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U.S. NAVY
SHIP SALVAGE MANUAL
VOLUME 6
(OIL SPILL RESPONSE)

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FOREWORD

This volume is the fifth in a series of six related publications that make up the *U.S. Navy Salvage Manual*. Each volume in the family addresses a particular aspect of salvage. The family collectively replaces the three volumes of the *U.S. Navy Salvage Manual* issued between 1968 and 1973.

The increasing importance of preventing pollution at sea, and the fact that major oil spills often result from ship casualties, has made spill prevention and response a specialized adjunct to ship salvage. Having accepted responsibility for a casualty, salvors are expected to endeavor to stop or reduce spillage in progress, to conduct salvage in a manner that minimizes the risk of further spillage, and to respond to spills that occur as a result of salvage work. Additionally, ship salvage or wreck removal may be conducted separately to limit or prevent pollution.

In recognition of these responsibilities, the Navy maintains as part of its salvage assets the ability to respond to major Navy and salvage-related oil spills. This capability is also a national resource. The National Oil Spill Contingency Plan specifically recognizes that:

> *The United States Navy is the Federal agency most knowledgeable and experienced in ship salvage, shipboard damage control, and diving. The Navy has an extensive array of pecialized equipment and personnel available for use in these areas as well as specialized containment, collection, and removal equipment specifically designed for salvage-related and open-sea pollution incidents.*

As a result, Navy salvage forces may be called upon to respond to spills of all types of oils, as well as the relatively limited range of products carried on Navy ships.

This volume provides guidance to the Navy salvor facing a major pollution incident resulting from a ship stranding, sinking, fire, collision or explosion. *Volumes 1, 2, and 3* provide practical guidance in dealing with the various types of marine casualties that may lead to a pollution incident. *Volume 5* addresses methods of removing fuels and liquid cargoes from damaged vessels in awkward situations.

Like the other *Salvage Manual* publications, this volume provides practical information of immediate use to Navy salvors in the field, and assists them in learning certain aspects of our trade before practicing them in the field. This volume is also intended for use by all naval personnel who may be tasked to participate in oil spill response or contingency planning. Like the other volumes, this publication provides guidance, not cookbook solutions. Salvors and spill responders must also apply imagination, intelligence and experience to each situation.

Salvage and spill response efforts often proceed simultaneously, and may either complement or conflict with one another. Only a thorough knowledge of the methods and requirements of both efforts can ensure a smooth, successful operation.

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STANDARD NAVY SYNTAX SUMMARY

Since this manual will form the technical basis of many subsequent instructions or directives, it utilizes the standard Navy syntax as pertains to permissive, advisory, and mandatory language. This is done to facilitate the use of the information provided herein as a reference for issuing Fleet Directives. The concept of word usage and intended meaning which has been adhered to in preparing this manual is as follows:

"Shall" has been used only when application of a procedure is mandatory.

"Should" has been used only when application of a procedure is recommended.

"May" and "need not" have been used only when application of a procedure is discretionary.

"Will" has been used only to indicate futurity; never to indicate any degree of requirement for application of a procedure.

The usage of other words has been checked against other standard nautical and naval terminology references.

GLOSSARY

ACRONYMS AND ABBREVIATIONS

ABS . . . . American Bureau of Shipping.
API . . . . American Petroleum Institute.
ARPA . . . . Archaeological Resources Protection Act.
ARS . . . . Auxiliary, Salvage Vessel; U.S. Navy 213- or 250-foot ocean going tugs designed and equipped for heavy salvage work and independent operations in all ocean areas including areas with significant ice cover.
ASR . . . . Auxiliary, Submarine Rescue Vessel. Older U.S. Navy ASRs (Chanticleer Class) are modified ATF designs, especially outfitted for deep diving and submarine rescue. These ships are slightly larger than the ATF-76 Class but with same general configuration, and equally well suited for oil spill response work. The ASR-21 Class ships are large, deep-draft catamarans with high freeboard. They are not well suited to spill response work other than as afloat command centers.
ATF . . . . Auxiliary, Fleet Tug; U.S. Navy 205-foot ocean going tug.
ATS . . . . Auxiliary, Salvage Tug; U.S. Navy 270-foot ocean going tug designed and equipped for heavy salvage work, deep diving, and submarine rescue.

CFR . . . . *Code of Federal Regulations*.
CFST . . . . Contaminated fuel settling tank.
CINC . . . . Commander in Chief.
CNET . . . . Chief of Naval Education and Training.
COE . . . . Army Corps of Engineers.
CONUS . . . . Continental United States.
CP . . . . Contingency Plan.
CWA . . . . Clean Water Act.

DERA . . . . Defense Environmental Restoration Account.
DFM . . . . Diesel Fuel, Marine.
DOC . . . . Department of Commerce.
DOD . . . . Department of Defense.
DOE . . . . Department of Energy.
DOI . . . . Department of Interior.
DOJ . . . . Department of Justice.
DOL . . . . Department of Labor.
DOMS . . . . Director of Military Support.
DON . . . . Department of the Navy.
DOT . . . . Department of Transportation.

EFD . . . . Engineering Field Division.
EPA . . . . Environmental Protection Agency.
FEMA. . . . . Federal Emergency Management Agency.
FOSC . . . . Federal On-Scene Commander.
FWPCA . . . . Federal Water Pollution Control Act.

GSA . . . . General Services Administration.

IAA, IAG . . . . Interagency agreement.
IMCO . . . . Intergovernmental Maritime Consultative Organization (*see IMO*).
IMO . . . . International Maritime Organization (formerly IMCO).
ISSA . . . . Interservice Support Agreement.

LCM . . . . Landing Craft, Mechanized; large, open-well craft with control station aft,
bow ramp, and hull designed for beaching. The most common types are the 56-foot LCM(6) and the 74-foot LCM(8).
LCU . . . . Landing Craft, Utility; landing craft generally similar to, but larger than LCM-type craft, and equipped with berthing and galley facilities.
LEL . . . . Lower Explosive Level.
LPD . . . . Amphibious Platform, Dock.
LSD. Landing Ship, Dock.
LST. Landing Ship, Tank.
LSV. Logistics Support Vessel; U.S. Army vessel with beaching capability, similar to very large LCU.
LT . . . . U.S. Army Large Tug. The LT designation includes large harbor tugs similar to the U.S. Navy YTB and YTM designations, as well as larger ocean going tugs.

MAC. . . . . Military Airlift Command.
MARPOL. . . . . International Maritime Convention for the Prevention of Pollution from Ships.
MESO. . . . . Marine Environmental Support Office.
MOA. . . . . Memorandum of Agreement.
MOU. . . . . Memorandum of Understanding.
MSC . . . . Military Sealift Command.
MSDS . . . . Material Safety Data Sheet.

NAVFAC . . . . Naval Facilities Engineering Command.
NAVFACENGCOM . . . . . . Naval Facilities Engineering Command.
NAVOSH . . . . Navy Occupational Safety and Health.
NAVSEA . . . . Naval Sea Systems Command.
NAVSEASYSCOM. . . . . . . Naval Sea Systems Command.
NAVSEA OOC . . . . Naval Sea Systems Command, Director of Ocean Engineering and Supervisor of Salvage.

NCEL . . . . Naval Civil Engineering Laboratory.
NCP . . . . National Contingency Plan.
NEESA . . . . Navy Energy and Environmental Support Activity.
NEPMG . . . . Navy Environmental Program Management Group.
NEPSS . . . . Naval Environmental Protection Support Services.
NESO . . . . Navy Environmental Support Office.
NOAA. . . . . National Oceanographic and Atmospheric Administration.
NOS . . . . National Ocean Service.
NOSC . . . . Navy On-Scene Coordinator; also Naval Ocean Systems Center.
NOSCDR . . . . Navy On-Scene Commander.
NRC . . . . Nuclear Regulatory Commission, National Response Center.
NRT . . . . National Response Team.

OCIMF. . . . . Oil Companies International Marine Forum.
OHS . . . . Oil or hazardous substances.
OPLAN . . . . Operations Plan.
OPNAV . . . . Office of the Chief of Naval Operations.
OPNAVINST. . . . . CNO instruction.
OPORD . . . . Operations Order.
OSC . . . . On-Scene Coordinator.
OSCDR . . . . On-Scene Commander.
OSHA . . . . Office of the Safety and Health Administration.
OSOT . . . . On-Scene Operations Team.
OWHT . . . . Oily waste holding tank.
OWS . . . . Oil-water separator.

POL . . . . Petroleum, Oil, and Lubricants.
PPM . . . . Parts per million.
PSI . . . . Pounds per square inch.

RCP . . . . Regional Contingency Plan.
RCRA. . . . . Resource Conservation and Recovery Act.
REC . . . . Regional Contingency Plan.
RRT . . . . Regional Response Team.

SCP. Spill Contingency Plan.
SECDEF. . . . . Secretary of Defense.
SECNAV . . . . Secretary of the Navy.
SERC . . . . State Emergency Response Commission.
SESO . . . . Ship's Environmental Support Office.
SITREP . . . . Situational Report.
SPCC . . . . Spill Prevention Control and Countermeasures.
SSC . . . . Scientific Support Coordinator.
ST . . . . U.S. Army Small (harbor) Tug.
SUPSALV . . . . Supervisor of Salvage.

T-ATF . . . . Auxiliary, Fleet Tug, MSC-operated; the T-ATF-166 Class design is based on the offshore supply vessel design. These vessels have large, low freeboard aft working decks well suited to oil spill response work and small craft support.

UEL . . . . Upper Explosive Level.

USCG . . . . United States Coast Guard.

USCGC . . . . United States Coast Guard Cutter.

USAV . . . . United States Army Vessel.

USNS . . . . United States Naval Ship.

USS . . . . United States Ship.

VHF . . . . Very High Frequency; radio transmissions in the 30-300 MHz range.

WLB . . . . USCG Offshore Buoy Tender.

WLI . . . . USCG Inshore (river) Buoy Tender.

WLM . . . . USCG Coastal Buoy Tender.

WTGB . . . . USCG 140-foot Icebreaking Tug.

WYTM . . . . USCG I 10-foot (medium) Harbor Tug.

YTB . . . . USN 109-foot (large) harbor tug.

YTM . . . . USN 108-foot (medium) harbor tug.

DEFINITIONS

Accessories, boom. *Optional* mechanical devices used on or in conjunction with a boom system but not included with the basic boom and end connectors; that is, lights, paravanes, drogues, buoys, anchor systems, storage bags, boxes or reels, bulkhead connectors or repair kits, etc.

After peak. The aftermost tank or compartment of a ship forward of the stem post.

Anchor point, boom. A structural point on the end connector or along the length of a boom section designed for the attachment of anchor or mooring lines.

Ancillary equipment, boom. Those mechanical devices *essential* to the operation of a given boom system; that is, air pumps, hydraulic power supplies, control manifolds, etc.

Ballast. Weight applied to the skirt to improve boom performance.

Basin. A naturally or artificially enclosed or nearly enclosed harbor.

Bay. A recess in the shore or an inlet of a sea between two capes or headlands, not as large as a gulf, but larger than a cove.

Beach berm. A nearly horizontal part of the beach or backshore often with a steep or nearvertical face formed by the deposit of material by wave action. Some beaches have no bermsothers have one or several.

Boom. A floating mechanical barrier used to control the movement of substances that float.

Boom section. The length of boom between two end connectors.

Boom segment. Repetitive identical portion of the boom section.

Boom weight. Dry weight of a fully assembled boom section including end connectors.

Breakwater. A structure protecting a shore area, harbor, anchorage, or basin from waves.

Bulk cargo. Liquid or solid cargo made up of commodities such as oil, coal, ore, grain, etc., not shipped in bags or containers; more specifically applied to solid cargoes.

Catenary drag force. The tension on a boom that results from towing it in a U-configuration.

Clay. Generally, fine-grained soils having particle diameters less than 0.002 millimeter and exhibiting plastic properties when wet.

Coastal Zone. An area of Federal responsibility for response action under the NCP; includes all U.S. waters subject to the tide, U.S. waters of the Great Lakes, specified ports and harbors on the inland rivers, waters of the Contiguous Zone, other waters of the high seas subject to the NCP, and the land surface or land substrata, ground waters, and ambient air adjacent to those waters.

Code of Federal Regulations (CFR). Codification of the general and permanent rules published in the Federal Register by the executive departments and agencies of the Federal Government.

Cofferdam. Empty space separating two or more compartments as insulation, or to prevent the liquid contents of one compartment from entering another in the event of rupture or leak in the compartment bulkheads.

Conformance. The ability of a boom to maintain freeboard and draft when subjected to a given set of environmental conditions.

Containment mode. The placement of a boom to prevent movement of a floating substance.

Contiguous zone. A zone of the high seas, established by the U.S. under the Convention of the Territorial Sea and Contiguous Zone, which is contiguous to the territorial sea and which extends nine nautical miles (nm) seaward from the outer limit of the territorial sea.

Control draft. The minimum vertical depth of the boom membrane below the waterline.

Current response. Change in freeboard or draft due to current forces acting to displace the boom from rest.

"Curtain-type" boom. A boom consisting of a flexible skirt supported by flotation.

Deep tanks. Tanks extending from the bottom or inner bottom of a vessel up to or higher than the lowest deck.

Discharge. Discharge, as defined by the Clean Water Act, includes, but is not limited to, any spilling, leaking, pumping, pouring, emitting, emptying, or dumping of oil. For National Contingency Plan purposes, discharge also means threat of discharge.

Dispersant. Chemical agents that emulsify, disperse, or solubilize oil into the water column or promote the surface spreading of oil slicks to facilitate dispersal of the oil into the water column.

Diversion mode. The placement of a boom to redirect the movement of a floating substance.

End connector. A device permanently attached to the boom used for joining boom sections to one another or to other accessory devices.

Ends. Groupings of the hydrocarbon compounds containing in crude oil; grouped as light ends, with low viscosity, density, and boiling point, and heavy ends with high viscosity, density, and boiling point.

Expansion trunk or tank. A trunk extending above a space which is used for the stowage of liquid cargo. The surface of the cargo liquid is kept sufficiently high in the trunk to permit expansion without risk of excessive strain on the hull or of overflowing, and to allow contraction of the liquid without increase of free surface.

Explosive range. See *flammable limits.*

Federal On-Scene Coordinator (FOSQ). The Federal official predesignated by EPA or the USCG to coordinate and direct Federal responses under the NCP, except for DOD HS releases. In the case of HS releases from DOD facilities or vessels, the DOD-appointed OSC is the FOSC.

"Fence-type" boom. A boom consisting of a self-supporting or stiffened membrane supported by flotation.

Fire point. The lowest temperature at which a liquid fuel sustains combustion.

Flammable limits. The range in which there is enough oxygen to ignite a vapor.

Flammable liquid. Liquid with a flash point below 100 degrees Fahrenheit.

Flash point. The lowest temperature at which a liquid fuel gives off sufficient vapor to form an ignitable mixture near its surface.

Float. That separable component of a boom that provides buoyancy.

Flotation. That portion of a boom which provides buoyancy.

Foreign areas. Any other countries, territories, or jurisdictions not contained under the definition of U. S.

Forepeak. The watertight compartment at the extreme forward end of a ship. The forward trimming tank.

Freeboard, boom. The vertical height of a boom above the waterline.

Groin. A shore protection structure built (usually perpendicular to the shoreline) to trap littoral drift or retard erosion of the shore.

Gross buoyancy. The weight of fresh water displaced by a boom totally submerged.

Gross buoyancy to weight ratio. Gross buoyancy divided by boom weight.

Harbor. Any protected water area affording a place of safety for vessels.

Heave response. The ability of a boom to react to the vertical motion of the water surface.

Hinge. A location between boom segments at which the boom can be folded back 180 degrees upon itself.

Ignitable mixture. A mixture of vapor and air that is capable of being ignited by an ignition source, but usually is not sufficient to sustain combustion.

Ignition point, ignition temperature. The lowest temperature at which a fuel will bum without continued application of an ignition source.

Intertidal Zone. The land area that is alternately inundated and uncovered with the tides, usually considered to extend from mean low water to extreme high tide.

Inner bottom. The plating over the double bottom; also called *tank top*.

Intrinsically safe. Equipment or devices that do not produce sparks, heat, or provide other ignition source. Primarily applicable to electrical and communication equipment.

Jetty. On open seacoasts, a structure extending into a body of water, and designed to prevent shoaling of a channel by littoral materials, and to direct and confine the stream or tidal flow. Jetties are built at the mouth of a river or tidal inlet to help deepen and stabilize a channel.

Lead agency. The authority within the Federal Government designated under the contingency plan as having overall responsibility for response to marine emergencies.

Lifting point. A structural point on the end connector or along the length of a boom section designed for the attachment of a lifting device, such as a crane.

Lighter. To transport goods or cargo short distances by water; to discharge cargo from a larger vessel into a smaller vessel for further transport; vessels used for lighterage.

Lower Explosive Level (LEL). Minimum concentration below which a flammable gas or liquid vapor will not bum.

Low Water Datum (LWD). An approximation to the plane of mean low water that has been adopted as a standard reference plane.

Marine (pollution) emergency. Any casualty, incident,, occurrence, or situation, however caused, resulting in substantial pollution or imminent threat of substantial pollution to the marine environment by oil and including collisions, strandings, and other incidents involving ships, oil well blowouts, pipeline ruptures, and the presence of oil arising from the failure of industrial installations.

Material Safety Data Sheet (MSDS). Written or printed data concerning hazardous material prepared by the manufacturer to inform users of safe handling procedures, hazards, appropriate precautions, emergency procedures, etc., in accordance with paragraph (g) of 29 *CFR* 1910.1200

Membrane. The continuous portion of a boom which serves as a barrier to the movement of a substance.

Navy On-Scene Commander (NOSCDR). Commanders or commanding officers of designated naval shore activities or complexes (Shoreside NOSCDRs) and of fleet units (Fleet NOSCDRs) predesignated by the cognizant NOSC to direct on-scene OHS spill response operations within assigned areas.

Navy On-Scene Coordinator (NOSQ). The Navy official predesignated to coordinate Navy OHS pollution contingency planning and direct Navy OHS pollution response efforts in a preassigned area. The NOSC is the Federal OSC for Navy HS releases.

National Contingency Plan (NCP). The National Oil and Hazardous Substance Pollution Contingency Plan which provides the legal framework for Federal Government OHS pollution contingency planning and response. The NCP establishes national, regional, and local Federal organizations and plans for response to release or threatened releases of OHS; assigns responsibilities to participating Federal agencies and outlines the state, local government, and nongovernment cooperation needed during a response.

National Response Center (NRC). The 24-hour OHS spill notification center, located at USCG Headquarters in Washington, D.C.

National Response Team (NRT). The Federal response organization, consisting of 15 Federal agencies, including DOD, established to coordinate OHS spill planning and response efforts. The NRT is chaired by the EPA with the USCG providing the vice chair.

Nearshore (zone). An indefinite zone extending seaward from the shoreline well beyond the breaker zone.

Oil. Oil, as defined by the CWA, means oil of any kind or in any form, including, but not limited to, petroleum, fuel oil, sludge, oil refuse, and oil mixed with wastes other than dredged spoil.

Oily Waste. Any liquid petroleum product mixed with wastewater and/or oil in any amounts which, if discharged overboard, would cause or show a sheen on the water.

Oil Waste Water. An oil-water mixture that has a water, content of greater than 50 percent. The mixture may also contain other nonpetroleum matter.

On-Scene Commander (OSCDR). The person responsible for deployment and operation of the response resources on-scene.

On-Scene Operation Team (OSOT). Specially trained and equipped Navy shore-based unit responsible for providing complete OHS spill containment and recovery for inland waters and harbors.

Overall height. The maximum vertical dimension of a boom.

Percolation. The process by which water flows through the interstices of a sediment. Specifically,in wave phenomena, the process by which wave action forces water through the interstices ofthe bottom sediment. Tends to reduce wave heights.

Performance. The ability of a boom to contain or deflect oil under a given set of environmental conditions.

Permeability. The characteristics of a material which allow a liquid or gas to pass through. Pour point. The lowest temperature at which a substance flows under specified conditions.

Public vessel. Vessels owned or bareboat-chartered and operated by the U.S., or by a state or political subdivision thereof, or by a foreign nation, except when such vessel is engaged in commerce.

Reclamation. The processing of used oil to recover useful oil products.

Regional Response Team (RRT). The Federal response network under the NRT consisting of regional Federal agency and state representatives. There are 13 RRTs, one for each of the ten standard Federal regions, a separate one for Alaska, one for Hawaii and the Pacific U.S. areas, and one for the Caribbean areas.

Release. Any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment (including the abandonment of discarding of barrels, containers, and other closed receptacles containing any HS or pollutant or contaminant). For NCP purposes, release also means threat of release.

Reserve buoyancy. Gross buoyancy minus boom weight.

Reserve buoyancy to weight ratio. Reserve buoyancy divided by boom weight.

Response; oil spill response. Action taken to prevent, reduce, monitor, or combat oil pollution.

Roll response. Rotation of the boom from rest due to wave, wind, or current forces.

Sheen. An iridescent appearance on the surface of the water,

Skirt. That continuous portion of the boom below the floats.

Sounding tube. A pipe leading to the bottom of an oil or water tank, used to guide a sounding tape or jointed rod when measuring the depth of liquid in the tank; also called a sounding pipe.

“Sour” crude. Crude oil that contains hydrogen sulfide (H2S), or a relatively high percentage of sulfur.

Special-purpose boom. A boom that departs from the general characteristics of “fence-type” and “curtain-type” booms, either in design or intended use.

Specific gravity. Ratio of the density of a substance's density to that of a reference substance. Specific gravities for liquids and solids are commonly referred to water at a specified temperature; specific gravities for gases (also called *vapor density*) are commonly referred to air.

Spill. An accidental or unpermitted discharge of OHS into or upon surrounding waters.

Stiffener. A component which provides support to the membrane.

Straight line drag forces. The tension on a boom that results from towing it from one end.

Support agency. Any organization assigned specific tasks under the plan in support of the response.

