal operation or prematurely fill the landfill. Large landfills can accept several thousand tons per day. The High flow oil burners which burn oil in the open atmosphere are capable of matching our present oil recovery systems, if the oil is free of heavy debris when entering the burner. (Ref. #4)

Arctic

Conventional methods of temporary storage and ultimate disposal of oil recovered from spills are grossly inefficient or may not handle products of high viscosity (100,000 ssu). The effects of the interaction with ice and snow and cold sea water are not completely understood for a wide range of oils. Burning has been the most highly recommended technique to be used for the disposal of oil at sea. For information concerning burning techniques applicable to arctic areas (See Reference 2). Destruction of oil by burning can be accomplished by open air burners, burning on the water surface or by incineration in a closed chamber. As stated earlier closed chamber burning or incineration is limited in the quantities of oil which can be handled; however, open flame burners can handle quantities of oil which match present day recovery rates. One burner is now capable of burning over 250 gallons per minute. These burners could be fitted to operate in Arctic or temperate climate. They could operate on land or while attached aboard ship. The oil can be fed directly to them from the recovery equipment or from a storage container. (See Appendix I) also (Reference 28 and 31).

The temporary storage of recovered oil in the arctic will be troublesome due to the snow and ice and permafrost. Existing facilities will only be used when in close proximity to the spill site. If the material can not be burned immediately the best storage method will probably be pillow tanks or portable pools with rigid sides. These containers can be erected with a minimum of labor and are relatively inexpensive. The open pool must be covered in order not to allow overflow due to snow load. The bags and portable pools should be constructed of heavy material in order to prevent breaks from occurring and thus avoiding a secondary spill. According to the Battelle report (Reference #2) natural features in the artic can be used for temporary storage of oil in the case of large spills. Petroleum companies at Prudhoe Bay have developed contingency plans to use local thaw lakes for emergency oil storage.

B. <u>HAZARDOUS SUBSTANCES</u>

<u>Hazardous Chemicals</u>

Hazardous substances are those materials referred to in the Federal Register volume 39 number 164, pages 30467-71, August 22, 1974 and in the CHRIS list by the U. S. Coast Guard (CG-446-1, January 1974) (CHRIS - chemical Hazards Response Information System).

A considerable number of hazardous materials will behave similar to oil and could be disposed of in the same manner as oil. On the other hand, oils, especially the crudes with high sulfur content, can also be treated as hazardous materials especially in the case where they might be burned or incinerated since they can produce considerable quanitities of SO_2 and

NO_x which are hazardous materials (See Appendix II). Further, anything that is incinerated using atmospheric air directly, which contains Nitrogen, of course, will produce NO_x which is hazardous (Reference #8). Much like an oil spill, a release of a hazardous material could contaminate a wide area if not controlled. Control, recovery or amelioration of a hazardous material will have a great effect on the physical characteristics of what must be disposed of finally, if such ultimately is required. Treatment of released gaseous materials is certainly going to be different than that of liquids or solids. Since the Coast Guard is primarily concerned with spills which will become water borne, understanding the behavior of hazardous materials when in contact with water will be of great importance.

Some materials, after making contact with the water, will sink, some will float and others, such as the cryogens, will be released to the atmosphere.

There is a high probability that those materials released to the atmosphere or which tend to be released to the atmosphere; such as cryogens will not be candidates for disposal in the sense that we need to recover and deliberately destroy, bury, burn or incinerate. The amelioration of these materials was discussed quite extensively in Reference 9 by Battelle. Those materials most likely to require ultimate disposal in the sense that we must burn, bury or otherwise dispose will undoubtedly be the floating or sinking material.

Storage

As with the oil spill, the first step after recovery will be to contain the material in a suitable storage device. In many cases, the storage container used for oil will suffice; however, there are a variety of hazardous substances which will certainly attack chemically, materials now used to contain oil. Determination of these materials must be made, not only for skimmers, booms, etc., but also for storage containers. The hazard properties of 39 substances likely to be encountered are listed in Reference 9. (See Table 11)

Disposal

Many of the possible disposal techniques have been discussed earlier and also in Reference 9. Some of these are as follows:

a. Dilution - This method may be accomplished naturally or by forced technique the later accomplished when the waters are very still. The mixing can be accomplished by some method of agitation causing the material to be dispersed and thus be diluted by the body of water.

b. Neutralization - For water soluble substances neutralizing agents can be used to reduce the hazards associated with the spill and thus dispose of the material in the body of water. Similarly, precipitation agents can be added which will cause the material to sink and if necessary later be dredged from the bottom.

c. Chelation - Complex formation of the atomic structure may be accomplished to remove heavy metals from solution, one example is that of zinc chloride. One of the most widely used chelating agents is ethylene diamine tetracetic acid (EDTA). As is with other chemical additives there is always danger that the reaction may yield additional toxic substances to the water. Chelation is a rather controversial subject.

d. Sorption - physical sorption of hazardous releases can be accomplished. The recovery of the sorbed material and the sorbent now must be disposed of, therefore, the sorbent may tend to compound the ultimate disposal problem, although it may be an aide to the control and recovery of the spilled substances.

