AD-A078 431 CIVIL ENGINEERING LAB (NAVY) PORT HUENEME CA F/G 6/6
ENGINEERING EVALUATION OF SORBENT DISPENSING/COLLECTION SYSTEM---ETC(U)
FEB 79 C I SKAALEN , A B RAUSCH MIPR-Z-70099-7-73715-A

UNCLASSIFIED USCG-D-33-79 NL

1 OF 1
AD
A078431

END
DATE
FILMED
1-80
DDC

REPORT NO. CG-D-33-79

12

LEVEL II

ENGINEERING EVALUATION OF SORBENT DISPENSING/COLLECTION SYSTEM UNIVERSAL MOUNTING ARRANGEMENT

Clifford I. Skaalen
Arthur B. Rausch

CIVIL ENGINEERING LABORATORY
NAVAL CONSTRUCTION BATTALION CENTER
PORT HUENEME, CALIFORNIA 93043

FEBRUARY, 1979

FINAL REPORT

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

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD
OFFICE OF RESEARCH AND DEVELOPMENT
WASHINGTON, D.C. 20590

NAVAL SEA SYSTEMS COMMAND
SUPERVISOR OF SALVAGE
WASHINGTON, D.C. 20362

NOTICE

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
CG-D-33-79		(11)

4. Title and Subtitle	5. Report Date
(6) ENGINEERING EVALUATION OF SORBENT DISPERSING/COLLECTION SYSTEM-UNIVERSAL MOUNTING ARRANGEMENT	Feb[redacted]979
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
(10) Clifford I. Skaalen, Arthur B. Rausch	(12) 46

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Civil Engineering Laboratory Naval Construction Battalion Center Port Hueneme, California 93043	4110.8.1
	11. Contract or Grant No. (15) MIPR-Z-70099-7-73715-A
	13. Type of Report and Period Covered

12. Sponsoring Agency Name and Address	
Department of Transportation United States Coast Guard Office of Research and Development Washington, DC 20590	(9) Final Rep[redacted]t
	14. Sponsoring Agency Code G-DOE-1

15. Supplementary Notes

Co-Sponsor: Naval Sea Systems Command
Supervisor of Salvage
Washington, DC 20362

(18) USCG

16. Abstract

The success of the Sorbent Oil Recovery System in the open sea will depend greatly on its mode of transportation through the oil slick. This study was made to identify optimum vessels and mounting concepts. Sorbent system requirements were established from which candidate vessels were identified. Alternative mounting concepts were defined and evaluated which resulted in the recommendation of developing a new component arrangement which minimizes interaction between the Sorbent Oil Recovery System and the candidate vessel.

(19) D-33-79

17. Key Words	18. Distribution Statement
	Document is available to the U. S. public through the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	46	

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

391 111

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). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

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
m^2	square meters	1.2	square yards	yd^2
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	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

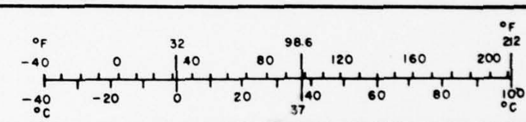


TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

INTRODUCTION

Both the U.S. Coast Guard and U.S. Navy Supervisor of Salvage (SUPSALV) are interested in an oil recovery system for use on the open sea based on the concept of broadcasting, harvesting, and recycling a sorbent material. Recent experimentation by the EPA with a system for inland water (Reference 1)* and by the Civil Engineering Laboratory (CEL) and SUPSALV with a system designed for the open sea have further demonstrated the strong potential of this system concept.

The system being considered for the open sea envisions attachment to one or both sides of a larger vessel with oil recovery taking place as the vessel proceeds through the slick. A possible alternative is towing the recovery system through the slick behind the main vessel or broadcasting the sorbent from one vessel for recovery later by another vessel.

The Coast Guard would prefer to use the recovery system in conjunction with its 82-ft (25-m) cutters and the Navy with a 218-ft TATF-class salvage vessel. However, designing a system or systems specifically fitted to these vessels is a severe restriction on its availability and usefulness. Therefore, it is desirable to develop a system for adaption to a wider variety of available vessels of opportunity such as chartered commercial vessels. The success of the vessel of opportunity concept for cleaning up oil spills depends to a great extent on the ability of the recovery system to be attached to the vessel in a timely manner, and with as few modifications to the vessel as possible. Results presented in this report will become a portion of the design criteria for the procurement of a prototype sorbent application and retrieval system.

BACKGROUND

An experimental prototype mechanized offshore oil recovery system (MSORS) was built for CEL under contract to Ocean Design Engineering Corporation in 1975 with sponsorship of the Naval Sea Systems Command. During the installation of the experimental CEL sorbent system on a 110-ft (34-m) FYN barge at Long Beach, Calif., considerable time was spent in preparing the barge for the installation. Decking had to be scraped clean of a thick layer of tar to allow the welding of the mounting brackets to the barge. Following the preparation, the installation went smoothly.

It was apparent that the installation of the system aboard a vessel of opportunity will be hampered by the lack of a completely clear deck area as was encountered with the barge and by possible limitations on welding for structural or other reasons.

---

*Environmental Protection Agency. Contract Report: Development of a sorbent distribution and recovery system, by S. H. Shaw, R. P. Bishop, and R. J. Powers. Edison Water Quality Research Laboratory, (in publication).

APPROACH

An investigation was made to establish both the restrictions and points of similarity between candidate vessels, with the objective of identifying a mounting concept that is universally compatible. The investigation was primarily one of information gathering and qualitative analyses. Candidate vessels were surveyed to establish operating characteristics, mounting restrictions, and points of similarity between these vessels and the Coast Guard's 82-ft cutters. Alternative methods for attaching system components to the vessel are identified and evaluated. That concept which exhibited the most potential for meeting the Coast Guard requirements is identified. Specific tasks are as follows:

a. Establish the requirements imposed by a sorbent system on the candidate vessel and on the mounting arrangement.

b. Identify candidate vessels and establish pertinent operating characteristics, mounting restrictions, and areas of similarity between vessels.

c. Survey availability of vessels of opportunity.

d. Define alternative mounting concepts.

e. Evaluate the alternative concepts in terms of the recovery system and vessel requirements and restrictions.

SYSTEM DESCRIPTION

The present sorbent system built for SUPSALV is for recovery of spilled oil from the water surface in offshore conditions. It utilizes a vessel of opportunity and mechanized dispensing, harvesting, and recycling of sorbents. It consists of five major subsystems: sorbents, broadcaster, herding barrier, harvester, and sorbent regenerator. In addition, conveyors are used to transport the sorbent material between some of the subsystems. These subsystems are presently arranged as follows (Figure 1): (1) the sorbent material is broadcast onto the water near the forward side of the vessel pointing into the oil slick; (2) the oil enters the absorption zone bound by the vessel on one side and an oil-sorbent herding boom on the other; and (3) after passing through this channel the oil-soaked sorbent is picked up by the harvesting device, de-oiled by the sorbent regenerator, and carried forward to the broadcaster for recycling. Other arrangements of system components are described in the Mounting Concepts section of this report. Detailed descriptions of system components are cited in Reference 2*.

System Performance Goals

The system was designed to have air transport capability within limitations imposed by suitable aircraft (Table 1) and to be installed

---

*Ocean Design Engineering Corporation. Mechanized sorbent oil spill recovery system information technical manual, 1975.

TABLE 1. TRANSPORT SIZE AND WEIGHT REQUIREMENTS

[Heavy boxed values are the maximum values for transport by both truck and aircraft.]

Item	Aircraft					Flatbed Truck
	C-130A	C-130B	C-130E	C-141A	C-5A	
Transport Capabilities						
Cargo Load, lb	$\boxed{29,500}$	35,000	45,000	68,500	185,000	73,000
Range Miles, mi	2,000	1,500	2,250	3,300	4,000	unlimited
Cargo Dimensions						
Height, in.	109	110	$\boxed{108}$	109	162	144
Width, in.	124	120	123	123	240	$\boxed{96}$
Length, in.	498	492	496	840	1,680	$\boxed{420}$

on vessels of opportunity. The system was to be able to operate in the following sea environment (Reference 3)*: (1) wave height of 5 feet, (2) wind velocity of 25 mph, (3) current speed of 2 knots, and (4) ambient air temperature of 30° to 100°F.

The design goals for the original system were:**

Recovery rate (for 1.5-mm-thick slick) . . . . . 50,000 gph

Throughput efficiency (oil encountered versus oil recovered) 90%

Type of oil . . . . From Navy distillate to Navy special fuel oil

Quality of recovered oil . . . . Water content less than 10%

System Size

The system has a total weight of 40,760 lb. The physical size of the components vary with the largest being the regenerator (9 ft-9 in. x 8 ft x 15ft, 13,220 lb). Weights and sizes of all components are itemized

*Civil Engineering Laboratory. Technical Note N-1476: "An offshore mechanized sorbent oil recovery system using vessels of opportunity," by J. Der and D. E. Brunner. Port Hueneme, Calif., Mar 1977.

**It was not intended that the design goals would be met during operations in the worst environmental conditions.

in Table 2. Improvement goals in terms of component weight reduction are listed in Table 3.*

Weight Distribution Analysis

Of critical importance for system universal mounting is weight distribution. The present system involving a floating broadcaster and harvester and other components attached to and supported by the boat (40,760 lb) has a center of gravity of 11.36 in. beyond the edge of the vessel on which it is mounted (Table 2). For an 18-ft-beam, 82-ft-long Coast Guard cutter the overturning moment with this equipment would be:

$$[(18 \text{ ft})(12 \text{ in./ft})/2 + 11.36 \text{ in.}]\,[40{,}760 \text{ lb}] = 4{,}865{,}100 \text{ in.-lb or } 202.7 \text{ ft-tons}$$

A complete weight distribution analysis of the system shown in Figure 1 is included in Table 2. A system having a harvester on each side of the boat or other counterbalancing weights would not exhibit the cited large moments which tend to roll the vessel. Alternatives which could alleviate this type of problem are cited in the Mounting Concepts section of this report. Component weight reduction goals cited in Table 3 would also reduce the problems associated with system unequal weight distribution.

CANDIDATE VESSEL CHARACTERISTICS AND AVAILABILITY

The five major types of candidate vessels evaluated in detail are shown in Figures 2 through 6. These are: Coast Guard 82-ft (25-m) patrol craft, Coast Guard 175-ft (53-m) coastal buoy tender, Coast Guard 210-ft (64-m) medium endurance cutter, 200-ft (61-m) offshore supply boats, and 135-ft (41-m) Navy utility landing craft. Highlights of the most important vessel considerations are cited in the following sections and detailed characteristics for each type of vessel are summarized in the Appendix. Complete registers of Coast Guard cutters, American offshore vessels, large foreign offshore vessels, and major American tug fleets are cited in References 4, 5, 6, and 7, respectively.**

---

*Developed from information provided by E. P. Skillman of CEL.