Surf zone. The area between the outermost breaker and the limit of wave uprush.

Sweeping mode. Movement of a boom relative to the water for the purpose of controlling or collecting a floating substance.

Tank, ballast. Tanks used for carrying water ballast.

Tank, peak. See *after peak, forepeak.*

Tank, settling. Fuel oil tanks used for separating entrained water from the oil. The oil is allowed to stand for a few hours until the water has settled to the bottom, when the latter is drained or pumped off.

Tank top. See *inner bottom*.

Tank, trimming. A tank located near the ends of a ship. Seawater (or fuel oil) is carried in such tanks as necessary to change trim.

Tank, wing. Tanks located well outboard adjacent to the side shell plating, often consisting of a continuation of the double bottom up the sides to a deck or flat.

Tension member. Any component which carries horizontal tension loads imposed upon the boom.

Territorial Seas. The zone established by the U.S. under the Convention on the Territorial Sea and Contiguous Zone. For most Federal legislation passed before 1989, the territorial sea extends three nautical miles (nm) seaward from the mean low waterline of the U.S. shoreline. For international law purposes, the *territorial sea* extends out 12 nautical miles (nm).

Total draft. The maximum vertical dimension of the boom below the waterline.

Towing. Transporting a boom from one place to another by pulling from one end.

Twelve Nautical Mile Zone. Contains the Territorial Sea Zone plus the Contiguous Zone and equals 12 nautical miles (nm).

Ullage. The void above a liquid surface in a tank, and the measurement of this void.

United States. The 50 states, the District of Columbia, the Commonwealth of Puerto Rico, the Commonwealth of the Northern Marianas Islands, Guam, American Samoa, the Virgin Islands, and the Trust Territory of the Pacific Islands, and any other territory or possession over which the U.S. Federal Government has jurisdiction.

Upper Explosive Level (UEL). Maximum concentration above which a substance will not burn.

Used oil. Oil whose characteristics have changed since being originally refined but which may be suitable for future use and is economically reclaimable. Synthetic-based lubricating and transmission products are not considered used oil.

Volatile. Readily vaporizable at a relatively low temperature.

Waste Oil. Oil whose characteristics have changed markedly since being originally refined and has become unsuitable for further use, and is not considered economically recyclable.

Waterway. A narrow gutter along the edge of the deck for drainage.

Well. Space in the bottom of a ship to which bilge water drains so that it may be pumped overboard; space between partial superstructures or between the wing walls of landing craft.

Wind response. Change in freeboard or draft due to wind force acting to displace the boom from rest.

BIBLIOGRAPHY

Navy Policy, Organization, Procedures, and Equipment:

OPNAVINST 5090.1 (Series), *Environmental and Natural Resources Protection Manual*

NAVFAC P-908, *Oil Spill Control for Inland Waters and Harbors*, Department of the Navy, Naval Facilities Engineering Command, January 1986

NEESA 7-021 (Series), *Oil and Hazardous Substance Spill Response Activity Information Directory (AID)*, Naval Energy and Environmental Support Activity, revised annually

Contingency Planning Information for Offshore and Salvage Related Oil Spill Response Operations, Supervisor of Salvage, U.S. Navy, 1985

NEESA 7-029, *Oil Spill Contingency Planning Manual*, Naval Energy and Environmental Support Activity

NSTM Chapter 593, *Pollution Control*, 1 June 1980

NAVSEA S9597-AC-MMO-010, *Operation and Maintenance Manual with Parts List for Oil Containment Boom and Boom Mooring System*

General Spill Response Methods and Strategy:

Manual on Oil Pollution, International Maritime Organization, London

Section I	*Prevention*, (1983)
Section II	*Contingency Planning*, (1988)
Section III	*Salvage*, (1983)
Section IV	*Combatting Oil Spills*, (1988)

Coping with an Oiled Sea, Office of Technology Assessment, U.S. Congress, 1990

World Catalog of Oil Spill Response Products, Port City Press, Baltimore MD, 1987

A Catalogue of Crude Oil and Oil Product Properties, unpublished report by Environment Canada, Environmental Protection Directorate, River Road Environmental Technology Centre, Ottawa K1A 0H3, Canada, updated periodically

National Policy and Applicable Federal Regulations:

National Oil and Hazardous Substance Pollution Contingency Plan, *Code of Federal Regulations*, Title 40, Part 300 (40 *CFR* 300), revised periodically

Tanker Operations and Cargo Handling:

Tanker Cargo Handling, D. Rutherford, Charles Griffin & Company, Ltd, London, 1980

Tanker Operations, A Handbook for the Ship's Officer, Second Edition, G.S. Marton, Cornell Maritime Press, Centreville MD, 1984

International Safety Guide for Oil Tankers and Terminals, Third Edition, International Chamber of Shipping, Oil Companies International Marine Forum, International Association of Ports and Harbors, Witherby Marine Publishing, London, 1988

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CHAPTER 1

INTRODUCTION

1-1 INTRODUCTION

Oil pollution at sea comes from many sources. Because oil spills often result from ship casualties, spill response has become a highly specialized adjunct to salvage operations. In every casualty, salvors have a responsibility to prevent further pollution. They may also be tasked to undertake or participate in the response to oil spills originating with the casualty. Environmental protection is such a sensitive issue that oil spill response may affect or take precedence over salvage operations. Commercial salvage agreements contractually bind the salvor to use his best endeavors to prevent the escape of pollutants. Pollution control and abatement efforts may delay the commencement of salvage work or limit the methods available to the salvor; in some cases, vessel or cargo salvage is undertaken to support pollution control efforts by securing or removing the pollution source. Navy salvage forces become involved with pollution control in one of four situations:

- Prevention and control of pollution during salvage of Navy or other publicly-owned vessels. This includes action to stop or limit spills in progress when salvage forces arrive, to prevent spills during subsequent operations and to contain and clean up any spills that do occur. In military spill response operations, a Navy On-Scene Coordinator (NOSC) and a Navy On-Scene Commander (NOSCDR) will be designated by the applicable Navy Regional Contingency Plan. The NOSC may or may not be involved in the salvage operations. The senior salvage officer or officer in tactical command (OTC) is charged with complying with Navy, national and local pollution control regulations during the salvage operations and is typically assigned as the Navy On-Scene Commander (NOSCDR).

- Containment and recovery of major Navy-originated spills. Navy salvage units may be designated as fleet NOSCDRs under Fleet NOSC Contingency Plans to deal with offshore spills. The Supervisor of Salvage (SUPSALV) maintains containment and cleanup equipment and is prepared to deal with salvage-related and offshore spills from Navy and other publicly owned vessels or facilities. Navy salvage forces and SUPSALV assets may also be tasked to support response to nonsalvage-related, near-shore oil spills that are the responsibility of but beyond the response capacity of the designated shoreside NOSC.

- Response to spills originating with other Department of Defense (DOD) components. Navy assistance for DOD-originated spills may be requested by DOD, the DOD component or the Federal On-Scene Commander (FOSC). Assistance provided may include oil response equipment, personnel, ships and craft or salvage services.

- Federalized oil spill response operations. Responsibility for spill cleanup rests with the owner or operator of the offending vessel. The Navy can be requested to provide SUP-

SALV assets and/or locally deployed Navy assets to assist in response to spills from civilian sources under National and Regional Contingency Plans via a Navy/Coast Guard interagency agreement if the owner or operator is unable or unwilling to handle the incident in a timely manner. In most cases, cleanup work is performed by specialist contractors with Emergency Ship Salvage Material (ESSM) equipment supported by fleet assets. The Navy may conduct salvage work to secure or remove the spill source at the request of the Federal On-Scene Coordinator (FOSC).

The Navy and other federal agency organizations, state and local governments and international organizations have specific obligations for response to oil spills. When a spill occurs, the response must be coordinated to effectively contain and remove the oil and to minimize its impact. Immediately following a spill, the response organization must quickly gather information, make decisions and mobilize. Free oil on the water does little environmental damage if it is contained and removed before it reaches the shore. The costs of free oil removal are relatively low compared to the astronomical costs of cleaning oiled shoreline.

Coordination within the Navy and between other agencies and groups is vitally important to an effective response. Salvors engaged in salvage work on casualties that have discharged or may discharge oil because of damage are an integral part of the oil spill response team.

1-2 HISTORICAL PERSPECTIVE

The Navy takes significant measures to prevent spillage of oil and to clean up those spills for which it is responsible. In fulfilling this responsibility, Commander, Naval Sea Systems Command (COMNAVSEASYSCOM) and Commander, Naval Facilities Engineering Command (COMNAVFACENGCOM) maintain inventories of oil pollution response equipment tailored for the risks presented by the Navy's day-to-day operations. The COMNAVFACENGCOM inventory is tailored towards dealing with spills in sheltered waters and is distributed to NOSCDRs throughout the Navy. Within NAVSEASYSCOM, the Supervisor of Salvage (SUPSALV) maintains and operates equipment for response to offshore and salvage-related spills.

The SUPSALV spill response inventory, maintained in the Emergency Ship Salvage Material (ESSM) System, is one of the largest and most capable response inventories in the world. Its value as a national asset has been proven by its effective participation in many operations. Because it is a significant national asset, SUPSALV equipment is available to other U.S. Government agencies and is frequently called upon to assist with non-Navy spills. Deployments of SUPSALV oil pollution response equipment for non-Navy spills have included:

- Antarctica - to remove fuel oil from the capsized Argentine Government vessel *BAHIA PARASIO* and to recover spilled oil.

- Alaska - to collect oil spilled from the Very Large Crude Carrier (VLCC) *EXXON VALDEZ* and to protect environmentally sensitive areas.

- Arthur Kill (New York) - to recover oil discharged from a severed underwater pipeline.

- Huntington Beach (California) - to recover crude oil spilled from the damaged oil tanker *AMERICAN TRADER*.

- Arthur Kill (New York) - to recover oil spilled as a result of oil tanker *BT NAUTILUS* grounding.

- Chesapeake Bay - to recover fuel oil spilled following a collision between two cargo ships.

- Gulf of Mexico - to recover crude oil from *IXTOC 1* oil well blowout.

The Navy's position in the national effort to mitigate the effect of oil pollution has been established by its performance. Response to oil spills has become and can be expected to remain a major responsibility of the Navy salvage organization.

1-3 THE NATIONAL RESPONSE ORGANIZATION

The Federal Water Pollution Control Act (Clean Water Act) mandated the *National Oil and Hazardous Substances Pollution Contingency Plan (NCP)* which is codified as Title 40, Part 300, of the *Code of Federal Regulations* (40 *CFR* 300). The NCP establishes national concept, policy, plan and organization for response to oil and hazardous substance spills. It sets guidelines for federal response, establishes the National Response Team (NRT) and 13 Regional Response Teams (RRT), designates participating agencies, Federal On-Scene Coordinators (FOSC) and special forces and resources. NEESA Publication 7-021 (Series), *Oil and Hazardous Substance Spill Response Activity Information Directory,* gives names and addresses of members of the NRT and key members of the RRTs and special resource agencies.

National planning for oil spill response was greatly enhanced by the *Oil Pollution Act of 1990.* That legislation requires the addition of Coast Guard District Response Groups and Area Committees. Area Committee members are to be appointed from federal, state and local agencies. Of particular significance is a requirement for procedures to coordinate Coast Guard Strike Teams, FOSCs, District Response Groups and Area Committees. Areas are to have contingency plans that harmonize with the NCP.

1-3.1 National Response Team (NRT). The NRT is a planning and oversight body whose members represent 15 federal agencies, including the Department of Defense, as shown in Figure 1-1. Representatives from the Environmental Protection Agency (EPA) and U.S. Coast Guard, respectively, chair and vice-chair the NRT. The National Response Center (NRC), located at USCG Headquarters and staffed constantly, is the single federal point of contact for all oil and hazardous substance (OHS) spill reporting and is the NRT communications center.

1-3.2 Regional Response Teams. (RRT). The standing RRTs are responsible for regional planning and preparedness activities and for maintaining Regional Response Centers (RRC). Standing RRT membership consists of designated representatives from each federal agency participating in the NRT, together with state and (as agreed upon by the states) local government representatives. Navy activities within a region are represented indirectly through the DOD member of the RRT.

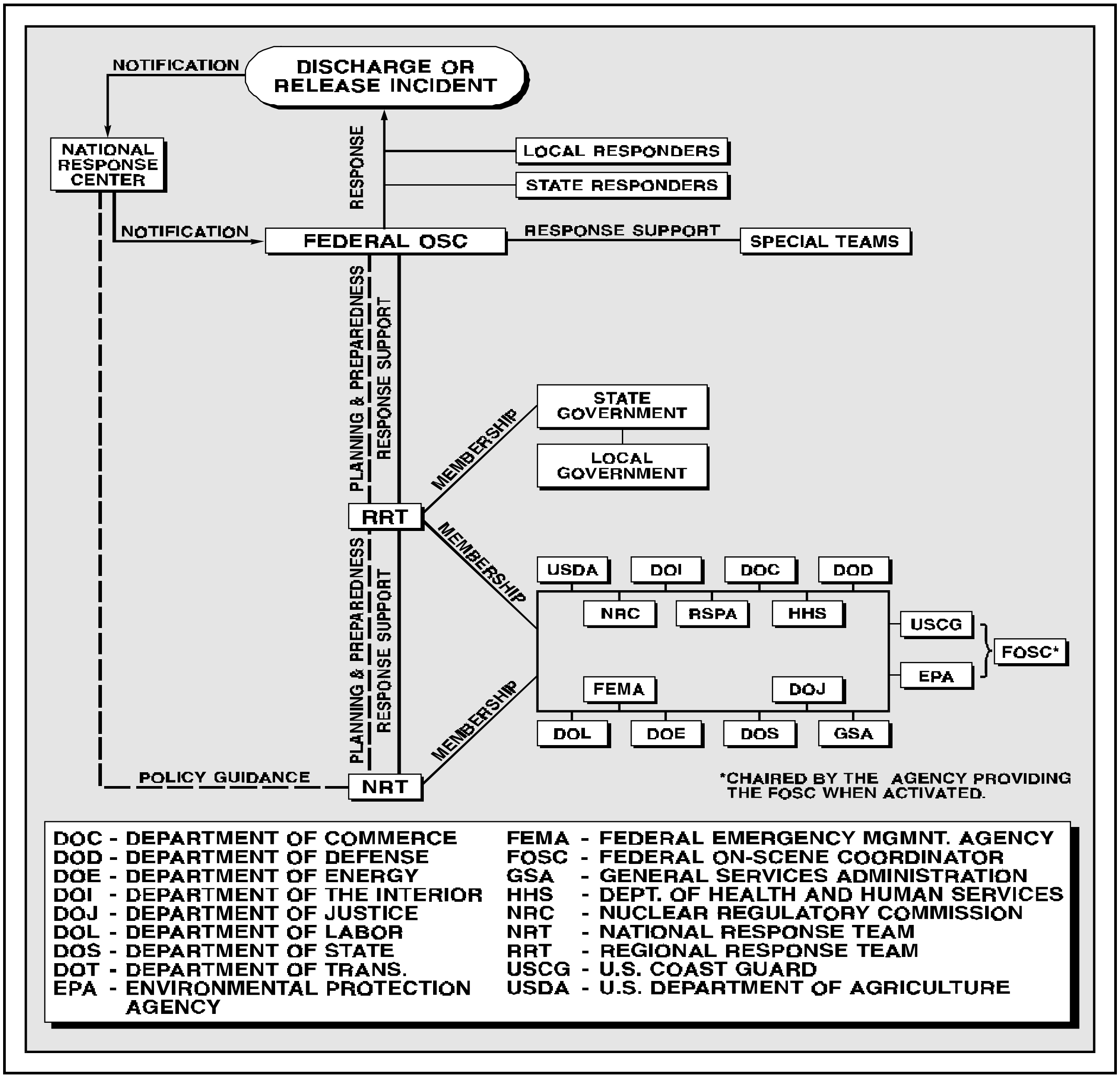


Figure 1-1. National Response Organization.

The jurisdiction of the standing RRTs corresponds to the ten Federal Regions shown in Figure 1-2, with separate RRTs for Alaska, the Caribbean area and Hawaii and the Pacific Island area. When an oil or hazardous substance spill is reported, an incident-specific RRT is activated to provide advice and support to the FOSC. Agencies represented on the RRT, including DOD, are obligated to provide personnel and equipment assets to the FOSC in so far as possible without interfering with operations or degrading mission readiness. If spill response requirements exceed a region's resources, the spill involves significant population hazards or national policy issues or assistance is requested by an NRT member, an incident-specific NRT is activated. The incident-specific NRT may act as an advisory board, request resources from other federal agencies and settle matters referred to it by the RRT.

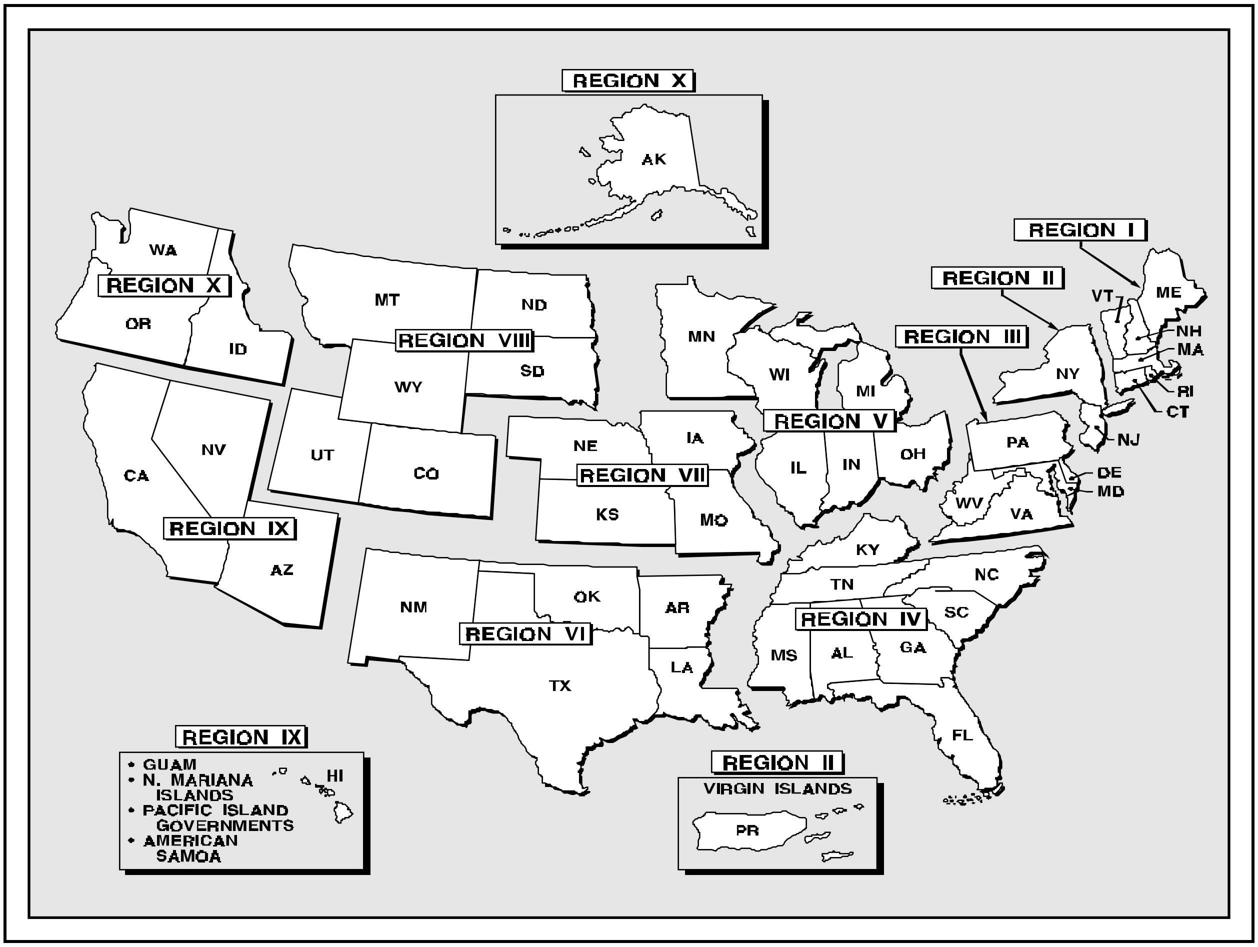


Figure 1-2. Federal Regions.

1-3.3 Federal On-Scene Coordinator (FOSC). The FOSC is the principal federal official who directs response efforts and coordinates all other efforts at the scene of a discharge or release. The Coast Guard provides predesignated FOSCs for oil and hazardous substance (OHS) spills into or threatening U.S. coastal waters; the EPA provides FOSCs for spills into or threatening inland regions.

1-3.4 Special Teams and Resources. Special teams are available to the predesignated Federal On-Scene Coordinator. Each team has special technical skills upon which the OSC may call. Special teams are available to the Navy OSC via the predesignated Federal OSC or by special direct arrangement.

1-3.4.1 National Strike Force (NSF). The NSF consists of three Coast Guard strike teams based at Fort Dix, N.J., Hamilton Air Force Base, Calif. and Mobile, Ala. The National Strike Force Coordination Center (NSFCC) located in Elizabeth City, N.C. coordinates activity among the teams and ensures that they are uniformly trained and equipped.

The strike team concept was designed to airlift pollution response experts and specialized containment and removal equipment to the spill site to assist and advise the FOSC. Strike teams also provide communications support and expertise in shipboard damage control.

1-3.4.2 Environmental Response Team (ERT). The Environmental Protection Agency (EPA) maintains an ERT to meet its disaster and emergency responsibilities. The ERT has expertise in treatment technology, biology, chemistry, hydrology, geology and engineering. The ERT can provide technical advice on risk assessment, cleanup techniques and priorities, water supply decontamination and protection, application of dispersants, environmental assessment, degree of cleanup required and disposal of contaminated material to oil and hazardous material spills.

