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NATIONAL STRIKE FORCE (NSF) OIL SPILL RESPONSE EQUIPMENT UPGRADE

MAR, Incorporated
Rockville, Maryland 20852

FINAL REPORT
OCTOBER 1991

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16. Abstract

Current options for upgrading oil spill response equipment for the Coast Guard's National Strike Force (NSF) were investigated. Specific systems and equipment addressed included oil/water separation systems, temporary storage devices, skimmers and pumps. In addition, a concept for an alternative design for the NSF's skimming barrier retrieval system has been proposed. A worldwide survey of oil spill response equipment was conducted to identify candidate replacement equipment. Evaluation criteria were developed and applied in the screening of prospective equipment. Generic test and evaluation parameters are presented to provide a means of assisting in future evaluations of potential equipment. This study is the first of a two phase program directed to evaluate replacement equipment for the NSF.

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UNCLASSIFIED	UNCLASSIFIED		

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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (WEIGHT)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (EXACT)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly).

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
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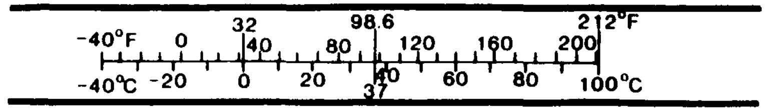
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (WEIGHT)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	0.125	cups	c
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (EXACT)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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EXECUTIVE SUMMARY

The United States Coast Guard Research and Development Center has conducted a study to assess current options for upgrading the oil spill response equipment of their National Strike Force (NSF). The study assesses options for equipment upgrade in four specific areas:

- Oil/water separation
- Temporary storage
- Skimmers
- Pumps.

The emphasis is on identifying options that will have an immediate impact on Strike Team oil recovery capabilities and identifying opportunities that will enhance future developments in this critical area. In addition, a concept for an alternative design for the skimming barrier retrieval system has been developed, and the need to replace the Open Water Oil Containment Recovery System (OWOCRS) boom in the future has been identified.

The study is organized in two phases.

- *Phase One* started with a review of the NSF inventory to determine the status of present oil spill response equipment. Technical discussions were held with each strike team to assess operational requirements and to define equipment performance issues. A worldwide survey of oil spill response equipment manufacturers and vendors was conducted to generate a list of candidate replacement equipments. An initial screening of the responses was conducted to define those with future potential, and a generic test plan, which is structured to provide a means of assisting in the future evaluation of the candidates, was defined.

- *Phase Two* is programmed to augment the list of candidate replacement equipments with specific physical and performance data to allow the Coast Guard to directly select replacement equipments or to define evaluation tests that might be needed.

This report presents the results of Phase One and explains how Phase Two is to be accomplished.

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Section 1

INTRODUCTION

The recent increase in the number of major oil spills, in addition to other events impacting our environment, has necessitated a review of the the Coast Guard's inventory of oil spill response equipment and delivery techniques. Currently, the U.S. Coast Guard's NSF consists of two strike teams: the Atlantic Area Strike Team (LAST) and the Pacific Area Strike Team (PAST). The inventory of NSF oil spill response equipment presently in use was developed many years ago. The centerpiece of their inventory is the Open Water Oil Containment and Recovery System (OWOCRS), which was developed in the early 1970's. While this equipment, together with other support pumps and specialized devices, has worked well for the NSF, the need to upgrade and obtain replacement oil spill response equipment has been recognized by the Coast Guard. Recent legislation authorizes the Coast Guard to increase the number of strike teams, and this has provided an additional incentive for upgrading the NSF inventory.

Four specific types of oil spill response equipment were identified as the focus of a study to define suitable replacements for NSF inventories. This study was to allow inputs from a worldwide market of suppliers of pumps, oil/water separators, skimmers, and temporary storage devices.

It was thought that recent advances in technology and hardware devices might allow an upgrade in performance without increases in the overall size and weight of some units, such as pumps and storage devices. At the beginning of the study, it was recognized that some physical testing would likely be needed to determine the best selection of replacement units.

Since it was not possible to predict the results of the market survey in advance and know what tests would be appropriate, a decision was made to structure the study into two phases. Phase One attempts to define the requirements for the replacement equipment, gather a current list of available candidates, and develop a generic test for general planning. Phase Two will organize the details of the testing phase and develop the criteria for the actual process of evaluating replacement equipment and making final selections.

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Section 2

APPROACH TO THIS STUDY

Specifically, Phase One of this study was organized to accomplish the following:

- Define current oil spill response capability
- Survey the world market of oil spill equipment manufacturers
- Identify candidate replacement hardware
- Organize a test plan that would aid in the selection of replacement equipment.

Since this plan necessitates making decisions about various types of equipment such as pumps, storage devices, oil water separators, skimmers, and special handling equipment, each of which have their own performance parameters, a decision was made to include a list of appropriate test facilities to help define what type of testing will be practical. As part of Phase One, a generic test plan, which addressed each type of candidate replacement equipment individually, was then assembled. Plans for Phase Two include creating a detailed test plan and conducting evaluation tests to make the final selections of NSF replacement equipment.

This study was initiated by having the technical staff visit both the LAST and the PAST facilities. Detailed technical discussions were held with each team, and these discussions provided a comprehensive explanation of the strike teams' equipment inventories. The discussions began with the OWOCRS. The complete OWOCRS system consists of the following:

- Six hundred and twelve feet of a High Seas oil containment boom with six integrated oil skimming weirs
- A pump float that is a flat-bottom platform, with a boat-hull design that houses three single-diaphragm, double-acting pumps
- Six hoses that connect the skimming weirs to the intakes of the pumps
- An ADAPTS TYPE III prime mover that provides the hydraulic fluid to drive the positive displacement pumps
- A towed DRACONE Barge for storage of the effluent from the pump float.

In addition, each strike team maintains six different submersible pumps, which are all hydraulically driven. Each pump provides a different function. For example:

- The Single-Stage Pump is used for general pumping service.

- The Double-Stage Pump is intended for high lift pumping.
- The Single-Stage Stripper Pump can be used to remove a tank's product to within 3 to 4 inches of the tank bottom.
- The Thune-Eureka Pump is used for high viscosity oils.
- The Sloan "Trash Pump" can be effectively used for pumping water and gasoline.
- The FRAMO TK5 is designed to handle hazardous chemicals as well as oils of varying viscosity and high temperature fluids.

A second prime mover referred to as the Viscous Oil Pumping System (VOPS) is frequently used by the strike team to power the Thune-Eureka Pump when working with heavy, cold oil.

A specially designed OWOCRS Retrieval/Recovery system consists of a retrieval rack with a hydraulically driven capstan to aid in recovering the OWOCRS. Use of this system is very labor intensive and requires a large amount of physical exertion, and often when the retrieval system is in use, the environmental conditions are also demanding on people and equipment. Technical discussions with the strike team personnel defined several operational difficulties associated with the OWOCRS Retrieval/Recovery system. Because this system is a custom piece of equipment developed solely for the OWOCRS boom, there is no practical replacement equipment available on the commercial market. However, during the current study, the issues of the retrieval rack were examined, and some general recommendations for improvement were defined. The difficulties with the rack and the new recommendations are discussed in Section 7 of this report.

The information that was gathered during the visits to the strike teams was assessed and grouped into the different categories of equipments that would benefit from upgrading or replacement. A separate list of manufacturers who advertised in the *World Oil Spill Response Equipment Catalog* and other published journals was compiled and used as a directory for mailing requests for technical information and product literature. The mailing list, which contained over 100 separate entries, included vendors from the United States, Canada, and numerous European countries.

A vast amount of return mail, telefaxed responses, and phone contacts were received from a large number of manufacturers in response to the equipment survey. The responses were grouped into four general categories: pumps, oil/water separators, temporary oil storage devices, and oil skimming devices. Each category was then reviewed separately to screen those responses that offered potential as possible replacements for the NSF equipment in that category.

In addition to the visits with the two NSF strike teams, a separate visit was made to the U.S. Navy's East Coast Oil Spill Response Equipment Depot. While the Navy uses oil spill clean-up equipment that is somewhat different in operational technique, they address some of the associated details in a similar manner. In fact, they also use the same make and model of some transfer pumps.

During the Navy site visit, discussions were held with the technical personnel to address issues associated with oil spill equipment performance, maintenance, cleanup, transportation, response time, and replacement. On the grounds of the depot, the Navy also has two test facilities that are available for use during Phase Two. These are discussed in more detail in Section 8.

The ultimate selection of replacement equipment for the NSF Strike Teams will be accomplished by a program manager and the strike team, using the test results from this study. Since there are numerous categories of equipment to be evaluated, a variety of tests must be defined and organized before actual testing can be conducted. To assist with planning these evaluations, Phase One includes a generic test matrix and a list of appropriate test facilities that will most likely be needed during the evaluations. The generic test and evaluation parameters are discussed in Section 9, and some suitable test facilities are discussed in Section 8.

Figure 2-1 presents a general flowchart to illustrate how the overall study is planned and organized. Information for both Phase One and Phase Two are included. This report includes the results of Phase One, which appear above the horizontal dashed line in the figure.

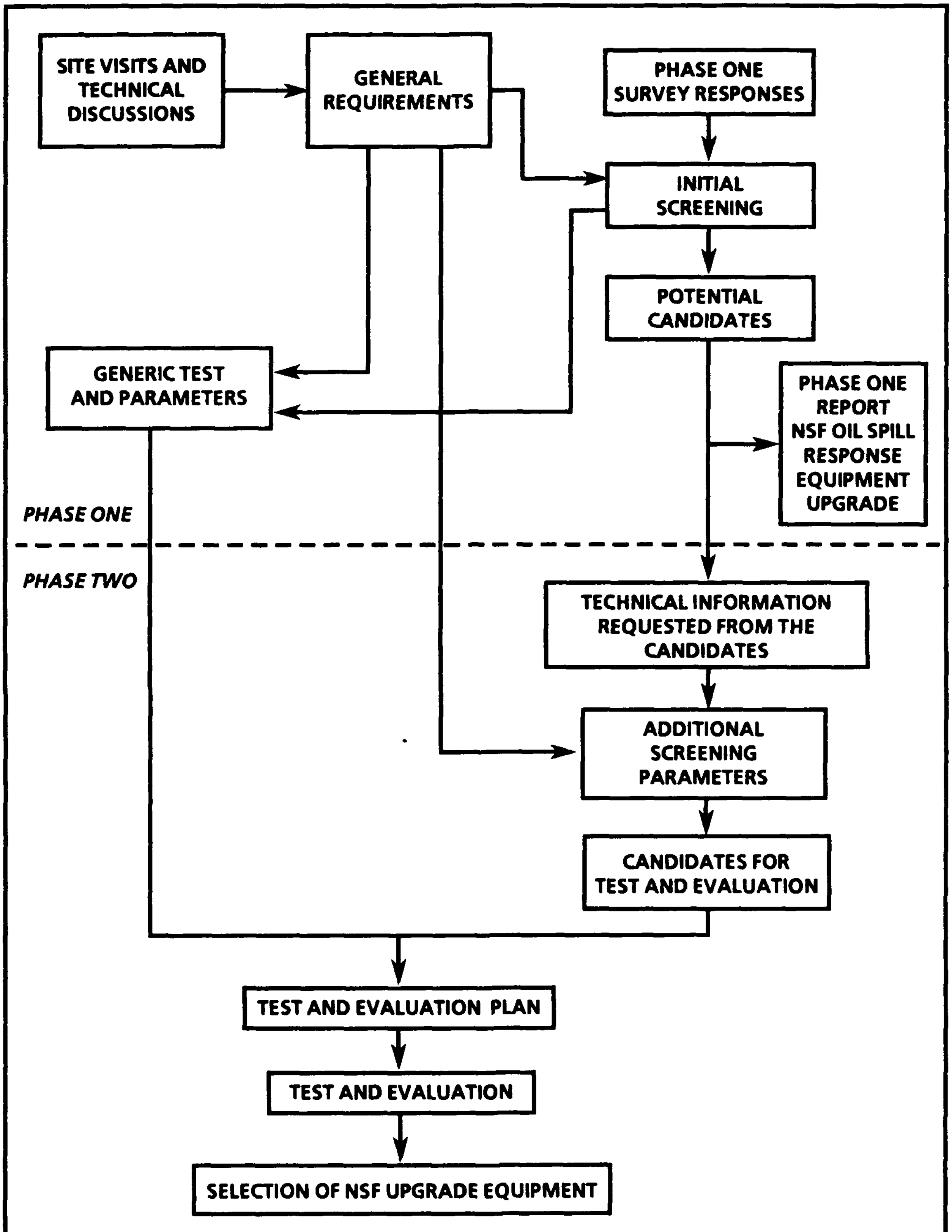

Figure 2-1. Study Plan

Section 3

SITE VISITS AND NSF INPUTS

This study has included an evaluation of most of the major pieces of equipment within the Coast Guard's NSF inventories. This evaluation was a prerequisite to assessing what equipment might be available to replace or augment existing NSF inventories. As part of the process of identifying suitable equipment for the NSF inventory, meetings with representatives of LAST and PAST were held. The purpose of these meetings was to:

- Identify specific requirements for equipment that is designated for review
- Identify the shortcomings of existing equipment
- Define common problems that should be considered when evaluating new or replacement equipment
- Establish compatibility parameters that are essential to new or replacement equipment performance.