**U.S. Coast Guard. CG-197: Register of cutters of the U.S. Coast Guard. Washington, D.C., Feb 1977.

Fleet Data Service. 1977 FDS specifications of large American offshore vessels. Houston, Tex., May 1977.

Fleet Data Service. 1978 FDS specifications of large foreign offshore vessels, Houston, Tex., Sep 1977.

Fleet Data Service. 1978 FDS guide to major American tug fleets. Houston, Tex., Dec 1977.

TABLE 2. PRESENT SORBENT SYSTEM EQUIPMENT WEIGHT DISTRIBUTION ANALYSIS

Description	Size (ft)	Weight (lb)	Moment Arm[a] (in.)	Moment (in.-lb) x 1000[b]
Harvester Davit	8x14x3	1,900	-48	-91.2
Regenerator	9.75x8x15	13,220	+12	+158.6
Deck Longitudinal Conveyor	29.5x2.5x1	620	-27	-16.7
Shunt Conveyor	13.5x2.5x1	300	+6	+1.8
Discharge Conveyor	8x2.5x3	300	-84	-25.2
Harvester	3x14x8	3,500	+42	+147.0
Oil Boom	55x5.75	550	+186	+102.3
Support Beam	0.6x36	400	+162	+64.8
Broadcaster	20x4x4	2,200	+156	+343.2
Broadcaster Floats & Bows	9.75x3x2	1,000	+156	+156.0
Broadcaster Cross Structure	20x8x2	600	+156	+93.6
Broadcaster Arm	40x5x2	2,000	+90	+180.0
Support Arm	1x1x15	1,000	0	0
Chip Storage Box	8x8x6	100	-150	-15.0
Storage Tank	14x7x6	2,870	0	0
Generator	6x3x10	3,750	-150	-562.5[c]
Broadcaster Davit & Stiffleg	10x2x3	1,450	-30	-43.5
Miscellaneous	700[d]	5,000	-6	-30.0
TOTAL		40,760	11.36[e]	463.2

[a]Out from side of boat.

[b]Over side of boat.

[c]Generator placement variable.

[d]Cubic feet.

[e]Calculated from (463,200)/(40,760).

TABLE 3. PRESENT SORBENT SYSTEM COMPONENT WEIGHT REDUCTION GOALS

Component	Current Weight (lb)	Proposed Weight (lb)	Probability (%)
Regenerator	13,220	4,000	90
Deck Conveyors			
Longitudinal	620		
Shunt	300		
Discharge	300		
	1,220	600	50
Broadcaster			
Broadcaster	2,200		
Broadcaster floats	1,000		
Cross structure	600		
Arm and conveyor	2,000		
Support arm	1,000		
Davit and stiffleg	1,450		
	8,250	2,500	80
Harvester			
Harvester	3,500		
Davit	1,900		
	5,400	1,500	80
Generator	3,750	3,750	
Chip Storage	100	100	
Storage Tank	2,870	2,870	100
Oil Boom	550	550	
Support Beam	400	400	
Sub-Total	35,760	16,270	
Miscellaneous	5,000	1,400	
TOTAL	40,760	17,670	

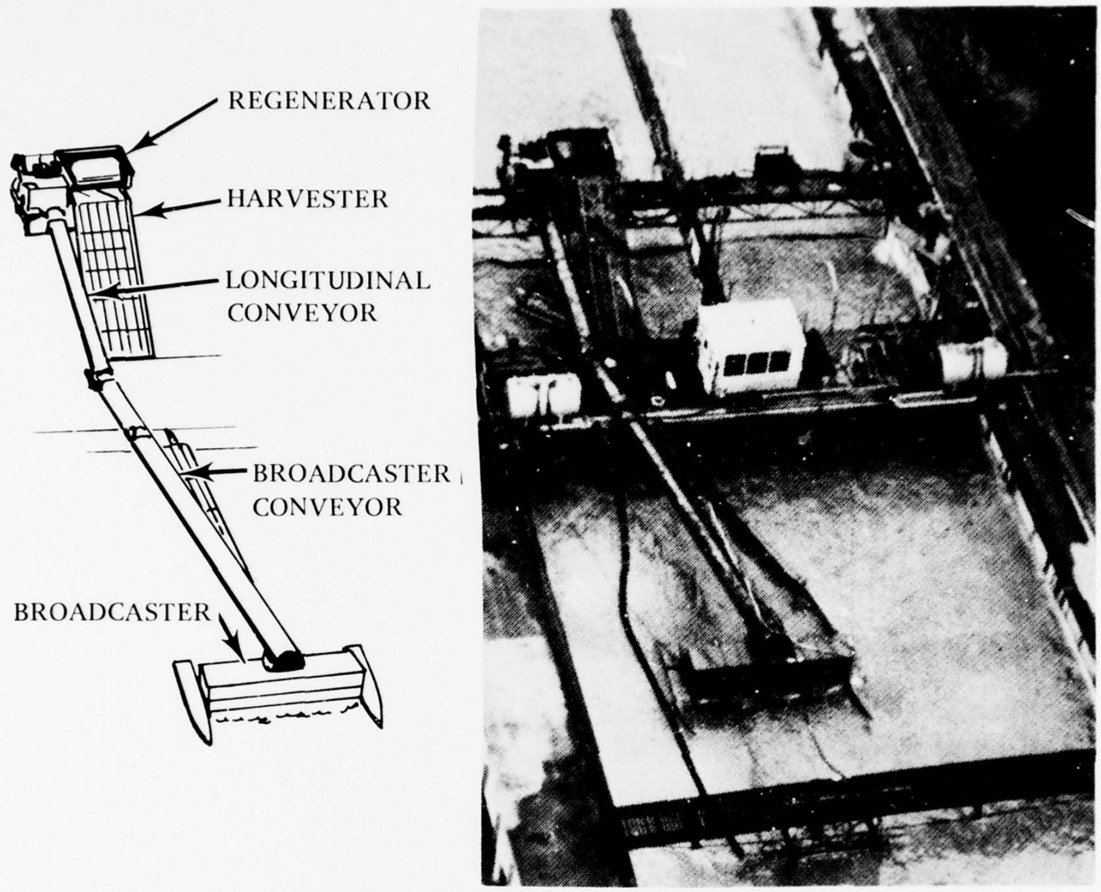


FIGURE 1. SORBENT SYSTEM ARRANGEMENT.

CAPE CROSS (WPB 95321)

FIGURE 2. COAST GUARD PATROL CRAFT, 82-FT WPB.

WALNUT (WLM 252)

FIGURE 3. COAST GUARD COASTAL BUOY TENDER, 175-FT WLM.

VIGILANT (WMEC 617)

FIGURE 4. COAST GUARD MEDIUM ENDURANCE CUTTER, 210-FT WMEC.

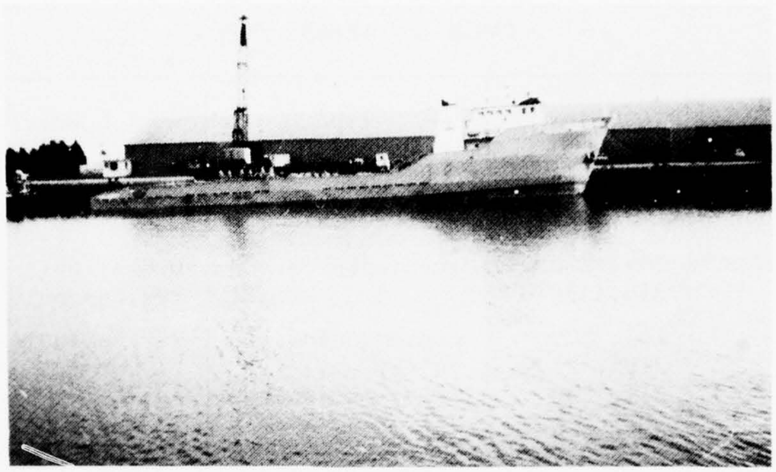


FIGURE 5. OFFSHORE SUPPLY BOAT, 200 FT.

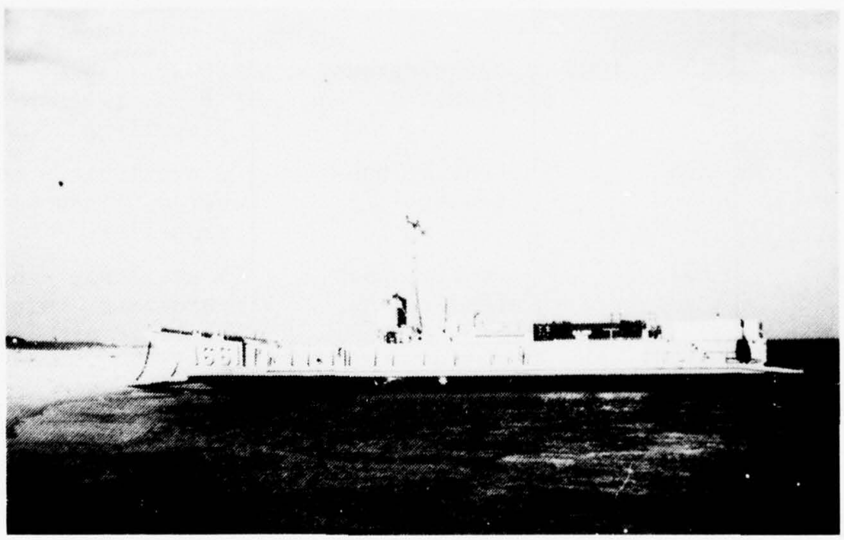


FIGURE 6. NAVY UTILITY LANDING CRAFT, 135-FT LCU

Several types of Coast Guard vessels are of reasonable size for consideration. These vessel types and general remarks are listed in Table 4.

TABLE 4. VESSEL TYPES

Vessel Designation	Class	Type	Remarks
WHEC	327, 378	high endurance cutter	17 available
WAGB	269, 290, 310, 399	icebreaker	6 available - northern regions only
WMEC	143, 205, 210A, 210B, 213, 230	medium endurance cutter	22 available
WPB	95A, 95B, 95C	patrol craft	22 available - cannot handle present system because of inadequate stability and space
WPB	82A, 82C, 82D	patrol craft	53 available - cannot handle present system because of inadequate stability and space
WLB	180A, 180B 180C	seagoing buoy tender	30 available - single screw, fixed pitch propellers
WLM	175	coastal buoy tender	3 available - twin screw, fixed pitch propellers
WLM	157	coastal buoy tender	5 available - bow thrusters, twin screw, variable pitch propellers
WLM	133	coastal buoy tender	7 available - twin screw, fixed pitch propellers

Class 210B, 82C, and 175 vessels are considered in detail within this report.