1-3.4.3 Scientific Support Coordinator (SSC). SSCs are available, at the request of the OSCs, to assist with actual or potential responses to oil discharges or releases of hazardous substances, pollutants or contaminants. SSCs also provide scientific support for the development of spill contingency plans. Generally, SSCs are provided by the National Oceanic and Atmospheric Administration (NOAA) in coastal and marine areas and by the Environmental Protection Agency (EPA) in inland regions. SSCs may be supported in the field by a team providing, as necessary, expertise in chemistry, trajectory modeling, natural resources at risk and data management.

During a response, the SSC serves under the direction of the OSC and is responsible for providing scientific support for operational decisions and for coordinating on-scene scientific activity. The SSC can be expected to provide specialized scientific skills and to work with governmental agencies, universities, community representatives and industry to compile information to assist the OSC in assessing the hazards and potential effects of discharges and in developing response strategies.

If requested by the OSC, the SSC serves as the principal liaison for scientific information and facilitates communications to and from the scientific community on response issues. The SSC strives for a consensus on scientific issues surrounding the response but also ensures that any differing opinions within the community are communicated to the OSC.

The SSC also assists the OSC in responding to requests for assistance from state and federal agencies regarding scientific studies and environmental assessments.

1-3.4.4 Public Information Assistance Team (PIAT). A U.S. Coast Guard PIAT is available to assist FOSCs and regional or district offices to meet demands for public information and participation. The use of a PIAT is encouraged any time the FOSC requires outside public affairs support. Requests for PIAT support are made through the National Response Center (NRC).

1-3.5 International Support. Provisions of the International Convention on Oil Pollution Preparedness, Response and Cooperation, 1990, held under the auspices of the International Maritime Organization, encourages international cooperation among member nations in oil spill response by:

- Requiring emergency plans aboard oil tankers.
- Requiring member nations to have national and regional oil spill contingency plans.
- Setting up a means of international cooperation with advisory services, technical support and equipment.

The type of equipment and response policy employed vary widely from country to country; some countries have much larger mechanical recovery systems than those available in the U.S. Assets may be held by the government or the private sector. Access to international technical assistance is through the NRT. Coordination by the U.S. Department of State may be necessary.

1-4 NAVY OIL SPILL CONTINGENCY PLANNING

The goal of Navy oil spill contingency plans is to provide an organized, coordinated response to oil spills, to stop the flow, contain the spill, mitigate the impact, remove the oil and restore the environment. These goals are consistent with those of federal, state and local agencies and accepted commercial practice. Contingency plans provide guidance to NOSCs, NOSCDRs, activity and unit commanders and other spill response managers; they are not cookbook solutions for oil spill response. Each oil spill is unique and requires some innovation on the part of trained personnel to make an adequate response. Contingency plans provide a head start by making certain decisions in advance and by identifying available response options.

1-4.1 NOSC Contingency Plans. The basis of NOSC contingency plans are the NOSC responsibilities, notification procedures, available assets and organizational arrangements. Each plan identifies:

- Notification procedures
- Response organization
- NOSCDR assignments and areas of responsibility
- Response operations
- Environmentally sensitive areas that must be protected and
- Other resources/agencies that may assist.

NOSC contingency plans are to be coordinated with and consistent with area coordinator plans and instructions, Federal regional (FOSC) plans, other DOD component OSC plans and commercial response plans, where appropriate.

Shoreside NOSC contingency plans cover assigned geographic areas (discussed in **Paragraph 1-5.1** and Appendix B) and are coordinated with regional and state contingency plans for those areas. Subordinate NOSCDRs and unit commanders develop contingency plans appropriate to their spill risk within the framework of the NOSC Plan.

Fleet NOSC Contingency Plans cover fleet operating areas and are coordinated with shoreside NOSCs, federal, state and foreign agency plans, as appropriate. Separate NOSCDR contingency plans are not required if the NOSC plan contains country-specific response guidelines for each country in the fleet operating area. Fleet plans contain information consistent with shoreside NOSC plans and applicable senior officer present afloat (SOPA) instructions. Fleet NOSC/

NOSCDR plans may be promulgated as stand-alone instructions or incorporated in fleet operational orders (OPORDs).

1-4.2 NOSCDR Plans. NOSCDR contingency plans amplify NOSC plan guidance for NOSCDR geographic areas and are coordinated with state and local authorities.

1-4.3 Local and Facility Plans. Commanders of shore activities with the potential for oil spills are required to develop activity contingency plans consistent with NOSC and NOSCDR plans.

1-4.4 Shipboard Plans. Each Navy ship is required to have a contingency plan coordinated with fleet NOSC/NOSCDR plans and consistent with adjacent shoreside plans. COMNAVSEASYSCOM is in the process of developing a shipboard plan which may be used by each ship in developing their own ship-specific plan.

1-5 NAVY SPILL RESPONSE ORGANIZATION

The Navy oil spill organization and response capability is established by the *Environmental and Natural Resources Protection Manual* of 2 October 1990, OPNAVINST 5090.1A. This instruction, consistent with the NCP, establishes the Navy oil and hazardous substance spill organization and the requirement for a Navy contingency planning system.

The Navy has a worldwide capability for responding to its own oil spills. Navy contingency plans can also be implemented to assist federal agencies under the National Contingency Plan.

The Navy organization for oil spill response and planning is divided into shoreside and fleet organizations, as shown in **Figure 1-3**. Area (Environmental) Coordinators are assigned coordination authority over broad geographic areas by OPNAVINST 5400.24 (series); Fleet Commanders in Chief (CINC) are charged to establish oil and hazardous substance (OHS) spill pollution contingency planning and response policies in their operating areas. Below the Fleet CINC/Area Coordinator level, both organizations consist of a hierarchy of Navy On-Scene Coordinators (NOSC), Navy On-Scene Commanders (NOSCDR) and supporting activities. NEESA Publication 7-021 (Series), Oil and Hazardous Substance Spill Response Activity Information Directory, commonly referred to as the AID manual, lists the Area Coordinators, NOSCs and NOSCDRs and their addresses for both fleet and shoreside organizations. Addresses for Area Coordinators and fleet and shoreside NOSCs are given in **Appendix B**.

1-5.1 Navy Shoreside Spill Response Organization. There are seven Navy Area Coordinators:

- Commander in Chief, Pacific Fleet (CINCPACFLT)
- Commander in Chief, Atlantic Fleet (CINCLANTFLT)
- Commander in Chief, U.S. Naval Forces Europe (CINCUSNAVEUR)
- Chief of Naval Education and Training (CNET)

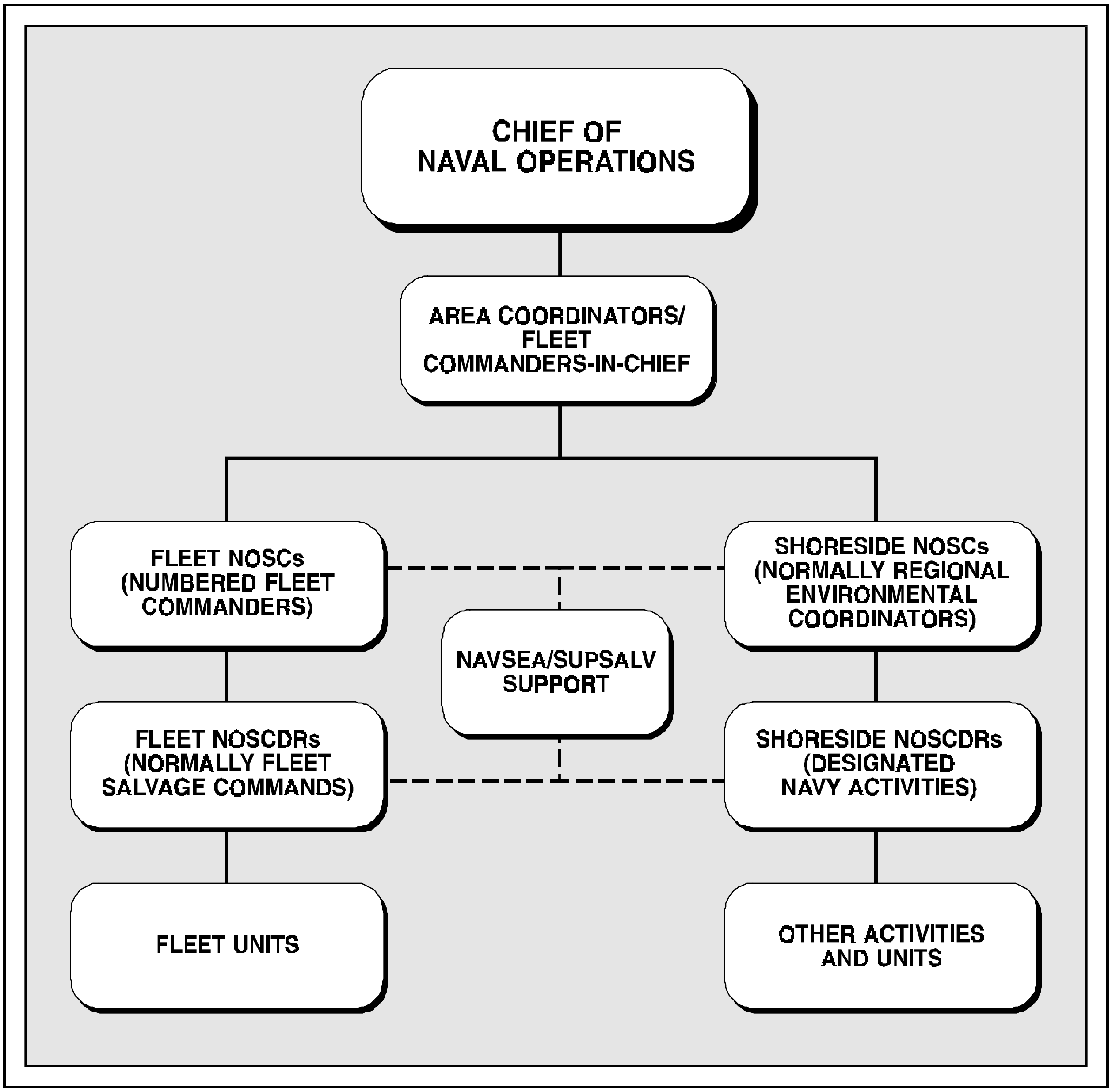


Figure 1-3. U.S. Navy Oil Pollution Response Organization.

- Commander, U.S. Naval Forces Central Command (COMUSNAVCENT)
- Commander, Naval Reserve Forces (COMNAVRESFOR)
- Commandant, Naval District Washington D.C. (NAVDISTWASH)

Navy Area Coordinators:

- Subdivide coordination areas into regions and predesignate shoreside NOSCs to plan and direct responses to oil spills from Navy ship and shore activities within each region.

- Develop and update areawide oil spill contingency planning instructions that specify NOSC and NOSCDR responsibilities.

- Coordinate, with the assistance of the Supervisor of Salvage, development, revision and update of area-wide oil and hazardous substance (OHS) spill contingency planning instructions and individual NOSC plans.

NOSCs, in turn, designate Navy On-Scene Commanders (NOSCDRs). This designation is based upon known or potential spill risk and the existence of prestaged response assets or the ability to rapidly obtain such assets. NOSCDRs are at the bottom of the shoreside oil spill response organization and typically own the front line forces—the On-Scene Operational Teams (OSOTs) and prestaged equipment utilized for response to minor Navy oil spills.

Regional and state environmental coordinators are assigned by area coordinators to coordinate environmental matters and public affairs in local regions and individual states. The regional coordinator is the senior naval officer in the local region and may be the designated NOSC. State coordinators are designated on the basis of which command can most effectively attend to Navy interests in the state and will normally be located within easy access of the state capital. In most cases, regional coordinators will also serve as state coordinator for the states in which they are located.

1-5.1.1 Navy On-Scene Coordinator (NOSC). NOSCs are either shoreside or afloat-based commands assigned to coordinate NOSCDRS in their areas. The coordination effort must ensure there are enough personnel and resources to clean up an oil spill and must interface with federal, state, local, commercial and volunteer response and support organizations. Shoreside NOSCs are generally designated to parallel existing regional environmental coordination authorities as designated under the NCP. Typically, the NOSC is a Naval Base Commander, Naval Force Commander or Naval Training Center Commander. For hazardous substance (HS) spills from DOD facilities or ships, DOD provides the predesignated FOSC; the NOSC is therefore the FOSC for HS spills from Navy ships or facilities. The predesignated Coast Guard or EPA Regional FOSC may assume control of the response if the Navy response is inappropriate or inadequate. For oil spills from DOD facilities or ships, DOD assumes responsibility for minimizing damage and cleaning up spilled oil, while the Coast Guard or EPA assumes the broader roles of the FOSC. Typically, the Coast Guard or EPA FOSC will monitor DOD response efforts and advise the DOD (Navy) On-Scene Coordinator. If the DOD (Navy) response is inadequate or inappropriate, the FOSC will assume direct control of the response.

The NOSC activates an Area Response Center (ARC) after a spill occurs. This center is a clearing house for all spill information, requests and inquiries to and from outside parties. Personnel man the center and monitor and direct response actions for the duration of the operation.

Specifically, shoreside NOSCs are responsible for:

- Directing all major Navy response efforts for Navy oil spills within assigned shoreside boundaries, including coastal areas extending out to 12 miles.

- Serving as the Federal On-Scene Coordinator (FOSC) under the NCP for Navy hazardous substance releases within assigned geographic boundaries.

- Predesignating shoreside NOSCDRs and preassigning geographic areas of responsibility.

- Coordinating response operations with adjacent NOSCs, including fleet NOSCs, for Navy oil spills that may impact more than one NOSC region.

- Developing, in the general format prescribed by COMNAVSEASYSCOM (Supervisor of Salvage) and consistent with the area coordinator's instructions, areawide NOSC oil spill contingency plans and coordinating the development of the plans with the overlapping regional federal OSC plans, as prescribed in the NCP.

- Coordinating response operations with the DOD representative to the RRT.

- Coordinating shoreside NOSC plans with fleet planning and operations and ensuring that Navy SOPA instructions contain fleet oil spill response guidance that is consistent with the shoreside NOSC plans.

- Ensuring that all federal, state and local oil spill notification procedures are followed.

Foreign shoreside NOSCs develop and coordinate contingency plans with host governments. Fleet NOSC responsibilities are outlined in **Paragraph 1-5.2**.

1-5.1.2 Navy On-Scene Commanders (NOSCDR). NOSCDRs are Navy commanders assigned to stop, contain and clean up oil spills in their designated areas. Typically, NOSCDRs are commanding officers of shore stations. The NOSCDR must set up an Activity Spill Response Center (ASRC) with a constantly manned telephone to receive incident reports. The ASRC, activated at the beginning of an oil spill, directs the spill response until the end.

The NOSCDRs are responsible for:

- Overseeing response efforts for Navy oil releases within preassigned NOSCDR areas until relieved by the NOSC and supporting the NOSC for Navy response in areas outside of NOSCDR boundaries.

- Developing, reviewing annually and updating periodically subregional or local NOSCDR plans in a format prescribed by COMNAVFACENGCOM and consistent with policy direction and guidance provided by the NOSC.

- Coordinating NOSCDR plans with appropriate state and local environmental and emergency planning authorities.

- Making all required federal, state and local notifications for Navy oil spills and making Navy chain of command notifications up to the NOSC level.

The NOSC may assume direct control of response activities when an oil spill exceeds the response capability of a NOSCDR, affects areas beyond Navy property, is catastrophic or for any other reason. This may be done, for example, to harmonize response operations between two adjacent NOSCDRs.

1-5.1.3 On-Scene Operations Team (OSOT). The OSOT is the NOSCDR's team of trained personnel who make the initial response to an oil spill. Their goal is to control and contain the spill. Personnel from the waterfront near potential spill areas typically make up the team. The second major effort of the OSOT is to remove oil and clean up after the spill. Environmental restoration started by the OSOT usually requires personnel and equipment from and coordination with other agencies, particularly the EPA Remedial Program Manager. The NOSCDR or NOSC support staff provides safety, health, security, public affairs and legal personnel services to the OSOT. As an alternative to forming OSOTs from military personnel or DOD employees, NOSCDRs may make arrangements to access commercial response personnel, including in-place contracts, arrangements to utilize Coast Guard or EPA Basic Ordering Agreements or other mechanisms. In some instances, naval installations may participate in oil spill response cooperatives. Spill response cooperatives are defined in **Paragraph 3-3.5**.

1-5.2 Navy Fleet (Offshore) Spill Response Organization. In additions to their responsibilities as shoreside area coordinators, CINCPACFLT and CINCLANTFLT are charged with establishing oil and hazardous spill contingency plans and response policies within their ocean operating areas. Numbered fleet commanders function as fleet NOSCs under the Fleet CINCs. Fleet NOSCs have responsibilities generally similar to those of shoreside NOSCs with several important differences:

- In waters outside U.S. jurisdiction, the NOSC does not function as the FOSC and no coordination with the NRT or RRT is required.
- Fleet NOSCs must coordinate responses with shoreside NOSCs and RRTs when a spill occurs within or threatens U.S. coastal waters (12-nautical mile zone).
- Fleet NOSCs must ensure required foreign government notifications are made and coordinate responses with foreign government response organizations when a spill occurs within or threatens foreign territorial waters.

Fleet NOSCs designate at least one fleet NOSCDR to provide operational assistance for large or complex fleet-originated oil spills. The fleet NOSCDRs are normally fleet salvage unit commanders. Fleet NOSCDRs oversee response efforts for Navy OHS spills within preassigned areas and support the fleet NOSC for Navy response in other areas.

Navy ships are required to have personnel prepared to initiate immediate actions to mitigate effects of a spill. COMNAVSEASYSCOM has developed a shipboard oil spill cleanup and containment kit to provide a quick "first aid" response. The cognizant fleet or shoreside NOSCDR will mobilize appropriate response assets and direct response actions for spills beyond the ship's limited capability.

1-5.3 Naval Sea Systems Command. The Chief of Naval Operations has assigned NAVSEA-SYSCOM, specifically the Supervisor of Salvage, to assist with the development and update of area coordinator and NOSC contingency plans. Specific responsibilities include:

- Assist area coordinators in the development of area-wide contingency plans, including identification of appropriate NOSC commands.
- Assist NOSCs in the development of NOSC contingency plans, including identification of appropriate NOSCDRs and NOSCDR response boundaries.
- Assist NOSCs in major spill response issues as they arise and in decision making for offshore or salvage-related response operations.

The Supervisor of Salvage is responsible for maintaining and operating oil pollution equipment for offshore and salvage-related oil spills. To meet this task, the Supervisor of Salvage has included oil spill response equipment in the Emergency Ship Salvage Material System (ESSM). Because major oil spills often result from ship casualties, oil spill response equipment is specialized salvage equipment as stated in 40 *CFR* 300.175. Rapid mobilization of the equipment from existing ESSM bases allows the Supervisor of Salvage to augment NOSCs at any location. This equipment is a national asset and has served frequently in Navy, federal, state and commercial oil spill responses. EPA and USCG Federal On-Scene Coordinators (FOSCs) have partially federalized oil spills solely for the purpose of augmenting resources with Supervisor of Salvage equipment and operators. Appendix C lists the oil pollution assets available through the Supervisor of Salvage and describes the procedures for requesting the equipment. The Navy and Coast Guard have an Interagency Agreement (IAA) in place that authorizes mutual support during an oil response operation and through which SUPSALV equipment and operators are usually provided to the USCG-designated FOSC. The IAA is reproduced as **Appendix D**.

1-5.4 Naval Facilities Engineering Command (NAVFACENGCOM). NAVFACENGCOM is responsible for writing local contingency plan guidance, purchasing NOSCDR oil spill equipment, providing technical expertise and compiling a Navy oil spill resources directory. Specific responsibilities include:

- Assisting shoreside NOSCDRs and other Navy activities in developing and updating local contingency plans.
- Determining requirements for budgeting for and procuring equipment for harbor and inland water oil spill control for use by shoreside NOSCDRs.
- With COMNAVSEASYSCOM, assisting major commands and area coordinators in the determination of training requirements and the development of associated training curriculums.
- Sponsoring oil spill response and contingency planning training courses for shoreside NOSCs and NOSCDRs.

- Providing specialized environmental engineering and information management.

1-5.5 Naval Environmental Protection Support Service (NEPSS). The NEPSS consists of special offices in various commands tasked to provide environmental engineering, research, legal assistance, data management and information exchange services to Navy and Marine Corps activities. NEPSS addresses all forms of pollution; its organization includes the following activities with oil pollution prevention and spill response support responsibilities:

- COMNAVFACENGCOM as the NEPSS manager.

- Naval Engineering Field Divisions (EFDs) that provide field level expertise in environmental engineering and legal support.

- Naval Energy and Environmental Support Activity (NEESA), Port Hueneme, California that maintains an activity information directory (AID), coordinates NEPSS actions and manages NEPSS specialty offices.

- Specialty offices and Navy laboratories, including:

    (1) The Marine Environmental Support Office (MESO) at the Naval Ocean Systems Center (NOSC), San Diego, California provides Navy-wide support relative to aquatic environmental protection.

    (2) The Naval Civil Engineering Laboratory (NCEL), Port Hueneme, California conducts environmental protection research and development with regard to shore facilities.

1-5.6 Salvor-NOSC Coordination. Salvors must notify the U.S. Navy command having NOSC responsibility when performing work that could result in an oil spill to which the NOSC would be required to respond. Such notification should be made as early as possible so the NOSC can ensure personnel and equipment are available should a response be necessary. Potential spills must also be reported by telephone to the National Response Center.

Likewise, the NOSC should request technical assistance from NAVSEA/SUPSALV whenever such assistance is needed to augment NOSC resources. Communications between the SUPSALV and NOSC organizations are most effective when they are initiated early during a response. Early notification by telephone should be encouraged wherever practical, with more formal means of communication used when time is less critical.