The NSF has not been provided with specific performance requirements for the various pieces of equipment within its inventories nor has the NSF been given specific mission performance criteria for its operational missions. Rather, NSF requirements are couched in subjective terms to include the wide variety of emergency situations to which the NSF might have to respond. Emergency responses must be rapid, and the equipment must be durable and easily transportable – some by air and some by truck.

Specific performance requirements for NSF services are not available. Some guidance can be found within the *National Contingency Plan* and the Coast Guard's *Marine Safety Manual*. While these requirements are probably the most definitive available for use in this evaluation process, even they do not allow easy identification of either missing capability or existing equipment deficiencies. As a general assistance for evaluating responses from the vendors' survey, the list of current NSF equipment capabilities, which are detailed in Appendix A, were used in Phase One.

Presently, it seems that current equipment capabilities have shaped or limited the expected requirements that have been placed on the NSF. The *Marine Safety Manual* directs that the equipment inventory should be continually evaluated against operational experience and then modified accordingly. However, since operational experience is generally limited in scope by the existing equipment, this by itself does not stimulate acquisition of an equipment inventory with a goal of providing the services that may be most needed or most wanted by the users.

A survey of the NSF users (i.e., the Federal On-Scene Coordinators (OSCs)) might be beneficial in determining useful NSF capabilities; however, the NSF requirements should be developed and directed by the MEP program manager. Certainly, a further definition of requirements is necessary to determine how much of what type of equipment must be available to provide an effective response to an oil spill emergency.

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Section 4

CURRENT NSF EQUIPMENT INVENTORIES: FUNCTIONS AND ISSUES

The previous section addressed the general outcome of the visits to the strike teams. This section discusses the particular information that was learned during the technical discussions with LAST and PAST and that was gleaned from our review of NSF literature. The information presented here formed a general understanding of the NSF function and approach to oil spill response situations, and, in the absence of detail requirements, it was useful during the initial screening task to select candidate replacement equipment.

Each category of NSF response equipment is addressed. Pumping Systems are discussed initially and, for general understanding, include a discussion of the problems related to the OWOCRS. Then fluid separators and temporary storage devices are discussed together. This is followed by a discussion about oil skimmers that can augment the OWOCRS system. The special OWOCRS Retrieval system is discussed last.

4.1 PUMPING SYSTEMS

In this study, the examination of NSF pumping capabilities is directed toward fewer, lighter, and more efficient pumps. Capability of pumps to process debris and perform across the spectrum of oil viscosities must be considered. Any replacement pumps must also facilitate handling and stowage. The pumping needs of the NSF were discussed with both LAST and PAST.

Pumping requirements can be divided into two categories. The NSF must be able to rapidly move large quantities of product from the hold of damaged tank vessels. For this operation, it has a variety of transfer pumps in its inventories. The NSF must also be able to efficiently move large quantities of products that are collected or recovered from the water by booms and skimmers. Within this second category, the Coast Guard's OWOCRS must be examined. This system combines the collection capability of oil booms with a weir-type oil recovery mechanism and a pumping system to transfer the recovered oil to storage facilities.

A third type pumping system is embedded within the first two pumping categories. The pumps used in both categories are driven by hydraulic motors and require separate prime mover hydraulic pumping systems. The NSF stocks two major pumping systems of this type that must be considered when examining compatibility of new or replacement equipment in the NSF inventory.

4.1.1 TRANSFER PUMPS. The transfer pumps within the NSF inventories have many similar capabilities, yet each pump has been found to fit the needs of various unique situations. However, stockpiling a large variety of pumps presents added preventive maintenance and training workloads that might be eliminated or reduced if a replacement can be identified for two or more of the types of pumps in the existing inventory.

A suite of transfer pumps was provided for the NSF when the Air Deliverable Anti-Pollution Transfer System (ADAPTS) was developed for the Coast Guard. The intent of this system was to provide emergency offloading capability for stranded tank vessels. In damaged tanks, a Single-Stage pump was able to be used since incoming water would raise the product to the level of the suction as pumping progressed. A Stripper pump with a bottom suction was provided to facilitate removal of the last remaining product in a tank. A Double-Stage pump was provided for removal of the product from an undamaged tank when shipboard pumping systems were incapacitated.

The three original pumps in the NSF inventory (the Single-Stage pump, the Double-Stage pump, and the Stripper pump) were designed to be lowered into a tank through the Butterworth openings in the tank tops and supported from a portable tripod assembly. All of these pumps have a common deficiency. They are large and heavy. The movement of these pumps around the deck of a stranded vessel, often at extreme degrees of list and trim, is difficult and slow and takes valuable time from limited and uncertain windows of opportunity for salvage prior to the onset of foul weather. These pumps must often be moved between tank opening locations as the lightering sequence and ballasting operations of the salvage operation dictate. Modifications to the tripod assembly should be considered to facilitate their use. An additional deficiency of the Single-Stage pump is its vulnerability to mechanical damage since hydraulic hard-piping for the pump motor is mounted external to the pump casing.

In addition to these three pumps, the NSF maintains three other transfer pumps in its inventory:

- The Thune-Eureka pump was obtained when the VOPS was acquired. It is made of bronze, has the suction located on the bottom, and can handle heavy products for high lift tasks at high flow rates.

- The TK5 pump, which is constructed of stainless steel, was acquired to accommodate transfer needs of hazardous materials that may attack the components of the other pumps. It also is provided with a suction located on the bottom and is reliably used for oil transfer situations where high capacity against high working heads is needed. One drawback of this pump is that the passage through the impeller is too small for use on impure products. Even small pebbles or debris become lodged in the small annulus through which the product must pass, and this can reduce the flow rate or even clog the entire pump.

- The Sloan pump is maintained as a "trash" pump for use on contaminated or debris-laden products. It is lighter than either the Thune-Eureka or the TK5 pump, can be easily handled by a single person, and works exceptionally well on light products. However, it has limited applications for heavier oils and must be redesigned to accommodate insertion into cargo tanks through Butterworth openings.

The Thune-Eureka pump, the TK5 pump, and the Sloan pump are all reasonably light and can be handled with relative ease by one or two persons.

Since the current number of pumps stockpiled by the NSF requires use of the very heavy and cumbersome Single-Stage, Double-Stage, and Stripper pumps when capacity is needed in excess of that provided by the TK5 and the Thune-Eureka for heavy oils, additional lighter pumps that will process heavy oils are needed in the inventory. For high lifts of heavy oil, consideration should be given to facilitating in-line boosting of the product with pumps of lighter weight. This could perhaps allow the retirement of the heavy Double-Stage pumps.

Lightering of damaged and stranded vessels is often slowed by considerations separate from inadequate pumping capacity. For instance, over-the-top transfers using multiple pumping systems are sometimes ruled out for health and safety issues associated with vapor control. Also, assessments of the material condition of vessel prior to and during offloading can delay or interrupt pumping operations. However, in spite of these obstacles, the NSF still has a limited capacity to rapidly offload a stranded tank vessel. Consideration should be given to providing greater total capacity for lightering operations. This might be accomplished by providing pumps with increased capacity, by providing a greater number of more easily handled pumps, or by providing additional capacity for the prime mover hydraulic pumps.

4.1.2 PRIME MOVER HYDRAULIC PUMPS. The NSF employs two different types of prime mover pumps. One was developed for the ADAPTS, and the other was procured for use with VOPS. The VOPS pump provides somewhat greater flow rates than the ADAPTS pump but at the expense of a package weight that is more than 175 percent of that for the ADAPTS. The VOPS also occupies nearly twice the space of the ADAPTS; however, it does have a larger hydraulic oil reservoir and a built-in oil cooling system. Neither of these systems is capable of driving NSF pumping systems to their rated capacities. The capacity of the prime movers needs to be considered for compatibility when evaluating alternative pumping devices. If a separate or new prime mover is considered when new pumps are evaluated, it must be as a replacement for one of the existing systems and not as an addition in order to keep extensive preventive maintenance requirements to a minimum.

The heavy weight of the existing prime mover hydraulic pumps makes their use very cumbersome. Once in place for a response, they are not easily moved. Placement at long distances from product pumps often requires long lengths of charged hydraulic hose, which is cumbersome and reduces maximum obtainable capacities. The possibility of obtaining lighter hydraulic hose should also be examined. Perhaps the weight problem of the prime movers is a problem upon which significant improvements cannot be made, but some thought should be given to providing a mechanism that could facilitate the movement of heavy equipment on the irregular and often tilted surfaces of a stranded ship's deck.

The storage of the ADAPTS prime mover in a floatable, fiberglass box was developed to meet air-deployable criteria. However, storage in the air-deployable boxes causes some sweating and corrosion problems and also makes preventive maintenance operations more difficult. Therefore, since these systems are not now air-deployed, the possible benefits of placing this system in an open, lightweight metal frame should be examined.

4.2 FLUID SEPARATION AND STORAGE EQUIPMENT

For this project, meetings with the NSF were directed at identifying requirements for oil/water separation and temporary storage of recovered oil. In addition, shortcomings of existing temporary storage mechanisms were to be identified.

The NSF currently has no specific equipment in its inventory designed to serve as an oil/water separation device. Natural gravity separation does take place when oil is stored in Vessels of Opportunity or in DRACONE Barges, but the entire volume of mixed oil and water has to be stored long enough for effective separation. In oil spill responses, the availability of storage devices for recovered oil is often limited. Obtaining two or three barges for the collection of recovered product can normally be achieved in adequate capacity to handle the total amount of product spilled. However, this does not begin to solve the storage problem faced in nearly all oil spill response operations where large product volume is mixed with equal or larger volumes of entrained water.

Most skimming devices currently available have very limited on-board storage capacities. The effectiveness of these skimming devices becomes extremely limited when they spend 20 minutes skimming and 3 to 12 hours transiting to one of the available barges or waiting for the arrival of an offloading barge. Skimming devices must work in close conjunction with temporary storage equipment to make them effective response tools. It is possible that oil/water separation equipment could enhance temporary storage capability, but it may have its greatest application in improving skimming devices on-board storage capacities. Still, providing effective and numerous temporary storage devices is probably the most critical factor for improving the overall effectiveness of oil recovery operations.

Existing temporary storage devices within the inventories of the NSF are the portable DRACONE Barges, which are of three different sizes. These devices, while functional, are not highly endorsed as a useful tool in oil spill response by anyone in the NSF. They are heavy and cumbersome in transport, deployment, and underway operations. They are bulky and take up significant room in warehouses, and the larger devices require odd sized pallets, which makes transport by C-130 difficult. They have no gauging system to indicate how close to capacity they are becoming, and they have no venting system to facilitate maximum loading or to dispose of vapors from decaying biological material. They are very difficult to clean and maintain. The flotation system of foam enclosed within rubber material running longitudinally along the sides is inadequate. It is encased within the lightest material used on the barge and located at the point of highest bending stresses. It is constantly ripping loose, causing the barge to nearly sink or float out of trim to the point where connecting devices for hoses are difficult to use. Alternatives to these barges are commercially available and will be evaluated.

4.3 OIL SKIMMERS

In this project, the potential use of alternative oil skimming devices with the existing OWOCRS was examined. Use of the OWOCRS by the NSF has been quite successful until a very heavy, cold oil or cold, weathered crude is encountered. The ability of the OWOCRS to handle debris is also limited. However, since the system still represents one of best available for coastal and offshore environments, some mechanism to expand its capability for these specifications is desirable.

One alternative that had successful applications during the response to the *Exxon Valdez* spill was the placement of an EGMOPOL paddle belt skimming device behind the containment boom. The design of this particular skimmer allowed it to float on the pump float side of the barrier while extending its inclined plane and movable belt over the barrier into the collected oil. A paddle belt skimming device works well in heavy oils and is also able to readily handle small sized debris such as entrained kelp. Other types or models of skimming devices could work equally well if positioned fully within the barrier; however, some mechanism should be developed for tie-off points along the barrier so that the recovery device did not have to be trailed on a long line from the towing vessels or require an additional vessel to maneuver the device.

4.4 SKIMMING BARRIER RETRIEVAL SYSTEM

During this project, a concept for an alternative design for the skimming barrier retrieval system was to be developed. Discussions with NSF personnel were conducted to evaluate system requirements and existing shortcomings.

The existing system is comprised of large and labor-intensive devices that perform a variety of functions: a power head platform, a rack upon which the recovered barrier is hung, and a separate rack used to facilitate repacking the barrier into its storage container. The current system consists of large devices that are greater than 8 feet in width, thus requiring oversize load permits when shipped over the road by tractor-trailer. It currently requires the use of a prime mover, either the ADAPTS or the VOPS, that is heavy and far exceeds the pressure and capacity requirements of the power head. A smaller prime mover, perhaps one built into the redesigned system, might be appropriate.

Some suggestions for consideration during the redesign include:

- Redesigning the frame for the rack into the bottom of a standard container to accept the pipes or struts for the hangers
- Replacing the power head drum, which is currently a smooth drum that lets oiled nylon line slip during the retrieval process
- Lowering the position for tailing the retrieval line from the power head to simplify the retrieval process
- Incorporating a cleaning device into the retrieval system to limit the number of times the barrier has to be handled
- Redesigning the hanger roller system, which, as currently used, is not appropriate since the welded stainless steel track causes the roller to hang up repeatedly.