LIST OF HAZARDOUS CHEMICALS*

1. acetic acid (AAC)	21. liquified natural gas (LNG)
2. acetone cyanohydrin (ACY)	22. methyl chloride (MTC)
3. acronlein (ARL)	23. molasses (MOL)**
4. acrylonitrile (ACN)	24. nitric acid (NAC)
5. anhydrous ammonia (AMA)	25. oleum (OLM)
6. benzene (BNZ)	26. phenol (PHN)
7. butadiene inhibited (BTI)	27. phosphorous (PPR)
8. n-butylene (BTN)	28. sodium cyanide (SCN)
9. butylene (BTN)	29. styrene (STY)
10. calcium fluoride (CAF)	30. sulfur (SXX)
11. carbon tetrachloride (CBT)	31. sulfuric acid (conc.) (SFA)
12. caustic soda (CSS)	32. sulfuric acid (spent) (SAC)
13. chlorine (CLX)	33. tetraethyl lead (TEL)
14. epichlorohydrine (EPC)	34. toluene (TOL)
15. ethane (ETH)	35. undecanol (UND)
16. ethylene (ETL)	36. vinyl chloride (VCM)
17. ethyleneimine (ETI)	37. vinyl chloride (VCM)
18. hydrochloric acid (HCL)	38. xylene (XLM, XLO, XLP)
19. hydrofluoric acid (HEA)	39. zinc chloride (ZCL)
20. hydrogen chloride (HDC)	

* Note: This is not a complete list of Hazardous Chemicals.

** Abbreviation assigned by Battelle. Other abbreviations are from Hazard Assessment Computer System, U. S. Coast Guard.

TABLE 11

e. Biodegradation - Water borne organic substances can be disposed of by biodegradation; however, in most instances it will be a lengthy process. A variety of cultures each of which is applicable to a specific substance to be degraded must be stored in order to have this technique used. The rate at which biodegradation takes place will be a function of the concentration of the culture used. Extermely large quantities may be required to accomplish a reasonable rate of degradation.

f. Underwater Burial - This method can be used to dispose of hazardous substances. Those materials which are heavier than water will sink and then they can be covered with burial material. This operation is not necessarily final in that the hazardous material might leach out; however, it does show promise as an available disposal method.

g. Land Burial - this method can be used to dispose of hazardous materials in the same way as oil can be buried; however, leaching into the water or streams can be possible as is the case with oil. The Environmental Protection Agency suggests that this method will become less and less attractive, if not completely banned.

h. Burning - This method of disposal could be used successfully in a very limited number of cases since hazardous substances when burned can produce toxic materials which could compound the problem. If the materials could be isolated in small remote areas burning in the atmosphere is a posibility; although, according to EPA there soon will be no such areas in the world. This kind of rigidity may not be the most practical approach for a given incident. In certain spill incidents, to burn in the open atmosphere may be the lesser of evils and thus the only approach at the time. Further, it should be pointed out, that large spills of hazardous materials are quite unlikely. The Battelle study (Reference 9) has pointed up the following probabilities in terms of spill sizes:

SIZE (Gallons)	PROBABILITY
105	.9670
6,937	.0307
390,000	.0023

If this work is accurate, the high flow burners and the open atmosphere burning may indeed be unnecessary and also impractical for hazardous substances.

i. Incineration - In consanance with the above spill size probabilities, incineration, as an ultimate disposal technique for hazardous spills, appears to be quite feasible. The fact that present day designs of portable incinerators are limited in flow rate capability, is not necessarily a major problem, if spill size probabilities remain as presently forseen. It is unlikely that they will increase if proper restrictions are placed on the quantities allowed to be shipped in a given container.

As mentioned in the earlier discussion on incinerators (Reference 5), EPA's Procurement Abstract of April 1975, describes an incinerator requirement to be used for oil and hazardous materials which is intended to handle 100 gph for liguids or fluidizable wastes and 1000 lbs/hr. for oil and hazardous material-soaked solids or semi-solid debris. EPA specifies that the residues shall be non-toxic and suitable for sanitary land filling with no leachate.

In terms of the specifications presented by EPA, the device planned will satisfy the Coast Guard's needs except that the flow rates of material disposed are reduced by a factor of 10. We require 1000 gallons/hr. which is presently beyond what EPA suggest. (See Typical Portable Incinerator Design Appendix III).