CHAPTER 2

OIL CHARACTERISTICS AND BEHAVIOR

2-1 INTRODUCTION

The behavior, spread and impact of oil on the water depends on the quantity of oil, the marine environment, prevailing weather and most importantly, the physical and chemical properties of the substance. Response actions must be tailored to the conditions of the spill. The type of oil and its characteristics must be identified as the first step of a timely and adequate spill response.

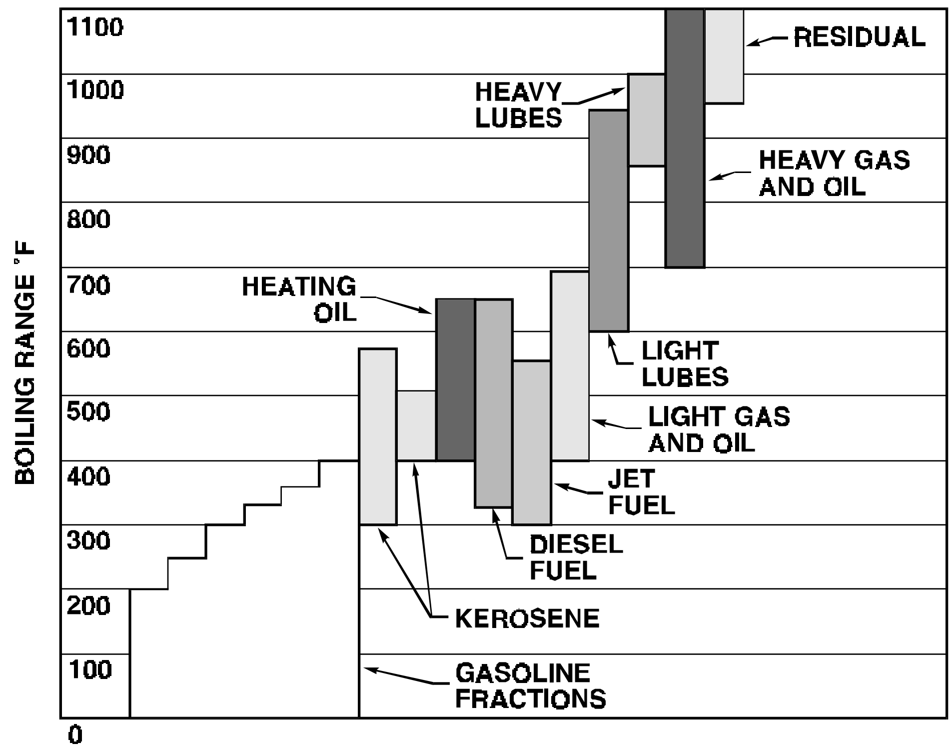
2-2 CHEMICAL AND PHYSICAL CHARACTERISTICS OF OIL

The term oil includes crude petroleum and refined petroleum products, as well as nonpetroleum oils (animal and vegetable oils). Both chemical and physical properties are important in assessing spill impact and developing appropriate response tactics. The chemical properties of concern are boiling point range, solubility in water, aromatic content and the presence of dissolved nonhydrocarbon compounds. The physical properties of greatest concern are density, viscosity, pour point, flash point and surface tension. The importance of each of these properties is discussed in the following paragraphs. **Appendix F** gives pertinent properties of petroleum and nonpetroleum oils.

Petroleum products are refined in a distillation process (boiling and vapor recovery) that separates fractions from the crude oil stock. The fractions or ends, with the lowest boiling points boil off and distill early in the refining process and are called light ends because of their characteristically low density. The fractions with higher boiling points, that distill later, are called heavy ends. Those that remain after all the lighter ends have been boiled off are called residuals. Like crude oil, refined products are not simple compounds, but mixtures of hydrocarbon compounds that boil (and distill) within a given temperature range. **Figure 2-1** shows a typical fraction separation.

2-2.1 Physical Characteristics. As hydrocarbon mixtures, the physical properties of oil are a composite of the physical properties of the various constituent compounds. If the relative proportions of the constituent compounds change, through evaporation, dissolution or other processes, the composite properties will also change. Several physical properties that affect behavior of spilled oil on both land and water are viscosity, pour point, density or specific gravity, surface tension, flash point and emulsibility.

2-2.1.1 Density and Specific Gravity. Density is the mass per unit volume and is expressed as pounds per cubic foot, grams per cubic centimeter or similar units. Density is expressed alternatively as specific gravity, the ratio of the density of a material to the density of fresh water at a certain temperature-usually 60°F. The specific gravity of water (at 60°F) is therefore 1.0. Most oils have a specific gravity of less than 1.0, which means that the material is lighter than and floats on fresh water. However, some oils have a specific gravity greater than 1.0 and will sink in fresh water. The specific gravity of saltwater is 1.025. A few oils have specific gravities greater than 1.025 and will sink in saltwater. The density of crude oils and petroleum products is also



THIS ILLUSTRATION IS FROM RESPONSE TO MARINE OIL SPILLS, 1987 (PUBLISHED BY WITHERBY & CO., LONDON, ISBN 0 948691) AND IS REPRODUCED WITH THE KIND PERMISSION OF THE AUTHORS, THE INTERNATIONAL TANKER OWNERS POLLUTION FEDERATION, LTD.

Figure 2-1. Typical Petroleum Distillation Fractions.

expressed as American Petroleum Institute (API) gravities or degrees API. API gravities are based on the arbitrary assignment of a gravity of 10 degrees to fresh water. Liquids with higher gravities are lighter than water; those with lower API gravities are heavier than water. API gravities are calculated by:

Oils having low density (high API gravity) generally have low viscosities and contain a high proportion of volatile compounds. Conversions between specific gravity, API gravity and density are given in **Chapter 1** and **Appendix B** of the ***U.S. Navy Ship Salvage Manual, Volume 5***, S0300-A6-MAN-050.

2-2.1.2 Viscosity. Viscosity is a measure of the resistance to flow or the internal friction of the product. Kinematic viscosity is expressed in centistokes (cSt) and varies with temperature for most liquids. The viscosity of water at 68°F is approximately 1.00 cSt. Viscosity may also be tabulated in other units:

- Absolute or dynamic viscosity is given in units of Poise. Absolute viscosity is kinematic viscosity multiplied by density.

- Viscosity is sometimes expressed as the number of seconds required for a specified quantity of oil to flow through an orifice of specified size. More viscous oils flow more slowly and have higher values. There are several viscosity scales based on this concept, including the Saybolt Second Universal (SSU) and Saybolt Second Furol (SSF) scales used in the U.S. and the Redwood and Redwood Admiralty scales used in the United Kingdom. The scales differ in quantity of oil and orifice used to determine viscosity.

The less viscous a material, the more readily it flows and spreads. Spills of low-viscosity oils necessitate rapid response to minimize spill migration.

2-2.1.3 Pour Point. Pour point, related to viscosity, is the lowest temperature at which an oil flows. As the pour point is approached, spill spread decreases. Consequently, oils spread more rapidly in warm weather than in cold. Pour point can vary widely; some crude and residual oils may have pour points as high as 80°F, while the pour point of light diesel fuel is -60°F. The physical state of spilled oil influences containment and recovery methods. Both air and water temperatures affect oil state. Some oils may be solid or semisolid during cool nights and liquid during the day or solid when in contact with cool water and liquid when stranded on shore.

2-2.1.4 Surface Tension. Surface tension is the attraction of a liquid for its own molecules. When oil is on water, the oil's surface tension holds the oil molecules together and discourages spreading, while the water's surface tension works to pull the water molecules together, allowing the oil to spread. Petroleum products with low surface tension spread readily over the water surface. Effective cleanup of spilled oil with low surface tension requires rapid response.

2-2.1.5 Flash Point. Flash point is the lowest temperature at which a substance ignites under standard conditions. A highly volatile oil with a low flash point is a serious safety hazard that greatly complicates response.

2-2.1.6 Emulsibility. Emulsibility is the tendency of spilled oil to form a stable suspension with water. High emulsibility will cause oil to spread throughout the water column, increasing the threat to the environment. This characteristic can force changes in cleanup priorities or methods.

2-2.2 Chemical Properties. The chemical and physical properties of an oil are closely related, as both are determined by the molecules that make up the oil.

2-2.2.1 Boiling Point Range. Boiling point range indicates the relative volatility of an oil. Volatility is the tendency of a liquid to evaporate and is related to boiling point; the lower the boiling point, the more volatile the liquid. Light (low-density) oils usually have lower boiling point ranges and are more volatile than heavy oils. Evaporation of highly volatile oils, such as JP-4 and gasoline, facilitates cleanup but may create an explosion hazard, especially in confined spaces. As the more volatile fractions of an oil evaporate, the remaining oil becomes denser and more viscous.

When accounting for spilled oil, the portion that has evaporated must be included. Light, low boiling point range oils, such as gasoline or JP-4, may evaporate completely in a few days. Significant portions of spills of heavier oils, including fractions with boiling points above ambient, may be lost to evaporation. Spilled Kuwait crude from the *TORREY CANYON* soon lost most of its fractions with boiling point less than 570°F and it is estimated that as much as one-third of the total spill volume was lost through evaporation. Because they have a very high, but relatively narrow boiling-point range, spilled residual fuels loose only a fraction of their volume to evaporation.

Boiling point range is a function of the homogeneity of an oil. Crude oils generally have broad boiling point ranges, while refined products have narrow boiling point ranges.

2-2.2.2 Relative Solubility. Relative solubility is a measure of an oil's ability to dissolve in water. The lightest petroleum fractions are slightly soluble in seawater; heavy compounds are virtually insoluble in seawater. Solubilities of the hydrocarbon compounds found in petroleum are shown in **Table 2-1**. Although the solubility of oil in water is low, many additives are both soluble in water and toxic. Small quantities of soluble oils can cause greater environmental impact than large spills of less soluble oil.

2-2.2.3 Aromatic Content. Aromatic content is important in assessing spill impact because aromatic hydrocarbons are both more toxic and generally more soluble than other hydrocarbons. Depending on ambient temperature, the toxicity and solubility of aromatic compounds may be tempered by their high evaporation rate. Because of their stable form, aromatics resist natural degradation more than paraffins or naphthenes.

2-2.3 Crude Oil. Crude oils are not simple compounds, but complex mixtures of hydrocarbon compounds. Most crude oils are amber-yellow to brownish-green or black, viscous liquids, with specific gravities ranging from 0.80 to 0.99, although some crude petroleum fractions have specific gravities greater than 1.0. Crude oil may also contain dissolved gases, solids, water and suspended solids. Hydrocarbon compounds typically account for more than 95 percent of a crude oil's composition. The molecular weight of the hydrocarbons ranges from 16 to more than 850. The principal hydrocarbon components of petroleum fall into three groups:

- *Paraffins* - saturated straight chain hydrocarbons.
- *Naphthenes* - saturated ring hydrocarbons.
- *Aromatics* - highly stable ring hydrocarbons.

Crude oils typically contain dissolved sulfur, nitrogen, oxygen and natural gas in varying proportions. Phosphorous, nickel, vanadium, cadmium or other metals may be present.

As mixtures of hydrocarbon and other compounds, the properties of oil are a composite of the properties of the constituent compounds and vary with composition. Composition and properties of crude oil or petroleum, vary widely with location of origin (producing field) and even between wells within the same field, particularly between wells producing oil from different depths.

Crude oils have been traditionally classified as paraffin base, asphalt base or mixed base. The concept of the base of an oil arises from the facts that the residual fractions of a crude oil might be waxy or asphaltic or both and that the character of the residual fractions can be correlated to the nature of the lighter fractions. For example, lubricating oils distilled from a paraffin base crude are usually less dense, have a higher boiling point range and are more likely to contain solid paraffin in solution than the corresponding products derived from an asphalt base crude. The classification system has been modified to include naphthene or hybrid base crudes that contain little asphalt and significant quantities of high molecular weight waxes that differ from conventional paraffin wax. This classification system was established primarily as a guide to the commercial applicability and value of crude oil stocks and is an imperfect measure of the overall characteristics of the oil. It does, however, provide some indication of the expected range of physical characteristics.

Table 2-1. Characteristics of Some Hydrocarbons Found in Crude Oil.

COMPOUND	CARBON NUMBER	BOILING POINT (°F)	SPECIFIC GRAVITY	SOLUBILITY IN WATER
Paraffins				
Methane	1	-258.70	0.424	90 ml/l (68.0 °F)
Ethane	2	-127.30	0.546	47 m/l (28.0 °F) (gases)
Propane	3	-43.96	0.542	65 m/l (64.4 °F)
Butane	4	31.10	0.579	65 m/l (64.4 °F)
Pentane	5	97.16	0.626	360 ppm (62.6 °F)
Hexane	6	156.20	0.660	138 ppm (59.9 °F)
Heptane	7	209.30	0.684	52 ppm (59.9 °F)
Octane	8	258.26	0.703	15 ppm (59.9 °F)
Nonane	9	303.44	0.718	about 10 ppm
Decane	10	345.38	0.730	about 3 ppm
Undecane	11	384.62	0.741	
Dodecane	12	421.34	0.766	
Tridecane	13	456.08	0.756	
Tetradecane	14	488.48	0.763	
Pentadecane	15	519.26	0.769	
Hexadecane (Cetane)	16	548.78	0.773	
Heptadecane	17	576.68	0.778	
Naphthenes				
Cyclopropane	3	-27.40		"Slight"
Cyclobutane	4	55.40		
Cyclopentane	5	120.74	0.751	
Methyulecyclopentane	6	161.24	0.749	
Cyclohexane	6	177.26	0.779	
Methylcyclohexane	7	213.62	0.769	

Table 2-1. Characteristics of Some Hydrocarbons Found in Crude Oil.

COMPOUND	CARBON NUMBER	BOILING POINT (°F)	SPECIFIC GRAVITY	SOLUBILITY IN WATER
Ethycyclopentane	7	218.30	0.763	
Ethylcyclohexane	8	269.24	0.788	
Trimethycyclohexane	9	286.16	0.777	
Aromatics				
Benzene	6	176.18	0.879	820 ppm (71.6°F)
Toluene	7	231.08	0.866	470 ppm (60.8°F)
Ethylbenzene	8	277.16	0.867	140 ppm (59.0°F)
p-Xylene	8	281.12	0.861	
m-Xylene	8	282.38	0.864	about 80 ppm
O-Xylene	8	291.92	0.874	
iso-Propylbenene (Cumene)	9	306.32	0.864	
n-Propylbenzene	9	318.56	0.862	60 ppm (59.0°F)
Napththalene	10	424.22	1.145	about 20 ppm
2-Methylnaphthalene	11	465.98	1.029	
1-Methylnaphthalene	11	472.64	1.029	
Dimethylnaphthalene	12	503.60	1.016	
Trimethylnaphthalene	13	545.00	1.01	
Anthracene	14	669.20	1.25	
Source: Nelson-Smith, 1973				

The primary oil producing areas of the world are certain areas of North America, northern South America, North Africa and the Middle East, the Caspian Sea region, the North Sea and to lesser degrees, continental Europe and the Malayan region. Because the U.S. is a net importer of oil, ship casualties, terminal accidents or pipeline ruptures in U.S. waters can spill oil from almost anywhere in the world.

It is customary to characterize crude oils by their area of production and producing fields by the oil they yield. These characterizations are roughly accurate so long as oil is produced from formations of the same depth and geologic age. Wells producing from different depths may yield very different crudes even though they are not widely separated. No firm rule can be stated, but it is approximately true that geologically younger crudes-usually those produced from shallower formations-are higher in sulfur, oxygen and nitrogen content, are more likely to be asphaltic and are more likely to oxidize when exposed to the air. Crude oils from deep, presumably older formations are more likely to be paraffinic. Crude oils lying in the presence of hydrocarbon gases in deep formations may be essentially colorless and much less dense than the normal darkly pigmented crude oils. **Appendix F** describes the general characteristics of crude oils from various producing regions.

2-2.4 Petroleum Distillates. Petroleum distillates consist of lighter petroleum fractions and include substances such as gasoline, kerosene, jet fuel, diesel fuels and some fuel oils. Some petroleum distillates contain additives, such as the lead and phosphorous compounds in gasoline. Because of their low boiling point range, petroleum distillates evaporate rapidly and are less viscous than residual oils and most crude oils. Petroleum distillates are sometimes divided into light and heavy distillates. Light distillates, such as gasoline, kerosene, jet fuels and light diesel fuels, have boiling points lower than 350° F and specific gravity generally less than 0.81. Heavy distillates, such as fuel oils and heavy diesel fuels, have boiling points greater than 350°F and specific gravity greater than 0.81.

2-2.5 Lubricating Oils. Lubricating oils are separated from crude oil by the distillation process, but tend to be relatively involatile. Spilled lubricating oils can be expected to remain on the sea surface. Lubricating oil spills may consist of clean oil from ruptured tanks or shipping containers or waste oil, i.e., oil that has been used to lubricate machinery. Waste oil will contain considerable quantities of suspended solids, including metals and oxidized material. Spills of waste oil result from ship damage that penetrates machinery space bilges or waste oil tanks or from unauthorized discharges.

2-2.6 Residual Fuels. Residual fuels or black oils, are distillation residues or blends of residue with distillates. Residual oils are used as fuel for ships, power plants and heating systems and are shipped and stored in bulk. They are generally very viscous with specific gravity approaching or sometimes exceeding that of seawater. When spilled, residual oils behave like weathered crude oil.

2-2.7 Nonpetroleum Oils. Most oil carried by sea is petroleum or petroleum-derived, but significant quantities of animal and vegetable oil are carried in bulk. The nonpetroleum oils carried by tankers in bulk are shown in **Table 2-2**.

Table 2-2. Nonpetroleum Oils Shipped in Bulk.

Animal Oil	Coumarone Oil	Mustard Seed Oil	Safflower Seed Oil	Vegetable Oil
Caarnation Oil	Fish Oil	Olive Oil	Soybean Oil	Whale Oil
Coconut Oil	Groundnut Oil	Palm Oil	Sperm Oil	Corn Oil
Linseed Oil	Pine Oil	Sunflower Seed Oil	Cottonseed Oil	Menhaden Oil
Rapeseed Oil	Tung Oil			

2-3 FATE OF OIL

Natural seeps constantly release small amounts of oil at steady rates into the marine environment. The oceans assimilate this oil through natural processes. These seeps affect the ocean very differently from accidental and unauthorized releases of large quantities of oil that occur in a relatively short period and overwhelm the natural ability of the oceans to assimilate oil.

Spilled oil is acted upon by natural processes that occur more or less simultaneously, although the processes proceed at very different rates. These processes lead to the removal of oil from the water surface and its eventual accommodation by the environment. The main processes acting on spilled oil are:

- Spreading
- Evaporation
- Dispersion
- Dissolution
- Emulsification
- Oxidation
- Microbial degradation
- Sinking
- Resurfacing

Nearly all the processes cause chemical or physical changes in the oil. The natural processes and resulting changes in the oil characteristics are collectively called weathering. Many of the changes from weathering help response efforts. Weathering of oil on water is much more complex than weathering of oil on land because of the dynamics of water movement and exposure to the elements. The specific processes that contribute to weathering of spilled oil are described in the following paragraphs. **Figure 2-2** is a graphical representation of the weathering processes. **Figure 2-3** shows the relative impact and time span of these natural processes.

Oils may be categorized as either persistent or nonpersistent. Persistent oils remain on the sea surface following a spill and require response activity for removal. Nonpersistent oils tend to dissipate without assistance, requiring less human intervention following such a spill. Crude oils and refined residual oils are persistent oils. Nonpersistent oils include gasoline; naphtha; kerosene; Diesel Fuel, Marine (DFM); and other diesel fuels. Nonpersistent oils are typically more toxic to marine life than persistent oils and safety concerns regarding vapors given off from nonpersistent oils may limit offensive response measures.

2-3.1 Spreading. The initial and very visible process of spreading of spilled oil can last as long as 10 days for a very large spill. Spreading thins the oil slick to a few millimeters or less. Rate of spreading depends upon the volume of oil spilled, the duration of the spill and physical characteristics of the spilled oil, particularly pour point, viscosity and surface tension.

Low-viscosity oils spread more rapidly than high-viscosity oils. Spilled oils at temperatures below their pour point spread very little.

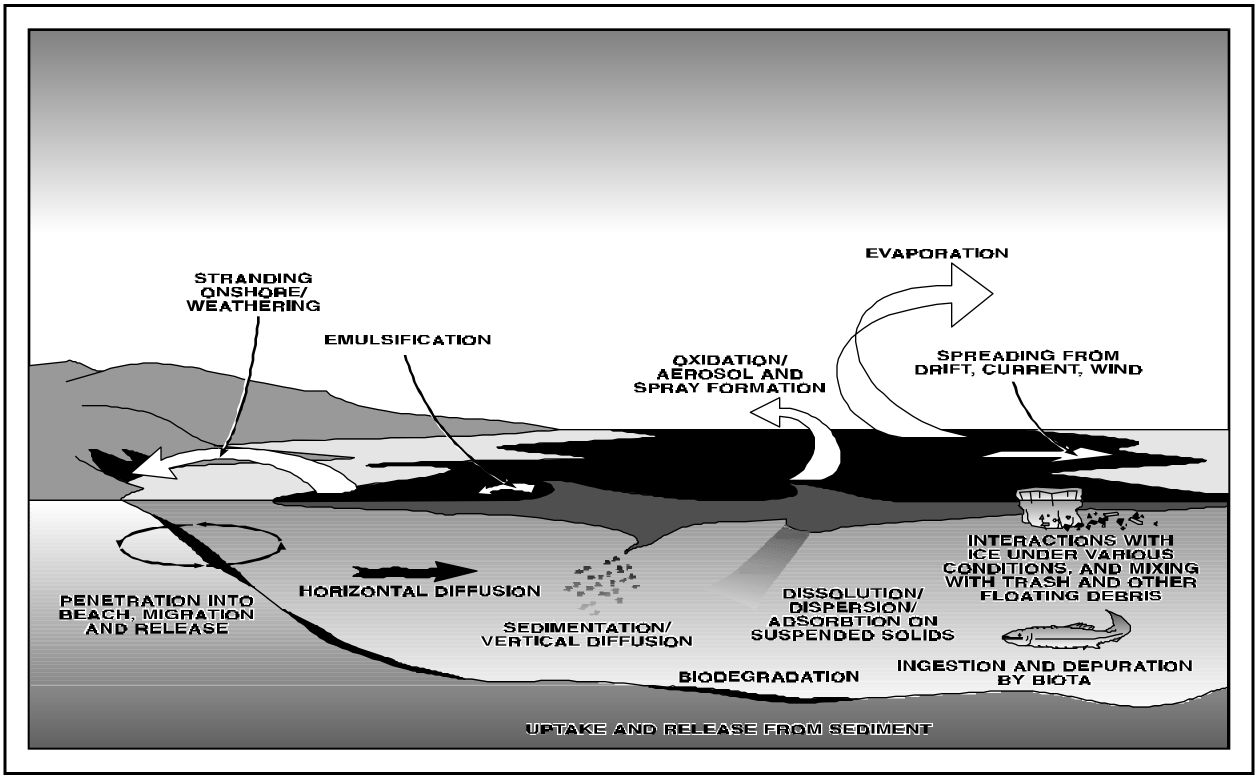


Figure 2-2. Various Processes Taking Place After an Oil Spill.