Perhaps the best suggestion for evaluating a total redesign of the system is to incorporate the retrieval, recovery, and storage box into a single device. This might require that contractor servicing, cleaning, and maintenance be provided at the place of retrieval. The initial criteria to make the storage box air-deployable may have prevented consideration of this concept when it was first designed. Since air deployment is no longer practiced nor desirable, this may be a viable option.

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Section 5

EVALUATION AND RANKING CRITERIA FOR SELECTING CANDIDATE REPLACEMENT EQUIPMENT

The product information received in response to the solicitation for candidate oil spill replacement equipment was voluminous. The quality of the information received in each response varied tremendously. Some responses were so sketchy that the equipment was easily eliminated since no potential was apparent. Other responses gave just enough information to pique interest in obtaining further information. Even in the cases where significant information was provided (often including operational videos), the data were not sufficiently complete to make an accurate assessment of actual capabilities. Typically, the best attributes were touted without enough information to form a complete picture, e.g., capability to handle 100,000 cSt viscosity oil is advertised without giving a flow rate; a capability to provide huge temporary storage capacities is advertised without identifying container weights; or high volume separation capability is advertised without addressing purity of product, etc. For competing pieces of equipment, the information provided by each response varied, and a comparison was not possible at this time.

Because of the incomplete and varied information, the initial screening of oil pollution response equipment was, by necessity, quite subjective in nature. The first cut at equipment evaluation sought to classify the equipment as either having potential for use within the NSF equipment inventory or as being inappropriate for further consideration. As a general reference to aid in this determination, a list of physical and performance characteristics of the current NSF equipment inventory was used. This list, which is not as complete as desired, is presented in Appendix A. In some instances, this approach resulted in a rather lengthy list of candidate replacement equipment in the Potential Category. Prior to making selections for testing and evaluation, a further screening is necessary. This screening should request specific design, construction, and operating parameters from the equipment suppliers to allow a paper comparison of the competing equipment. These parameters are identified in the following paragraphs on the individual categories of equipment and form the basis for the generic test and evaluation parameters that are discussed further in Section 9.

5.1 PUMPS

Evaluation of pumps was divided into three different categories: pumps suitable for use as transfer or salvage pumps, those suitable as replacements for the pump float, and those that could be used as prime movers for the transfer pumps and the OWOCRS pump float pumps.

5.1.1 TRANSFER PUMPS. Transfer pumping systems are used by the NSF to lighter stranded or damaged vessels whose on-board pumping systems are incapacitated. For this operation, pumping systems that can handle high volumes of light and viscous products are needed. They must be of relatively light weight to facilitate movement aboard and around stranded vessels, and they must be capable of moving the product against the significant heads presented by tank vessel cargo tanks. Considering the need for the NSF to sometimes employ these pumping systems for cargoes of hazardous materials, the construction materials of the pumping systems should be compatible with such use.

5.1.1.1 Selection Characteristics. Three pumps within the NSF inventory (the Single-Stage, the Stripper, and the Double-Stage) are being considered for replacement. The remaining pumps, which are the Thune-Eureka, the TK5, and the Sloan, function satisfactorily and essentially cover the spectrum of NSF transfer pumping needs. However, with elimination of the heavier, older pumps, additional pumps would be required. The characteristics of the replacement transfer pumps should provide capabilities identical or similar to the Thune-Eureka, the TK5 and the Sloan pumps and cover any unique capabilities of the pumps being eliminated.

Augmenting the existing supply of Thune-Eureka, TK5, and Sloan pumps with more of these same pumps initially appeared acceptable. However, the FRAMO TK5 is no longer produced. According to FRAMO, it has been replaced with the FRAMO TK150. Since it is desirable to limit the total number of different pumps that the NSF must maintain, it would be preferable to replace the TK5 with a new pump that could also perform the functions currently reserved for the Thune-Eureka and/or the Sloan pumps.

Considering all of the preceding requirements, potential replacement pumps should:

- Be of rugged construction
- Be of weights comparable with the TK5 (or the Thune-Eureka for pumping viscous products)
- Be of a size that allows access to tankship compartments through Butterworth openings
- Be able to accommodate in-line coupling of pumps to facilitate pumping against significant heads
- Be capable of handling the full range of potential viscosities of product
- Be capable of handling products other than oil, i.e., hazardous materials, by virtue of appropriate material specifications of pump components
- Be capable of taking suction from bottom of pumping system
- Be capable of being driven by hydraulic motor and operated at maximum rated capacity by hydraulic pressure and flow provided by the ADAPTS, VOPS, or an equivalent/superior prime mover system
- Be capable of providing flow rates equivalent or superior to the TK5 and/or the Thune-Eureka
- Be proven effective by substantial commercial use or extensive field testing.

5.1.2 PRIME MOVER PUMPS. The NSF has a need to provide a portable prime mover mechanism that can operate safely in the presence of flammable liquids and explosive vapors for both its transfer pumping systems and its pump-float pumps. To achieve this goal, the NSF has relied upon hydraulic motors for the operation of these systems. This requires the availability of hydraulic pumps driven by internal combustion engines that can deliver significant flow rates at high working pressures.

5.1.2.1 Selection Characteristics. The NSF currently employs two different hydraulic pumps as prime movers for their pumping systems. These are referred to as the ADAPTS and the VOPS. The ADAPTS employs a Type III, 70 horsepower, Avco Lycoming diesel, and the VOPS employs a General Motors, 87 horsepower, GM-4-53 diesel. Both of these prime movers have proven to be reliable and capable equipment; however, both are heavy and cumbersome to move around and place aboard vessels, whether underway or stranded. At times, the number or types of pumps to be run off of the prime movers make greater capacities desirable. Consideration for the replacement prime mover pumps would be made on the basis of their being lighter, of greater capacity, or more readily transportable.

Considering the preceding requirements, potential replacement pumps should:

- Be of lightweight construction
- Afford protection from damage during transport and placement on remotely located vessels in adverse weather conditions
- Be powered by an internal combustion engine
- Be able to deliver a minimum of 32 gpm of hydraulic fluid at 2500 psi and preferably in excess of 52 gpm at 2500 psi
- Incorporate mechanisms within the design to accommodate transportation by vessel and helicopter and to facilitate easy movement around the decks of stranded or damaged vessels.

5.2 OIL/WATER SEPARATION DEVICES

A frequent shortage in availability of storage capacity for recovered product makes the employment of oil/water separation equipment an attractive item for the NSF inventory. At present, neither LAST nor PAST endorses the use of separators for normal oil recovery operations. Typically, flow rates for oil/water separation equipment are inadequate to accommodate oil recovery at the rated capacity of the OWOCRS equipment. In addition, most existing oil/water separation devices will not accept significant quantities or sizes of recovered debris. Since most existing oil/water separation devices that have reasonable flow rates are large and heavy, the transportability problems negate potential advantages. Therefore, the alternative of identifying and providing excess temporary storage has been a preferred solution.

5.2.1 SELECTION CHARACTERISTICS. There is no existing oil/water separation device or scheme within the NSF inventory to which candidate devices might be compared. Candidate devices must overcome some institutional inertia to be viewed as a valuable addition to the NSF inventory. Oil/water separation devices should have a goal of accommodating the maximum flow rate of the OWOCRS pumping system. Oil/water separation devices must be able to handle the sizes and amounts of debris processed by the OWOCRS. In-line oil/water separation devices may be particularly desirable if they can be incorporated within the existing system with little additional weight and space demands. Any acceptable oil/water separation device must be readily transportable to remote locations.

Considering the preceding requirements, potential oil/water separation devices should:

- Be of limited size and weight
- Be capable of handling debris-laden, highly viscous products
- Be capable of accommodating high flow rates (goals should be the sum of the three existing pump float pumps, a maximum of 825 gpm)
- Present minimal friction losses to be overcome by the OWOCRS pumps
- Incorporate mechanisms within the design to accommodate transportation by vessel and helicopter
- Be compatible with ADAPTS
- Be reliable
- Provide easy maintenance.

5.3 TEMPORARY STORAGE DEVICES

The availability of adequate temporary storage equipment for recovered product has been identified as a major deficiency in spill response capability. Total capacity to handle all recovered product from a spill is not necessarily a problem. The ability to provide numerous storage devices to each on-water location where recovery operations are in progress is important.

The only equipment in the NSF inventory for the temporary storage of recovered product (DRACONE Barges) is inadequate in many respects. These devices are difficult to store, transport, deploy, empty, and clean. Alternatives that will improve pump-out capabilities, handling, and gravity separation are desired.

5.3.1 SELECTION CHARACTERISTICS. Because of difficulties during deployment and use, the DRACONE Barges provide a poor comparison for replacement items. They do offer a range of storage capacities that lend a degree of versatility, but their weight is prohibitive. Replacement devices should offer greater ease in handling; (preferably) be of lighter construction while maintaining adequate strength for intended service; accommodate the rigors of at-sea conditions comparable to the OWOCRS; be adaptable for easy handling in the water; have hookups that are compatible with the OWOCRS; and be capable of venting and gravity separation as necessary. Removal of product from the device should be possible without great difficulty. Some redesign of the DRACONES may make them more competitive.

Considering the preceding requirements, potential temporary storage devices should:

- Be of a durable, lightweight construction
- Be available in a variety of sizes, with capacities ranging from 5,000 to 300,000 gallons
- Be adaptable for use at sea aboard vessels and/or in the water
- Be capable for towing in the water and remaining in a condition that is easily controlled and will contain collected product in conditions up to Sea State 6
- Be packaged in unused condition so that rapid transport to spill sites can be accomplished by standard load overland routes or C-130 aircraft
- Be equipped with venting, gauging, and gravity separation mechanisms
- Be designed to facilitate rapid and complete offloading.

5.4 OIL SKIMMING DEVICES

Oil skimming devices can range in size from several pounds to full-scale ships. The devices that are being considered are those that can be used to augment the skimming capability of the NSF's weir-type high seas boom, the OWOCRS. Of particular interest is whether candidate augmentation devices are towed- or tethered-type devices that can be used inside the OWOCRS boom to provide skimming capacity when the existing skimming/pumping system is not effective. Since the existing system operates quite effectively in freshly spilled oils of low and medium viscosities, skimming systems that can provide a capability for debris-laden, weathered oils of high viscosities are desirable.

5.4.1 SELECTION CHARACTERISTICS. The difficulties encountered by the OWOCRS as spilled product becomes weathered and debris-laden are related both to the weir design and the types of pumps employed. The openings for the weirs are of a limited size and can easily become partially clogged by the debris-thickened oil. This prevents the continuous flow of fluid into the suction side of the pumps, which, being diaphragm-type pumps, have no mechanism to stimulate or reinitiate the flow. Manual intervention must take place to keep this system functional. In addition, the relatively small (3 inch) size of the suction side hoses presents significant friction losses to the pumping system as the viscosity of the product increases, and this condition greatly diminishes achievable flow rates. Skimming devices intended to augment the OWOCRS should be capable of independent operation inside the towed boom and should use as a source of power the hydraulic flow from the OWOCRS prime mover of 32 gpm at 2500 psi. The skimming devices to augment the OWOCRS should be able to handle weather and sea conditions for which the OWOCRS was designed. These have been advertised to be Sea State 5 for sustaining operational function and Sea State 6 for surviving without damage.

Considering the preceding requirements, potential oil skimming devices intended to augment the OWOCRS should:

- Be a self-priming, positive displacement type device capable of collecting and pumping viscous products in the range of 2,000 to 300,000 cSt and independently sustaining or reinitiating flow of heavy products

- Be capable of handling debris-laden products and providing mechanisms to exclude or process the debris

- Be able to achieve maximum needed horsepower to sustain advertised flow rates from flow of 32 gpm to hydraulic motor at 2,500 psi

- Be adaptable, i.e., able to be floated and moored inside the OWOCRS boom or capable of functioning from a position located behind the OWOCRS boom

- Be of rugged construction and capable of operating in conditions up to Sea State 5 and able to survive conditions up to Sea State 6

- Be capable of delivering the flow against a head comparable to existing OWOCRS pumps.

Section 6

SELECTION OF CANDIDATE REPLACEMENT EQUIPMENT

The comments that introduced Section 5 pertain here as well. The initial plan was to be able to make specific selections of candidate replacement equipment by examining the technical data included in the large list of vendor responses. The quality of the responses, however, does not permit this. A general comparison with the physical and performance characteristics of the current NSF oil spill response equipment contained in Appendix A was made to assist in eliminating those responses that were not appropriate for further consideration. Because the initial equipment survey was a worldwide inquiry, this step was necessary to reduce the voluminous response to a manageable list of vendors from whom more specific technical data can be obtained.

6.1 PUMPING EQUIPMENT

This section lists all of the pumping devices that have been identified during the course of this project as showing potential for replacing or augmenting existing NSF inventories. It also identifies a list of additional screening parameters for which further information is needed on the specific pieces of equipment to allow a refinement of the field of candidates.