A list of chemicals which can be incinerated and which cannot be incinerated must be provided for the users of such a device. The hazardous materials will be more difficult to understand than oil in terms of their characteristics for incineration; however, they can be separated into chemical classes which are based upon likely combustion products, as follows:

a. Hydrocarbons which would yield primarily CO_2 and water vapor in complete combustion.

b. Materials which yield oxides of nitrogen as well as CO_2 and H_2O upon complete combustion.

c. Materials which would yield HCL, CO_2 and H_2O upon complete combustion.

d. Materials which contain sulfur, phosphorous, chlorine, flourine, Bromine and combinations of certain of these.

e. Noncombustibles - During incineration, the temperature must be high enough to insure complete combustion. Stack gas scrubbing can also be accomplished.

Class d materials may also form oxides or acids of nitrogen. If proper temperatures are maintained and scrubbing is accomplished these oxides or acids can be eliminated. Special refractories will be required for Flourine compounds, however. Class e materials are the noncombustibles which are not suitable for incineration. Debris will normally be mixed with materials selected for incineration. These additional materials will compound the disposal problem because they too are now cataminated. The debris materials themselves should not change the products of combustion over those already discussed. The incinerator "feed system" design will become complicated depending upon what kind of debris one is willing to accept. It may be impractical and exteremly costly to build a feed system capable of accepting big 2' x 4's and large tree stumps, etc., if these can be separated, since the appendage for acceptance of this could be huge. (see Reference 10).

Alternatives for Storage

The alternatives for storage of transport of oil or hazardous materials are many and are listed below:

a. Tank Trucks

b. Tankers or Barges

c. Rail Car Tanks

d. Storage Pillow Tanks

e. Refinery Tanks

f. Dump trucks

g. Lagoons

h. Natural Lagoons

i. Garbage bags

The type of storage device selected to do a particular job will depend upon the spill situation, the size of the spill, type material recovered (debris, fluids, solids, chemically hazardous, chemically capable of attacking the container material, etc.). The proximity of the spill to shoreline etc.

Alternatives For Ultimate Disposal

The alternatives for ultimate disposal of oil and hazardous materials are as follows:

OIL	HAZARDOUS MATERIAL
Recycling	Reuse
Land forming	Dilution
Activiated sludge treatment	Neutralization
Landfilling	Chelation
Incineration	Biodegradation
Municipal	Underwater burial
Portable	Land burial
Burning	Burning
on water	Incineration
open container	
High flow nozzle burner	

The best route for disposal for either oil or hazardous substances, of course, is reuse or recycling. In terms of being the least detrimental to the environment if reuse or recyling are not chosen, incineration is the best alternative; it is timely and final. The other alternatives such as land forming, landfilling, burning, dilution, biodegradaion, burial, etc., although in many cases may be less expensive than incineration, are not positive in that they could result in contamination of the soil and/or water; they are long term and therefore, not considered final.

IV CONCLUSIONS

Several methods for storage of oil and hazardous materials do presently exist. At sea, vessels (ships) can be used. On land, lagoons, tanks, rail cars, tank trucks etc., are available for storage.

For destruction, incineration, burning, biodegradation and chemical breakdown exist in many forms, all but burning and incineration appear less than totally acceptable. Reuse or recycling, of course, are most acceptable since these take into account conservation of resources.

There are no existing portable incinerators which will satisfy the Coast Guard's requirements at the present time. Specifically the high rate of incineration suggested, 1000 gallons per hour, in a small trailer mounted system. A complete listing of existing municipal incinerators, available for use in an oil/hazardous material spill does not exist. Although the EPA is compiling lists, these contain insufficient information for Coast Guard use.

Proper materials, known to be compatible with certain hazardous substances, have not been firmly established for use in storage and other handling and recovery devices.

Portable storage containers for use in the arctic region must be evaluated and/or designed to withstand that extreme environment.

Note: It should be pointed out, that temporary storage containers are less desirable than a permanent storage facility due to the secondary spill possibility; however, in an emergency situation they must be made available.

High Flow Rate oil burners do exist which are reported to be capable of rapidly destroying large quantities of oil. The Coast Guard lacks first hand technical knowledge about the capability of these devices. Locations suitable for sites for incinerators (fixed), lagoons, burial, landfilling, and land forming are lacking.

The location of existing, available storage vessels to receive spilled material, both water borne and land based is lacking or incomplete.

The location of suitable existing re-refiners is lacking for Coast Guard use.

The present RFP prepared by the EPA is inadequate to satisfy the Coast Guard's requirements for incineration capability, particularly in terms of flow rate (See Reference 5).

Separators will be needed to insure that sea water is left at sea. The Foster Miller study being conducted by the Coast Guard is designed to establish suitable separators for this purpose.