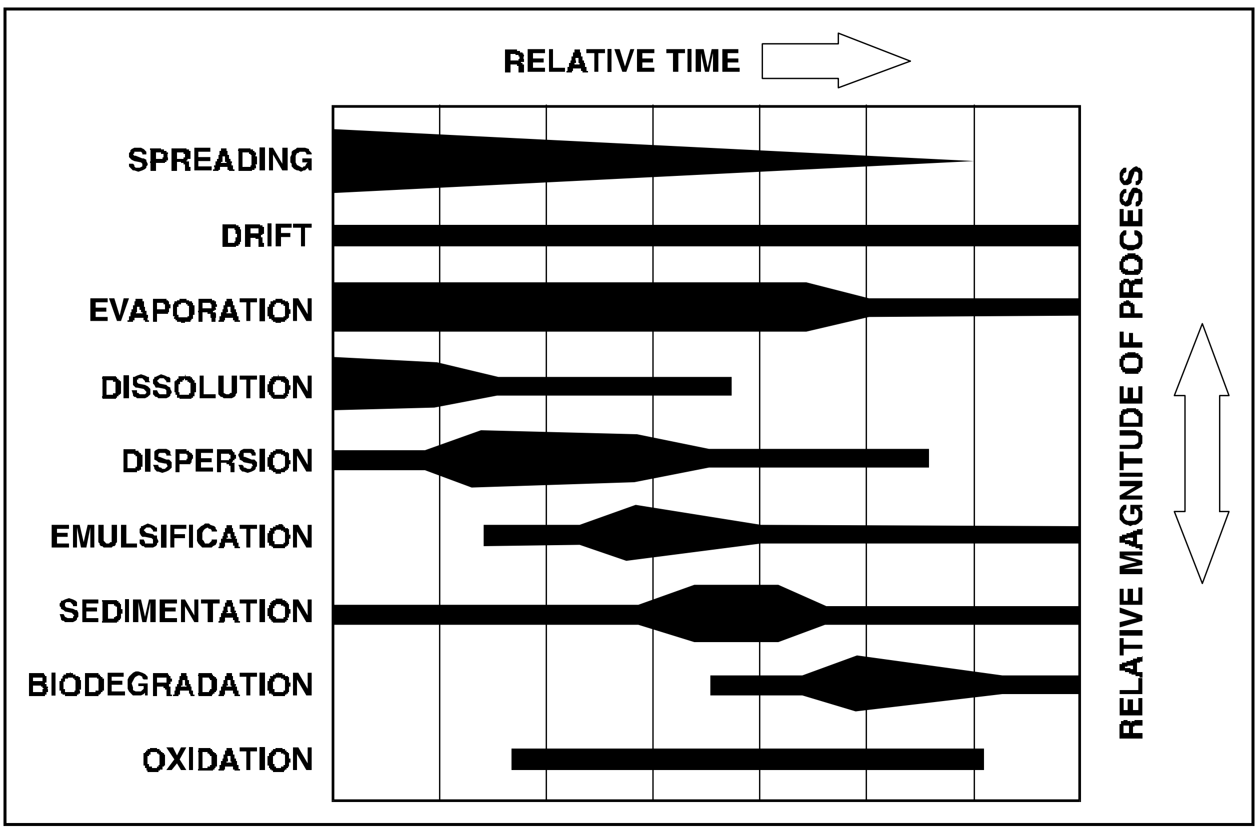


Figure 2-3. Time Span and Relative Importance of Processing Acting on an Oil Spill.

Spilled oil begins to form windrows a few hours after spilling. Windrows are narrow bands or rows of oil that form parallel to the wind direction from the trailing edge of spilled oil. Spreading at this point is influenced by turbulence and other hydrographic conditions, including currents, tidal action and wind velocity. Skimming operations should take advantage of windrows in order to engage the most oil on each sweep.

2-3.1.1 Evaporation. Evaporation removes more oil from a spill than any other natural process. The rate of evaporation is primarily determined by the volatility of the various components of the oil. High volatility is usually associated with low boiling point and low molecular weight. Evaporation rate is influenced by air and water temperatures, sea state, wind, relative humidity and rate of spreading. Evaporation proceeds at a greater rate from a thinly spread oil layers slick in hot, dry, windy conditions than from thick oil layers in cool, calm, humid conditions.

Light oils, such as diesel or jet fuel evaporate quickly, loosing as much as 50 percent of the spill volume in only a few hours. Crude oils may loose significant portions of spill volume to evaporation, depending on the percentage of light fractions. In one test, the bulk of a controlled spill of 120 tons of an Iranian light crude in the North Atlantic had disappeared in four days, mainly by evaporation. Residual fuel oils and lubricating oils, containing few light ends, evaporate very slowly.

Evaporation alters the physical characteristics of the remaining oil. The mix of less volatile components of oil remaining will have higher density, viscosity, pour/flash point, carbon residue and wax content and in the case of crude oil and residual fuels, higher asphaltene and metals content than the original oil. The rate of evaporation decreases with time as the percentage of light ends in the residue steadily decreases.

The composite physical characteristics will change as the light ends evaporate. Heavy, dense residue remains when all the light fractions have evaporated from spilled oil.

2-3.1.2 Dispersion. Oils disperse in water as small droplets that diffuse within the upper layers of the seas. The droplets may remain suspended in the water or rise to the surface, depending upon the sea state and difference between the densities of the oil and water. Natural dispersion of oil occurs more quickly in moderate to rough seas than it does during calm weather. Very small droplets of dispersed oil tend to remain mixed in the water column. Larger droplets, particularly of light oils, tend to rise to the surface. The large collective surface area of the dispersed oil droplets enhances oxidation, dissolution and biodegradation. Most small oil slicks disappear within a few hours as a result of natural dispersion when accompanied by breaking waves. Natural dispersion and evaporation are the primary environmental factors affecting the persistence of an oil slick on the open sea.

2-3.1.3 Dissolution. Although most hydrocarbons are relatively insoluble in water, some low molecular weight and polar compounds will dissolve in seawater. The rate and degree of dissolution depends on relative solubility, viscosity, slick thickness, water temperature, amount of oxidation the oil has undergone, turbulence and dispersion. More compounds dissolve in warm turbulent water than in cold calm water. However, concentrations of dissolved hydrocarbons in seawater rarely exceed one part per million because of the low solubility of most petroleum fractions. Because light compounds are more likely to evaporate than dissolve in water, very little of the total spill volume is lost to dissolution. Dissolution starts immediately and continues as long as oil is in the water because oxidation and microbial action constantly produce water-soluble polar compounds.

2-3.1.4 Emulsification. Emulsification is the process by which one liquid is dispersed into another immiscible liquid in droplets of optically measurable size. Light and medium crude oils (those having asphaltene contents greater than 0.5 percent) absorb water to form stable water-in-oil emulsions. Because of their typical dark color and foamy texture, water-in-oil emulsions are called chocolate mousse or simply mousse.

The rate at which emulsions form is a function of oil viscosity and sea state. Emulsions of low-viscosity oils, such as diesel oils and JP-5, form very easily and may occur in just two or three hours during winds above Beaufort Force 3, absorbing 60 to 80 percent water, by volume in the process. More viscous oils, under the same conditions, may absorb only 10 percent water, by volume, in 10 hours. Emulsions seldom occur in calm water. The stability of emulsions varies directly with the amount of asphaltenes contained in the oil. Some emulsions separate when heated by sunlight during calm weather or when stranded on shorelines. Water-in-oil emulsions break down readily in hot climates and persist for long periods of time in cold environments. Color varies from black for low water content, large-droplet emulsions through brown and reddish brown to orange for high water content, small-droplet emulsions.

2-3.1.5 Oxidation. Hydrocarbon molecules react with oxygen to water-soluble (polar) compounds and persistent tars. The polar compounds-keytones, alcohols, aldehydes and carboxyolic acids–dissolve in water or act as detergents and emulsifiers. Although enhanced by sunlight (photo-oxidation), oxidation is a slow process. Thin films will break down under strong sunlight by no more than 0.1 percent per day.

Oxidation of thick oils sometimes creates tar balls and tar mats. This phenomenon occurs when the lighter fractions oxidize, leaving a persistent skin that isolates the unaffected oil from further oxidation and other weathering processes. Oil in this form weathers slowly and remains in the marine environment for a long time.

2-3.1.6 Biodegradation. Hydrocarbons and their oxidation products are food to some naturally occurring bacteria and other microbes. Most of the microorganisms which consume hydrocarbons require oxygen in either the free or dissolved form. There is usually sufficient oxygen near the surface to allow the maximum biological degradation to occur. However, in benthic regions and below the photic zone, the supply of oxygen is severely limited. Degradation by microbes is not a significant removal mechanism in these areas, although there are a few organisms that will decompose hydrocarbons when little or no dissolved or free oxygen is present.

The initial effects of biodegradation on oil spills are generally minimal and are limited by the quantities of the nutrients nitrogen (N) and phosphorus (P), which the microbes need to survive and grow. If the limiting nutrients nitrogen and phosphorous are present in sufficient quantities, temperature controls the rate of microbial degradation. As microbes can only attack that part of the oil which is in contact with the water the opportunity for degradation is enhanced when the oil is spread thinly or dispersed to expose a greater surface area to microbial attack.

2-3.1.7 Sinking and Sedimentation. Evaporation, dissolution, oxidation and adhesion of particles of sediment or organic matter to oil will sometimes increase the density of oil enough to make it sink. Adhesion to sediments occurs with heavy crude oils, some heavy fuel oils and water-in-oil emulsions with specific gravities only slightly less than one. These heavy oils, visible by day when warmed by the sun, may submerge during hours of darkness as they cool and become more dense. As sediment and debris adheres to heavy oil, the oil is more likely to sink, become embedded in the ocean bottom and remain there for an extended period. Sinking complicates cleanup operations and poses a danger to bottom-dwelling organisms. This phenomenon occurs most frequently close to shore, where the water column entrains particulate matter.

2-3.1.8 Resurfacing. Density of oil on the seabed may be decreased by anaerobic oxidation. If density is reduced sufficiently, the oil will resurface and be exposed to weathering processes which will continue until the oil sinks again or disappears completely.

2-4 EFFECTS OF OIL

The effects of spilled oil depends upon the quantity spilled, its physical and chemical characteristics, the nature of the environment and prevailing weather. For example, weathered crude or black oil may sink and impact life on the sea bottom as well as in the water column and intertidal zone. Light oils, on the other hand, tend to remain near the water surface and thus impact marine life on or near the water surface and intertidal region. However, because they tend to be more toxic than heavy oils and penetrate shoreline soils and porous stone more deeply, light oils cause long-lasting environmental harm.

The extent of damage is not necessarily proportional to the quantity of oil spilled. A small amount of oil in an environmentally sensitive area can cause considerably more damage than more oil on a rocky shoreline. What happens to the environment is a combination of the impact of oil and measures taken by response personnel.

Response measures mitigate spill effects, but impact the environment in their own ways. Timely booming may keep oil from impacting environmentally sensitive shorelines. Removing oil by mechanical means may do more damage to the environment than if no response were made. Leaving impacted marshlands alone can prevent plants from being trampled by well-meaning cleanup personnel.

Ecological effects from an oil spill include physical contamination of habitats, changes in growth, physiology and behavior of organisms and species, toxicity and increased mortality in plants and animals and destruction or modification of entire communities of organisms. Effects from an oil spill are more than ecological. The oil spill fouling of recreational areas, industrial facilities, ports, wetlands and wildlife has economic impact; degrading or destroying scenic, natural areas has a negative impact on the quality of life in the region. Negative effects of oil pollution include:

- Direct kill of organisms through coating and asphyxiation.
- Direct kill of organisms through contact poisoning.
- Direct kill of organisms through exposure to water soluble toxic components of oil at some distance from the oil spill and/or some time after the incident.
- Destruction of food sources for animals higher in the food chain.
- Destruction of juvenile organisms that are generally more sensitive to pollution.
- Sublethal exposure of organisms resulting in reduced resistance to infection and other stresses.
- Destruction of commercial value of food fish and shellfish by oil tainting.
- Introduction of carcinogens and cumulative toxins into the marine food chain and human food sources.
- Low-level effects that may interrupt the events necessary for the survival and reproduction of marine species.

2-4.1 Physical Contamination. Oil on the water surface may contaminate mammals and birds that populate that area. This contamination is more likely to occur in coastal areas than on the open ocean. Shorelines may be coated with oil. The degree of contamination depends on the physical characteristics of the shoreline. Oil may penetrate a gravel or sand beach to several inches while coating only the surface of a rocky coastline. Oil dispersed throughout the water column or emulsified, can contaminate fish and fishing gear.

2-4.2 Toxicity. It is difficult to quantify the toxicity of oils because they may consist of thousands of different compounds of varying toxicity. Mortality in test organisms exposed to different crude oils has been as low as 1 percent and as high as 89 percent. In general, the lighter petroleum fractions are more toxic to marine life than heavier oils. Many low boiling point aromatics, such as benzene and toluene, are deadly poisons to almost any form of life, while some higher boiling point paraffins are essentially nontoxic. Less persistent than heavy oils, the light components of oil are present in greater proportions during the initial stage of a spill than they are after some time has passed. The lighter components evaporate quickly from the sea surface and leave little residue.

The effects of the toxic components of oil on marine life can be severe if a spill occurs during a peak period of animal reproduction. The impact may last for several reproduction cycles if oils sink into the bottom sediment where oils may be retained for several years.

The toxicological effects of oil may be transient if oil remains on the water surface and does not impact the shore.

2-4.3 Bioaccumulation. Organisms that survive the initial effects of an oil spill may take in petroleum compounds from the water column, bottom sediments and contaminated food. The petroleum compounds accumulate in their tissues and may affect growth, reproduction and ability to escape predators.

Bioaccumulation may taint food fish making them unmarketable. Tainting may last from a few days to several months, depending upon the marine life affected, type of oil and severity of the contamination.

2-4.4 Rate of Recovery. Repopulation of marine life involves population dynamics of reproduction, growth and maturation and the ecological interactions of predation and competition for food. In general, recovery in the water column is very rapid, but estuarine and coastal systems may require years to recover and repopulate. Damage to marshy areas can last for decades if loss of vegetation leads to soil erosion and consequent changes in the marine environment.

2-4.5 Recreational Beaches and Sea Areas. Beaches impacted by oil must be closed, causing adverse impact on tourism and regional economics. This impact increases if spills occur during a tourist season. Recreational beaches and shorelines sometimes serve as staging points for response activity because of immediate, easy access to the water and are closed to the public during the spill response and may suffer lasting damage from vehicle and personnel traffic. Oils, particularly light oils, may penetrate porous shorelines, such as sand, shingle or cobble beaches and resurface with successive high tides for months following the initial contamination.

2-4.6 Ports and Marinas. Ports are sometimes closed to marine traffic to enable response forces to retrieve oil without the water surface being disturbed by vessel wakes or oil being moved about by ships and boats. Port closures affect the local economy adversely. While “trapped” in port, fishing vessels, merchant ships, coastal tugs and other vessels cannot generate income. Similarly, fishing vessels and gear coated with oil from a spill must be taken out of service and cleaned before use, causing further loss of income.

2-4.7 Industrial Installations. Oil drawn into water intakes can foul heat exchangers, making them ineffective. Oily water can contaminate distilling units. Typically, electric utilities and other industrial facilities are affected by spills and must be warned when spills are likely to affect their operations. Light oils, especially gasoline and aircraft fuels, generate flammable vapors. Hot work in a spill area must be secured until risk of fire and explosion is past.

2-4.8 Fisheries. The largest impact on fisheries from an oil spill may be the threat to fish hatcheries and fish larvae. There are usually few fish killed in open water from an oil spill. However, the impact on larvae or eggs near a spill can be severe. Closure of a fishing season or loss of stock from a fish hatchery can have a devastating regional economic impact. Shellfish and crustacean stocks can be severely depleted in oil-impacted areas because of their relative immobile lifestyle. High mortality among eggs or larvae of commercially important species may cause significant economic impact that is first felt several years after the spill.

2-4.9 Marine Mammals. Oiled sea otters, seals and other animals may die from hypothermia because oiled fur has no insulating value. Animals in areas impacted by oil are subject to toxic fumes, may eat food contaminated by oil or may ingest oil from grooming themselves. Weakening or starvation may result from a contaminated food supply. Most seal populations are harmed more by disturbance than by oil contamination. Observations have shown that seal pups handled or displaced by cleanup operations show a slower growth and higher mortality rates than undisturbed pups.

2-4.10 Birds. Bird mortality from oil contamination is well documented and frequently used to illustrate the ecological impact of an oil spill. Birds that spend much of their time on or in the water, such as ducks, penguins, auks, pelicans, etc., are the most vulnerable to oiling, but any bird that nests or feeds in coastal regions may be impacted by oil after it has come ashore.

Oil clogs the interstitial spaces of feathers causing them to mat together. The oiled, matted feathers lose their insulating value and water repellency. As the feathers absorb water, the bird looses buoyancy. The bird must expend more energy than normal to stay afloat, move about and maintain body temperature. At the same time, the bird may ingest oil and may not be able to find sufficient food in its oiled environment. Drowning and hypothermia are principal causes of death of oiled birds.

Resident bird populations often leave areas contaminated by oil spills, possibly because of oil fumes and feeding difficulties. The effects of this displacement are not well known, but may cause increased mortality of young birds if the displacement occurs during winter or nesting season. Increased mortality of young birds or abandonment of eggs may result from oil contamination of active nesting sites. Eggs can be lethally oiled by transfer of oil from the plumage of oiled adults. Minute amounts of oil can significantly reduce hatching success.

2-4.11 Wetlands. Coastal and estuarine ecosystems, such as mangrove forests and salt marshes, are highly vulnerable to impact from oil spills in coastal waters. Several natural features of coastal and estuarine wetlands detract from their ability to assimilate spilled oil:

- Networks of channels which transport oil deep into the vegetated coastal margin
- Low wave energy, resulting in minimal natural dispersion by physical forces
- Fine, highly organic, anaerobic sediments which entrap and hold oil for long periods

The immediate effect of an oil spill in a marsh ecosystem is the destruction of invertebrates and the above-ground portions of the marsh vegetation. Unless the marsh area is subjected to very rapid erosion or physical disruption of surface sediments (such as may occur during cleanup operations), the underground rhizome system of the plants is likely to survive the oiling. Recovery of the plant community usually begins within one year and vegetative recovery is likely within three to ten years. However, oily components will probably persist in fine-grained sediment for ten years or more. Disruption by erosion or removal of sediments and the rhizome system by mechanical removal, in contrast, may result in long-term changes in the wetland ecology and prolong the recovery process. Marshes generally recover well from a single oil spillage or successive spills provided enough time has elapsed between spills.

2-4.12 Archeological Sites. Archeological or historical sites can be irretrievably harmed when sites are damaged to the extent that material to be excavated or examined is lost due to oil contamination-either directly or because of response measures. For this reason, archeological sites should be noted in contingency plans and be protected in the same manner as environmentally sensitive areas.

2-5 OIL SLICK MONITORING

Knowledge of the quantity and movement of spilled oil helps responders to select and deploy appropriate response resources to be used. **Chapter 5** discusses selection of response resources in detail.

2-5.1. Visual Quantification. The volume of oil spilled from ships or handling facilities may be determined by comparing oil container levels before and after the spill. When soundings are not available, the amount of spilled oil may be determined by visual observation of the oil slick. Estimates of quantities of spilled oil can be made with the information in **Table 2-3**. Although theoretical estimates can be made, experience has shown field estimates of spilled oil quantities to be highly inaccurate.

Table 2-3. Relationship Between Appearance, Oil Thickness and Volume of Free Oil.

APPEARANCE	APPROXIMATE THICKNESS (MM)*	APPROXIMATE VOLUME (GAL/SQ MI)
Barely discernible	---	25.0
Silvery sheen	---	50.0
Faint colors	---	100.0
Bright bands of Color	---	200.0
Iridescent	0.0003	265.0
Dull brown	---	600.0
Dark Brown	---	1,300.0
Black/dark brown	0.1	88,500.0
Brown/orange, frothy (mousse)	>1	885,000.0+
* 1/10 mm = approximately 0.004”		

2-5.2 Remote Sensing. Sensors deployed from aircraft enable oil slicks to be identified during hours of darkness and during periods of reduced visibility. This technology makes spill detection possible around-the-clock rather than being limited to daylight hours.

Three sensors, used separately or in combination, comprise present remote sensing technology: Side-Looking Airborne Radar (SLAR), Infrared Line Scanners (IRLS) and Ultraviolet Line Scanners (UVLS).

SLAR can define the extent of an oil spill. With microwave radiation, SLAR detects differences in signal energy between returns from prevailing sea waves and waves dampened by oil. As a consequence, SLAR is least effective during periods of calm weather and is influenced by tide rips and other phenomena that dampen waves. SLAR is effective up to twenty miles and is largely unaffected by cloud cover and moisture. SLAR cannot be used to determine oil thickness.