6.1.1 CANDIDATE REPLACEMENT TRANSFER PUMPS. The following pumps were identified from the responses to our equipment information solicitation as showing the potential to meet the selection criteria stated in Section 5:

- FRAMO TK6
- FRAMO TK8
- FRAMO TK125
- FRAMO TK150
- FRAMO TK200
- OEL NOLTE - MAST Pump T20.

6.1.1.1 Additional Screening Parameters. The following further information should be obtained as a basis for a paper comparison of the candidate transfer pumps:

- Material specifications of pump
- Dimensions and weight of pump
- Drawings of pump including schematics of hydraulic hookups and transfer connections
- A description of the mechanical process employed in moving the fluid

- Performance charts that display horsepower requirements and flow rates as a function of fluid viscosity and static geometric head (performance information should cover the viscosity range from 3 to 300,000 cSt and geometric heads up to 120 ft)

- Specifications of hydraulic prime mover requirements, flow rates, and pressures to develop required horsepower

- An indication of any limitations on continuous use of pumps

- A description of maximum size of debris that can be accommodated by the pump.

6.1.2 CANDIDATE REPLACEMENT PRIME MOVER PUMPS. The following prime mover pumps were identified from the responses to our equipment information solicitation as showing the potential to meet the selection criteria stated in Section 5:

- PHAROS MARINE's P-60 power pack

- VIKOMA INTERNATIONAL LTD.'s VM 115 power pack

- VIKOMA INTERNATIONAL LTD.'s VM 67 power pack.

6.1.2.1 Additional Screening Parameters. The following further information should be obtained as a basis for a paper comparison of the candidate prime mover pumps:

- Drawings and dimensions of the prime mover system

- Weight of the prime mover system, clearly identifying weights associated with built-in fuel capacity and hydraulic reservoir

- Any necessary ancillary equipment such as hydraulic fluid coolers, fuel bladders, etc.

- Performance charts that display horsepower requirements and flow rates when using recommended hydraulic fluids and maintaining a 2500 psi working pressure

- Performance information if Exxon Teresstic 46 hydraulic fluid is used

- Maximum horsepower available under continuous operating conditions and any operating limitations that may result from extremes in ambient conditions.

6.2 OIL/WATER SEPARATION DEVICES

This section lists all of the oil/water separation devices that have been identified during the course of this project as showing potential for augmenting existing NSF inventories. It also identifies a list of additional screening parameters for which further information is needed on the specific pieces of equipment to allow a refinement of the field of candidates. While some of these systems seem rather heavy to be operated efficiently within the NSF Strike Team scenario, the vendors' brochures indicated that they could be designed to meet specific requirements, i.e., be transportable by truck.

6.2.1 CANDIDATE REPLACEMENT OIL/WATER SEPARATION DEVICES. The following oil/water separation devices were identified from the responses to our equipment information solicitation as showing the potential to meet the selection criteria stated in Section 5:

- ABASCO's Oil/Water Separator
- ALSTHOM ATLANTIC INC.'s Turbiflux LL Separator
- ALSTHOM-ATLANTIQUE, Cyclonet Dynamic Oil Skimmer
- FLORIDA PRECISION SYSTEMS, INC.'s Richter System
- HYDE PRODUCTS' Tailored Design Oil/Water Separators
- JASTRAM FORSCHUNG's Oil/Water Separators.

In addition to these six Oil/Water Separators, the following separator has been identified independently by other Coast Guard personnel as deserving of further consideration:

- INTR/SEPT CORPORATION's Annular Centrifugal Contractors.

6.2.1.1 Additional Screening Parameters. The following information should be obtained as a basis for a paper comparison of the candidate oil/water separators:

- Drawings and dimensions of the oil/water separation device
- Weight of the oil/water separation device
- Performance information describing maximum flow rates attainable and indication of friction losses as a function of flow rates for fluids with viscosities ranging from 3 to 300,000 cSt
- A description of the maximum sizes of debris that can be processed.

6.3 TEMPORARY STORAGE DEVICES

This section lists all of the Temporary Storage Devices that have been identified during the course of this project as showing potential for replacing or augmenting existing NSF inventories. It also identifies a list of additional screening parameters for which further information is needed on the specific pieces of equipment to allow a refinement of the field of candidates.

6.3.1 CANDIDATE REPLACEMENT TEMPORARY STORAGE DEVICES. The following temporary storage devices were identified from the responses to our equipment information solicitation as showing the potential to meet the selection criteria stated in Section 5:

- FRANK AYLES & ASSOCIATES LTD.'s Module "F" of their SPILLSKIM oil recovery system
- DANTRAWL A/S' "OILTRAWL"
- COMPLETE ENVIRONMENTAL SERVICES, INC.'s "TEXABLAD"
- HOYLE MARINE LTD.'s "PILLOW TANKS" and "FLOATING TANKS"
- JW AUTOMARINE's flexible storage tanks
- KEPNER PLASTICS FABRICATORS, INC.'s "SEACONTAINER" pillow tanks and towable, collapsible transfer tanks
- OIL POLLUTION ENVIRONMENTAL CONTROL LTD.'s "FLEXITANK"
- SILLINGER's "POLLUTANK"
- VERSATECH PRODUCTS INC.'s "FLOATING OIL/WATER SEPARATOR."

6.3.1.1 Additional Screening Parameters. The following further information should be obtained as a basis for a paper comparison of the candidate temporary storage devices:

- Drawings and dimensions of the temporary storage device in both deployed and packaged conditions; drawings of venting, gauging, and decanting mechanisms
- Weights of the temporary storage device as they correspond to the various sizes offered
- Material specifications of fittings
- Material specifications of fabrics including tensile and shear strengths
- Description and/or drawings of flotation mechanisms
- Description and/or drawings of methods employed to ensure retention of recovered product within the device
- Stability information for the device if excessive pitch, roll, or heave could cause loss of retained product
- Description of offloading methods and cleaning methods if applicable
- Maximum towing speed for both "full" and "empty" conditions.

6.4 OIL SKIMMING DEVICES

This section lists all of the oil skimming devices that have been identified during the course of this project as showing potential for augmenting existing NSF inventories. It also identifies a list of additional screening parameters for which further information is needed on the specific pieces of equipment to allow a refinement of the field of candidates.

6.4.1 CANDIDATE AUGMENTATION OIL SKIMMING DEVICES. The following oil skimming devices were identified from the responses to our equipment information solicitation as showing the potential to meet the selection criteria stated in Section 5:

- ANTI POLLUTION, INC.'s D-12 SKIMMER
- WALOSEP's WALOSEP W4 SKIMMER
- PHAROS MARINE's GT-185 AND GT-260 SKIMMER/PUMPS
- DOMIL & ASSOCIATES' ORS WP-1-50 HEAVY OIL SKIMMER
- ENVIRONMENT PROTECTION MACHINES, LTD.'s PORTLAND SKIMMERS
- FRANK MOHN A/S' FRAMO/TRANSREC SKIMMING SYSTEM
- A/S De SMITHSKE's DESMI-250 and DESMI DESTROIL SKIMMER SYSTEMS
- OIL RECOVERY SWEDEN's WP-1-30 SKIMMER
- KEPNER PLASTICS FABRICATORS, INC.'s SEAVAC HELI-SKIMMER SYSTEM and the SEAVAC DELTA SKIMMER SYSTEM
- MORRIS INTERNATIONAL TRADING LTD.'s MI-30 SKIMMER
- OIL EQUIPMENT B.V.'s V.A.B. FOXTAIL SKIMMER.

In addition to these 11 oil skimming devices, the following device has been identified by the members of the NSF as deserving further consideration based on experience in using it in conjunction with the OWOCRS during the *Exxon Valdez* response:

- S.E.P. EGMOs' EGMOPOL SKIMMER.

A letter was sent to the manufacturer of this device as part of the initial solicitation for equipment information; however, no response was received. Because of the strong endorsement it has received from NSF members, additional efforts are warranted to establish contact with the manufacturer or the distributors.

6.4.1.1 Additional Screening Parameters. The following further information should be obtained as a basis for a paper comparison of the candidate oil skimming devices:

- Material specifications of system
- Dimensions and weight of system
- Drawings of system including schematics of hydraulic hookups and discharge connections
- Description of the mechanical process employed in moving the fluid and sustaining the flow to the suction side of the pumping mechanism
- Performance charts that display horsepower requirements, flow rates, and discharge fluid velocities as a function of fluid viscosity and static geometric head (performance information should cover the viscosity range from 3 to 300,000 cSt and geometric heads up to 50 feet)
- A list of recovery efficiency at various flow rates and how that was determined, i.e. OHMSETT, etc.
- Specification of hydraulic prime mover requirements, flow rates, and pressures in order to determine required horsepower
- An indication on any *limitations on continuous* use of the system
- A description of maximum size of debris that can be accommodated by the pump and the method whereby such debris is processed or excluded
- A description of flotation mechanism employed and any alterations that would be required to work in conjunction with the OWOCRS
- A description of system stability and weather and sea conditions in which the system can operate and survive.

Section 7

RETRIEVAL RACK AND OWOCRS ATTRITION PROBLEMS

Both the OWOCRS Retrieval Rack and the OWOCRS boom have current problems that are unrelated to the identification of replacement equipment. They are discussed separately in this section, and some suggested conceptual designs for improvements are offered.

7.1 RETRIEVAL AND STORAGE RACK FOR OWOCRS

When the OWOCRS system has been deployed and used in the water for oil containment, it has to be retrieved in such a way as to allow repacking of the soiled boom. Most frequently, the retrieval rack is positioned on the aft section of a ship, on a pier or dock, or on a shore line or beach. The general arrangement requires the retrieval personnel to bring one end of the boom into the open end of the rack to engage a separate retrieval towing line that can provide traction force to the boom. A hydraulically powered capstan is used to pull the retrieval line into the rack. As the retrieval line tows the boom near the rack, the retrieval personnel unfasten snap-hook clips, which are woven into the retrieval line, from each section of the boom. As each snap-hook is released from the boom, another man attaches another snap ring into a rollerdolly that is engaged in a slide track mounted in the ceiling of the retrieval rack. This procedure continues section by section along the entire length of the boom. As the boom is brought into the rack, the man who is operating the dollies can select any one of three tracks to engage the dolly. One track runs along the center line of the rack, one track runs along the right hand side of the rack, and one track runs along the left hand side of the rack. By alternating the track selection from middle to right to middle to left to middle etc., the operator can pack the boom into the rack by folding it back and forth until all of the boom is stored inside the rack. The entire rack and boom is then transported to another location for cleaning and repacking.

7.1.1 CURRENT DIFFICULTIES. Several problems exist during OWOCRS retrieval operations. Many times the retrieval site is not on a level footing. This can cause the rack to sit in an attitude that has the tracks and dollies leading down hill, thus causing the stored portion of the boom with its dollies to slide back toward the open end of the rack. There are added locations for retaining pins to secure the stored portion of the boom, but men must physically hold the stored boom in position until enough boom is in the rack to occupy the space between one retaining pin and the next pin.

The portion of the boom that is initially in the rack cannot be pushed all of the way to the back of the rack due to the dimensional limitation imposed by the track separation distance as compared to the spacing on the boom from one hook attachment point to the next. The current packaging arrangement has the three overhead tracks separated by a space that is less than the space from the center line of one boom panel to the center line of the next panel, as measured when the boom is in a stretched out position. When the boom is suspended across all three tracks, the extra length of boom, which is flexible, buckles between the panels. If the retrieval personnel attempt to push the suspended portion of the boom toward the back of the rack, the distance between any two adjacent hook points increases, thereby taking the slack out of the buckled portion of the boom. When all slack is removed, the boom becomes taut and any further attempt to push the suspended portion toward the back of the rack causes the dollies to bind in their tracks.

As a result of this situation, the retrieval personnel are only able to push the previously hung portion of the boom partially into the rack until more folded boom becomes available with which to push. This situation increases the force needed to push the entire boom and its approximately 102 dollies in the three tracks. Another problem that this causes is that the boom cannot be packed very tightly since the boom, which is soft and compliant, is not an effective media to transmit packing pressure.

The entire procedure to retrieve the full length of boom takes several hours of difficult work. The retrieval task is made more difficult by the problems associated with the use of the power capstan. The capstan is small in size and is mounted off center of the initial track. The men have to physically maneuver the boom to properly engage the dollies into the track. The tow line continually attempts to override itself under large amounts of tension thus requiring delays while the line is slipped or the capstan is reversed to prevent or release the override. In addition, there are other small difficulties caused by bends and kinks in the track assemblies.

7.1.2 CONCEPTUAL DESIGN. A new capstan design is proposed to help improve the performance of the retrieval rack. The design is referred to as a "canted drum capstan." The geometry of the new design uses two rollers instead of a single capstan head, one mounted in front of the other. The back roller is mounted at a different angle than the front roller. This configuration causes the in-hauling cable to walk on the back roller in the opposite direction of the front roller, thus eliminating the tendency of the tow line to continue to walk in one direction until it reaches the edge of the roller. This non-walking feature of the new design will completely eliminate the overriding problem of the current capstan. In addition, a compliant coating of polyurethane can be provided on the rollers to improve traction with the wet, oily in-haul line.