V RECOMMENDATIONS

In view of the many alternate approaches to the disposal of oil and hazardous substances that are obviously available, it is recommended that further detailed study be conducted that will establish for a number of spill situations, exactly what the best disposal technique will be for each.

The results of this study will enable the Coast Guard to decide which approach will be the most effective one in both cost and environmental impact.

It is recommended that for each alternate approach chosen, that a program plan be required which will outline the work units, cost and time schedule necessary to arrive at the desired finished system(s). All research necessary for certain elements of the systems will be included.

It is further recommended that this study be initiated early in calendar year 1976. Some elements of this study will necessarily include the following:

(1) Catagorize hazardous materials in terms of their ability to be handled and disposed of.

(2) Investigate the materials problem with regard to storage and handling.

(3) If burning or incineration are recommended, which materials disposed of will be troblesome in terms of effluent to the atmosphere.

(4) Is a portable incinerator development program a cost effective one for the Coast Guard, in view of existing fixed disposal facilities, incinerators, landfills etc.

(5) Particularly in the case of oil alone, are portable incinerators effective devices to use. When would this device be most useful?

APPENDIX

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G-DET-1
3913
Ser: 1872
9 April 1975

High Oil Flow Burner System for Pollution Control

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1. The off-loading of oil from a stricken tanker at sea and the transfer of this cargo to other vessels can be logistically a costly, time consuming and uneconomical use of manpower and equipment. The physical transfer can be extremely difficult when faced with a high current or rough sea situation. Although the cost of the oil itself is high, salvage may prove to be much more costly. Further, if salvage attempts fail and a spill occurs in the process, the cost of cleanup could far exceed the cost of the oil. Therefore, burning of such cargo at sea may well prove to be the quickest, safest, simplest and most economical means of disposing of such material. Other advantages of this process for disposal of oil include:

a. A smaller number of support vessels are required.

b. The system could be used in conjunction with ADAPTS supplying oil to the burner system.

c. Lesser environmental impact by burning at sea as opposed to land disposal, since solid combustion products would not be harmful to the ocean or the atmosphere.

2. The technique of burning oil at sea is not new. The idea has been proven by oil companies and is presently used to dispose of crude oil obtained during initial off-shore exploration. Industry claims that present burner designs are capable of handling as high as 400,000 U. S. gallons per day (1514 cubic meters per day). (See Enclosure (1) for additional details concerning burners available).

3. Preliminary investigation indicates the present level of development of burners to be quite advanced. Adaptation by the Coast Guard for subject use would, therefore, require only moderate Research and Development effort. It is estimated that concept feasibility could be established for approximately $200,000.00 (See Enclosure (1)).

4. There are at least two (02) operational alternatives available by which the Coast Guard could secure the necessary hardware and manpower to satisfy a requirement for High Oil Flow Burners for pollution control. These are through service contracts with companies in the field or procurement of necessary hardward and utilization of National Strike Teams for operation. (See Enclosure (1) for additional information).

AI

Subj: High Oil Flow Burner System For Pollution Control

5. The development of the Burner System would enhance the Coast Guard's capability to accomplish its pollution response mission:

a. In cases where accessibility to the stricken tanker by salvage vessel is restricted.

b. By disposing of the oil directly and thus eliminating the pollution hazard of an oil spill.

In view of the above it is recommended that necessary program documentation be prepared to secure funding for concept feasibility determination and prototype system development. My staff is prepared to provide additional information on the potential of the technique and to assist in preparing funding documents.

s/s A. H. SIEMENS

Encl: (1) "High Oil Flow Burners For Pollution Control"

Copy to:
Project File 4103.10

HIGH OIL FLOW BURNERS FOR POLLUTION CONTROL

BURNERS AVAILABLE

1. A French device is sold or leased by Johnston of Houston, Texas, a division of Schlumberger Technology Corporation. This system atomizes oil with air and uses water to reduce the heat radiated by the flame, improve combustion and reduce smoke. The oil is burned in the open atmosphere. The vendor claims this burner can handle mixtures of oil and water with a water content as high as 50%. The basic unit provided by Johnston is claimed to have a maximum capacity of 250 gall[illegible] per minute or .945 cubic meters per minute.

2. A British device is marketed/leased by the John Zinc Company and the Baker Tool Company. This system functions in a similar manner as the French system and can be procured having flow capacities ranging from 85gpm to 292gpm. (.32 cu. meters/min. to 1.1 cu. meters/min.)

AUXILIARY EQUIPMENT REQUIRED

1. A pre-burning handling unit to insure the oil mixture will burn efficiently in the burner head. This unit may be required to handle a wide range of oil types having viscosities up to 2000 centistokes or more. The pre-burning handling unit may also be required to separate solid materials in order not to clog the burner. This unit could be used to pre-heat the oil/water mixture prior to burning; this may be needed with more viscous material at low temperatures.