IRLS determines the presence of oil by measuring natural radiation emitted from the sea surface in the thermal infrared region and detecting the difference between sea temperature and the temperature of substances floating on the sea surface. IRLS has a much shorter effective range than SLAR. Because IRLS operates on a temperature differential principal, it may indicate the presence of substances other than oil. As an oil slick absorbs heat from the sun, the thicker portions of the slick will become warmest, enabling IRLS to determine slick thickness. IRLS cannot see through fog and cloud cover. UVLS, useful only during daylight, detects differences in UV light reflected from the sea surface. UVLS can detect very thin films of oil. Like IRLS however, it does not discriminate between oil and other substances.

These sensing devices display their outputs on video screens in aircraft. The information then must be interpreted by an equipment operator and later by personnel at the oil spill response command post. Because all three remote sensors can return contacts that may not be oil, the presence of oil detected by remote sensors should be confirmed visually. Relay of the information gained by the remote sensing devices can take an inordinate amount of time, so plans should be made to communicate this information quickly. The most common method of information transmission at this writing is videotape, however, other means of electromagnetic data transmission are being developed.

The Coast Guard AIREYE remote sensing system is a composite package incorporating SLAR, IRLS and UVLS. AIREYE is installed in several aircraft and is scheduled for upgrading. The Marine Spill Response Corporation (MSRC) is presently designing a remote sensing system to support around-the-clock spill response operations. SUPSALV does not have a remote sensing system in its inventory, but is examining site-specific systems, such as remote cameras to support skimmer operations.

Free oil is not distributed uniformly throughout an oil slick. Influenced by wind, current and the oil source, free oil will consist of oil, water-in-oil emulsion and oil sheen. Estimates of the volume of floating oil must be made by adding the contribution of each form of oil. Such an estimate may be done by estimating the percentage of the total spill area consisting of each form of oil with the total equal to 100 percent. An example using **Table 2-3** follows:

EXAMPLE 2-1

During an overflight, the spotter estimated that a slick of free oil measuring 1 mile x 2 miles square consisted of patches totaling 15 percent mousse, 25 percent black-appearing oil and 60 percent iridescent sheen. Fifty percent of the mousse was water.

Contribution of mousse: 885,000 gal/sq mi x 2 sq mi x 0.15 x 0.50 = 132,750 gallons oil

Contribution of black appearing oil: 88,500 gal/sq mi x 2 sq mi x 0.25 = 44,250 gallons oil

Contribution of iridescent sheen: 265.5 gal/sq mi x 2 sq mi x 0.60 = 319 gallons oil

Total gallons estimated = 132,750 + 44,250 + 319 = 177,319 gallons oil

These calculations illustrate two important points. Although the sheen covered 60 percent of the affected water surface, it accounted for less than 1 percent of the oil. The type of oil should be taken into account when deploying skimmers. Skimmers will engage much more oil when operating in black/brown patches of oil than in a sheen.

The other point is that although a very large proportion of mousse is water and was not included in these calculations, water will be retrieved as part of the mousse during an oil spill response. The volume of oily water emulsion (mousse) that must be handled is nearly twice the volume of oil spilled. Once mousse begins to form, skimmer and waste oil storage capacity requirements increase dramatically.

2-5.3 Oil Slick Movement. When the projected slick track is known, assets may be deployed efficiently to capture the oil and areas needing protection may be identified.

Wind, tides, currents, wave action and weathering of oil all affect oil slick movement. Because most of these parameters may be measured or are predictable, computer programs have been written to forecast free oil movement. While not an exact science, accuracy of oil spill trajectory forecasts keep improving. Government and commercial services are available that offer this information. Regional Response Teams and NOAA can make arrangements for such services. Rough estimates of free oil movement are made by summing wind and current drift vectors. In general, oil spills are influenced mostly by prevailing wind and water movement. For rule of thumb calculations, the wind-drift vector is three percent of true wind velocity, in the direction of true wind. The water movement vector is the velocity and direction of prevailing current. The sum of these vectors give an approximation of oil spill movement. Example 2-2 illustrates an estimate of oil slick movement:

EXAMPLE 2-2

Assume that wind is from the west (270°) at 25 knots and current sets to the south (180°) at 2.5 knots.

Wind vector = 0.003 x 25 knots = 0.75 knots

Current vector = 1.00 x 2.5 knots = 2.5 knots

Predictions of oil spill movement are made easily by utilizing a radar transfer plotting sheet or maneuvering board. Wind and current vectors for oil slick movement are plotted the same as current set and drift are plotted to solve for influence of current on a ship's heading. Figure 2-4 shows how a plotting sheet may be used to predict movement of an oil slick. The resultant movement is 163° at 2.6 knots.

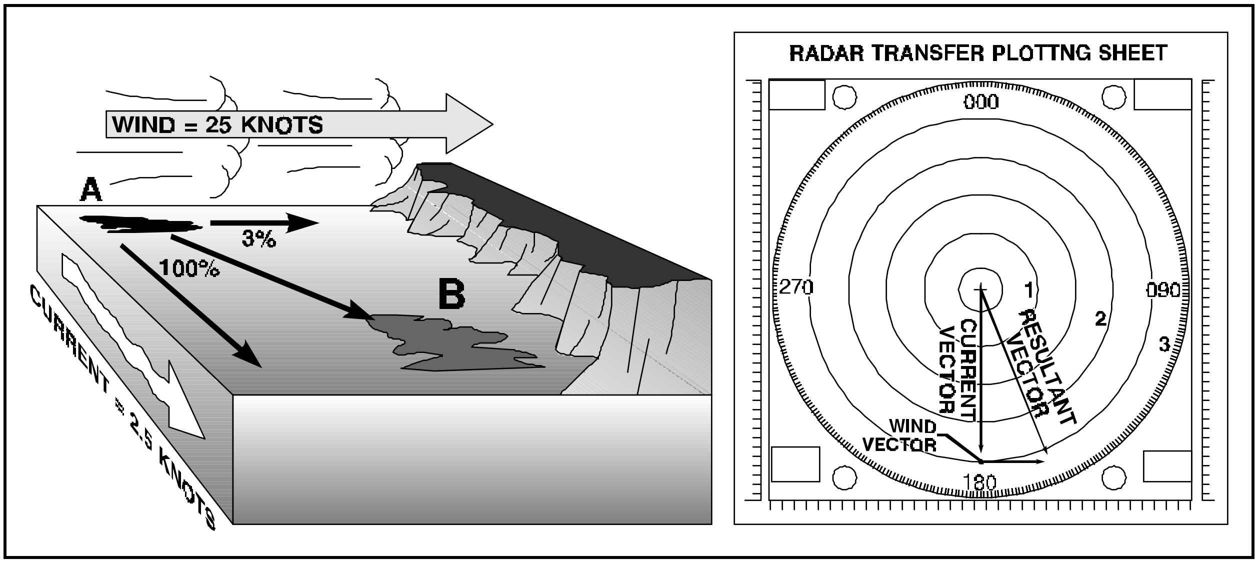


Figure 2-4. The Influence of Three Percent of the Wind Speed Combined with 100 Percent of the Current Speed Results in the Movement of Oil from A to B.

2-6 HAZARDS

Oil spill response presents hazards to persons working in that activity. Oils may be toxic as well as flammable. In addition, walking surfaces at spill sites are often very slippery, making work not only difficult but dangerous. Spills often occur during inclement weather and in remote areas, exposing spill response persons to the rigors of adverse environments. All of these things must be taken into account during a spill response. This subject is addressed in more detail in Chapter 3, Appendix G and in the *U.S. Navy Salvage Safety Manual*, S0400-AA-SAF-010.

CHAPTER 3

OIL SPILL RESPONSE OPERATIONS

3-1 INTRODUCTION

Protection of the environment demands incident-free handling of oil, but despite the most careful handling some spills will occur. Cleanup that minimizes environmental harm must follow an oil spill immediately—regardless of the size of the spill. The *Oil Pollution Act of 1990* (OPA 90) reiterates this expectation with several new standards for oil spill prevention, response preparedness, removal, liability and compensation. Public reaction to oil spills has heightened awareness of the impact of oil in the marine environment.

An oil spill response operation is much like combat. Response organizations and planning must provide:

- Intelligence about the enemy
- A high state of readiness and training
- Proper weapons
- Communications up and down the chain of command
- Logistical support
- Coordination

A well-constructed contingency plan, practiced and revised regularly, increases the chance of success in oil spill response. The similarity of an oil spill response to a military operation is one reason DOD units were effective in the *EXXON VALDEZ* oil spill response.

The interval between the initial report of an oil spill and the engagement of forces in its removal can be very frustrating for responders. Although much action is in progress to start the operation, personnel on scene become anxious as oil moves closer to shore and no help is in sight. The frustration is similar to that experienced when a stranded ship breaks up before salvors arrive.

The person in charge of an oil spill response operation must determine the action necessary and have the personal energy to see the operation to a successful end. This effort requires the combined talents of a seaman, technician, laborer and statesman. It is never easy. It must be done correctly the first time.

Spill responses are conducted within the framework of the applicable Navy or regional contingency plan. For Navy-originated spills, the response forces will consist of Navy personnel, civilian workers and/or contractors, as specified in the contingency plan. If necessary, assistance will be sought from adjacent NOSCDRs or NOSCs, Navy salvage forces or SUPSALV (ESSM) assets. For non-Navy-originated spills, Navy assistance may be requested by the FOSC through regional response team agreements or the USN-USCG interagency agreement. Navy assistance may include fleet salvage forces, shoreside NOSC/NOSCDR assets and other fleet assets, as well as ESSM equipment and contractors. With the exception of offshore and salvage related spills, where commanders of fleet salvage units are likely to be the designated NOSCDR, Navy salvage forces are not usually in charge of the overall spill response, nor are they likely to constitute the entire response force. Rather, they will be part of an integrated team. It is important that leaders of Navy units tasked to assist with an oil spill response understand the applicable contingency plan and their unit's place and function in the overall organization.

The success of a response is measured by the quantity of oil recovered, number of animals cleaned and returned to their habitat and amount of sensitive area protected successfully. The specific goals of the response should be defined early in the operation. Every action taken should contribute to achieving these goals.

3-2 NAVY RESPONSE RESOURCES

The Navy's principal inventory of spill response equipment suitable for offshore spill operations is maintained and operated by the Supervisor of Salvage as part of the Emergency Ship Salvage Material (ESSM) System. The ESSM gear is organized and deployed under a systems concept. A boom or skimmer system includes not only the boom or skimmer, but all necessary ancillary and accessory equipment, such as air compressors, spare parts, rigging supplies, etc. The standard quantities of accessory and ancillary equipment may not be optimum for all conditions, but the system will function. Additional accessory and ancillary items can be ordered separately to modify the system to suit particular conditions. The majority of the equipment is located in nearly equal amounts at two bases in Virginia and California. A single skimmer system is stored at Pearl Harbor. Oil spill response equipment can be prepositioned at any of the Navy's other ESSM bases (Livorno, Italy; Singapore; Aberdeen, Scotland; and Sasebo, Japan) if required. The equipment is built for rapid mobilization and shipment to spill sites anywhere in the world on U.S. Air Force Military Airlift Command (MAC) or commercial cargo aircraft. ESSM-based equipment is designed for offshore use in terms of deployability and ruggedness, but is not effective at containing or recovering oil in conditions more severe than sea state.

NAVFACENGCOM funds equipment purchases for shoreside NOSCDR response inventories. The equipment is staged at NOSCDR locations and is configured for response to small oil spills in sheltered waters. Collectively, the inventory for all NOSCDRs is vast, but widely dispersed. NEESA Publication 7-021 (Series) contains a periodically updated inventory of all NOSCDR equipment. The major assets provided by NAVFACENGCOM consist of:

- Permanent, deployed and stored containment boom systems of up to 10,000 feet long (12- to 36-inch height).

- Boom anchoring systems (small).

- Small, medium and large harbor skimmer systems.
- Small utility boats for placing boom.
- Barges and waste oil rafts.

This equipment, already distributed throughout the Navy, is a readily available resource. Although designed for harbor and inland spills, the NOSCDR equipment may be usable in some offshore or salvage-related spills. It is particularly useful for protecting harbors and sheltered shorelines threatened by major offshore spills, freeing limited quantities of offshore equipment for use in open waters.

Fleet NOSCDRs have no organic spill response equipment other than the small shipboard spill response kits. They rely on nearby shoreside NOSCDRs, the ESSM system and/or area commercial or foreign government assets for equipment to respond to offshore spills.

The Navy spill response capability, built around dispersed shoreside NOSCDR and mobile ESSM-based equipment, is more substantial than that of any other U.S. Government agency. The offshore response equipment of the ESSM system, however, is designed to be air-transportable; individual pieces of equipment are therefore limited in size and capacity. **Chapter 4** and **Chapter 5** describe Navy spill response equipment in greater detail.

3-3 OTHER RESOURCES

Various government agencies, in compliance with the National Contingency Plan, provide specialized services to the predesignated Federal On-Scene Coordinator during an oil spill response. Navy forces assisting a federally coordinated spill response will need to coordinate their activities with some or all of the agencies listed here.

These agencies are not specifically tasked or organized to assist a Navy OSC during response to a Navy-originated spill, but the NOSC can access their expertise and assets through the DOD member of the Regional Response Team or the FOSC.

3-3.1 Coast Guard Assets. Coast Guard strike teams, as well as vessels, aircraft and other response assets, are available to predesignated FOSCs through the NCP. They can be made available to the Navy Response Organization through the USN-USCG interagency agreement.

A significant amount of strike team equipment is devoted to lightering stricken vessels to minimize oil spillage. Significant strike team equipment includes:

- Open Water Oil Containment and Recovery Systems, consisting of skimming barriers, pumps and oil storage bladders (dracones).
- Air-Deliverable Anti-Pollution Transfer Systems (ADAPTS) consisting of hydraulic submersible pumps, similar to the ESSM six-inch POL pump and associated discharge hose, hydraulic power units and fuel bladders.

- Additional equipment in limited quantities, such as boats, vehicles, chemical transfer systems, viscous oil pumping units, nonsubmersible pumps, communications gear, monitoring equipment and computers.

Like the ESSM-based equipment, the open water containment and recovery systems are designed for offshore use in terms of deployability and ruggedness, but are not effective at containing or recovering oil in conditions more severe than sea state 3.

3-3.2 NOAA. Because NOAA is a member of each Regional Response Team, NOAA personnel receive early notice of an oil spill. A NOAA member acts as the Scientific Support Coordinator to the FOSC. Although it is an advisory agency, NOAA operates computer programs that forecast oil and hazardous substance movement through trajectory modeling. This information assists in the determination of sensitive areas that must be protected from free oil. The trajectory prediction capabilities form a vital part of any contingency plan. NOAA also provides expertise on living marine resources and their habitats, including endangered species, marine mammals and National Marine Sanctuary ecosystems. Other information provided includes actual and predicted meteorological conditions for marine, coastal and inland waters and tide and circulation data for coastal, territorial waters and for the Great Lakes. NOAA operates a number of research vessels that are suitable platforms for command sites and oil slick monitoring.

3-3.3 State and Local Agencies. States have state and local contingency plans in place and assets to combat oil spills. Fish and game departments customarily have small boats that can be used to monitor the effects of the spill. Advice from state agencies should be sought on:

- The location of sensitive areas
- How sensitive areas should be protected and/or cleaned
- Impact on local populations
- Managing security and crowd control
- Other matters of local concern, interest or expertise

In a large spill, local assets can be critical to success.

3-3.4 Marine Spill Response Corporation (MSRC). The MSRC was created by oil companies to respond to major oil spills in and around U.S. waters extending out to approximately 200 miles. Through this mechanism, oil companies plan to be able to respond quickly to contain and clean up major oil spills generated by member companies. The organization was to be fully equipped and functioning by early 1993.

MSRC, headquartered in Washington, D.C., is to have five Regional Response Centers:

- New York/New Jersey (Northeast)

- Miami/Port Everglades, FL (Southeast)
- Lake Charles/Hockberry LA (Gulf)
- Port Hueneme, CA (Southwest)
- Seattle, WA (Northwest)

Each region will have four to six pre-staging areas where equipment and vessels will be located. Coverage will extend to Hawaii and the Virgin Islands. Regional Response Centers will have personnel and spill response equipment capable of responding to *EXXON VALDEZ* size spills (10 million gallons).

Spill response equipment will be staged at about 27 sites throughout the U.S. including Hawaii and the Virgin Islands. Its inventory is to be the largest in the world and will include:

- Sixteen 200-foot offshore command vessels
- Tank barges and trucks
- Skimmers and booms
- Dispersants
- Shoreline cleanup equipment
- Pumping equipment

3-3.5 Cooperatives. Apart from Navy and Coast Guard assets, much of the rest of the available oil spill response equipment in the U.S. is maintained by industry oil spill cooperatives. Cooperatives are local spill response organizations created by pooling of resources. Typically, membership is from oil terminals or other waterfront petroleum-handling facilities. Cooperatives range from small mutual-aid groups, to large organizations having specially built response vessels and full-time staffs. There are about 90 cooperative organizations in the U.S. Virtually all U.S. cooperatives are set up to deal with spills in protected harbors, sheltered waters or inland areas; only a small portion of the available industry maintained equipment is suitable for offshore use. According to a recent American Petroleum Institute report, *"...no U.S. cooperative has been designed to deal with a catastrophic spill."* Despite this limitation, cooperative resources can augment Navy and Coast Guard inventories, particularly when large offshore spills threaten coastal areas.

General guidelines for accessing cooperative assets for Navy spills include:

- NOSCDR and NOSC contingency plans should list cooperative resources.
- Agreements for contracting for cooperatives' participation should be in place before spills occur.

- Communications should be established between all parties.
- Cooperatives should be invited to participate in NOSCDR drills and training sessions.
- Cooperative equipment may be available for response to non-Navy (civilian) spills if the spiller is a member of the cooperative.

There are also a number of oil spill cooperatives in overseas locations, some of which are equipped to respond to catastrophic or offshore spills. The largest oil spill cooperative in the world is Oil Spill Response Ltd (OSR) based in Southampton, England. The large equipment inventory is estimated by the Congressional Office of Technology Assessment to be roughly equivalent to that of one of the ESSM bases. As a full member of the cooperative, Exxon was able to obtain and use 50 percent of OSR's equipment to respond to the *EXXON VALDEZ* spill.

3-3.6 Volunteer Groups. Volunteer groups that have trained personnel with expertise in beach cleanup, bird and mammal cleaning, emergency communications, security and other disaster-related skills should be part of any contingency plan. Volunteers must meet training requirements as required by federal and state OSHA regulations to ensure that they are available immediately. In large spills, manpower for the physical removal of oil will be one of the major problems. Trained volunteers can make the difference between failure or success in a major cleanup.

3-3.7 Commercial Companies. The oil industry has many oil spill response resources located at refineries and oil terminals. Although most oil companies rely heavily on specialist contractors, they may have internal response forces and equipment ready for the initial response. There is also an increasing number of commercial contractors who deal with oil and hazardous materials on a full time basis, with marine oil spill response being part of their business. Several of these companies have accumulated a considerable amount of response equipment and experienced personnel. They can usually provide the following services:

- Oily waste collection, transportation and disposal.
- Cleanup of oiled shoreline.
- Waterborne oil and debris collection.
- Environmental impact surveys and other field scientific and engineering services, including computerized spill trajectory tracking and forecast.

3-4 INITIAL RESPONSE ACTIONS

Every spill response begins with a report of spilled oil. Following the spill report, an applicable spill contingency plan is put into effect. A well-written plan will guide responders to appropriate actions quickly and include useful information about area resources, probably spill movement and identify sensitive areas to be protected. The plan may have made certain decisions in advance or may include decision trees similar to those shown in **Figures 3-1** and **3-2**.

3-4.1 Initial Reports. As with fires or other catastrophes, an early spill report with incomplete information is preferable to a delayed complete report. An early partial report enables response forces to begin mobilization. Initial reports are made to the Navy organization having responsibil-

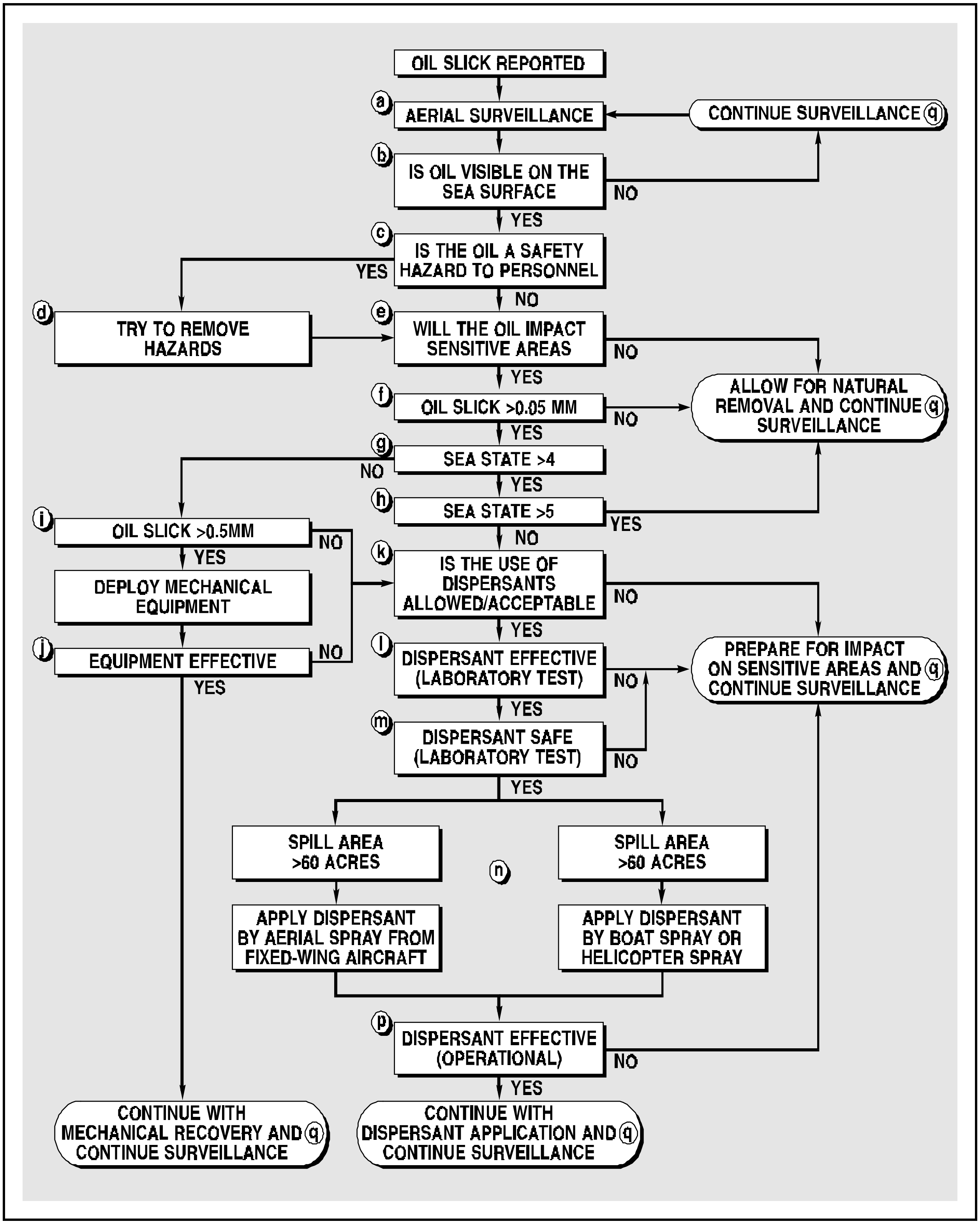


Figure 3-1. EPA Computerized Spill Response Team Decision Tree.