Performance Limitations

Of the five vessels explored in detail (see Table 5), the offshore supply boat is best suited to the present sorbent system on the basis of its capability to operate at slow speeds. Many offshore supply vessels can maintain control in moderate seas with no forward motion using bow thrusters and variable pitch propellers. On the basis of heavy seas capability, the offshore supply boat rates high, being able to operate in 15-foot waves and 25-mph winds.. The performance characteristics for the boats cited are summarized in Table 6. Of these boats the 82-foot cutter, having twin screws of fixed pitch, cannot operate continuously at the slow speeds required without overheating the engines. This would require that the 82-ft cutter use only one screw and sea anchors to achieve the desired slow speeds or operate under speeds with intermittent power. The offshore supply boats - the 210-ft Coast Guard medium endurance cutter and the 157-ft Coast Guard coastal buoy tenders with variable pitch propellers - can operate at the required speeds (Reference 8)*.

Spatial Characteristics

The present system component size necessitates considerable deck space when mounted in the operational mode. Of the five types of vessels studied, the offshore supply boat has the largest available deck space for system component mounting. The deck space available on the 82-ft cutter prohibits mounting the necessary system components in the system's present configuration. A summary of vessel available deck space is included in Table 5. Other system arrangements as cited in the Mounting Concepts section of this report would greatly increase the spatial compatability between the boats cited and the sorbent system. A comparison of deck space available on three of the types of vessels cited can be made from Figures 7, 8, and 9.

Hydrodynamic Performance and Stability

The hydrodynamic performance of most importance for the present system is roll amplitude in the open sea environment. Excessive roll will cause the harvester to leave the water surface with the present system. The amount of roll that can be endured depends on the vessel beam. The harvester's vertical motion amplitude relative to the water surface should not be greater than 2 ft. This 2-ft amplitude would be the result of a combination of not only roll but wave height, vessel pitch, and heave. Of the five vessels studied, the 82-ft Coast Guard patrol craft would exhibit the maximum roll in an open sea. A roll of 20 deg is not uncommon in relatively mild seas. This would result in a relative vertical motion of 6 ft with respect to the mean water surface and the side rail of the vessel. The motion with respect to the moving water surface would often be significantly greater.

---

*University of Michigan. Analysis of the response of an open-ocean oil slick to a vessel involved in oil-spill recovery, by W. S. Vorus, V. A. Phelps, and W. P. Graebel. Ann Arbor, Mich., Aug 1977.

TABLE 5. DESCRIPTIONS OF SELECTED VESSELS

Vessel	Dimensions (ft)			Displacement (ton)		Propulsion					Spatial	
	Length	Beam	Draft	Minimum	Full	Screws	Props	Shaft (hp)	Maximum Range (miles)	Speed (knots)	Location	Area (ft^2)
82 ft WPB Coast Guard Patrol Craft	83	18	5	52	66	2	fixed pitch	1,600	1,500	23.7 max, 8.0 econ	Bow Stern	≈150 ≈700
175 ft WLM Coast Guard Coastal Buoy Tender	175	34	12	759	967	2	fixed pitch	1,350	1,000	12.0 max, 7.5 econ	Frame 55 to 80	1,400
210 ft WMEC Coast Guard Medium Endurance Cutter	211	34	10	971	1,007	2C	control pitch	5,000	6,100	18.0 max, 14.0 econ	Fantail Flight deck (Frame 100 to 176)	900 2,100
200 ft Offshore Supply Boat[a]	200	40	14	1,000	2,000	2	fixed pitch or control pitch and bow thrusters	5,000	2,000 to 10,000	14.0 max	Stern	≈2,000 to 3,000
135 ft Navy Landing Craft Utility	135	29	3	174	342	2	fixed pitch	1,000	–	11.0 max	Entire length	2,500

[a] Dimensions of Offshore Supply Boats vary, length is generally around 200 ft.

TABLE 6. STABILITY AND STRUCTURAL CHARACTERISTICS OF SELECTED VESSELS

Vessel	Stability[a]				Structural			Cranes (capacity, reach and location)
	KG (ft)	KGM_T (ft)	GM_T (ft)	Heel Characteristics	Tie Points	Weld Points	Bow	
82 ft WPB Coast Guard Patrol Craft	8.69	12.02	3.33	0.3 ft rt-arm at 5° (full load) 0.6 ft rt-arm at 10° (full load) 0.9 ft rt-arm at 20° (full load) 1.1 ft rt-arm at 30° (full load) 1.1 ft rt-arm at 40° (full load)	Several pairs of small bits are available. Towing bits could be used, one aft and one at rear of superstructure. The rail around the stern is solid and could be used.	Deck is steel and could be welded to if necessary. House is aluminum and cannot be used. Hull is steel but the Coast Guard does not want anything on it.	Bow appears to have sufficient strength to push a system if the load is distributed across longitudinal framing.	Small davit can be installed on bow to lift 200-300 lbs with block and tackle.
175 ft WLM Coast Guard Coastal Buoy Tender	12.58 12.59 11.75	14.83 14.96 15.04	2.25 2.37 3.29	30 ft-ton rt-mom at 1° (min. op.) 35 ft-ton rt-mom at 1° (nor. load) 56 ft-ton rt-mom at 1° (full load)	Bits are available along both sides. Portions of railing could be tied to for small loads.	Deck and hull are steel and could be welded to especially at the work area forward of the boom.	Bow appears to have sufficient strength to push a system if the load is distributed across framing.	One crane with 50-ft boom located at frame 53. It has a lift capacity of 30,000 lbs at a 35-ft radius and can rotate approximately 80° to each side of the ship centerline.
210 ft WMEC Coast Guard Medium Endurance Cutter	15.44 15.30	17.90 17.75	2.46 2.45	1.30 ft rt-arm at 33° (min. op.) 36.9 ft-ton rt-mom at 1° 1.33 ft rt-arm at 33° (full load) 36.6 ft-ton rt-mom at 1°	Bits are available at regular points all along both sides. No railings on helicopter platform.	Ship is all steel with the helicopter deck being high strength (1/4 in. HY80).	Bow is very sharp and high. It appears to be capable of handling a distributed load.	Portable davits of 500 and 1500 lbs can be located at the following positions. Frame — Location Off ℄ (ft) 4 — 7 5 — 1.5 42 — 16 75 — 16 96 — 16 173 — 9 177 — 2 180 — 14
200 ft Offshore Supply Boat[c]	14.46[b] 13.96[d]	19.64[b] 19.58[d]	5.18[b] 5.62[d]	0.45 ft rt-arm at 5° (min. op.) 0.95 ft rt-arm at 10° 2.41 ft rt-arm at 39° (max.) 0.45 ft rt-arm at 5° (full) 0.87 ft rt-arm at 10° 1.44 ft rt-arm at 37° (max.)	Large, strong rails around stern 1/2 of boat designed for tying to.	Cargo area inside rail can be welded to easily. Some decks are all steel and some are steel/wood combinations.	Bow appears to be of sufficient strength to push a system. Some are reinforced for ice breaking.	There is generally no crane capacity but there is room to carry a portable or wheeled crane.
135 ft Navy Landing Craft Utility (LCU)	5.35 6.35	27.35 21.35	22.0 15.0	66.8 ft-ton rt-mom at 1° (light) 58.6 ft-ton rt-mom at 1° (w/50t)	Bits are located fore and aft on both sides and midships on the port side. On deck cloverleaf tie-downs are spread along the full length.	All steel construction. Could weld almost anywhere.	Square bow is slanted to the flat bottom for beachings. Could be used for pushing if problem of slanted bow is taken care of.	None, but there is room for carrying a portable or wheeled crane.

[a] KG - distance from metacenter to center of gravity; KGM_T - distance from metacenter to center of buoyancy; GM_T - metacentric height.
[b] With 10% consumables and no deck load.
[c] This type of boat is built for heavy duty work.
[d] With 100% consumables and no deck load.

FIGURE 7. DECK SPACE CHARACTERISTICS OF AN 82-FT WPB COAST GUARD PATROL CRAFT.

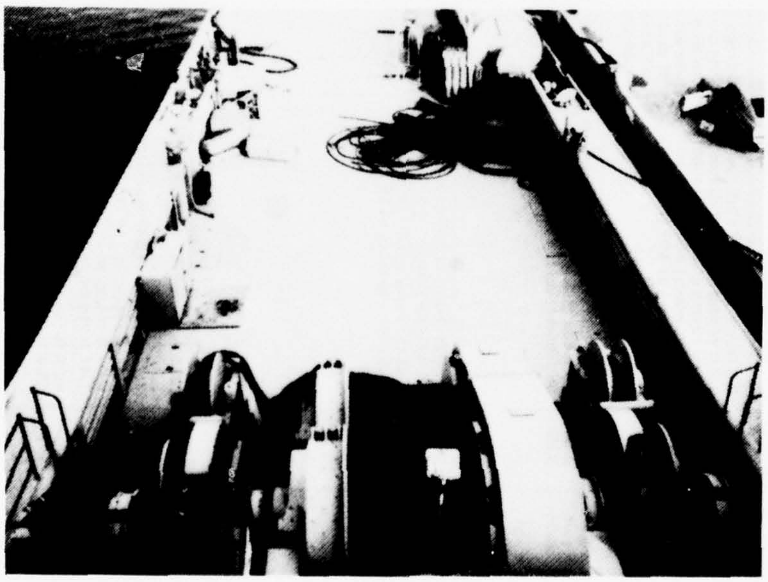
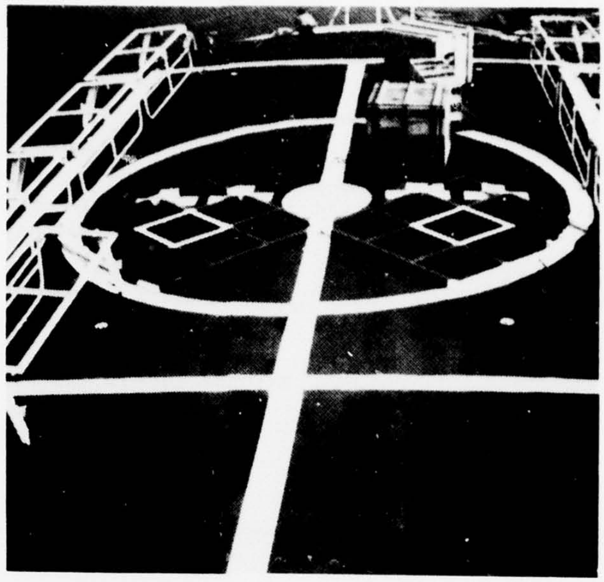
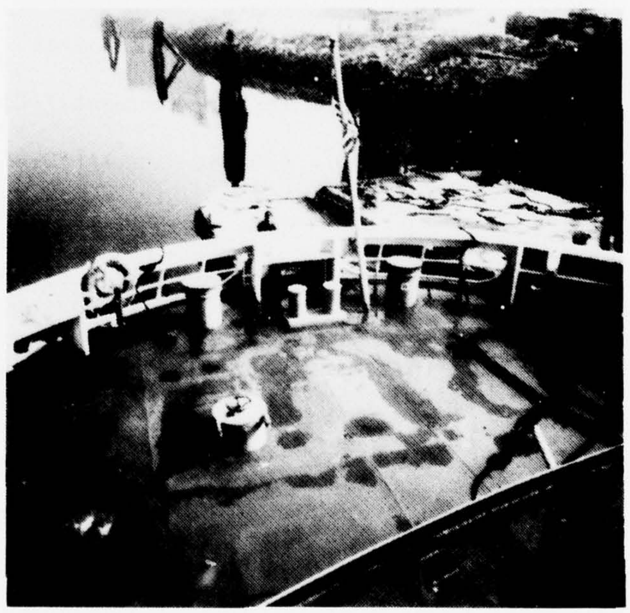


FIGURE 8. DECK SPACE CHARACTERISTICS OF A 200-FT OFFSHORE SUPPLY BOAT.