2. A water supply system will be required since water is injected as fine droplets into the flame. This has two effects: It will assist in keeping the heat radiation by the flame to a minimum and it will reduce the amount of smoke generated. This water injection claim sounds reasonable, since water injection during combustion processes is known to induce more complete burning.

3. An air supply system consisting of compressed air is required to atomize the fuel and insure efficient burning. Air for combustion is drawn directly from the atmosphere.

4. Pressure tanks to contain the compressed air for the above air supply will be required.

5. An adapter system to mount the burner on stricken tanker. In order to safely adapt the burner holding boom a cable assembly would need be developed to assist in stowing and in restraining the device during use, particularly to reduce the load caused by the overhung moment.

6. Equipment to insure rapid delivery of the device to the scene; such as, pallets, suitably sized packing modules, boats, aircraft loading equipment including proper tie down gear.

7. Incidental transfer hoses, pumps, valves, plumbing fittings or such equipment necessary to make the burner system compatible with support vessels and the transfer systems such as adapts or equivalent.

Items 1, 5, 6 will require moderate research and development. The other items should be available either from the burner supplier or other shelf sources.

RESEARCH AND DEVELOPMENT APPROACH

1. Concept Feasibility Study - Select a contractor from whom the Coast Guard would buy or lease the basic burner and necessary auxiliary equipment. The device could be set-up and tested under R&D supervision using either Contractor or National Strike Force personnel. Approximate cost $200,000.00.

2. Prototype Hardware Development - If feasibility is established, begin prototype hardware design, development and evaluation including all the elements necessary to meet expected potential oil spill situations considering oil type, viscosity, temperature, debris problem, etc.. Approximate costs $500,000.00.

COAST GUARD OPERATIONS

1. Operationally, the following alternatives exist:

a. The Coast Guard could procure, maintain and use a selected number of systems after completion of RDT&E.

b. The Coast Guard could contract with a burner company or other suitable contractor to procure and maintain a selected number of systems. The Coast Guard National Strike Force would use these in the event of an oil spill.

c. Proceed as in (b), but have a contractor operate the system under the direction of the Strike Force as required during oil spills.

COST SUMMARY POTENTIAL SPILL SITUATION

1. For a potential spill situation covering a one (01) month period contract costs would be as follows:

Lease burner	2000
1 Technician	4800
Transportation costs	2000
Miscellaneous	800
Total cost	$9600

2. These costs assume that development costs have already been expended to bring contractor capability up to Coast Guard needs. Also, vessel/s is/are available with adapter pad in place and other rigging as previously described.

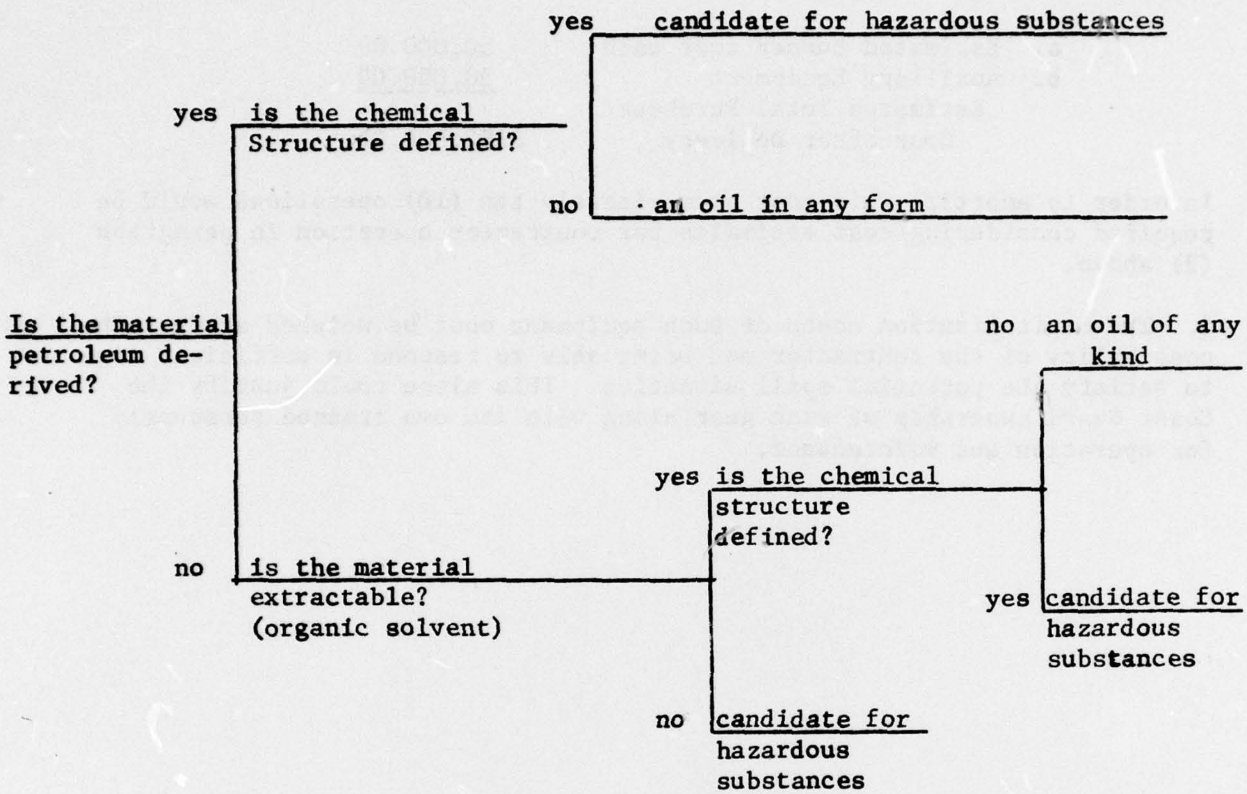
3. The contractual costs would be reduced by $4800.00 if a strike team member was trained to take the place of the contractor furnished technician.