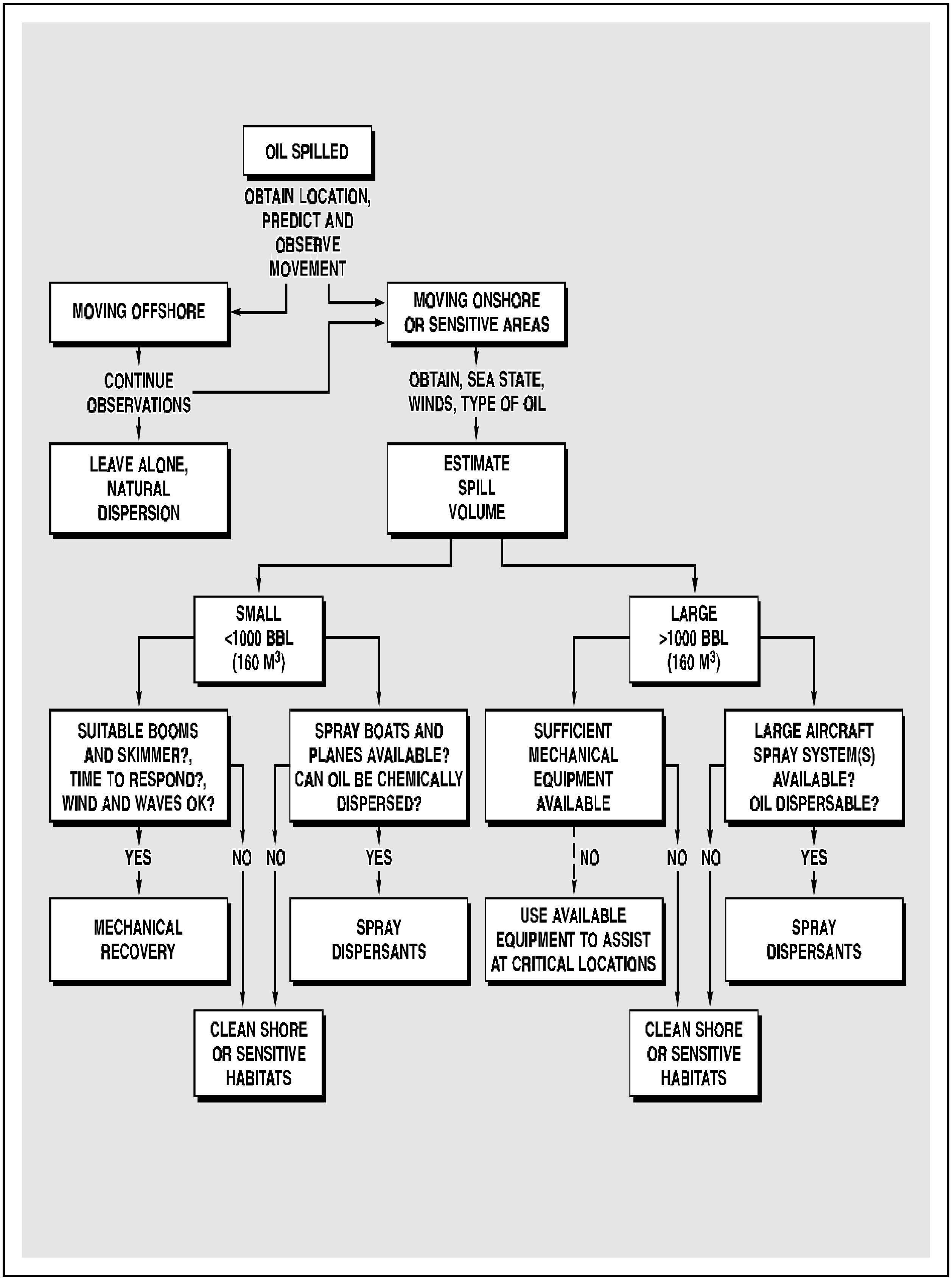


Figure 3-2. American Petroleum Institute Oil Spill Control Decision Diagram.

ity for oil spill response. Telephonic reports are most timely. The inside front covers of telephone books list phone numbers of oil spill responders and other emergency numbers. The base or unit duty office should be called if no other phone number is given.

Spilled oil reports also may be directed to the National Response Center (NRC) at 1-800-424-8802; within the Washington, D.C. area: (202) 267-2675. The National Communications Center is located at Coast Guard Headquarters and manned continuously for handling oil spill response actions. The NRC receives and immediately relays telephone notices of oil discharges to the proper predesignated Federal On-Scene Coordinator (FOSC). By this mechanism the FOSC may inform the Navy of a Navy spill.

Timeliness is important in reporting oil spills, particularly those that threaten shorelines. Spill responders work around tide cycles and strive to contain oil before a flood tide carries it ashore. The interval between successive high tides may be as short as 11 hours; it is never more than 25 hours. A timely report will help responders to be effective within the initial tide cycle.

Federal penalties emphasize the importance of reporting oil spills. The penalty for spilling oil is $5,000; that for the spiller failing to report a spill is $10,000. The larger fine for failure to report is an incentive for spillers to report oil spills.

3-4.2 Initial Actions. Definition of the spill is prerequisite to a proper response. Initial reports seldom contain complete information. Acquisition of missing information, including spill location, size of spill, type of oil spilled and source of spill, is an early task for responders. Often, phone calls to persons near the spill site or a quick view with binoculars from a nearby vantage point can develop the information. With some imagination, large quantities of information can be collected quickly.

Overflights give the best spill observation by giving a view of the entire spill, the spill environment and the flow direction. An experienced person can determine relative thickness of the spill by noting the various colors of the oil. Overflights also enable the person in the air to determine the probable source of the spill. The person making the initial overflight should take along a large scale chart of the area and a video camera. The boundaries of the spill should be plotted on the chart, the entire spill videotaped and a description of the spill communicated to the response command center immediately. Such a report from the air saves valuable hours of initial response time. For consistency, the same observer should make follow-up overflights along the same flight path with observations made in the same format as the initial overflight.

Military or charter aircraft normally make the overflights. However, to save time, other operators such as state police, civil air patrol or highway traffic reporters should be solicited. Public service organizations such as these are pleased to help and need only to be asked for their services.

Oil spills into ocean or coastal waters are defined as minor, medium and major discharges:

- Minor discharge - less than 10,000 gallons of oil
- Medium discharge - 10,000 to 100,000 gallons of oil
- Major discharge - more than 100,000 gallons of oil

Catastrophic spill describes exceptionally large discharges such as the *EXXON VALDEZ* spill or smaller spills that impact very sensitive areas.

With a rough spill definition, responders can make proper notifications, set up a command center, make initial resource orders and begin to refine resource requirements.

3-4.3 Spill Movement Forecast. Projection of the movement of the oil slick permits determination of its potential impact on shorelines or its location in open water. The projected path of an oil slick is the spill trajectory. **Chapter 2** contains information on estimating oil movement. Government and commercial services are available to project spill movement. Spill trajectory projections ease decisions on staging and deploying resources to combat the spill and protect environmentally sensitive areas.

Trajectory forecasts predict spreading, rate of evaporation, slick size and thickness and direction of movement. With this information, time of impact with a shoreline can be projected. Computer generated forecasts can be provided any time and can be corrected after comparison with actual spill observations. A good contingency plan includes probable spill trajectories for likely spill sites and conditions and lists sources for spill-specific trajectory forecasts.

3-4.4 Initial Prediction of Required Response Effort. The size of the effort can be estimated when spill size, type of oil, location and direction of oil flow is known. The characterization of the spill determines the response. The response to an open water spill is primarily skimming free oil from the surface and transporting the skimmed oil to a disposal facility but may include in-situ burning, bioremediation or even dispersant use. Response to oil on a shoreline is primarily a rake and shovel operation with little skimming of free oil, but again, could include such methods as bioremediation.

Although the extent of the required response effort may be defined shortly after a spill is reported, mobilization and transportation of personnel and equipment takes time. The time depends upon the location of the spill and the extent of the mobilization. It is while the response effort begins to get underway, before any oil is recovered, that agencies charged with protecting the environment and the general public, as well as people associated with an oil spill response feel the most frustrated. Apparent and visible action in this period is important both to start the response effort and to convince the many interested parties that a positive response is in progress.

Initial estimates of equipment requirements are based on spill size and the environment to be protected. As in a salvage operation, it is false economy and potentially disastrous to deploy too little equipment to the scene. It is better and more effective to send too much equipment than too little. The correct procedure for any oil spill response is to order quickly whatever may possibly be needed for the response.

3-5 DELIBERATE RESPONSE OPERATIONS

After the type and size of the spill have been determined, the command center located and response equipment mobilized, the typical spill response becomes several busy, simultaneously functioning activity centers. Emergent problems compete for managers' time and limit the time available to concentrate on recovering oil and minimizing harm to the environment. A challenge in every oil spill response is to focus on limiting environmental damage and recovering oil. This section describes the activities that must receive attention, particularly during the initial phase of an oil spill response. **Figure 3-3** shows organizational relationship for a Navy-coordinated spill response. **Figure 3-4** shows the relationships between various aspects of a federalized spill response. **Figure 3-5** shows how the relationships can change when the spiller takes an active role in the spill response.

3-5.1 Spill Response Tasks. The initial goal of the response is to deploy resources to recover oil and minimize harm to the environment. Specific actions that can be accomplished separately or concurrently include:

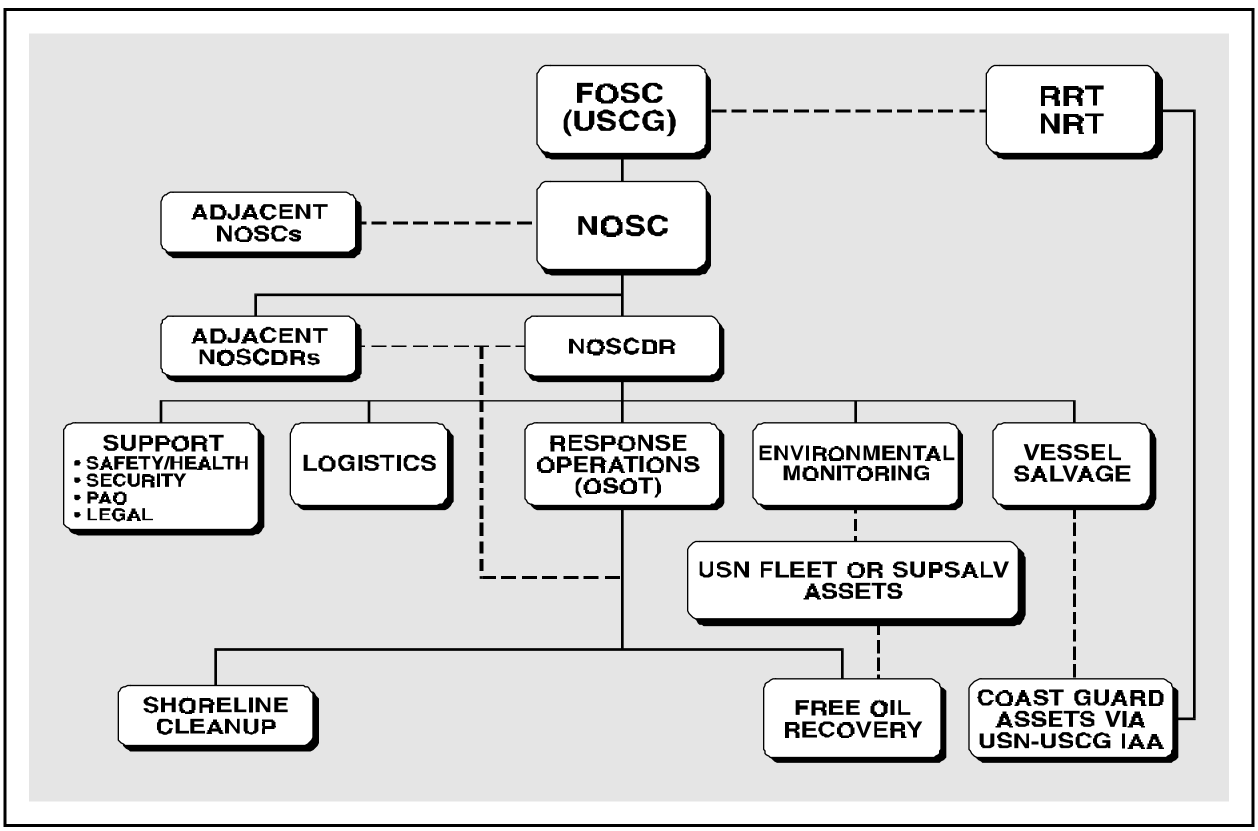


Figure 3-3. Navy Oil Spill Response.

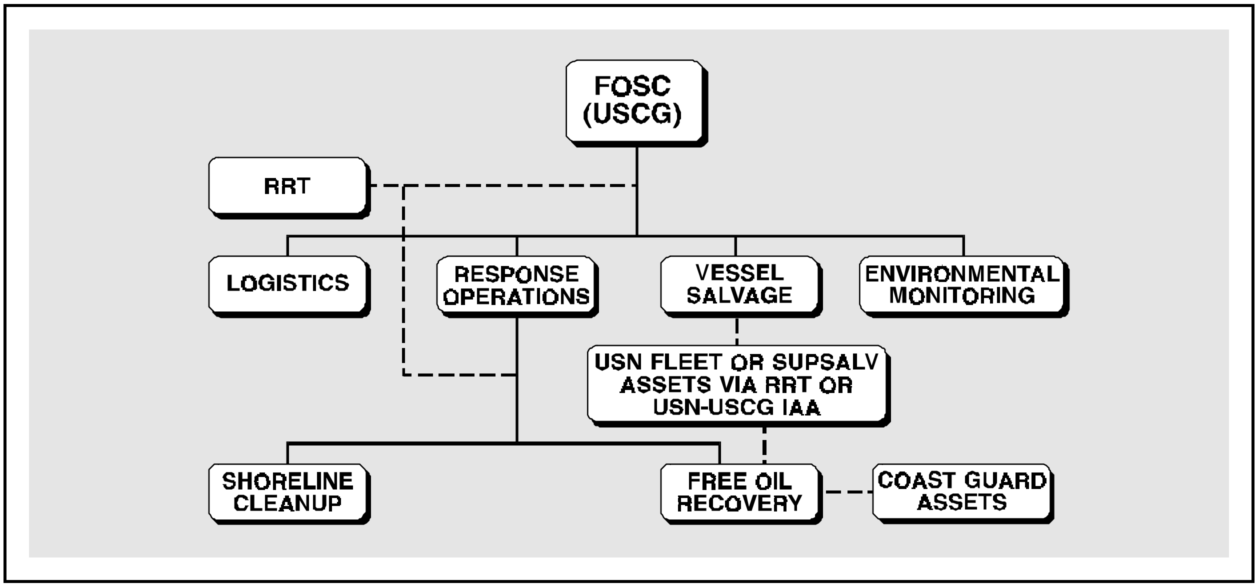


Figure 3-4. Federalized Oil Spill Response.

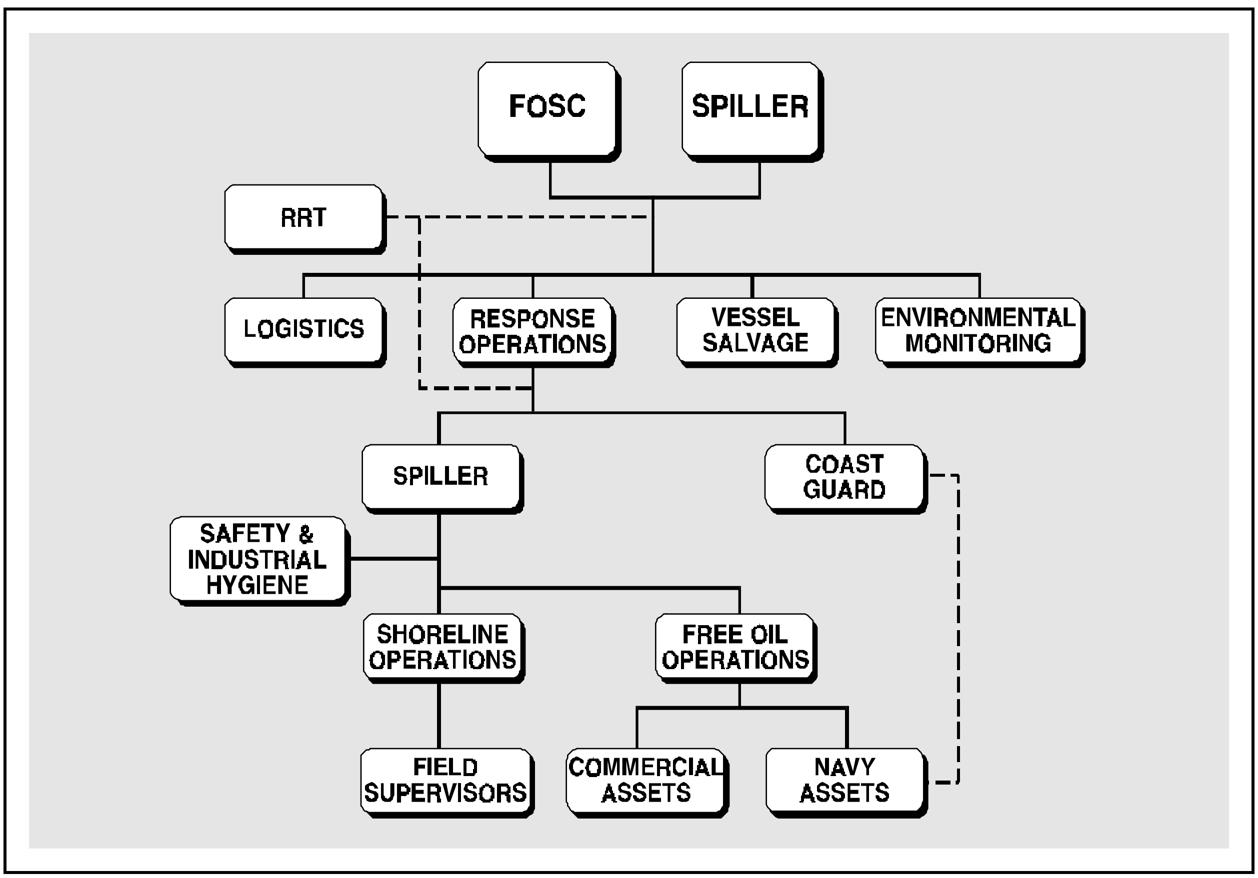


Figure 3-5. Federalized Oil Spill Response with Spiller Involvement.

- Securing the spill source and preventing further discharge
- Containing spilled oil and/or diverting it away from sensitive areas
- Recovering spilled oil from the sea surface
- Cleaning oil fouled shoreline, structures and wetlands

The elements of a functional contingency plan were discussed in **Paragraph 1-4**. Reference to a well-written contingency plan can help response managers to:

- Identify the cause(s) of a spill to facilitate securing the source
- Identify sensitive areas that should be protected
- Estimate probable oil spill movement and spread
- Determine optimum deployment of containment and recovery assets for the prevailing conditions
- Identify sources of primary and backup response assets and procedures for mobilizing them
- Identify sources for logistics and other support services and procedures for accessing them

3-5.1.1 Securing the Source. Oil spilled from a very large or unlimited source, such as a pipeline or well, cannot be contained effectively until the spill source is secured. Unless oil can be recovered and removed as fast as it is spilled, the spreading oil slick will eventually flow under, over or around containment barriers. Limited oil sources, such as ship's tanks or shoreside storage facilities will stop discharging oil on their own in a relatively short time, but it is still desirable to secure the source as soon as possible to limit spill size. Spill sources are secured by one of the following means:

- Transferring liquids from damaged tanks to sound tanks aboard a ship casualty
- Transferring liquids from damaged tanks to another vessel (lightering)
- Plugging or sealing submerged gas vents, tank overflows and damage openings; closing submerged valves, sounding/ullage openings, etc., that may have been left open at the time of the casualty.
- Stopping pumps, closing valves and or isolating damaged piping if the spill is caused by a pipeline leak

Damaged deep tanks on ships will not necessarily spill all their contents. If a deep tank containing oil less dense than the surrounding water is holed below the waterline, oil flows out until the oil within the tank reaches a level where the sea pressure and oil pressure balance as shown in **Figure 3-6**. The depth of oil above the hole is deeper than the depth of water outside the tank because of the oil's lower density. Some additional oil will flow out as the relative heights of the oil-water interface and the upper edge of the hole fluctuate because of passing waves or vessel rolling, establishing a shallow water bottom beneath the oil. For ships stranded in tidal areas, additional oil will flow out as the water level falls below that at the time of the casualty. Little oil will be spilled on subsequent tide cycles, unless later low tides are lower than the previously experienced lowest water level. It was estimated that in the *EXXON VALDEZ* casualty, approximately half the oil spilled flowed out of the damaged tanks in the first 20 minutes after the grounding, while most of the remaining oil spillage occurred over the next 24 hours as the tide rose and fell.