(a) FLIGHT DECK.



(b) FANTAIL.

FIGURE 9. DECK SPACE CHARACTERISTICS OF A 210-FT WMEC COAST GUARD CUTTER.

Of equal importance is vessel static stability in roll. Attaching 40,760 lb to the side of a statically unstable vessel will result in large degrees of heel, which will not only affect sorbent system operations but boat steerage and operations as well. The stability and heel characteristics of several vessels are summarized in Table 6. The heel characteristics are cited in terms of righting arms for various degrees of heel. In general, for small degrees of heel the righting moment can be calculated knowing the metacentric height and displacement of the vessel. Conversely, knowing the metacentric height and displacement, one can calculate an approximation for vessel heel when loaded on one side only. For small roll angles, the metacenter does not shift appreciably. An example calculation follows:

Vessel - 210-ft Coast Guard WMEC medium endurance cutter
Displacement - 1,007 tons
Metacentric height - 2.46 ft (GM_T)
Vessel beam - 34 ft

Sorbent system moment = [(34 ft)(12 in./ft)/2 + (11.36 in.)] [40,760 lb]

= 8,778,100 in.-lb

= 366 ft-tons (applied moment)

Approximate heel angle = arc sin (applied moment)/(GM_T x displacement)

= arc sin (366 ft-tons)/[(2.46 ft)(1,007 tons)]

= 8.5° (note: beyond small angle approximation)

A similar calculation for the 82-ft WPB Coast Guard patrol craft will result in a very large angle of heel. It can be seen from Table 6 that the largest righting arms that are generated for the 82-ft patrol craft are 1.1 ft, resulting in a maximum righting moment of 72.6 ft-tons

righting moment = (1.1 ft)(66 tons) = 72.6 ft-tons (Ref 9*)

If one compares the sorbent system moment when mounted on the 82-ft patrol craft (calculated previously as 202.7 ft-tons) to the maximum righting moment one can readily see that this vessel will not handle the present system. The sorbent system moment can be reduced by movement of certain equipment (generator, storage tanks, etc.) to the opposite side of the vessel for counterbalance. This would result in a reduction of

*U.S. Coast Guard, Naval Engineering Division. 82 foot WPB class patrol craft stability and loading data booklet. Washington, D.C., Feb 1971.

the vessel applied moment by as much as 15% in some cases. A 15% reduction would not, however, be sufficient to overcome appreciably the imbalance caused by side mounting the present system on the 82-ft Coast Guard patrol craft.

Of the five vessels cited, the Navy landing craft exhibits the best stability using the present sorbent system. Vessel stability is not so important when considering water-supported alternative arrangements, which are discussed later in this report.

Structural Aspects

When mounting system components as heavy as 13,000 lb, structural integrity of the vessel may be altered. Of particular importance are weld points for padeyes and davits when mounting the present system. In most cases, the vessel decks and hull must be strengthened when mounting heavy equipment. For the vessels studied, general deck and hull strengthening* requirements are as follows:

82-ft WPB Coast Guard Patrol Craft	Internal strengthening would be considered permanent such as the addition of frames. External strengthening such as flat load distribution plates spanning frames would be considered temporary. Internal frame strengthening would likely be required for most systems.
175-ft WLM Coast Guard Coastal Buoy Tender	External deck strengthening would be required in all areas except the work area forward of the boom.
210-ft WMEC Coast Guard Medium Endurance Cutter	External deck strengthening and internal bow strengthening would be required for some systems.
200-ft Offshore Supply Boat	No strengthening is required. This vessel is designed to carry heavy equipment.
135-ft Navy Landing Craft, Utility	No strengthening is required. The flat bow may require special adaptions to the system.

The major weld points and tie points for the vessels cited are summarized in Table 6. An alternative arrangement involving the management of the system by pushing with the bow of the vessel involves structural integrity of the bow and fendering. The bow strength and accommodations for fendering are also noted in Table 6.

*Strengthening is required only in those areas where concentrated system component loads exceed the design capability of the vessel hull or deck.

The offshore supply boat appears to be ideally suited to the task of cleaning up oil spills. This type of vessel has the characteristics that make it adaptable to any mechanism that would be used to pick up the oil. These characteristics include large clear deck space and high deck load capability along with excellent low speed maneuverability.

The Navy 218-ft, TATF class, salvage vessel was not considered separately since it is a modified offshore supply boat and only four TATF's will be initially constructed. Other tug boats and fleet tugs can accommodate a system such as the sorbent system; however, these vessels are best suited to assist clean up operations, handling large oil barriers, towing collapsible storage tanks, etc.

Availability Survey Methods

The methods required to determine availability of four types of applicable vessels have been analyzed. The four types of vessels considered in order of capability to support an oil collection system envisioned herein are (1) offshore supply boats, (2) Navy landing craft, (3) Coast Guard vessels, and (4) merchant vessels. Mobilization plans for these vessel types are as follows:

OFFSHORE SUPPLY VESSELS (200-ft approximate length)	• Contact owners through the Offshore Marine Services Association (OMSA) (System requirements can be presented in the (OMSA) newsletter for an initial familiarization.) • Contact port authority near spill site • Contact owners of desired vessels
NAVY VESSELS (135-ft utility landing craft)	• Contact NAVSURFPAC or NAVSURFLANT • Contact Assault Craft Unit One (Little Creek, Va.) or Assault Craft Unit Two (Coronado, Calif.)
COAST GUARD VESSELS (82-ft patrol craft) (210-ft medium endurance cutter) (175-ft coastal buoy tender)	• Contact National Response Center, Washington, D.C. (800-424-8802)

MERCHANT VESSELS (150-ft approximate length fishing vessels and tow vessels)	• Utilize information from current edition of Merchant Vessels of United States (Reference 10*) for area near spill site • Select vessel and contact owner • Contact port authority near spill site • Contact owners of desired vessels

MOUNTING CONCEPTS

The present sorbent system shown in Figure 1 is designed to be mounted to the side of the vessel. The broadcaster floats on the surface of the water and is connected to the harvester through a boom and conveyor belt system. Mounting this system requires welding brackets and padeyes to the deck and side of the vessel for connection of the regenerator and davits for lifting harvester and broadcaster. These present vessel preparation and welding requirements are time consuming and require special structural precautions.

Alternative Mounting Concepts

Several alternative mounting concepts which involve rearrangement of system components (to alleviate the present mounting difficulties) are possible. System mounting is most affected by component arrangement. In addition, for a given component arrangement the mounting alternatives are varied. The various arrangements are shown on an offshore work boat in Figures 10 through 14 and summarized in Table 6 with remarks on mountings. For the most part, the remarks on mountings are closely associated to vessel weld points and tie points criteria from Table 6.

The concept most compatible to all vessels is a completely floating arrangement utilizing a floating broadcaster and two floating harvester/regenerators, as shown in Figure 10. This arrangement would be pushed through the water by the bow of the boat in contact with the broadcaster. A chaffing fender would be required between the boat and sorbent system. The chaffing fender could be composed of standard marine fenders and rubber bumpers. Several other system arrangements are possible depending on the practicality of developing the rearranged system components. The various arrangements can be either self-supported or boat-supported with respect to power for operation of system components.

---

*U.S. Coast Guard. Merchant vessels of the United States, 1975. Washington, D.C., Jan 1975.

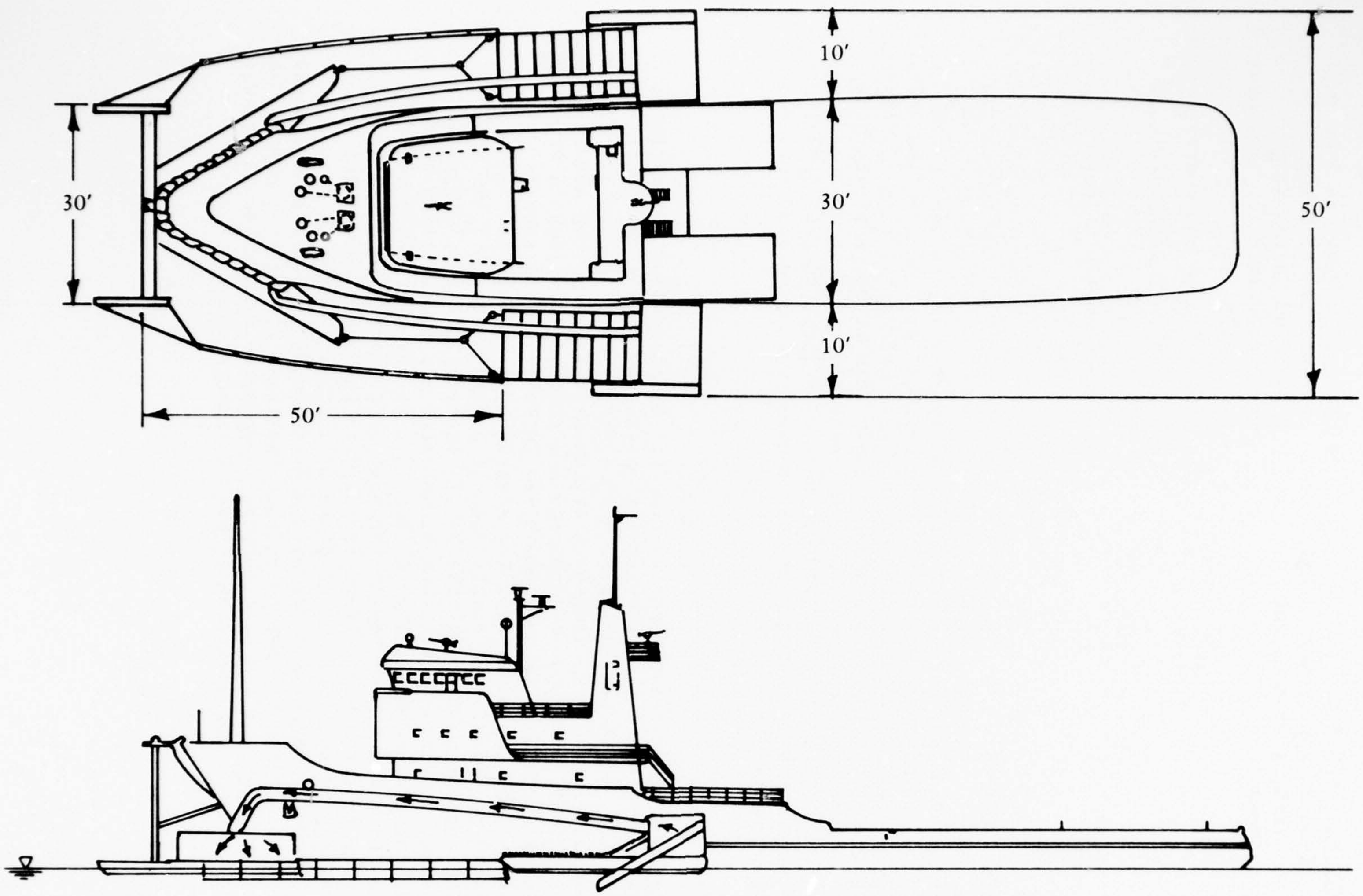


FIGURE 10. BROADCASTER PUSHED WITH BOW, HARVESTERS FLOATING ALONG EACH SIDE (ARRANGEMENT 1.A IN TABLE 7).