A second proposed change in the design of the retrieval rack is to change the technique of storing the boom in the rack. Instead of folding the boom from side to side, it can be folded into the rack along the long axis of the rack, i.e., front to back. This arrangement will require some design changes to the rack, but basically the rack will still be made of the same material and components. The open end can be closed using the same pipe and clamp construction. The side can be opened sufficiently to allow enough working room for the boom to enter but still be made of enough pipe and clamps to provide adequate side wall stiffness. The overhead tracks would consist of 8 sections that are each 8 feet long and mounted parallel to each other, for a total track length of 64 feet as compared to the present track length of 60 feet.

The new canted drum capstan could be mounted at one end of the rack near the overhead piping. An additional section of track would be mounted along the outside upper edge of the rack to serve as a distribution rail. The technique for retrieval would be as follows: the existing in-haul line would still be used to provide traction to the boom and the same snap-hooks would be used to support the weight of the boom; however, the sequence of dolly-to-track engagement would be different.

The first dolly would be inserted into the first available track and the second dolly would be inserted into the second track etc., but the next 14 dollies would be inserted into the new section of track that runs along the outside of the rack. As the third through the eighth dollies are fed along the new track, they will approximately line up with the third, fourth, fifth, sixth, seventh, and eighth track ends. As each of these dollies nears the track for which it is intended, the retrieval personnel can manually transfer the dolly snap-hook from the new track to the closest storage track. When the first 8 dollies have been transferred, the next 8 (numbers 9 through 16) are now also approximately in line with the 8 tracks. The in-hauling process can be temporarily halted while the retrieval personnel transfer dollies 9 through 16 to their respective tracks. At this point, 2 folds of boom have been recovered, which is equal to 40 feet of boom. The process can begin again to in-haul dollies 17 through 32 for the next 2 layers of boom. When the last layer has been stored, additional vertical posts can be inserted into the open sidewall of the rack to strengthen it for transport to the cleaning area.

This technique of retrieval has several advantages, most of which will result in time savings for the strike team. It will reduce the number of folded layers from 34 to 13, and this will greatly reduce the physical effort needed to push the suspended boom sections into the tracks because each layer of boom will have seven buckled areas that will provide a significant amount of slack to allow the layer to be pushed farther into the rack before any dolly binding occurs. In addition, the shorter length tracks will lend themselves to being stiff and straight, thereby reducing sliding friction. Since the tracks are short, they can be mounted in the rack so that their back end is positioned slightly lower than their front end, thus providing some compensation for those situations when the rack may be resting on an incline. This feature will also further reduce the sliding friction and provide a natural tendency for the boom to slide toward the back of the rack on its own and stay there. The final benefit of loading the rack in this way is the potential for an overall reduction in the size of the rack due to denser packaging of the boom. This could eliminate the need for special permits for transportation of oversized equipment.

Consideration should also be given to including a feature for preliminary cleaning of the boom as it is being recovered in 20-foot segments.

7.2 OWOCRS FUTURE CONSIDERATIONS

The OWOCRS system has been a good open-water containment and recovery system for many years, but there are some concerns for the future. A finite number of systems still exist in the NSF inventory, but the manufacturing firm that originally produced them has gone out of business. Every time the system is deployed in a spill situation, it is contaminated with oil and other grime that require extensive cleaning. To date, each cleaning cycle has produced some amount of attrition and loss of OWOCRS hardware. At some time in the future, it is logical to assume that the number of available OWOCRS will be reduced to a critical limit. Therefore, a plan for future OWOCRS development and procurement is necessary.

Phase Two of the current study should contain a task to examine the developmental history and the performance characteristics of the OWOCRS boom for the purpose of defining the requirements of a future replacement boom. These new requirements should include a stipulation for ease of cleaning to eliminate future attrition.

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Section 8

SUITABLE TEST FACILITIES

Several test facilities that can provide a large portion of the test capability required to properly evaluate the candidate oil spill response equipments have been identified. These facilities have been grouped into three categories: fixed or stationary facilities, mobile facilities, and special events and deployments. They are discussed separately to highlight their respective capabilities.

8.1 FIXED FACILITIES

Four fixed facilities that can be very instrumental in evaluating NSF candidate equipment were identified.

8.1.1 THE OIL AND HAZARDOUS MATERIAL SIMULATED ENVIRONMENTAL TEST TANK (OHMSETT). The OHMSETT in Leonardo, New Jersey, was developed expressly for oil spill response equipment test and evaluation. It is an outdoor tow tank that can simulate actual oil spills by pouring oil and other materials on the water and then towing models and other prototype equipment to evaluate their effectiveness in removing the contaminants. The facility was decommissioned in 1988; however, it is being renovated and plans exist for reopening it next year. The facility is an outdoor, above-ground test tank that is built of concrete and measures 203 meters long and 20 meters wide inside. The water is 2.4 meters deep, and a wave maker is installed at one end of the tank. The maximum tow speed is approximately 6.5 knots. The main towing bridge has a demonstrated capability to support 1.2 metric tons per square meter static load. The point of contact is as follows:

Mr. James Evans
Minerals Management Service
381 Elden Street
Herndon, VA 22070-4817
(703) 787-1559

8.1.2 UNDERGROUND STORAGE TANK (UST) TEST APPARATUS. A facility has been designed and built in Edison, New Jersey, to aid in developing a comprehensive understanding of the physical phenomena that can influence the accuracy of precision tank tightness tests and line tightness tests and to provide experimental support for the development of national underground tank regulations. The apparatus consists of a pair of 8,000-gallon tanks installed underground. Two insulated tanks (22,500 and 11, 250 liters, respectively) are located above ground and are situated between the two underground tanks. Each of these tanks contains heat exchangers to permit thermal conditions to be controlled. Extensive instrumentation is available for monitoring the product conditions. A pair of 1500-liter-per-hour transfer/circulation pumps specifically designed to handle petroleum liquids are available. The point of contact is as follows:

Mr. Robert W. Hilliger
U.S. Environmental Protection Agency
Risk Reduction Engineering Laboratory
Release Control Branch, MS-104
2890 Woodbridge Avenue
Edison, New Jersey 08817
(201) 321-6639

8.1.3 U.S. NAVY OIL SPILL RESPONSE DEPOT. A facility for testing pumps is installed on the grounds of the U.S. Navy Oil Spill Response Depot at Cheatham Annex near Williamsburg, Virginia. This facility consists of an underground tank with several sizes of pipe connections that are configured in pairs to serve as inlet and outlets. For example, to test a given pump, the pair of pipes that most closely matches the pump size would be selected, and proper sized couplings and adapters would be used to connect the inlet of the pump to the inlet of the pipe and the outlet of the pump to the outlet pipe. If instrumentation such as a flow meter is required, it would be installed concurrently with the pump. The test can then be performed by providing power to the pump and allowing it to draw fluid from the tank through the instrumentation and return it back to the tank. By inserting various sized resisters in the line, the pump can be made to work against different fluid pressures. At this time, the tank is restricted to using water only. The point of contact is as follows:

Mr. Joseph Stahovec
NAVSEA
Washington, D.C. 20362
(703) 697-7403

8.1.4 DAVID TAYLOR RESEARCH CENTER (DTRC) TOW TANK. DTRC is located in Carderock, Maryland, which is a short distance from Washington, D.C. The facility contains numerous indoor towing basins and tow carriages and is world renowned for its technical work in hydrodynamics and underwater research. While the facility does not permit spilling contaminants into the water, it provides excellent underwater visibility for examining and evaluating towed arrays, cables, models, and other water-borne devices. Added capabilities include model shops, pressure tanks, tensile testing machines, and instrumentation of various kinds. The point of contact is as follows:

Commander
David Taylor Model Basin
Bethesda, Maryland 20084-5000
(202) 227-1515

8.2 MOBILE FACILITIES

There are several mobile facilities available that might play an important role during the test and evaluation phase of the study. Each of the facilities discussed have a primary mission other than oil spill response, but they can support the NSF candidate equipment evaluation when necessary.

8.2.1 COAST GUARD VESSELS. During the test phase of the NSF candidate equipment, there will likely be times when open-water testing requirements will necessitate the use of ships and boats of various sizes. When conducting a test of new or modified equipment, it is desirable to have a dedicated test platform if possible. Coast Guard vessels can be of great value in these situations because the Coast

Guard has a vested interest in the success of the current study. In times of emergency, these same vessels could be summoned to assist in the oil spill response. A general knowledge of the equipment and its operation could bring large dividends to the operation. Certainly, the general skills and seamanship that the Coast Guard vessel's captain and crew would bring to the at-sea test operations would be invaluable.

8.2.2 RESEARCH VESSEL (R/V) *ATHENA*. Unique facilities that can support the NSF equipment evaluation are the Navy's research ships R/V *Athena* and R/V *Athena* II. These ships are specifically configured to conduct open-water test and evaluation exercises involving towing and the use of hydrodynamic arrays and equipment. They have controllable pitch propellers that enable them to tow test gear at low speeds with excellent precision. Their crews are well-versed in safe and efficient deck handling procedures and in the launch and recovery of unusual systems and arrays. Both ships are also equipped with turbine propulsion, which allows them to rapidly transit from port to distant test operating areas. The R/V *Athenas* are sister ships that have a displacement of 265 tons, and overall length of 165 feet, and a maximum beam of 24 feet. Both ships are home-ported in Panama City, Florida. The point of contact is as follows:

Mr. James Heffner
David Taylor Model Basin
Bethesda, Maryland 20084-5000
(202) 227-2005

8.2.3 CONTAINERIZED BARGE. The Navy operates and maintains a containerized barge designated *YOM* at the Cheatham Annex near the pump test facility. The barge is listed here with other mobile facilities because it is afloat and could be moved to another site if assisted by a tug or other self-propelled vessel. The barge is moored to the sea wall and is frequently used for personnel training in oil tank inspection techniques. The barge contains eight independent tanks, each equipped with fluid level sounding meters. A diesel-powered prime mover is mounted in a deck level control room. A manifold of piping, which could allow transferring fluid from one tank to another, extends along the surface of the deck. The portion of the piping nearest to the control room is configured in a way that would allow mounting a pump in the line for test purposes. The tanks are suitable for use with oil of a wide range of viscosities, temperatures, and quantities. The point of contact is as follows:

Mr. Joseph Stahovec
NAVSEA
Washington, D.C. 20362
(703) 697-7403

8.3 SPECIAL EVENTS AND DEPLOYMENTS

The third category of facilities includes special situations and events that might happen from time-to-time to permit a test involving actual oil spill conditions. Some of these special situations and events can be preplanned and expected while others might require the preparation of test equipment and a standby arrangement until the opportunity arises.

8.3.1 FIRE AND SAFETY TEST DETACHMENT OF THE MARINE SAFETY LABORATORIES. In Mobile, Alabama, the Coast Guard operates and maintains a facility that permits open-air burning of spilled oil on water in a contained test tank. This facility is intended for testing the burn resistance of experimental fire booms designed to be used for spill response when burning has been approved as the selected means of disposing of the spill. The environmental issues of open-air burning are still being examined, and there is strong resistance to open-air burning by many environmentalists. The point of contact is as follows:

R.C. Richards
Chief, Marine Fire and Safety Division
U.S. Coast Guard
Marine Safety Laboratory
Avery Point
Groton, Connecticut 06340
(203) 441-2760

8.3.2 MULTINATIONAL OIL SPILL EXERCISES. While the United States prohibits any intentional spilling of oil in or on our public waterways, some European countries permit controlled spills for test purposes. Likewise, Canada sometimes allows special spill testing. To benefit from such arrangements, detailed planning, coordinating, and communications will be necessary. Test plans and objectives must be streamlined and direct to avoid adding any new complications to the spill situation; goals and objectives must be clearly defined and stated to all concerned; and to minimize costs, logistics and transportation must be handled expeditiously.

8.3.3 NSF EXERCISES. A contingency plan to conduct some open-water tests of oil spill response equipment in support of the NSF Strike Teams during an actual spill response exercise may be possible. All of the previous comments relative to using spill exercises of other nations also apply to spills-of-opportunity in our own country.

Section 9

GENERIC TEST AND EVALUATION PARAMETERS

The intent of this section is not to develop detailed test plans but rather to identify the types of tests that should be conducted to adequately evaluate the performance of the equipment. In Phase Two, once the type of equipment (e.g., oil/water separators) has been selected, then a detailed test plan will be developed.

The process of analyzing NSF equipment requirements identified numerous considerations or characteristics by which the various candidate pieces of equipment could be judged. Some of these criteria were quite specific and wholly quantitative. Others were much more subjective in nature. Some of the criteria were found to be applicable across the entire spectrum of equipment types that are being considered for replacement or augmentation.

An initial step in formulating a comprehensive test and evaluation procedure was to identify, and, where possible, quantify essential requirements. This has been done in matrix format (see tables at end of Section 9) for each category of equipment under consideration. The selection characteristics developed for each category of equipment in Section 5 were integrated into essential requirements, listed in Column 1 of the matrices. These requirements have been identified in Columns 2 and 3 as being related to either Performance Requirements or Feature Requirements, respectively. Column 4 identifies the generic type of test that is needed to prove the essential requirement, and Column 5 provides further definition to the testing process by briefly listing the test parameters that are germane to each individual requirement. Column 6 has the coded description for the test facility most appropriate to the type of tests planned for each unit.