4. If a decision was made to purchase Burners and have them on hand, of course this would reduce the individual oil spill incident contractual costs, but the capitalization costs (Purchase of Burner/s), the storage costs, etc. would be higher.

a. Estimated burner cost each	50,000.00
b. Auxiliary Equipment	50,000.00
Estimated Total Purchase Cost after Delivery	$100,000.00

In order to amortize this cost approximately ten (10) operations would be required considering cost estimates for contractor operation in paragraph (2) above.

5. The capitalization costs of such equipment must be weighed against the possibility of the contractor not being able to respond in sufficient time to satisfy the potential spill situation. This alone could justify the Coast Guard ownership of such gear along with its own trained personnel for operation and maintenance.



RATIONALE FOR DISTINGUSHING BETWEEN OILS AND MATERIALS

THAT MAY BE HAZARDOUS SUBSTANCES

See Reference 19

EXAMPLES OF MATERIALS TO TEST THE RATIONALE TO DISTINGUISH BETWEEN OILS AND POSSIBLE HAZARDOUS SUBSTANCES

Materials	Petroleum Derived	Chemical Structure	Extractable (Solvent)	Chemical Structure	Oil/ Haz.S
Crude Oil	Yes	No	--	--	Oil
JP-4 Fuel	Yes	No	--	--	Oil
Toluene	Yes	Yes	--	--	H.S.
Tallow	No	--	Yes	No	Oil
Molasses	No	--	No	--	H.S.
Refinery Waste	Yes	No	--	--	Oil
Plating Waste	No	--	No	--	H.S.
Mix - Kerosene & Benzene	Yes	No	--	--	Oil
Corn Oil	No	--	Yes	No	Oil
Stearic Acid	No	--	Yes	Yes	H.S.
Meat Renderings	No	--	Yes	No	Oil
Coal Dust	Yes	No	--	--	Oil
Cresol	Yes	Yes	--	--	H.S.
Whale Oil	No	--	Yes	No	Oil
Hexanol	Yes	Yes	--	--	H.S.
Lacquer Based Paint	No	--	Yes	No	Oil
Methyl Mercury	No	--	Yes	Yes	H.S.
DDT	Yes	Yes	--	--	H.S.

See Reference 19

A PROPOSED INCINERATOR TECHNIQUE

Incinerators can be designed in many ways and use several different methods to provide combustion of the material to be destroyed; however, the two general classifications of incinerators are the excess air and the controlled atmosphere types. These can be built in numerous sizes and configurations.

In the case of an excess air type the burning rate and temperatures are extremely variable and sometimes very erratic. If the temperatures are suitably high even heavy metals can be volatilized; however, this will require scrubbing to reduce toxicity of the effluent. This of course adds complexity to the device. If properly controlled; however, this technique can be very useful for a number of materials. The high temperature incinerator produces oxides of nitrogen. This is not true of the controlled atmosphere design which keeps the temperature low. As mentioned, if the high temperature device is used an after-burner and caustic scrubber will usually insure that toxic material does not enter the atmosphere. A typical system for incineration consists of a feed system, a kiln, which will handle liquid and solid material mixed, an ash removal device and a scrubber or other system to remove noxious gases and particulate matter from the effluent. The above, as shown in the following schematic, could be mounted on 2 - 8' x 40' trailers. The basic incinerator could be mounted on one trailer along with the feed mechanism and ash removal device. The after-burner or scrubber would undoubtedly require an additional trailer of approximately the same size as for the incinerator etc. This provides an appreciation of the relative size of an incinerator system designed to be portable. Of course, this device is for the incineration of 50-100 gal.

of oil and hazardous material per hour or 1000 pounds per hour of oil or hazardous soaked solid or semi-solid debris.