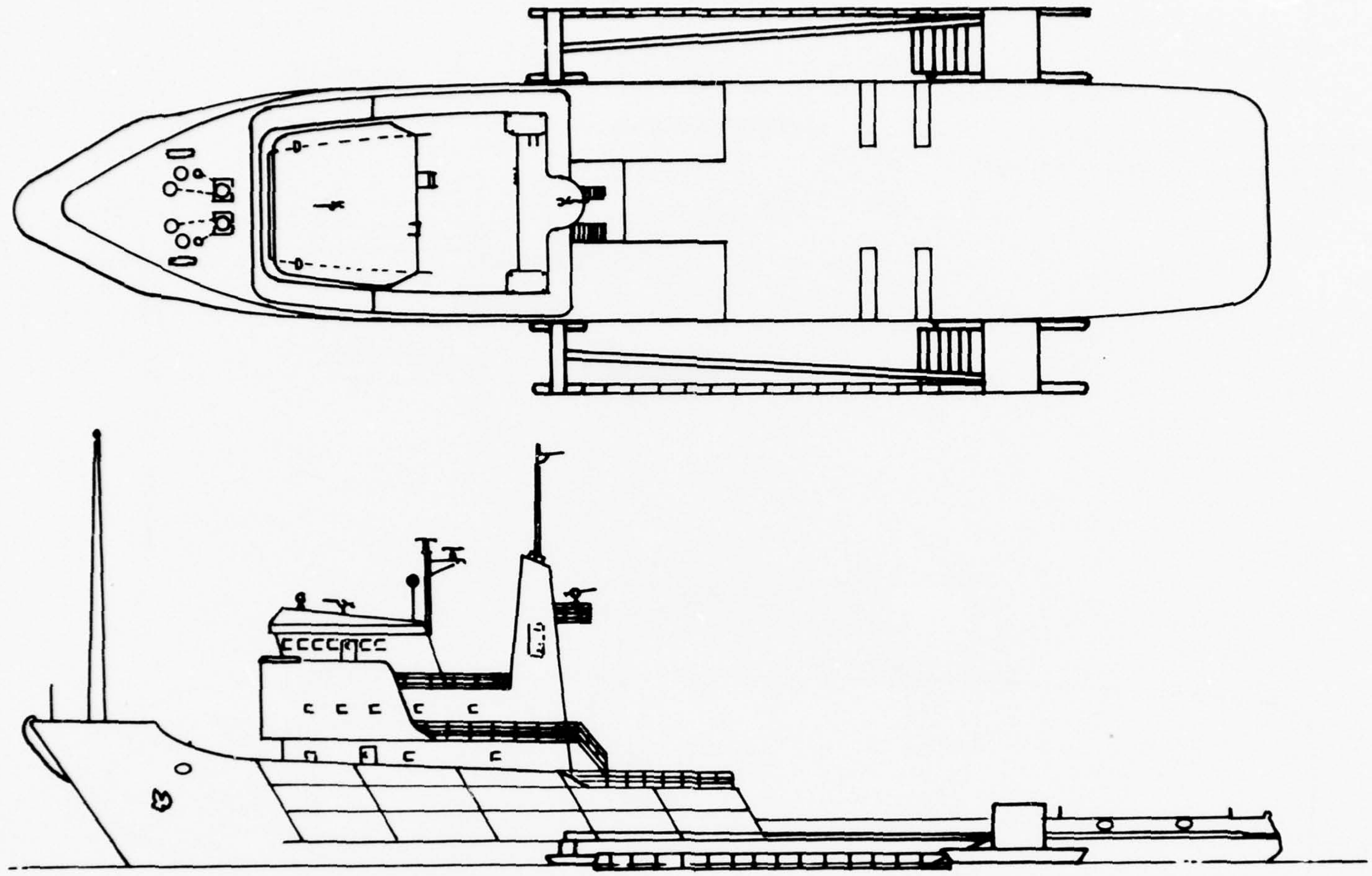


FIGURE 11. BROADCASTERS AND HARVESTERS FLOATING ALONG EACH SIDE (ARRANGEMENT 1.E IN TABLE 7).

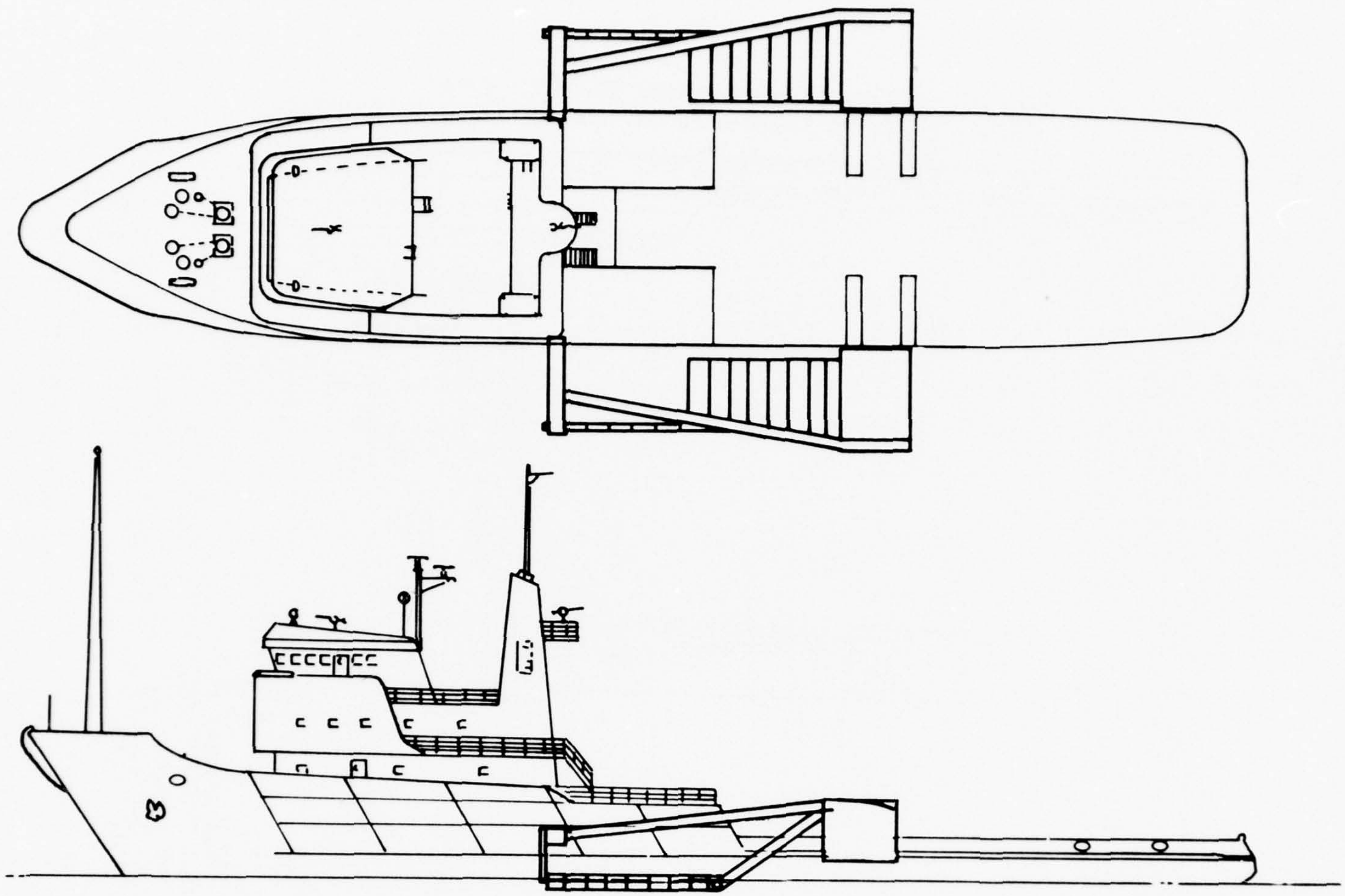


FIGURE 12. BROADCASTERS AND HARVESTERS ATTACHED TO BOTH SIDES (ARRANGEMENT 2.A IN TABLE 7).