In general, most requirements have been identified as either performance related or feature related. In some instances, such as with the Oil/Water Separators' requirement to handle debris, the requirement has been deemed both performance and feature related. It would not be advisable, or perhaps even necessary, to test a separator for this requirement without examining its design features to decide if a test could be conducted. Generally, most requirements identified as feature related are more qualitative in nature and can be verified through engineering review and physical inspection. In most cases, a formal testing procedure will not have to be developed. However, to provide a basis for comparison of candidates, standardized methods of describing the features will have to be developed.

Generally, in the case of performance-related requirements, an operational test will be necessary and will require the presence of the candidate equipment at an identified testing facility. Testing performance-related requirements will be more time intensive from the standpoint of conducting the test and in finalizing the logistics and procedures to obtain meaningful results.

9.1 TRANSFER PUMPS. Table 9-1 outlines the generic test matrix for Transfer Pumps. For Transfer Pumps, the proof of requirements is fairly well balanced between operational tests and engineering verification. Of the operational tests, it appears that it may be possible to conduct all necessary tests at a single testing location.

9.2 HYDRAULIC PRIME MOVER PUMPS. Table **9-2** outlines the generic test matrix for Hydraulic Prime Mover Pumps. For Hydraulic Prime Mover Pumps, most requirements can be proved through engineering verifications. Of the two operational tests needed, both should be able to be conducted at a single time in one location.

9.3 OIL/WATER SEPARATORS. Table **9-3** outlines the generic test matrix for Oil/Water Separators. For Oil/Water Separators, proof of requirements is evenly balanced between operational tests and engineering verifications. It appears that it should be possible to conduct all operational tests at a single location.

9.4 TEMPORARY STORAGE DEVICES. Table **9-4** outlines the generic test matrix for Temporary Storage Devices. For Temporary Storage Devices, proof of requirements is nearly evenly split with operational tests numbering one less than engineering verifications. The operational tests are still not well defined, but these tests appear to be much more independent than the tests associated with the previous categories of equipment. The operational tests for Temporary Storage Devices are likely to require individual testing sites and times.

9.5 OIL SKIMMING DEVICES. Table **9-5** outlines the generic test matrix for Oil Skimming Devices. For Oil Skimming Devices, proof of requirements is heavily weighted toward operational tests. This category of equipment presents the most extensive need for operational tests, which are also probably the most difficult to arrange and coordinate. It appears that they will have to be conducted at several locations and on occasions that may be separated by substantial blocks of time. Under the column for Requirements, there are both Heavy Product Flow and High Viscosity Capable. High Viscosity has the most common meaning for fluid resistance as a function of fluid thickness. Heavy Product is a more generic term to describe the oil residue that has been contaminated with debris, ice, etc., In the case of a gravity fed skimmer, Heavy Product may defy gravity and fail to feed itself into the intake of the skimmer.

NOTE

Tables 9-1 through **9-5** appear on pages 9-3 through 9-7, respectively.

Definitions of the Acronyms used in Column 6, **TEST FACILITIES**, of the tables are as as follows:

- **PTF** Pump Test Facility
- **CB** Containerized Barge
- **OHMSETT** Oil and Hazardous Material Simulated Environmental Test Tank
- **DTRC** David Taylor Research Center
- **UST** Underground Storage Tank

Table 9-1. Requirements and Generic Test Plans for Transfer Pumps

REQUIREMENTS FOR TRANSFER PUMPS	PERFORMANCE REQUIREMENTS	FEATURE REQUIREMENTS	GENERIC TESTS	TEST PARAMETER	TEST FACILITIES
Rugged Construction		X	Drop Test	TBD	
Weight		X	Verification	Drawings and Scale	
Size		X	Verification	Drawings and Visual Examination	
In-Line Coupling		X	Coupling Test	Drawings, Visual Examination, and Fit Up	
Suction Location		X	Verification	Drawings	
Hazardous Material Capable	X	X	Compatibility Test	Material Specifications and Test TBD	?
Hydraulically Driven	X	X	Pumping Test	Range of ADAPTS III or VOPS	PTF UST
Viscosity Range	X		Pumping Test	Range from 3 to Max cSt	CB UST
Flow Rates	X		Pumping Test	Pressure from 0 to 150 Feet of Head	PTF UST
Reliability	X		Endurance Test	Multiple Copies Tested Simultaneously at Selected Design Points and Durations	PTF CB UST

Table 9-2. Requirements and Generic Test Plans for Hydraulic Prime Mover Pumps

REQUIREMENTS FOR HYDRAULIC PUMPS	PERFORMANCE REQUIREMENTS	FEATURE REQUIREMENTS	GENERIC TESTS	TEST PARAMETER	TEST FACILITIES
Rugged Construction		X	Drop Test	TBD	
Light Weight		X	Verification	Drawings and Scale	
Inclusion of Fossil Fuel Power Plant		X	Verification	Drawings	
Transportability by Ship or Helicopter		X	Verification	Drawings and Visual Examination	
Maneuverability		X	Verification	Evaluation by NSF Team Members	
Flow Rate	X		Pumping Test	Measure Flow over Range of Pressures	PTF UST
Reliability	X		Endurance Test	Multiple Copies Tested Simultaneously at Selected Design Points and Durations	PTF CB UST

Table 9-3. Requirements and Generic Test Plans for Oil/Water Separators

REQUIREMENTS FOR SEPARATORS	PERFORMANCE REQUIREMENTS	FEATURE REQUIREMENTS	GENERIC TESTS	TEST PARAMETER	TEST FACILITIES
Size and Weight		X	Verification	Drawings and Scale	
In-Line Compatibility with OWOCRS		X	Design/Integration Effort Required	TBD	
Transportability by Ship or Helicopter		X	Verification	Drawings and Visual Examinations	
Ability To Handle Debris and Viscous Products	X	X	Pumping Test/ Verification	Debris Characteristics TBD/Drawings	CB UST
Product Clarity	X		Flow Test	Chemical Analysis	CB UST
Low Flow Resistance	X		Pumping Test	Range of Pressures	CB UST
OWOCRS Flow Rate Capacity	X		Flow Test	Rates TBD	CB UST
Reliability	X		Endurance Test	Multiple Copies Tested Simultaneously at Selected Design Points and Durations	PTF CB UST

Table 9-4. Requirements and Generic Test Plans for Temporary Storage Devices

REQUIREMENTS FOR TEMPORARY STORAGE DEVICES	PERFORMANCE REQUIREMENTS	FEATURE REQUIREMENTS	GENERIC TESTS	TEST PARAMETER	TEST FACILITIES
Lightweight Construction		X	Verification	Drawings and Scale	
Variable Sizes - 5,000 to 300,000 Gallons		X	Verification	Calculations	
Small Package for Transport		X	Verification	Determination from Drawings and Visual Interpretation	
Compatible for On-Vessel or In-Water Use		X	Verification	Drawings	
Durability	X	X	Handling Test	Procedures TBD/Material Specifications	CB OHMSETT
Equipped with Venting, Gauging, and Decanting Mechanisms	X		Determination from Drawings	Calibration Tests	CB UST
Provide Rapid and Complete Offloading	X		Simulation Test	Procedures TBD	CB
Towable up to Sea State 6	X		Tow Test	Simulated Sea State	DTRC OHMSETT
Cleaning and Maintainability		X	Determination from Provided Instructions	Determination from Instructions and from Visual Inspection	

Table 9-5. Requirements and Generic Test Plans for Oil Skimming Devices

REQUIREMENTS FOR SKIMMERS	PERFORMANCE REQUIREMENTS	FEATURE REQUIREMENTS	GENERIC TESTS	TEST PARAMETER	TEST FACILITIES
Rugged Construction		X	Drop Test	TBD	
ADAPTS Compatible	X		Pumping Test	Range of Hydrodynamic Characteristics: 0 - 2500 psi/32 gpm	CB OHMSETT UST
Self Priming, Positive Displacement Pump	X	X	Pumping Test	Determine from Drawings/Break Suction	CB UST
OWOCRS Boom Compatible	X	X	Integration and Design	Mounting and Arrangement/Deployment	OHMSETT
Ability to be Operated in Sea State 5	X		Tow Test/Pumping Test	Simulated Sea State	OHMSETT DTRC
Heavy Product Flow	X		Pumping Test	Heavy Product/H_20 Interface Arrangements	PTF CB UST
Debris Handling	X		Pumping Test	Debris Characteristics TBD	CB OHMSETT
High Viscosity Capable	X		Pumping Test	Viscosity Range from 3 to 300,000 cSt	CB OHMSETT UST
Flow Rates	X		Pumping Test	Pressure from 0 to 150 Feet of Head	PTF UST
Reliability	X		Endurance Test	Multiple Copies Tested Simultaneously at Selected Design Points and Durations	PTF CB UST

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Section 10

RECOMMENDED SEQUENCE OF TESTING

The generic test plan discussed in Section 9 defined the type of tests needed to evaluate each category of equipment involved in the NSF equipment upgrade study, but it did not specify the sequence of testing that should be performed. The overall cost of any test program is always related to the complexity of individual tests, the total number of tests, and the number and variations of test setups required.

A large number of candidate equipments passed the initial screening process in Phase One. The paper analysis planned in Phase Two will reduce the number further. It is not very likely that all candidates will actually be tested. More likely, a specification will be developed for the capabilities of the equipment that encompasses the Coast Guard requirements. Solicitation will be invited for any equipment that meets the specification, and one (equipment) will be procured and tested.

It is suggested that a complete matrix of expected tests be organized and examined before any tests are performed. During this examination, the interdependency between the various categories of equipment should be defined. For example:

- Suppose a certain pump is needed to serve as a power source during a test of a separator or storage device but is also listed as an independent device that will require testing. The test setup should be configured to allow both tests to be performed without requiring a second setup.

- Tests that require deploying the OWOCRS boom to test design modifications to the retrieval rack should also plan to evaluate the skimmer within the OWOCRS barrier during the same setup.

- Tests that involve using the same equipment in more than one way should be configured to use the device in a clean environment before conducting tests that require the same device in an unclean environment.

Priority should be given to tests that might present a well-defined challenge to a candidate device. This will accelerate the screening process and reduce the total number of tests that will be needed to make final selections of the upgraded/new equipment.

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Section 11

STUDY CONCLUSIONS

The plan for Phase One of the study, which was to define candidates for replacement of NSF oil spill response equipment, focused on specific items used by the strike teams, such as pumps, separators, storage devices, skimmers, and the retrieval rack. The main conclusions of the Phase One study were as follows:

- After the initial screening was complete, there was still a significant list of candidate replacement equipment in the categories of pumps, separators, storage devices, and skimmers; however, due to the lack of detailed technical data on much of the candidate equipment, no final selections could be made. A second screening will require specific physical, operational, and performance data to reduce the number of candidates to only those that meet the requirements for NSF service.

- Sufficient information was provided to organize a generic test plan. The requirements for each category of equipment were examined separately and used to define the key generic test parameters and the appropriate test facilities where the tests might be conducted.

- The NSF should only accept new oil spill response equipment that has proven itself by actual field testing. Any future test plan should include field testing and, if possible, the strike team personnel should be involved.

- Two conceptual design changes, which should improve the performance of the retrieval and storage rack and reduce its size in width, were identified. A modification to replace the single head power capstan with a set of canted double drum rollers will eliminate the retrieval line walking on the capstan and the overriding of the line on itself. A modification to the retrieval rack to allow it to retrieve the OWOCRS boom through the side wall instead of through the end wall can provide tighter packaging of the boom in the rack. This will allow redesign of the rack to reduce its width to a value less than 8 feet, thereby eliminating the need for "oversize load "road permits.

During the study, other problem areas were identified as well. The most important of these was the pending difficulty of future replacement for the OWOCRS boom and skimming weirs. While the NSF has several copies of OWOCRS booms in their inventory, the attrition due to deployment, refurbishment, and cleaning operations is continually depleting their supply. Because there has not been a suitable replacement for the OWOCRS since the original supplier went out of business several years ago, the NSF will eventually run out of OWOCRS booms. Therefore, through a concerted effort, a plan that will define a suitable replacement for the OWOCRS must be developed.

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Section 12

RECOMMENDATIONS

The conclusions of Phase One of the study strongly suggest that the Coast Guard implement the following four recommendations:

- During Phase Two of the study, obtain detailed technical operational and performance data from each of the candidate manufacturers who passed the initial screening of Phase One. Use this information to perform additional screening of the candidates to make final selections of those candidates that show the most promise as NSF replacement equipment.

- Refine the generic test plan from Phase One into a specific test plan to be used for performance testing of the candidate upgrade equipment. Include in the plan such information as logistical support items, test facility designation, test schedules, identification of support instrumentation, subcontracting plans, and cost estimates.

- Conduct a preliminary design analysis of the retrieval rack to determine the feasibility of incorporating the two proposed conceptual design modifications. If the results of this recommendation are positive, incorporate the modifications into the retrieval rack and include the rack in the test plan. Implement the test plan to make final selections of candidate upgrade equipment.