To increase the capacity of a single unit much beyond the 1000 pound/100 gallon capacity per hour would undoubtedly reduce the portability to an impractical level, with the exception of a barge mounted device. Each trailer assembly mentioned would probably weigh over 50,000 pounds which is beyond present Coast Guard air transportability capability, unless the systems could be utilized on skids. In this case it would take two (02) - C130's to move the equipment. Depending on the design, a 100 gallon/1000 pound/hour, device conceivably could be air transported. It should be clearly pointed out that the device described here would be useful in very small spills wherein say 10,000 - 30,000 gallons are recovered for destruction. An example of the impracticility is the case where 250,000 gallons are recovered. At a destruction rate of 100 gallons per hour then:

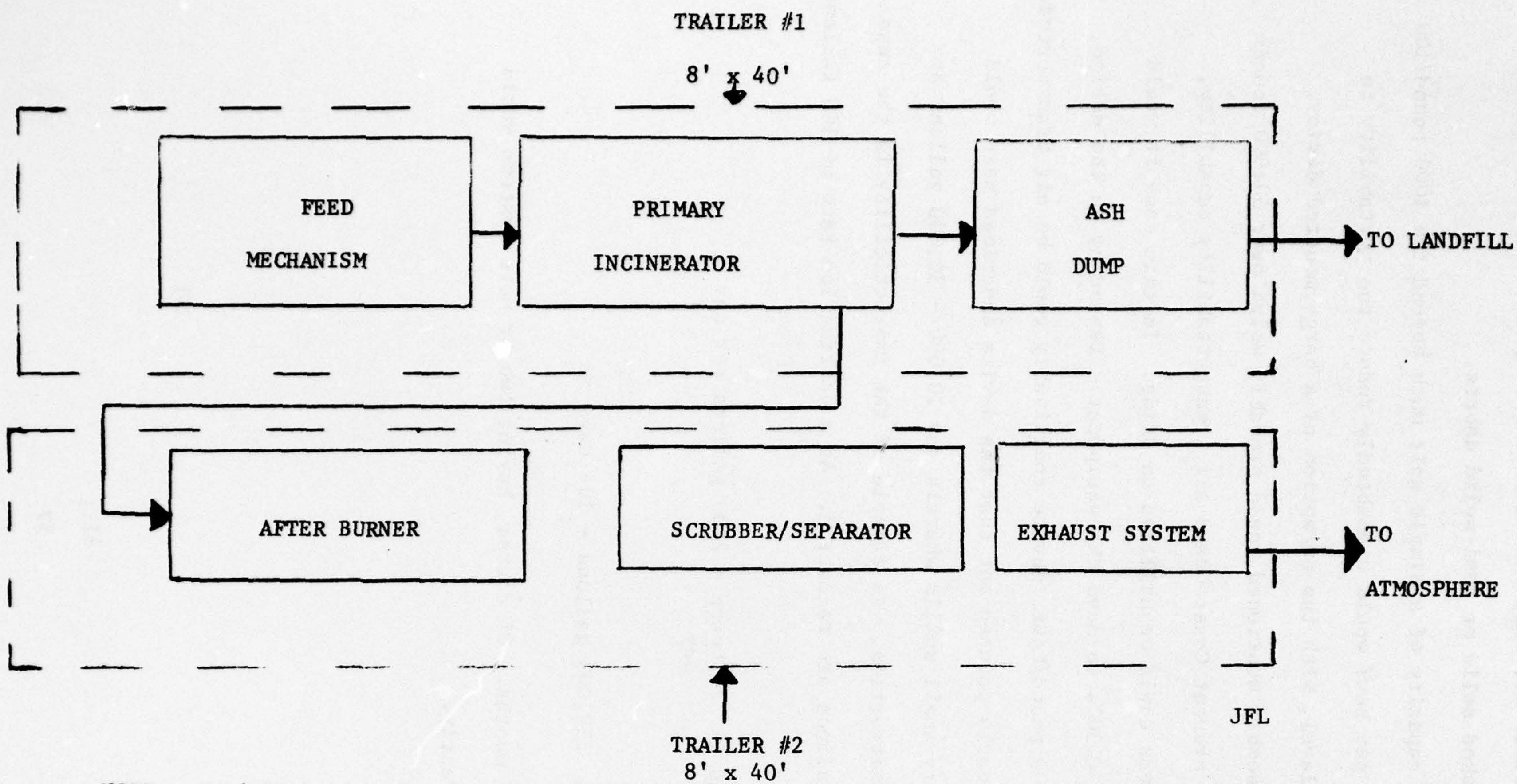
$$\frac{100 \text{ gallons}}{\text{hour}} \times \frac{24 \text{ hours}}{\text{day}} = 2400 \text{ gallons per day}$$

or:

$$\frac{1 \text{ day}}{2400 \text{ gallons}} \times 250{,}000 \text{ gallons} = 104 \text{ days or}$$

over three (03) months. Of course, having two or more systems would reduce this directly.