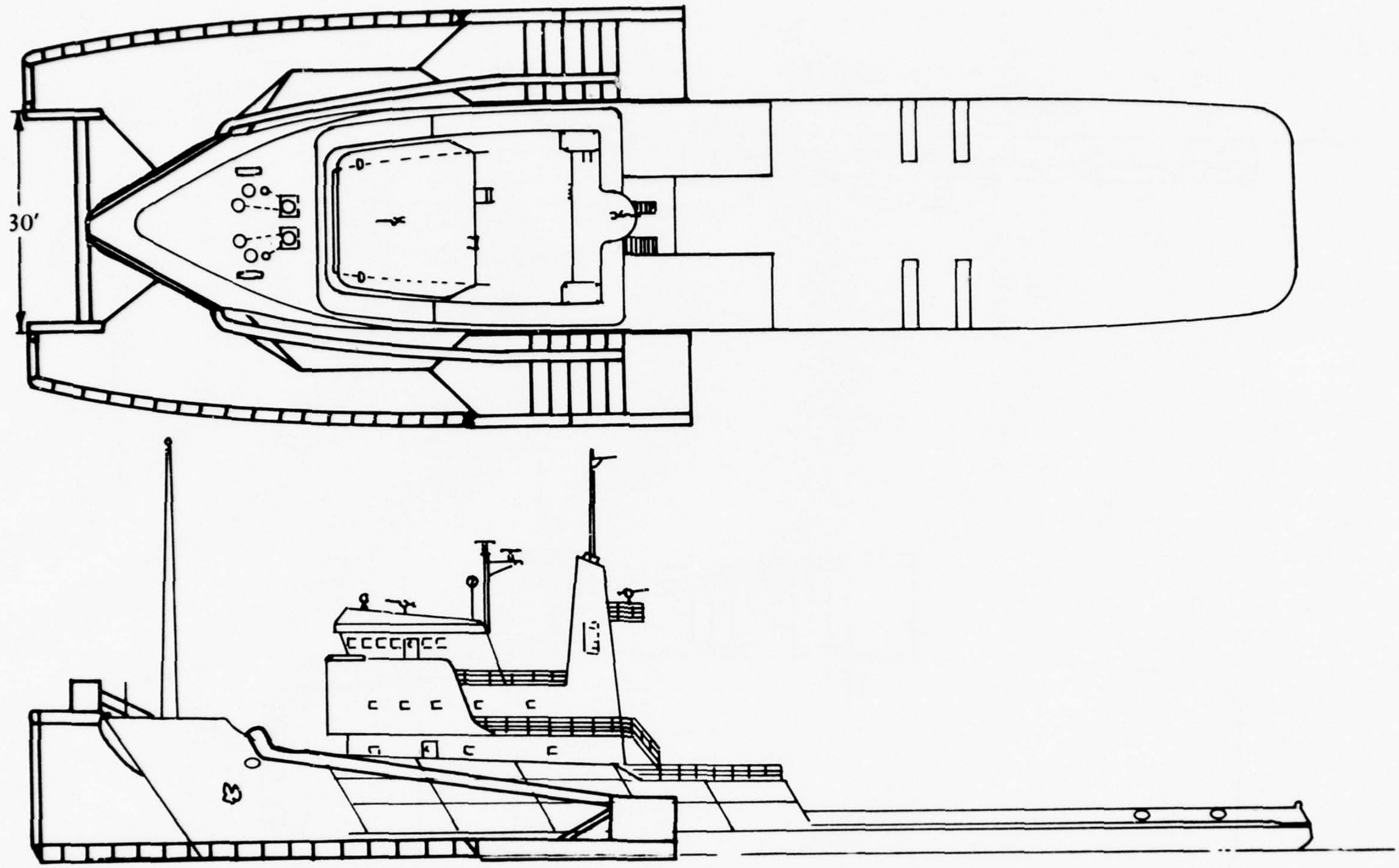


FIGURE 13. BROADCASTER ATTACHED TO BOW, HARVESTERS FLOATING ALONG EACH SIDE (ARRANGEMENT 3.A IN TABLE 7).

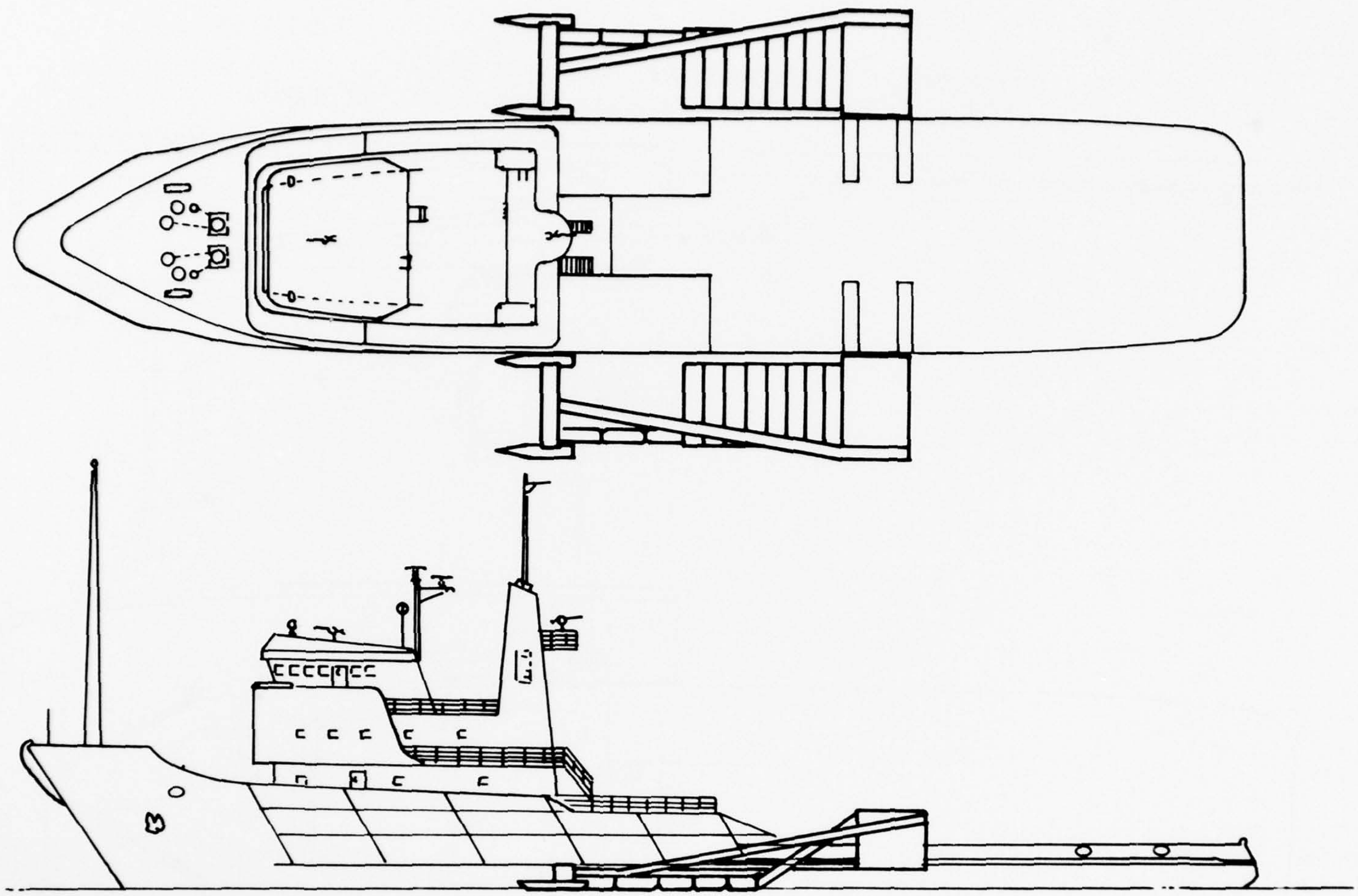


FIGURE 14. BROADCASTERS FLOATING ALONGSIDE, HARVESTERS ATTACHED TO EACH SIDE (ARRANGEMENT 3.C IN TABLE 7).

Concepts Parametric Analysis

The fifteen system arrangements cited in Table 7 (five of which are shown in Figures 10 through 14) have been parametrically analyzed in Table 8. The parameters involved and associated parametric weights are discussed herein. The three most important parameters selected are use in heavy seas, ruggedness, and adaptability to all boats. Of lesser importance, boat modifications, practicality of arrangement, transportability, installation complexity and time, and oil absorption effectiveness were considered. The five additional parameters of design state-of-the-art- weight, bulk, boat functions, compatability, and cost - complete the analysis.

Boat Modifications. Vessels must be modified with weldments in some cases to accept the sorbent system. With certain system arrangements and boats, welding is not necessary to mount the system. It is felt that system arrangement has the primary effect on boat modifications and that different vessels will be modified similarly for a given arrangement. An arrangement requiring considerable weldments for system mounting would receive a low rating in this category.

Adaptability to All Boats. For the sorbent system to be of maximum effectiveness it must be capable of being mounted on several types of vessels of opportunity, preferably within 200 miles of any sizable oil spill. Some arrangements of system components cannot be mounted on all types of vessels and would receive a lower adaptability rating accordingly.

Design State-of-the-Art. Several conceptual system arrangements will require considerable hardware analysis for system development. Some development may be pushing the state-of-the-art. Those systems requiring considerable development would receive a low rating in this category.

Cost of Manufacture. The cost of manufacture or production depends on the use of lightweight metals or special machining processes to achieve the desired product. Those systems requiring special production care would receive a low rating in this category.

Practicality of Arrangement. Some system arrangements may not be practical because of the behavior of the sorbent material, behavior of the water surface around and in the wake of the vessel, or behavior of the vessel. Those arrangements that do not appear to be practical will receive a low rating in this category.

Ruggedness. The system arrangement must be able to withstand hydrodynamic impacts from waves and dynamic impacts from vessel hulls. A system which will remain intact and operational in waves up to 5 ft high will rate high in this category.

Use in Heavy Seas. A sorbent system functional performance may be altered because of wave motion or vessel response to the heavy sea environment. A system which will remain operational and effective when attached to a rolling, pitching, heaving vessel will receive a high rating in this category.

TABLE 7. ALTERNATIVE COMPONENT ARRANGEMENTS FOR SORBENT APPLICATION AND RETRIEVAL SYSTEMS

System	Broadcaster Location	Harvester Location	Component Power Source Location
1. Completely Floating Systems			
A[a]	push with bow	one on each side[b]	self-supported
B	push with bow	one on each side[b]	boat-supported
C	pull behind vessel	with broadcaster	self-supported
D	pull behind vessel	with broadcaster	boat-supported
E[c]	alongside tow	with broadcaster - one system each side[b]	self-supported
F	alongside tow	with broadcaster - one system each side[b]	boat-supported
2. Completely Boat-Suspended Systems			
A[d]	alongside vessel	with broadcaster - one system each side[b]	self-supported
B	alongside vessel	with broadcaster - one system each side[b]	boat-supported
3. Combination Floating, Boat-Suspended Systems			
A[e]	attached to bow	floating alongside - one on each side[b]	self-supported
B	attached to bow	floating alongside - one on each side[b]	boat-supported
C[f]	floating alongside	attached alongside - one system each side[b]	self-supported
D	floating alongside	attached alongside - one system each side[b]	boat-supported
E	attached to stern	floating in tow	self-supported
F	attached to stern	floating in tow	boat-supported
4. Separated Systems			
A	on lead vessel	on following vessel	boat-supported

[a]Shown in Figure 10.
[b]Harvesters shown are 10 ft wide.
[c]Shown in Figure 11.
[d]Shown in Figure 12.
[e]Shown in Figure 13.
[f]Shown in Figure 14.