- While the replacement of the OWOCRS was not the subject of this study, it is obvious from the information obtained during the study that a replacement system must be considered because the OWOCRS is "running out of time."

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APPENDIX A

PHYSICAL AND PERFORMANCE CHARACTERISTICS

OF CURRENT NATIONAL STRIKE FORCE

OIL SPILL RESPONSE EQUIPMENT

TRANSFER PUMPS

The NSF maintains and can provide six different transfer pumps for oil spill response. They are described in the paragraphs that follow.

1. Double-Stage Pump

This is a 10-inch diameter, two-stage, mixed flow pump, driven by a hydraulic motor through an enclosed direct drive coupling. The suction intake is located 24 inches above the bottom of the pump housing. The power source for this pump can be either of the two prime movers maintained by LAST.

Weight:	*500 lbs*
Dimensions:	*20" x 20" x 113"*
Cubic Dimensions:	*26.1 cubic ft*
Pumping Rate	*900-1645 gpm*

NOTE

Pumping rate will be directly dependent on product viscosity, with product discharge through 6-inch discharge hose.

2. Single-Stage Pump

This is an 8-inch diameter, one-stage, mixed flow pump driven by a hydraulic motor through an enclosed direct drive coupling. The suction intake is located 18 inches above the bottom of the pump housing. The power source for this pump can be either of the two prime movers maintained by LAST.

Weight:	*265 lbs*
Dimensions:	*13.5" x 19.5" x 59"*
Cubic Dimensions	*7.7 cubic ft*
Pumping Rate:	*750-1500 gpm*

NOTE

Pumping rate will be directly dependent on product viscosity, with product discharge through 6-inch discharge.

3. Thune-Eureka

This is a 12-inch diameter, one-stage, mixed flow pump driven by a hydraulic motor through an enclosed direct drive coupling. The suction intake is located on the bottom of the pump housing and is capable of stripping a tank's product to within 3 to 4 inches of the tank's bottom. The power source for this pump is the VOPS Prime Mover maintained by LAST.

Weight:	*280 lbs*
Dimensions:	*21" x 23" x 54"*
Cubic Dimensions:	*15.1 cubic ft*
Pumping Rate:	*200-1800 gpm*

NOTE

Pumping rate will be directly dependent on product viscosity, with product discharge through 6-inch discharge hose.

4. Sloane "Trash Pump"

This is a 20-inch diameter trash pump driven by a hydraulic motor. The suction intake is located on the bottom of the pump. The power source for this pump can be either of the two prime movers maintained by LAST.

Weight:	*140 lbs*
Dimensions:	*27" x 27" x 31"*
Cubic Dimensions:	*13.1 cubic ft*
Pumping Rate:	*1147 gpm (40' head)*

NOTE

This is a low viscosity pump used for pumping products such as water and gasoline, with discharge through 6-inch discharge hose.

5. Single-Stage "Stripper Pump"

This is an 8-inch diameter, one-stage, mixed flow pump driven by a hydraulic motor through an enclosed direct drive coupling. The suction intake is located on the bottom of the pump housing and is capable of stripping a tank's product to within 3 to 4 inches of the tank's bottom. This pump can also be used as an in-line booster for long pumping distances. The power source for this pump can be either of the two prime movers maintained by LAST.

Weight:	*356 lbs*
Dimensions:	*18" x 20" x 66"*
Cubic Dimensions:	*12.6 cubic ft*
Pumping Rate:	*600-1330 gpm*

NOTE

Pumping rate will be directly dependent on product viscosity, with product discharge through 6-inch discharge hose.

6. FRAMO TK-5 Pump

This is a 12-inch diameter corrosive chemical pump that can also be used to pump viscous oils and fluids of high temperatures. It is constructed of stainless steel. This pump is normally used with stainless steel hydraulic and discharge hose. This pump can also be used as an in-line booster for long pumping distances. The power source for this pump can be either of the two prime movers maintained by LAST.

Weight:	*155 lbs*
Dimensions:	*20" x 22" x 56"*
Cubic Dimensions:	*14.3 cubic ft*
Pumping Rate:	*200-1147 gpm*

NOTE

Pumping rate will be directly dependent on product viscosity, with product discharge through 6-inch discharge hose.

PRIME MOVERS

In addition, the NSF has two prime mover systems to support use of any of the six transfer pumps and the OWOCRS. The two prime movers are described below.

- **Air Deployable Anti-Polution Transfer System (ADAPTS)**

  ADAPTS is powered by a Type III Avco Lycoming diesel prime mover that pushes hydraulic fluid to a submersible pump. The hydraulic fluid drives a hydraulic motor that is part of the pump. The pump then pushes product through a discharge hose for lightering into a suitable container. The prime mover is equipped with spark arrestors and a hydraulic starting system, allowing operation in a volatile atmosphere. The prime mover weighs 1,650 pounds and delivers 32 gpm of hydraulic fluid at 2.500 pounds per square inch. It occupies 80 cubic feet of space. It is normally contained in a 225 pound, 4 cubic foot rigging box and is supplied with fuel from a 485 pound, 9.5 cubic foot fuel bladder.

- **Viscous Oil Pumping System (VOPS)**

  The VOPS has the capability to pump high viscosity petroleum products. It is very similar in concept to the ADAPTS and shares some of the same components such as the tripod, hydraulic hoses, discharge hoses, and the fuel bladders. The VOPS prime mover is a General Motors GM-4-53 water-cooled diesel engine. The pump pushes the product through a discharge hose for lightering into a suitable container. The VOPS will operate any of the submersible pumps in the LAST inventory. The system has the capability to drive two pumps simultaneously. The unit weights 5,340 pounds and delivers 52 gpm of hydraulic fluid at 2,500 pounds per square inch.

TEMPORARY STORAGE DEVICES

The NSF maintains a series of temporary storage devices referred to as the Portable DRACONE Barges, which are available in three sizes and are described below.

- **Portable DRACONE Barges**

  THE DRACONE Barge is a flexible tube designed to carry petroleum products or other liquid materials with a specific gravity less than 1. It is constructed of nylon cord and woven nylon fabric that has been proofed with weather- and abrasion-resistant synthetic rubber outside and nitrile rubber inside. Buoyancy tubes are an integral part of the barge. Nose and tail cones of an aluminum alloy provide for a cargo seal, loading/discharge hose, and a means to tow the barge when deployed. The DRACONE Barge can provide an alternative container for recovered product. The DRACONE Barge is rolled up on pallets for storage and transit. Heavy load handling equipment (16,000 lb crane) is required for their deployment and recovery. **Table A-1** contains the dimensions for the different types of Dracone Barges.

Table A-1. DRACONE Barge Dimensions

DRACONE	TYPE "D"	TYPE "F"	TYPE "O"
Length (in Feet)	103	165	300
Diameter (in Feet)	4.6	7.7	13.9
Weight (in Pounds)	1,715	5,005	14,300
Cubic Foot Dimension	150	270	570
100% Capacity (in Gallons)	12,000	50,400	290,500
85% Operational Capacity (in Gallons)	10,200	42,840	246,925
50% Land Capacity (in Gallons)	6,000	25,200	145,250

APPENDIX B

REVIEW SUMMARY OF ALL VENDOR RESPONSES

PUMPS

TRANSFER PUMPS

Potential Category:

- FRANK MOHN HOUSTON INC., distributors for FRANK MOHN A/S, offers a number of pumps that should be considered for potential replacement of the existing NSF pumping capabilities. These include the TK6, TK8, TK125, TK150, and the TK200. All of these pumps except the TK6 would fit through a standard size Butterworth opening, and all are in the 70 to 85 kg range except the TK8 and the TK200, which both weigh 130 kg. Characteristics of the individual pumps were not provided in a standard fashion to facilitate comparisons, and additional information is needed to further screen these candidate replacement pumps.

- OEL NOLTE - MAST pump T20, a submersible electric drive pump, may bear some consideration based on limited flow data. More information is needed to determine if hydraulic drive is a possibility and to evaluate the flow characteristics with varying oil viscosities.

Not Appropriate Category:

- ABASCO offers a positive displacement pump; however, it is made of heavy cast iron and its capacity is too limited for this application. No design data were provided to evaluate potential for modifications or upscaling.

- MEGATOR CORPORATION's pump line is not adequate for transfer pump use because of inadequate flow rate, and it would require reworking to accommodate hydraulic power instead of electric motors.

FLOAT PUMPS

Potential Category:

- OEL NOLTE - MAST pumps NP 4 J, NP 8 J, and NP 12 J appear to offer promise as a pump float replacement. The current configuration incorporates gasoline, diesel, or electric drive, which would have to be changed to hydraulic drive. Even greater potential appears to be offered by the NOLTE FLOWMATIC, which is capable of accommodating 1060 gpm and handling debris up to 4 inches. This pump comes with a diesel or electric drive and would require conversion to hydraulic drive.

- FLOW TREND SYSTEMS, INC. - MASTR-PUMP offers considerable potential. It is a peristaltic pump that is designed to handle viscous slurries, advertises a 30 ft suction head, a 102 ft delivery head, and a capacity of 132 gpm. It can accommodate hydraulic power. However, this pump has one drawback: it can be to be upscaled to attain a satisfactory flow rate but will only accommodate debris up to .75 inches.

Not Appropriate Category:

- ABASCO offers a positive displacement pump; however, it is made of heavy cast iron and its capacity is too limited for this operation. No design data were provided to evaluate potential for modifications or upscaling. The ability to exclude or process debris-laden, highly viscous products could not be determined.

- MEGATOR CORPORATION's pump line offers positive displacement capability that is desirable and has adequate capacity for consideration. However, from the information given, it does not appear that it could accommodate debris of any significant size.

PRIME MOVER PUMPS

Potential Category:

- A.S.I., as agents for PHAROS MARINE, offers prime mover power packs that are compact and can handle their largest skimming pumps. More information is needed on actual specifications, but the potential should be explored, in particular the P-60 pump.

- AUTOMATIC POWER INC., distributor for PHAROS MARINE products, offers a variety of power packs to accompany their skimmer/pumping systems. These are compact self-contained systems. The Type P-60 is their largest, incorporating a 60 kW diesel engine to drive the hydraulic pump. It provides a flow of approximately 40 gpm and weighs approximately 2000 pounds.

- VIKOMA INTERNATIONAL LTD., offers two prime mover pumps, the VM 115 Diesel/Hydraulic Powerpack and the VM 67 Diesel Hydraulic Powerpack, both of which offer considerable flow rates at reasonable package weights.

Not Appropriate Category:

- For their system, A.S.I., as agents for WALOSEP, offers a prime mover power pack that is compact and relatively light, but the flow rate is not adequate to support other NSF equipment.

- MORRIS INTERNATIONAL TRADING LTD., offers a Diesel/ Hydraulic Power Pack, Model "M" for use with its skimming device. Its limited flow rate, a maximum of 7 gpm, is inadequate to support other NSF equipment.

SKIMMERS

Potential Category:

- ANTI POLLUTION, INC., offers a B-11 and a D-12 skimmer. The former unit is too small for consideration; however, the D-12 is advertised as being able to handle heavy oils and to process small and intermediate size debris automatically. It is a paddlewheel skimming device with a recovery rate that is in question. The OHMSETT data show a maximum recovery rate of 35.4 gpm in heavy oil; however, this device was supposed to have recovered 365 gpm in field use.

- A.S.I., agents for WALOSEP, offer the WALOSEP W4 skimmer, which provides good capacity, up to 560 gpm, and incorporates an archimedean screw type pump. It is advertised as being able to handle oil mousse, but its operating mechanism appears susceptible to failure in heavy concentrations. More complete information is needed on its debris excluding/cutting capabilities.

- AUTOMATIC POWER INC., distributors for PHAROS MARINE products, offers the GT-185 and the GT-260 Skimmer/Pumps. These skimming devices appear to be identical except for size and capacity. They employ an archimedean screw pump and incorporate debris cutting knives. The 440 gpm capacity of the GT-260 is more than double that of the GT-185. Both appear adaptable to incorporation within the OWOCRS design and offer a unit to remotely control the pumps.

- BOHUS INVEST INTERNATIONAL AB also provided information on WALOSEP products. See discussion under A.S.I., preceding.

- DOUGLAS ENGINEERING offers the Skim-Pak 19500 double weir-type skimmer, which incorporates a debris grinder and advertises reasonable flow rates (200 - 500 gpm) for debris-laden oils between 1,000 and 10,000 cSt. Claims are also made for capabilities at reduced flow rates for oils up to 200,000 cSt. This skimmer is not light. It weighs 3,000 pounds and has a 12' length and a 9' beam. Type of pump is not described.

- DOMIL & ASSOCIATES offers the ORS WP-1-50 heavy oil skimmer. This appears to be a unique device that incorporates a rotating intake with an archimedean screw type pump capable of handling small and intermediate debris within high viscosity products. It advertises a 300 gpm recovery rate. Information provided was scanty, and further information should be obtained.

- ENVIRONMENT PROTECTION MACHINES, LTD. offers Portland Skimmers of various sizes. These devices can be self-propelled or free-floating. They advertise recovery rates in excess of 400 gpm and the ability to recover debris.