JFL



NOTE: Feed Mechanism Can Be Augmented By Additional Preconditoners.

TYPICAL INCINERATOR COMPLEX (PORTABLE)

ABSTRACT

DESTRUCTION OF "ORANGE" HERBICIDE BY INCINERATION

Babbitt, R. P., Manager, Process Engineering

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A test program was conducted to evaluate the incineration of "Orange" Herbicide as a means of disposal in a commerical incinerator over a range of selected incineration conditions. "Orange" Herbicide is a chlorinated-phenoxy hydrocarbon herbicide composed of 50% normal butyl 2,4-dichlorophenoxyacetate and 50% normal butyl 2,4,5-trichlorophenoxyacetate (by volume). Particular emphasis was placed on the ability to destroy the dioxin present in the herbicide. Extensive sampling was conducted to evaluate the unscrubbed conbustion gases, the scrubbing used to cool and scrub the combustion gases, scrubbed effluent gases and any solid residues deposited in the system. Additional objectives were: to obtain engineering data relative to controlling and monitoring the incineration process, to evaluate noise produced by the incineration system, to evaluate long term effects of herbicide combustion on incinerator materials, to evaluate the effectiveness of a proposed drum cleaning procedure, and to assess the toxicity of discharged scrubber water to several aquatic organisms and the effects of scrubbed effluent gas on tomato plants.

The program sponsored by the U.S.A.F. was conducted at the Marquardt Company's laboratory at Van Nuys, California, utilizing a Marquardt incineration system. A total of 30.5 hours of burn time on undiluted

"Orange" Herbicide fuel was accumulated during eight record burn periods. Average combustion temperatures varied form 2273°F to 2772°F, "Orange" Herbicide destruction rates ranged from 0.123 to 0.185 pps, and excess air ranged from 34 to 89%. Incineration system "Stay time," before start of gas scrubbing, was from .14 to.18 seconds. An additional 7.1 hours of burn time were accumulated in incineration of drum rinse sotions of "Orange" Herbicide and JP-4. A total of 1540 gallons of "Orange" Herbicide were consumed.

No significant problems were encountered in the storage, transfer, steady state or transient combustion of "Orange" Herbicide. Likewise, no signifiicant problems were encountered in the structural integrity (safety) or deterioration of the incinerator or related process flow systems. Problems due to high viscosity of the "Orange" Herbicide were remedied by preheating to 95°F (± 5°).

Test data demonstrated that the incineration system operated very satisfactorily using undiluted "Orange" Herbicide as a fuel and that the herbicide was effectively and safely destroyed in the combustion process; i. e., unscrubbed combustion gas, scrubbed effluent gas and spend scrubber water effluents, within the analytical limits of detection, did not contain any of the compounds identified in the herbicide feed. Criteria were also established regarding effluent biological impact, incinerator noise generation, drum cleaning procedures, and incinerator process system functions.

CHEMICAL FIXATION OF HAZARDOUS MATERIAL SPILL RESIDUES

by

Jesse R. Conner

President

Chemfix, Inc.

One of the most promising approaches for the ultimate disposal of concentrated hazardous wastes has been the development and application of processes for chemical fixation and solidification. In the past, most of the effort had been directed toward the use of these methods to treat industrial residue streams and stored waste backlogs. However, the techniques which have been developed are easily adaptable for spill cleanup of certain hazardous materials, especially when a fast response, mobile treatment concept is required.

One process using this approach, the Chemfix Process, can produce non-toxic solids sutiable for general "clean" landfull purposes. The chemical parameters of this sytem can be varied to handle many types of waste. The physical and chemical characteristics of the solid can also be controlled to yield a product with specif properties tailored to the desired end use or disposition of the material.

This paper will briefly cover concepts of chemical fixation and properties of fixed materials. Pictorial review by the means os sides will show a number of pertinent applications to date, as well as demonstrating visually how a mobile chemical fixation process operates. Attention will be focussed on the handling and treatment of oily materials and those containing toxic metals in hazardous forms.

Methods of handling both liquids and solids will be discussed. The paper will also consider costs and avilability of the present commerical services.