TABLE 8. ATTACHMENT SCHEMES FOR SORBENT APPLICATION AND RETRIEVAL SYSTEM PARAMETRIC ANALYSIS

Item No.	Parameter Weight														
	4	5	6	6	6	7	8	8	8	8	9	10	10	95 ... 950	
	Cost of Manufacture	Bulk	Design State-of-the-Art	Operational Compatibility With Boat Functions	Weight	Absorb Oil Effectiveness	Boat Modifications	Practicality of Arrangement	Installation Complexity and Time	Transportability	Adaptable to All Boats	Ruggedness	Use in Heavy Seas	TOTALS	Parametric Ranking
1.A	2 ... 8	4 ... 20	5 ... 30	10 ... 60	4 ... 24	10 ... 70	10 ... 80	10 ... 80	10 ... 80	7 ... 56	10 ... 90	4 ... 40	9 ... 90	728	1
B	5 ... 20	6 ... 30	7 ... 42	5 ... 30	5 ... 36	10 ... 70	8 ... 64	9 ... 72	7 ... 56	8 ... 64	7 ... 63	5 ... 50	10 ... 100	697	2
C	2 ... 8	4 ... 20	5 ... 30	10 ... 60	4 ... 24	2 ... 14	10 ... 80	2 ... 16	10 ... 80	7 ... 56	10 ... 90	4 ... 50	10 ... 100	628	5
D	5 ... 20	6 ... 30	7 ... 42	5 ... 30	6 ... 36	2 ... 14	7 ... 56	1 ... 8	7 ... 56	8 ... 64	7 ... 63	6 ... 60	10 ... 100	579	10
E	3 ... 12	4 ... 20	5 ... 30	5 ... 48	4 ... 24	8 ... 56	9 ... 72	8 ... 64	9 ... 72	7 ... 56	8 ... 72	4 ... 40	8 ... 80	646	3
F	6 ... 24	6 ... 30	7 ... 42	4 ... 24	6 ... 36	8 ... 56	6 ... 48	7 ... 56	6 ... 48	8 ... 64	6 ... 54	5 ... 50	9 ... 90	622	7
2.A	4 ... 16	8 ... 40	6 ... 36	7 ... 42	8 ... 48	5 ... 35	4 ... 32	8 ... 64	4 ... 32	8 ... 64	3 ... 27	6 ... 60	8 ... 80	576	11
B	7 ... 28	9 ... 45	8 ... 48	4 ... 24	8 ... 54	5 ... 35	3 ... 24	7 ... 56	3 ... 24	9 ... 72	2 ... 18	7 ... 70	9 ... 90	588	8
3.A	6 ... 24	7 ... 35	7 ... 42	6 ... 36	7 ... 42	8 ... 56	5 ... 40	8 ... 64	5 ... 40	8 ... 64	6 ... 54	6 ... 60	7 ... 70	627	6
B	8 ... 32	8 ... 40	8 ... 48	3 ... 18	8 ... 48	8 ... 56	4 ... 32	7 ... 56	4 ... 32	9 ... 72	5 ... 45	7 ... 70	8 ... 80	629	4
C	6 ... 24	7 ... 35	7 ... 42	5 ... 30	7 ... 42	2 ... 14	4 ... 32	8 ... 64	4 ... 32	8 ... 64	7 ... 63	6 ... 60	7 ... 70	572	12
D	8 ... 32	8 ... 40	8 ... 54	2 ... 12	8 ... 48	2 ... 14	3 ... 24	7 ... 56	3 ... 24	9 ... 72	6 ... 54	7 ... 70	8 ... 80	580	9
E	6 ... 24	7 ... 35	7 ... 42	5 ... 30	7 ... 42	3 ... 21	4 ... 32	5 ... 40	4 ... 32	8 ... 64	6 ... 54	7 ... 70	8 ... 80	566	14
F	8 ... 32	8 ... 40	8 ... 48	2 ... 12	8 ... 48	3 ... 21	3 ... 24	4 ... 32	3 ... 24	9 ... 72	5 ... 45	8 ... 80	9 ... 90	568	13
4.A	4 ... 16	9 ... 45	2 ... 12	7 ... 42	9 ... 54	9 ... 63	3 ... 24	0 ... 60	6 ... 48	8 ... 64	3 ... 27	9 ... 90	0 ... 0	545	15

NOTE: All weighting values selected for the cited parameters and the various system arrangements are highly subjective in nature. The values represent the judgment of the authors and may not reflect the thinking of all others familiar with the Sorbent System Mounting question. The reader can, however, select his own values and can easily compare his results with the authors.

Absorb Oil Effectiveness. A system must have a maximum detention time associated with the sorbent material on the water surface. The detention time can be increased by increasing distances between broadcaster and harvester or by moving the vessel more slowly through the water. A system that can accommodate long detention times will be rated high in this category.

Operational Compatibility With Boat Functions. A system must receive operational power from the vessel or be self-powered. A self-powered system would not be dependent on the vessel. A system requiring excessively slow vessel speed may not be compatible with some vessels that do not function in the very slow speed range. When considering all vessels, a system relying heavily on boat resources or boat functional capability will be rated low in this category.

Installation Complexity and Time. For the system to be effective it must be operational within a very short time frame. This requires that the components be assembled and mounted on a vessel quickly. A system that can be installed and operational before the oil slick has a chance to disperse will be rated high in this category.

Transportability. The system should be modularized for ease of transport and breakout at the site using minimal equipment. A system that can be easily and quickly transported would be most effective and rated high in this category.

Weight. Weight is important when handling, assembling, and operating the system. The lightest weight system meeting the required performance criteria would be rated high in this category.

Bulk. Bulk is also important when handling, assembling, and operating the system. A system that is functional with small, modular, effective components would be rated high in this category.

Universal Concept and Advantages

The most universal concept generated from the parametric analysis appears to be the completely floating self-supported system (System 1.A of Table 7 and Figure 10). The completely floating system envisioned consists of one floating broadcaster, two floating harvesters/regenerators and self-supported blower type assemblies for transferring the sorbent material. This type of system possesses a number of advantages or differences over other systems as follows:

- Harvester separations vary, depending on boat width.
- Each harvester/regenerator has its own power supply.
- Harvesters will not roll with the boat.
- Broadcaster will roll with vessel; however, broadcasting is not affected by roll.

- Chaffing material is located between harvester and vessel bow. Harvester is kept against chaffing material and boat hydrodynamically by vessel's forward motion.
- Broadcaster is kept against fender material and bow hydrodynamically by vessel's forward motion. Mooring lines would also be used to keep the broadcaster and bow together.
- Sorbent material can be blown forward using blowers and air ducting. Conveyor belt can be used for sorbent transport; however, conveyor belts would be difficult to mount and hard to manage in heavy seas.
- Each of the two 5-ton harvesters would require 160 cu ft of buoyancy which could be provided by a catamaran hull for each harvester.
- Width of 10 ft for each harvester could provide a maximum cleaning width of 50 ft for a (typical) boat of 30-ft beam.
- The regenerator would be attached to each harvester, and the sorbent material would be contained, using floating oil booms attached to the broadcaster and harvester.
- Ship's steerage is not affected by the symmetrical system.
- The ship can release the system by backing down.
- The system could be towed to the site and expanded for use at sea by maneuvering the boat between harvesters.
- Each harvester with two catamaran hulls of approximately 3x3x10 ft could be easily packaged for shipping.
- The hulls could provide storage for additional sorbent materials.
- The booms or rigging between broadcasters and harvesters can be collapsed easily for shipping.

SUMMARY

Several types of vessels and sorbent system component arrangements have been studied. The spatial characteristics and vessel stability were found to vary considerably among the vessels analyzed. Slow speed capability and stability were found to be less than adequate for the 82-ft Coast Guard patrol craft analyzed using the sorbent system as presently arranged. By reducing the size of the system, or by changing the system component arrangement, the use of the 82-ft Coast Guard cutter may be possible. The slow speeds necessary would, however, require that the 82-ft cutter use a sea anchor to slow the vessel without the engines having to operate in damaging slow speed ranges. The amount of oil collected would be significantly reduced at higher speeds. The smallest vessels which could handle the present equipment would be the 210-ft, medium endurance cutter and the coastal and the seagoing buoy

tenders. A substantial number of these vessels exist to assume the use of these vessels as a practical solution for oil spill clean up within the 200-mile limit of the coastal United States.

The offshore supply/work boats analyzed are well-suited for handling the presently configured system. A rearranged system, as pictured in Figure 10, could be handled with even greater effectiveness. This type of vessel is relatively stable, designed to carry heavy equipment, and has more than adequate space for handling bulky hardware. Tie-downs and weld points are numerous. The attachment of a sorbent system would not be difficult. The availability of these vessels varies in any one locality but for a given region is quite numerous. The probability of obtaining this type of vessel for oil spill cleanup is quite high as several are usually stationed at the larger ports.

Naval vessels capable of handling the sorbent system are numerous. However, Naval vessels are not as widely distributed as Coast Guard vessels but are rather concentrated near a few main Naval ports. The new Navy TATF fleet tug was not considered in detail since only four tugs are currently under construction. The fleet tug is, however, compatible with sorbent systems and could be used if it is available. The use of landing craft vessels (LCU and LCM-8) presents no unusual problems with physical attachment. The LCM-8 would be somewhat small for handling the present system. However, through system weight reductions the LCM-8 would have sufficient capabilities to operate with a sorbent system in the open ocean. Other Naval vessels such as the new self-powered causeway will readily accept the present system. These landing craft vessels may, however, reduce the amount of oil recovered due to significant differences in bow-wave interaction because of their more blunt bow shapes.

The sorbent system can be improved considerably. Weight reductions can be realized through optimization analysis of the system without sacrificing system performance. Rearrangement of the system's components will produce the greatest improvement - primarily because of the resulting easing of mounting difficulties. A completely floating component system is considered the most effective universal mounting arrangement. This type of arrangement poses many other advantages associated with performance and logistics.

CONCLUSIONS

1. To be truly universal the universal mounting arrangement should have as little vessel involvement as possible. Candidate vessels vary considerably and no single connection can be developed that will satisfactorily meet the requirements for system performance for all vessels. Welded connections, however, can be adapted to most vessels studied. The vessels usually have steel deck plates from 1/4 to 1/2 in. thick. Internal bulkheads add additional strength to accommodate the present system on the larger vessels. A vessel length of less than 150 to 200 ft, however, may not accommodate the present system when considering vessel space, stability, and structure.

2. A system's weight reduction of as much as 60% to 75% would have to be realized for operational capability with the 82-ft Coast Guard cutter. A system having the present capabilities can be reduced in size. However, weight reductions are limited and appreciable reductions would result in sacrificing performance. It is unknown at this time how much performance is sacrificed with this magnitude of weight reduction.

3. It is anticipated that system component rearrangement will have the least detrimental effect on overall system performance. With certain component arrangements, system performance may be enhanced.

4. The optimum system arrangement generated from this study and that arrangement most compatible with the notion of universal mounting is a completely floating self-supported system. It is believed that through further analysis of component weight a self-supported floating sorbent system can be developed without additional weight over the present system and with enhanced performance over the present system. This type system would have the broadcaster pushed through the oil spill area by the vessel with relatively little interaction between vessel motion and sorbent system operation. This concept will involve fendering and chaffing development for operation of the sorbent system.