- FRANK MOHN HOUSTON INC., distributors for equipment produced by FRANK MOHN A/S, offers the FRAMO/TRANSREC skimming system that has significant potential for incorporation within the OWOCRS design. It is advertised as being able to handle highly viscous products, exceeding 65,000 cSt, as well as debris and solids through the use of an archimedean screw type pump with cutter blades. The flow rate for emulsions is advertised to exceed 1,320 gpm.

- HYDE PRODUCTS, distributors for A/S DE SMITHSKE and for OIL RECOVERY SWEDEN, offers a number of skimming devices. The DESMI-250 appears to present excellent potential with debris cutters and an archimedean screw to handle debris-laden viscous products at significant flow rates. The DESMI DESTROIL Skimmer System appears to offer nearly comparable characteristics, but questions remain about its debris-handling capability. The OIL RECOVERY SWEDEN WP-1-30 advertises good qualities but gives little information by which to judge capabilities in actual scenarios. Further information should be obtained before choosing for testing or ruling out.

- KEPNER PLASTICS FABRICATORS, INC., offers two skimmers that appear to be satisfactory for incorporation with the OWOCRS, based on advertised characteristics. These are the SeaVac Heli-Skimmer System and the SeaVac Delta Skimmer System. The first claims 660 gpm and the second 330 gpm. They are of a lightweight design to accommodate transportability; however, their ability to handle debris-laden, highly viscous product is suspect and would have to be proven.

- MORRIS INTERNATIONAL TRADING LTD. offers three skimmers. The MI-7/24 and the MI-11/24 have recovery rates that are too low for consideration. The MI-30 has the best recovery rate of the three, advertised at 120 gpm. This rate may also be too low but could perhaps be scaled up. It is advertised as being good for all oils, not just light oils, and is said to have debris-handling capability. As a disc-type skimming device, the utility for recovery of heavy oil and debris is suspect, but it may be wise to test at least one disc-type device.

- OIL EQUIPMENT B.V. offers the V.A.B. FOXTAIL Oil Skimmer, which appears to be a rope-mop type device. They advertise ability to operate in extreme weather conditions with a capability to recover weathered oils of high viscosities, as proven by North Sea field tests. It has a recovery capacity of 320 gpm. Ability to accommodate debris may be questionable. The device is normally suspended from a davit on a supporting vessel. The possibility of floating this in front of or behind the OWOCRS would have to be explored.

Not Appropriate Category:

- ABASCO offers a Rope Mop Oil Skimmer, No. S-1600, and describes it as a "Vessel of Opportunity" skimming system, but it does not seem readily adaptable for use with the OWOCRS. Again, no design data were provided.

- AGAR CORPORATION offers the AGAR OS-101 Static Oil Skimmer. It does not appear capable of handling debris-laden, highly viscous product. It also has a very low recovery rate.

- APPLIED FABRIC TECHNOLOGIES INC., distributors for ALSTHOM-ATLANTIQUE, offers Cyclonet Dynamic Oil Skimmers whose design relies on the forward motion of the carrying vessel. This does not appear to be adaptable to augmentation of the OWOCRs. APPLIED FABRIC TECHNOLOGIES, INC., is also the distributor of FRANK AYLES & ASSOCIATES LTD's Spillskim system, which can be used as a Vessel of Opportunity system but does not appear to offer any advantages over the existing OWOCRS.

- AQUA-GUARD TECHNOLOGIES INC. offers a SIRI disc skimmer and some rope-mop type models. Insufficient data were provided from which to evaluate their suitability.

- BODAN-WERFT offers self-propelled oil recovery vessels of 15 meters in length and up. The information provided does not establish what method is applied to recover the oil. The recovery rates are quite low considering the size of the vessels. In addition, the system appears to be complex.

- ECOMARINE offers two skimming devices, the ECO-100 Pelican and the ECO-800 Dolphin. Both are self-propelled recovery devices but provide limited recovery capacities. These two skimmers and other craft designed by this company seem to have advanced capability to collect and process high volumes of debris from the water.

- ESCA S.A offers a weir skimming device in a variety of sizes. It employs no pumps but relies on the natural flow of recovered product to a tank on an accompanying vessel, entering the tank at its lowest point. Recovery rate, advertised up to 2200 gpm, would diminish as the liquid level in the tank increased. This approach would be compatible with the use of the OWOCRS, but it is doubtful that it would provide any advantage over the OWOCRS in the presence of debris-laden, highly viscous product.

- HYDE PRODUCTS, distributors for LORI recovery systems, offers a number of devices that could conceivably be incorporated within the OWOCRS, but the system is sizable and gives only moderate recovery rates.

- MEGATOR CORPORATION's Alpha S/S Skimmers do not have adequate capacity and provide no mechanism for handling debris.

- The skimmers suggested by OEL NOLTE are not considered appropriate. They do not appear capable of handling debris and viscous oils. The "MOPMATIC" skimming device does not appear adaptable to underway use.

- The Series 5000 skimming device, of OIL POLLUTION ENVIRONMENTAL CONTROL LTD., does not incorporate a pumping system and has no mechanism for excluding debris. The rope-mop type skimmers do not appear suitable for independent use inside of the OWOCRS.

- PRICE-DARNALL INC., offers the P.U.P. D-24 and the D-64. The D-24 has recovery too low to be of interest. The D-64 has a recovery rate of 219 gpm. It advertises the ability to efficiently recover any floating solid or viscous effluent through use of water jet action to concentrate the liquid being collected. It apparently does not have an offloading pumping mechanism and therefore offers little if any advantage over the OWOCRS.

- SILLINGER skimming devices do not appear adaptable to incorporation within the OWOCRS.

- SUNSHINE TECHNOLOGY CORPORATION, distributor for ELASTEC INC.'s products, offers a TDS-118 air powered skimming device. This system advertises ability to handle light products as well as weathered heavy crudes through use of "ELASTOL," a powder additive that develops visco-elastic properties in the oil. The rotating drum device used to collect the oil appears to be very susceptible to clogging from debris and offers no facility to exclude debris from the intake to the system.

- VERSATECH, distributors for LARSEN MARIN OY/AB, offers the LAMOR oil recovery system in a variety of sizes and configurations. For all sizes and configurations, the recovery rate appears very low for the size of vessel and equipment. It appears that handling debris would definitely become a problem, and modifications would probably be needed to handle the heaviest oils.

- The Weir Boom skimmer line of VIKOMA INTERNATIONAL LTD., incorporates recovery techniques into a boom similar to that of the OWOCRS; however, it does not appear adaptable for use with the OWOCRS nor does it appear to offer any particular advantage. The two disc-type skimmers offered do not readily accommodate debris-laden, highly viscous products. The Seawolf skimmer has a very low recovery rate and is not readily usable without considerable support systems with the OWOCRS.

STORAGE DEVICES

Potential Category:

- APPLIED FABRIC TECHNOLOGIES, INC., distributors for FRANK AYLES & ASSOCIATES LTD., offers SPILLSKIM, a single ship oil recovery system. As part of this system, a Flexible Storage Tank, referred to as Module "F," is provided. From very limited information, this tank appears to be structured of inflatable buoyancy tubes in barge-like shape. It is made of heavy-duty polyurethane coated nylon and is designed for towing. Further information should be obtained.

- A.S.I., distributors for DANTRAWL A/S, offers a product called OilTrawl. It appears to have potential, but its method of operation is somewhat complicated and not clearly evident from the literature. Further information should be obtained before making a decision about this equipment.

- BENNEX, a distributor for HOYLE MARINE LTD., offers a device called a Flexible Storage Tank. This is also offered by other distributors. See the entry under HYDE PRODUCTS INC., following.

- COMPLETE ENVIRONMENTAL SERVICES, INC., offers TEXABLAD products, which it advertises as suitable for marine and land use. These devices are limited to a 5,000-gallon capacity and could most readily be accommodated aboard vessels. Utilization in a towing mode in the water is not apparent.

- HYDE PRODUCTS INC., distributor of HOYLE MARINE LTD's products, offers a pillow tank of approximately 2,500-gallon capacity that may have some applications, particularly since larger sizes can be made to fit containers, trailers, or other vehicles. They also offer Floating Tanks up to approximately 10,000 gallons at a weight of only 300 pounds. This particular candidate deserves further examination.

- JW AUTOMARINE offers a wide range of products of relatively light weights and considerable capacity. They provide flexible storage tanks that could be adapted for shipboard use but none specifically for in-water towing applications. Still, the versatility of their product line suggests that a water-borne towing device might be easily accommodated.

- KEPNER PLASTICS FABRICATORS, INC., distribute a number of "SeaContainer" temporary storage devices referred to as pillow tanks and towable collapsible transfer tanks. The pillow tanks are advertised in capacities up to 100,000 gallons and the towable transfer tanks up to 10,000 gallons. Both offer other sizes upon request. The 100,000-gallon pillow tank weighs only 300 pounds and the 10,000-gallon towable transfer tank weighs only 500 pounds. Both seem to offer potential as an alternative to the DRACONE Barges.

- OIL POLLUTION ENVIRONMENTAL CONTROL LTD. offers the Flexitank in capacities up to 100 tons (approximately 26,400 gallons) and appears to offer considerable capacity at weights considerably less than the DRACONE Barges. In-water drawbacks may be similar to the DRACONE Barges.

- SILLINGER-POLLUTANK designs appear to offer considerable potential as alternative to DRACONE Barges. They can provide considerable capacity, appear to have stability and maneuverability in the water, and are relatively lightweight.

- VERSATECH PRODUCTS INC. offers a product called a Floating Oil/Water Separator. This device is of limited capacity, only 190 gallons, and works simply on gravity separation through use of settling time. If the concept were scaled up, it appears that this might provide reasonably large temporary storage capacity. VERSATECH also offers Open Top Oil Storage Containers, but these do not appear to have any marine applications.

Not Appropriate Category:

- ABASCO claims to be able to construct temporary storage devices from off-the-shelf items once a size and purchase order are specified; however, no design specifications nor other descriptions were offered.

- AQUA-GUARD TECHNOLOGIES INC., distributors for FIREFLEX MANUFACTURING LTD., offer Fireflex Water Reservoirs as temporary storage devices. These devices were designed for on-land use and do not appear adaptable for in-water use.

- FAST ENGINEERING LTD., offers a variety of tanks in various capacities. All are designed to be erected ashore, and it does not appear that they are adaptable to use either in the water or aboard a vessel.

SEPARATORS

Potential Category:

- ABASCO claims to have developed an oil/water separation device that they have been unable to sell but appears to still be in the prototype or R&D stage. No description or design data were provided, and it could easily be considered not appropriate. However, since only a few separators have been identified with promising potential for NSF applications, an attempt should be made to gather more information about this product.

- APPLIED FABRIC TECHNOLOGIES INC., distributor for ALSTHOM ATLANTIC INC., offers a Turbiflux LL separator. It advertised good flow rates and can be made-to-order for special applications.; however, the information provided does not answer questions about capability to handle debris-laden, highly viscous products. Also, a big drawback may be the size of the device. A 400 gpm unit would be 3.5 meters in height, and the weight appears to be substantial. They also offer an ALSTHOM-ATLANTIQUE, Cyclonet Dynamic Oil Skimmer. This does not appear adaptable as a skimming device with the OWOCRS but may offer potential as an in-line separating device, processing up to 240 gpm. Its ability to handle debris-laden, highly viscous product would have to be explored.

- FLORIDA PRECISION SYSTEMS, INC., offers the Richter System, which appears adaptable for use as an in-line separation system. It advertises clog-free capability through use of an open center impeller. Flow rates of up to 5,000 gpm are advertised to give an oil recovery rate of approximately 300 gpm. These flow rates are said to require prime mover capability of 50 hp.

- HYDE PRODUCTS offers a variety of separators but emphasizes designs tailored to individual requirements. The literature does not give flow rates since individual design is offered. Typical schematics indicate that the normal separation between coalescing plates may be enough to accommodate considerable amounts of debris.

- INTR/SEPT CORPORATION has licensing rights to the concept of separating oil from water through Annular Centrifugal Contractors. This concept was developed by the Idaho National Engineering Laboratory and full-scale versions of the model that have been tested may be able to operate at flow-through rates of up to 400 gpm. It is possible that a model may be available for testing. The description of the concept and the drawings of the mechanical process for the fluids make the possibility of handling highly viscous and debris-laden fluids questionable. Throughput appears to be dependent on rotor speed, and rotor speed must be adjusted to accommodate fluids of varying viscosities.

- JASTRAM FORSCHUNG offers high capacity and advertises capability for viscosities up to 10,000 cSt. A throughput of 440 gpm is possible from a device 4.5m x 3.5m x 2.5m. A throughput of up to 4,400 gpm is advertised as possible with a commensurate increase in size. This system can be built-in to a designated space on a vessel or placed within a container and conveniently placed on deck.

- JASTRAM-WERKE provided information on the same systems described by JASTRAM FORSCHUNG.

Not Appropriate Category:

- The separators of FLO TREND SYSTEMS, INC., use coalescing plates with spacing but cannot accommodate debris greater than 1 cm. This is not practical for normal oil recovery operations.

- MEGATOR CORPORATION's S.O.R.A.S. separator does not have the flow-through capacity needed nor an ability to accommodate any debris.