RECOMMENDATIONS

It is recommended that alternative sorbent system component arrangements as cited herein be evaluated. Each component function should be analyzed to take into consideration the alternative arrangements. It is recommended that a floating self-supported system be developed and component functions optimized to suit the performance characteristics and capability of various selected vessels. The requirements for davits and weldments should be minimized to maximize versatility of mounting. Specific mounting requirements should be generated and specified after optimization of all system components.

ACKNOWLEDGMENT

Considerable Coast Guard vessel technical information was provided through the cooperation of Mr. Bill Glasgow stationed at the Naval Engineering Office of the Eleventh Coast Guard District, Long Beach, California. Mr. Glasgow's efforts in arranging tours of several cutters and obtainment of the desired technical information is appreciated.

Mr. Edward P. Skillman of CEL furnished the information for the development of Table 3. His help is gratefully acknowledged.

Appendix

CANDIDATE VESSEL AVAILABILITY AND CHARACTERISTICS SUMMARY

82-FT WPB CLASS COAST GUARD PATROL CRAFT

1. Availability: Located at Coast Guard Stations along all coasts. See the "Register of Cutters in the U.S. Coast Guard" (Reference 4).

2. Time constraints on use: Would be available for as long as necessary.

3. Minimum operable speed range: 3-5 knots on one engine. It would have to be run at high speed occasionally to keep engine from fouling. Tow of barge or dracone would enable low speed operation at high rpm.

4. Low speed control aids: None.

5. Dimensions: Length - 82 ft 10 in.
   Beam - 17 ft 7 in.
   Draft - 12 ft.

6. Areas of possible welding: No welding on hull or superstructure. Deck acceptable.

7. Operating range: 1,500 miles. Endurance: 10 days.

8. Tank storage capacities: 1,830 gal diesel.
   1,200 gal freshwater.

9. Berthing: Officer and eight crew. Additional berthing: None.

10. Clear deck space: Forward - 10 ft x12 ft.
    Passage along superstructure - 3 ft wide.
    Stern - 17 ft x30 ft.

11. Deck tie down equipment: Very limited, should be supplied.

12. Workboats other than lifeboats: 14-ft Boston Whaler w/25-hp outboard or
    14-ft Zodiac boat w/25-hp outboard.

13. Services available: Electricity - Two 20-kW generators.
    Fuel - Diesel or gasoline carried in 5-gal cans.

14. Allowable deck loads: Unavailable.

15. Location for storage bladders: Stern or bow areas if small; large bladders could be towed.

16. Miscellaneous:

- Exterior steel half round extends to forward end to serve as a bumper.
- Hull plating is 3/16-in. steel, capable of breaking 3-4 in. of ice and therefore capable of pushing a system.
- The anchor hold in the bow could be used for oil or chip storage since it is watertight. The hatch is about 2x2 ft.
- The boswain hold aft could be used to store some equipment or chips. The hatch is about 3x3 ft.
- The 82-ft cutter will easily roll 20 deg (total excursion of 40 deg) in relatively mild seas (3-ft swells).
- The stern rail is welded to the deck but the upper curved rail that is added when towing large loads need not be attached.
- The 95-ft WPB class cutter is very similar to the 82-ft, the same mounting configuration could be used with more space left for storage.

175-FT WLM CLASS COAST GUARD BUOY TENDER

1. Availability: See the "Register of Cutters in the U.S. Coast Guard (Reference 4).

2. Time constraints on use: May be limited by other duties.

3. Minimum operable speed range: 3-4 knots with use of one prop only.

4. Low speed control aids: None.

5. Dimensions: Length - 175 ft.
   Beam - 34 ft.
   Depth - 12 ft.

6. Areas of possible welding: Main deck, possibly high on hull.

7. Operating range: 1,000 miles. Endurance: 14 days (est.).

8. Tank storage capacities: Unavailable.

9. Berthing: 38 crew. Additional berthing: None.

10. Clear deck space: Frame 55 to frame 80 - 34x42 ft.

11. Deck tie down equipment: Some available for buoys but should be provided with system.

12. Workboats other than lifeboats: 25-ft lifeboat can be used as a medium duty work boat.

13. Services available: Crane at frame 53. Capacity, 30,000 lb at 35 ft. Rotation, 80 deg to each side of centerline. Boom, 50-ft. Electrical and compressed air services, available.

14. Allowable deck loads: Unavailable.

15. Location for storage bladders: On forward work area or bow (if small). Aft between life boats (if small).

16. Miscellaneous:

- Buoy port opening each side, frame 66 to 75 - 15 ft.
- Approximate change in metacentric height due to adding weight at different locations.

Condition	Light	Minimum	Normal	Full
Displacement	696.9	759.3	833.8	967.4
Mean Draft	9'6-3/4"	10'1"	10'9"	11'11"
Center of Gravity Above Base	13.09	12.58	12.59	11.75
G M_T (Metacentric Height)	1.75'	2.25'	2.37'	3.29'
Moment to Heel 1 deg (ft-tons) (Displacement x G M x 0.01746)	21	30	35	56
10 tons added 5 ft above baseline (in hold), ft	+0.13	+0.15	+0.03	+0.07
10 tons added 12 ft above baseline (1st platform), ft	+0.04	+0.02	-0.11	+0.06
10 tons added 18 ft above baseline (main deck), ft	-0.05	-0.19	-0.19	-0.01
10 tons added 26 ft above baseline (upper deck), ft	-0.16	-0.16	-0.16	-0.11

NOTE: Weights up to two or three times the above will have approximately proportional effect on the metacentric height.

210-FT WMEC CLASS COAST GUARD CUTTER

1. Availability: See the "Register of Cutters of the U.S. Coast Guard" (Reference 4).

2. Time constraints on use: May be limited by other duties.

3. Minimum operable speed range: Variable to "stop."

4. Low speed control aids: Two control pitch propellers.

5. Dimensions: Length - 211 ft.
   Beam - 34 ft.
   Draft - 10 ft.

6. Areas of possible welding: Helicopter deck (high strength steel). Fantail and side alleys.

7. Operating range: 6,100 miles. Endurance: 21 days (est.).

8. Tank storage capacities: Ship's operating tanks only.

9. Berthing: 61 crew. Additional berthing: Temporary berthing can be rigged.

10. Clear deck space: Helicopter deck - 30x70 ft.
    Fantail - 30x30 ft.
    Side Alleys - 5 ft wide.

11. Deck tie down equipment: Helicopter tiedown equipment is available, but tiedowns should be provided with the system.

12. Workboats other than lifeboats: 25-ft lifeboat can be used as a light duty workboat.

13. Services available: Portable davits are available with capacities of 500 and 1500 lb. There are locations for these davits on both sides for the entire length of the ship.

14. Allowable deck loads: Unavailable.

15. Location for storage bladders: Large areas are available on the helicopter deck. Smaller bladders could be stored on the bow and fantail.

OFFSHORE SUPPLY BOATS (APPROXIMATELY 200 FT)

1. Availability: Available in most areas, concentrated where offshore oil drilling is taking place.

2. Time constraints on use: Time of use would be arranged by individual contracts.

3. Minimum operable speed range: Variable to "stop."

4. Low speed control aids: Some have controlled pitch propellers and most have bow thrusters.

5. Dimensions: Length - 150 to 250 ft.
Beam - approximately 40 ft.
Draft - 9.5 to 14.75 ft.

6. Areas of possible welding: Welding would be allowed everywhere except near fuel tanks.

7. Operating range: approximately 7,000 miles. Endurance: 20+ days.

8. Tank storage capacities: Fuel oil - approximately 100,000 gal.
Other tanks - 10 to 36,000 gal.
Ballast - 150,000+ gal.

9. Berthing: Approximately 12 Additional berthing: Varies with vessel.

10. Clear deck space: 25x70 ft to 35x100 ft (depending on boat).

11. Deck tie down equipment: Some available but should be supplied with the system.

12. Workboats other than lifeboats: None.

13. Services available: Fuel - diesel.
Electricity - standard 110V.
Air - limited.
Crane - small portable or mobile crane would fit.

14. Allowable deck loads: 500 to 1,000 lb/sq ft.

15. Location for storage bladders: Large ones on stern or small ones on bow.

16. Miscellaneous:

- Generally very large, solid railings (8-in. pipe) are around the stern cargo area. These could be used to tie to or brace against.
- Some deck space may have a wooden cover with steel holding it down at the ends.
- May have very large winches in stern. Capacities up to 300,000 lb.

NAVY LANDING CRAFT UTILITY 1610 CLASS

1. Availability: Located at Naval bases along all coasts.

2. Time constraints on use: LCU's would most likely be available for as long as necessary.

3. Minimum operable speed range: Unavailable.

4. Low speed control aids: None.

5. Dimensions: Length - 135 ft.
   Beam - 29 ft.
   Draft - 3 ft 3 in.

6. Areas of possible welding: All areas are suitable for welding except near fuel tanks.

7. Operating range: Unavailable. Endurance: Unavailable.

8. Tank storage capacities: Unavailable.

9. Berthing: 4 crew. Additional berthing: None.

10. Clear deck space: 125x20 ft.

11. Deck tie down equipment: Cloverleaf tiedowns built into main deck.

12. Workboats other than lifeboats: None.

13. Services available:

14. Allowable deck loads:

15. Location for storage bladders: Main deck area.

REFERENCES

1. Environmental Protection Agency. Contract Report: Development of a sorbent distribution and recovery system, by S. H. Shaw, R. P. Bishop, and R. J. Powers. Edison Water Quality Research Laboratory, (in publication).

2. Ocean Design Engineering Corporation. Mechanized sorbent oil spill recovery system information technical manual, 1975.

3. Civil Engineering Laboratory. Technical Note N-1476: "An offshore mechanized sorbent oil recovery system using vessels of opportunity," by J. Der and D. E. Brunner. Port Hueneme, Calif., Mar 1977.

4. U.S. Coast Guard. CG-197: Register of cutters of the U.S. Coast Guard. Washington, D.C., Feb 1977.

5. Fleet Data Service. 1977 FDS specifications of large American offshore vessels. Houston, Tex., May 1977.

6. Fleet Data Service. 1978 FDS specifications of large foreign offshore vessels. Houston, Tex., Sep 1977.

7. Fleet Data Service. 1978 FDS guide to major American tug fleets. Houston, Tex., Dec 1977.

8. University of Michigan. Analysis of the response of an open-ocean oil slick to a vessel involved in oil-spill recovery, by W. S. Vorus, V. A. Phelps, and W. P. Graebel. Ann Arbor, Mich., Aug 1977.

9. U.S. Coast Guard, Naval Engineering Division. 82 foot WPB class patrol craft stability and loading data booklet. Washington, D.C., Feb 1971.

10. U.S. Coast Guard. Merchant vessels of the United States, 1975. Washington, D.C., Jan 1975.