It is not always necessary to empty a damaged tank completely to stop oil leakage. Deepening or establishing water bottoms provides a buffer that can prevent further discharge of liquids lighter than water. As a practical matter, a water bottom has been established when the cargo pumps

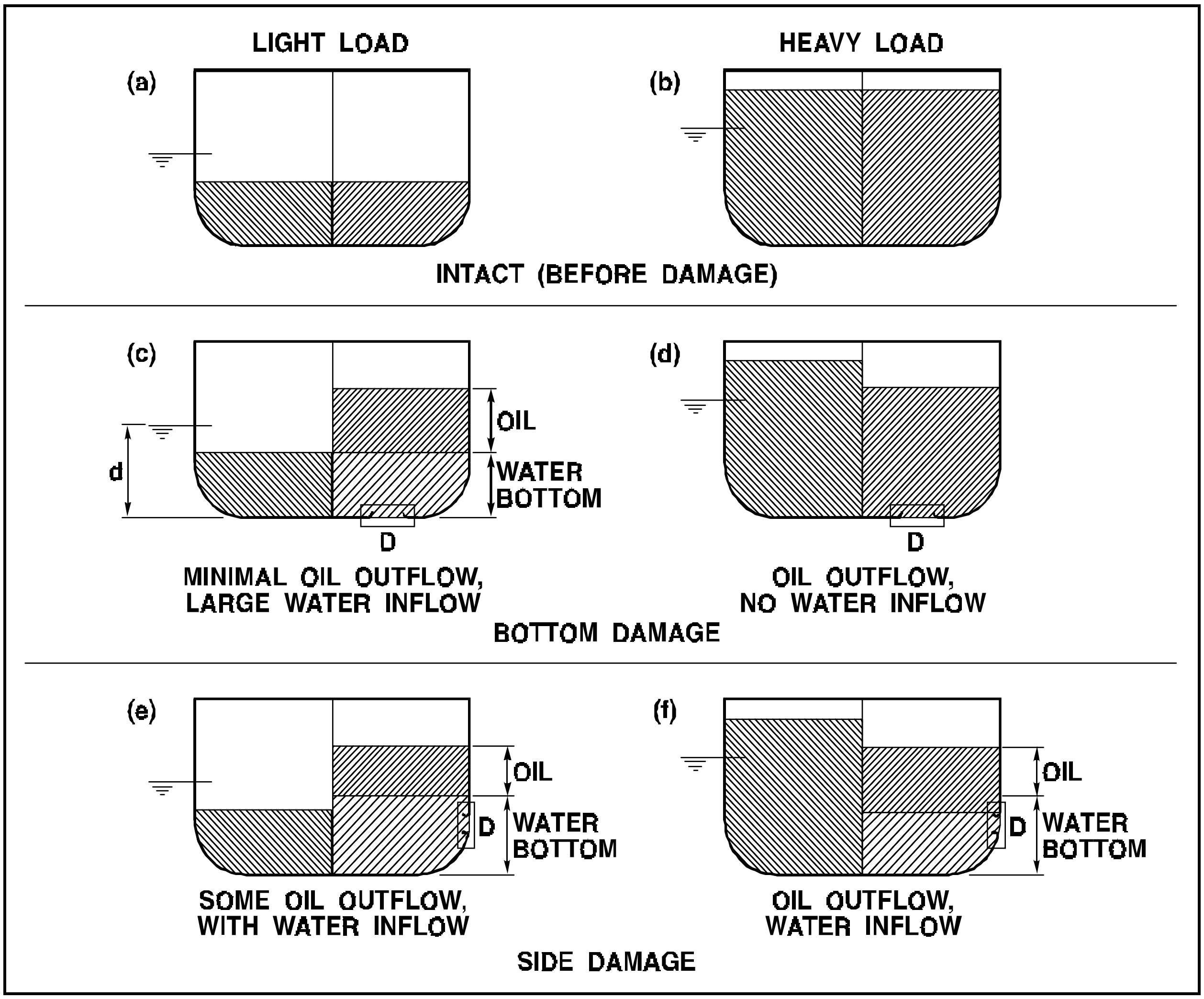


Figure 3-6. Oil Outflow and Formation of Water Bottom.

begin to draw water instead of oil. The thickness of the water bottom can be increased by drawing oil from the top of the tanks with portable pumps, allowing water to flow in through the breached plating. In the initial stages of the incident, salvors or spill responders should attempt to create or increase water bottoms in damaged tanks, especially if lightering capacity is limited and several tanks are leaking. Water bottoms should be deep enough to ensure that several feet of water remains beneath the oil at the lowest anticipated tide. As operations continue, water bottoms can be systematically increased until the tanks are completely discharged. The ***U.S. Navy Salvage Manual, Volume 5***, S0300-A6-MAN-050, discusses the use of water bottoms and methods to remove liquids from damaged vessels.

The effectiveness of water bottoms is limited for water soluble liquids or liquids with a specific gravity very near one. Water bottoms cannot be created at all under liquids with specific gravities greater than one. Many bulk chemicals fall into this category, as well as some crude oils and bunker fuels.

3-5.1.2 Preventing Further Discharge. Spills are prevented by taking appropriate precautions when handling pollutants. In many cases, spills are best prevented by removing the potential pollutant from the damaged vessel or by removing the vessel with the pollutant completely contained. The act of removing a pollutant carries the risk of accidental spill. The potential gain must be weighed against the possibility of a spill during transfer. ***U.S. Navy Salvage Manual, Volume 5*****,** S0300-A6-MAN-050, describes procedures to minimize incident potential during POL transfer.

3-5.1.3 Containment. Oil and other pollutants are most often contained with purpose-built booms. Booms are also used to corral, move or funnel spilled oil to recovery devices or to divert it away from sensitive areas. Trained aircraft spotters should be deployed to track oil movement, guide skimmers and recommend locations for placement of protective containment booms.

Booms range in height from under one foot for protecting calm water areas to over seven feet for offshore use. Smaller booms are less expensive, lighter, easier to deploy and require less power to tow. Deployment of large offshore booms requires larger boats and heavier equipment than smaller booms. Specialized equipment is sometimes required. Most booms become ineffective in currents greater than one knot or wave heights greater than six feet, as oil is entrained in the current and swept under the boom. Systems designed for severe conditions in the Norwegian sector of the North Sea are required by the Norwegian government to be effective in nine-foot waves and 1.5 knot currents. Even with booms built to these standards, efficiency is greatly reduced in six- to nine-feet seas. When wave height exceeds nine feet, oil is whipped into the water and splashed over booms; little containment or recovery is possible.

Boom heights of 18 to 80 inches have been used for offshore oil containment. Available evidence suggests that the largest booms are no more effective at containing oil than booms in the 32- to 42-inch height, but larger booms are useful for providing increased towing resistance to slow down boats that otherwise could not maintain the one- to two-knot speeds required for boom and skimmer towing.

Booms for sheltered waters can be field-fabricated from linked chains of logs, empty oil drums, small craft, etc. Effectiveness can be increased by adding weighted plastic or canvas skirts. Sorbent boom can be fabricated by binding straw or other sorbent materials to fiber line with floats of some type attached at intervals. In shallow waters such as marshes or tidal flats, sorbent barriers can be constructed by staking straw bales to the ground or fastening them to poles. Although containment or sorbent boom can be improvised in the field, the fabrication is so slow that purpose-built boom can be flown in and deployed before an improvised boom can be completed in most locations.

Ship hulls, quay walls, etc., can function as opportune barriers. Smaller spills can be contained or moved by water sprays or propwash, alone or in conjunction with booms. Chemical herding agents applied around an oil spill may consolidate the spill, but use of chemical agents is subject to strict controls by various authorities. Spill response chemicals are discussed in **Chapter 6**.

Spill containment is a temporary measure, not a final solution. In the presence of any wind or current, oil will build up along the boom, extending downward until at some point, oil will be entrained in the current passing under the boom. Contained oil must be recovered and disposed of properly. Containment methods and equipment and their integration with recovery systems are discussed in **Chapter 4**.

3-5.1.4 Recovery and Cleanup. Oil spill recovery and cleanup either removes oil from the water or shore or enhances natural processes such as evaporation, oxidation and photochemical and biological deterioration.

Oil is recovered by picking it up from the water surface with skimmers or sorbent materials. Oil sorbents range from sawdust to expensive sorbent mats. Sorbents are usually deployed and recovered by hand. Some can be re-used after squeezing or wringing the oil from them.

Skimmers are available in assorted sizes, some small enough to be used in large cargo tanks. Skimmers are generally used in sheltered waters, although a few types are effective in seas up to about six feet. Skimmer efficiency (ratio of oil recovered to total volume of oil-water mixture recovered) depends on several parameters:

- Oil slick thickness and degree of containment
- Oil viscosity and degree of emulsification
- Sea state

The basic types of skimmers and their relative strengths and weaknesses are discussed in **Chapter 5**. No skimmer is completely effective and all skimmers recover a mixture of oil and water. Oil-water separators are desirable to conserve storage capacity. **Chapter 5** addresses mechanical recovery of free oil from the water surface. **Chapter 7** describes methods for cleaning oil-fouled shoreline.

Most oil is recovered during the first days of a response, before it has spread and weathered so much that retrieval is difficult. Skimmers and containment boom fill very quickly in the initial period. An ideal skimming operation continues nonstop. Nonstop operation requires pumping oil frequently from skimmers and containment boom into reception facilities. Dracones, tank barges or other temporary receptacles must be near the skimming operations. Otherwise, oil recovery operations must stop while skimmers travel to and from a discharge facility.

A continuous skimming operation must have a quick and routine procedure to dispose of collected oil and oily debris. Oiled seaweed and other trash is usually retained onboard skimmers after it is separated from recovered oil. Skimmers recover large quantities of this material in areas with significant amounts of marine vegetation. Oily debris must be collected from skimmers and taken to disposal sites regularly. **Chapter 7** discusses the final disposal of oil and oily debris.

3-5.1.5 Dispersal. If left alone, crude oil and heavy bunker fuel residues will form tarry globs or emulsify into a mousse after the light ends have evaporated. The tar or mousse will coalesce into thick layers, retarding the natural deterioration of the oil. The rate of degradation of the oil by biological and chemical processes can be increased if the exposed surface area is enlarged by dispersion. The oil mass can be dispersed by agitation (prop wash, water spray, etc.) or by chemical dispersants.

The decision to disperse an oil spill rests with local regulatory officials. Dispersal is not usual in near shore waters, because most of the oil reaches the shore before it deteriorates. The use of dispersants near shore can compound the problem by adding still more chemicals to the environment and the oil will only merge again upon reaching shore. Many chemical dispersants are themselves environmental hazards; their use is subject to approval by environmental authorities, including the Coast Guard designated Federal On-Scene Coordinator (FOSC).

For effectiveness, dispersants are deployed before oil weathers, i.e., as early as possible. Aircraft or boats deploy dispersants depending upon the volume of dispersant and the time to reach the spill site. Dispersant application must be coordinated with skimmer and containment boom operations so personnel and equipment remain clear of areas where chemical dispersants are to be applied. Although the Navy neither stockpiles nor uses dispersants, Navy personnel must sometimes coordinate with deployment of dispersants. Chemical dispersants and their use are discussed in **Chapter 6.**

3-5.2 Safety. Response to large spills, particularly light distillate or crude oil spills, must include an awareness of the fire and explosion potential of the slick or damaged vessel given the right temperature and atmospheric conditions. Spill recovery is dirty, slippery work and involves working with moving machinery, heavy rigging, operations at the waters edge and exposure to potentially toxic petroleum products. Spill responders may also be exposed to inclement weather or extremes of temperature. Safety of response workers and personnel aboard damaged vessels must be safeguarded by adherence to appropriate safety precautions, including, but not limited to:

- Restriction of smoking, open flames and hot work in the vicinity of volatile slicks and ruptured tanks, on tank decks during lightering and on tankers whose inert gas system is not functioning.

- Use of appropriate protective clothing, such as hardhats, steel-toed boots, coveralls, gloves, eye protection, life preservers, etc.

- Provision of functioning and adequately sized firefighting equipment.
- Provision of adequate safety training and environmental hazard training to all response workers.
- Ensuring that equipment is operated by properly trained and qualified operators.
- Strict enforcement of boat safety requirements for boat and skimmer operations.
- Provision of adequate first aid equipment, medical treatment facilities and evacuation capability.

Response managers must implement and enforce safety standards. Oil spills often occur in remote areas and with harsh climates. In the intensity of a response, people become tired, careless and less alert than in their usual work place and routine.

3-5.3 Documentation. Response management also must set up administrative and documentation procedures on the first day. Persons must know where to report, where to mess and berth and what is expected of them. Costs must be documented. Cost tracking is vital when Navy forces are working for the Coast Guard under the interagency agreement and must document reimbursable expenses. Field accounting practices should be simple and uniform and kept up to date daily. Records not kept daily become garbled and require an inordinate amount of time and effort to correct. Cost accounting requirements are discussed in **Paragraph 3-8**.

3-5.4 Coordination with Other Agencies. Coordination among the several agencies working on a spill increases the effectiveness of the operation. Sharing equipment and experts enhances effectiveness and develops a synergy that benefits everyone. Coordinated field activities assist planning for future operations and demobilization.

State and local governments are represented on the Regional Response Team to provide a conduit for Regional/local information into the spill response decision-making process. State and local officials have local knowledge of the environment impacted and how to do things. This sort of information is helpful during a response and is not always obvious to military people who have been in the spill area only a short while. Local people can identify environmentally and economically important areas.

State officials can bring on board manpower, such as police, marine patrols, conservation employees, firefighters and public health officials. Their organizations often have resources such as communication equipment, four-wheel-drive vehicles, aircraft and boats that are useful during a response. Contingency plans should identify the contributions expected from or arrangements made with state and local governments.

The Director of Military Support (DOMS), a military agency made up of representatives of several DOD agencies, is activated in times of national crisis or emergency, to provide DOD assets for specific situations. During the *EXXON VALDEZ* oil spill response, DOMS coordinated flights of ESSM oil spill equipment from CONUS to Alaska. This organization is not available for all major oil spill responses. When it is activated, it can provide substantial logistics assistance.

3-5.5 Media. A major oil spill is a news event. The media can be expected to be present and to report the response. Knowledgeable people should be available to ensure the media has correct information about the strategies and tactics in use. Unfortunately, the demand by media for information is greatest when response efforts are most intense and managers find it difficult to make time available for anything other than spill response operations.

Media relationships are a specialized business. Mutually satisfactory media relationships require knowledge of the media's motivations and requirements. In major spills, Navy public information specialists should coordinate media relationships, advise managers and assure that the Navy is presented in the most favorable manner.

Adherence to the following principals will enhance media relationships:

- The media should be treated fairly as professionals who have an important job.
- Information presented to the media should be correct and phrased in nontechnical terms that people not familiar with oil spill response technology understand.
- Information should be positive, never defensive or evasive.
- Interviews should be prepared in advance and the scope discussed with the interviewer.
- All media reports should include numbers—skimmers in operation, the number of persons involved in the response, the number of gallons of oil collected, the miles of marshlands protected by boom, etc.

Media coverage should be coordinated by a single person or office throughout the operation, giving the media a single, initial point of contact. Whenever possible, the media coordinator job should be a full-time position. Nearby naval facilities, the Coast Guard, the DOMS organization or other federal agencies may be able to provide a full-time public affairs officer (PAO). When career PAOs are not familiar with response operations, a knowledgeable member of the response organization should be assigned as technical liaison. The Coast Guard Public Information Assist Team (PIAT), discussed in **Paragraph 1-3.4.4**, is one of the National Response Organization special teams available to the FOSC.

3-5.6 Volunteers. There are two classes of volunteers. Volunteers who deliver professional services requiring special skills—such as bird and mammal cleaning and beach cleaning—make up the first class. Many volunteer groups have highly motivated, highly skilled and experienced people. Contingency plans should recognize their special expertise, need for space and utilities and food and shelter.

The second class consists of people not specifically trained for oil spill response who just want to help in some way. Restoration of environmental damage caused by an oil slick coming ashore is very appealing to persons wanting to do a good turn. Adverse effects on wildlife increases the appeal. It is not unusual for a few hundred volunteers to come forward to help with a spill response. These volunteers may approach the response organization as members of organized groups or as individuals. There must be a plan for these people to work safely in concert with professionals. Turning them away loses many manhours of labor and much goodwill.

A common issue is risk of personal injury to someone not trained or otherwise unfit to participate in the handling of oily debris. Volunteers should not engage in the actual cleanup of oil until they have had required training. **Appendix G** reproduces excerpts from the 29 *CFR* 1910 (OSHA) detailing training required for oil spill response workers. Eliminating the risk requires a screening process, a simple security system and periodic advice from qualified persons. The screening should check for skills or training that may be of use to the response organization.

Navy policy is to put volunteers under another organization whenever possible. Volunteer assignments should be worked out with state representatives, environmental groups or others on scene who have a relationship with volunteers. The Navy can draw on the volunteer’s sponsor organization for resources. Many volunteers have local knowledge useful to people in a hurry to get things done.

Legal and security issues require very quick, case-by-case handling. The person in charge must make contact with the local Navy facility or otherwise have immediate access to Navy personnel who can give guidance.

3-6 MOBILIZATION AND LOGISTICS

Timeliness of equipment arrival at the spill site is an indicator of the potential success of a response. The sooner the response can begin, the smaller the oil slick and oil fouled area and the greater the likelihood that the oil can be contained and removed. While personnel can be drawn from local commands and agencies or respond quickly to remote areas, special measures must be taken to move equipment quickly enough for it to be effective. Getting the logistics train moving is a crucial step in combatting an oil spill. Equipment requirements are proportional to spill size; equipment support and transportation requirements expand rapidly as spill size increases. The following paragraphs deal with logistics requirements for SUPSALV (ESSM) spill response operations. Specific support requirements for ESSM spill response are discussed in **Appendix C.** Responders and equipment from other sources will have similar requirements.

3-6.1 Mobilization. The ESSM oil spill response equipment is ready-for-issue (RFI) and configured and packaged for mobilization by all modes of military and commercial transportation to spill sites worldwide. The primary staging sites for ESSM pollution equipment are the ESSM bases at Cheatham Annex, Williamsburg, Virginia and Stockton, California. An additional skimmer system is at the ESSM complex in Pearl Harbor, Hawaii. Oil spill equipment can be positioned in all the Navy’s other ESSM bases—Aberdeen, Livorno, Singapore and Sasebo. When placed on alert by notification of a major spill, ESSM contractors start around-the-clock operations to mobilize personnel and equipment.

NOSCDR equipment is maintained ready for immediate use by the local On-Scene Operations Team(s).

3-6.2 Logistics. Those intimately involved often characterize response to a major oil spill as logistics, logistics and more logistics problem solving. The same people always make the two points: that equipment must be identified quickly and get to the scene as soon as possible. All aspects of the transportation network must be considered; barges and other support vessels are often overlooked and not available.

The *U.S. Navy Emergency Ship Salvage Material Catalog,* NAVSEA 0994-LP-017-3010, contains a complete description of oil pollution and response equipment in the ESSM system. The manual contains technical descriptions of equipment, photographs and data such as dimensions and weights useful for transporting system components. This information is invaluable to those charged with transporting, staging or handling response equipment. Similar documentation should be sought for equipment provided by other sources.

Trucks or aircraft transport ESSM (or similar) material depending upon distance to the scene and availability of materials handling equipment (MHE) at the destination. Trucking skimmers and other large items from the ESSM bases to almost any coastal port in CONUS is as fast as air transportation. Although time in the air may be only a few hours, repeated handling, examining and restowing removes most, if not all, of the expected time savings.

The transportation method, particularly air, affects the equipment selected for the initial shipment. The first plane should contain enough equipment to get a skimming or booming operation underway. A C-5A with a cargo capacity of 226,000 pounds can carry one modular Class V skimmer, two boom handling boats, several vans and additional ancillary equipment. Alternatively, these aircraft may carry three nonmodular skimmers. Because of the width of these units, little space remains for additional equipment. C-141 aircraft with a cargo capacity of 64,200 pounds can carry three-quarters of a modular skimming system. **Figure 3-7** shows typical stowage arrangements for a C-5A aircraft.

Stored equipment complies with published Air Force and FAA requirements for air transportation. Special handling requirements for fuel, storage batteries, compressed gases and other potentially hazardous materials should be discussed with Air Force officials when arranging flight for ESSM equipment. In general, fuel tanks must be empty, engine-starting batteries disconnected and compressed gas cylinders isolated. Compliance with these requirements may adversely impact initial operations in remote areas. For example, special arrangements may be required to get fuel for skimmers, boom handling boats and auxiliary equipment. When strict compliance with transportation regulations may inhibit the operation, exceptions can be made.

Transportation by truck is more flexible. Trucks can move out as soon as they are loaded and documentation prepared. Additional trucks cost much less than additional aircraft. It is faster and more economical to put additional trucks in service than it is to put additional aircraft in service. On arrival at the spill site, trucks unload their cargo at the waterfront, operations area or storage area—even when transported by air, the first and last legs of the journey will be by truck. When

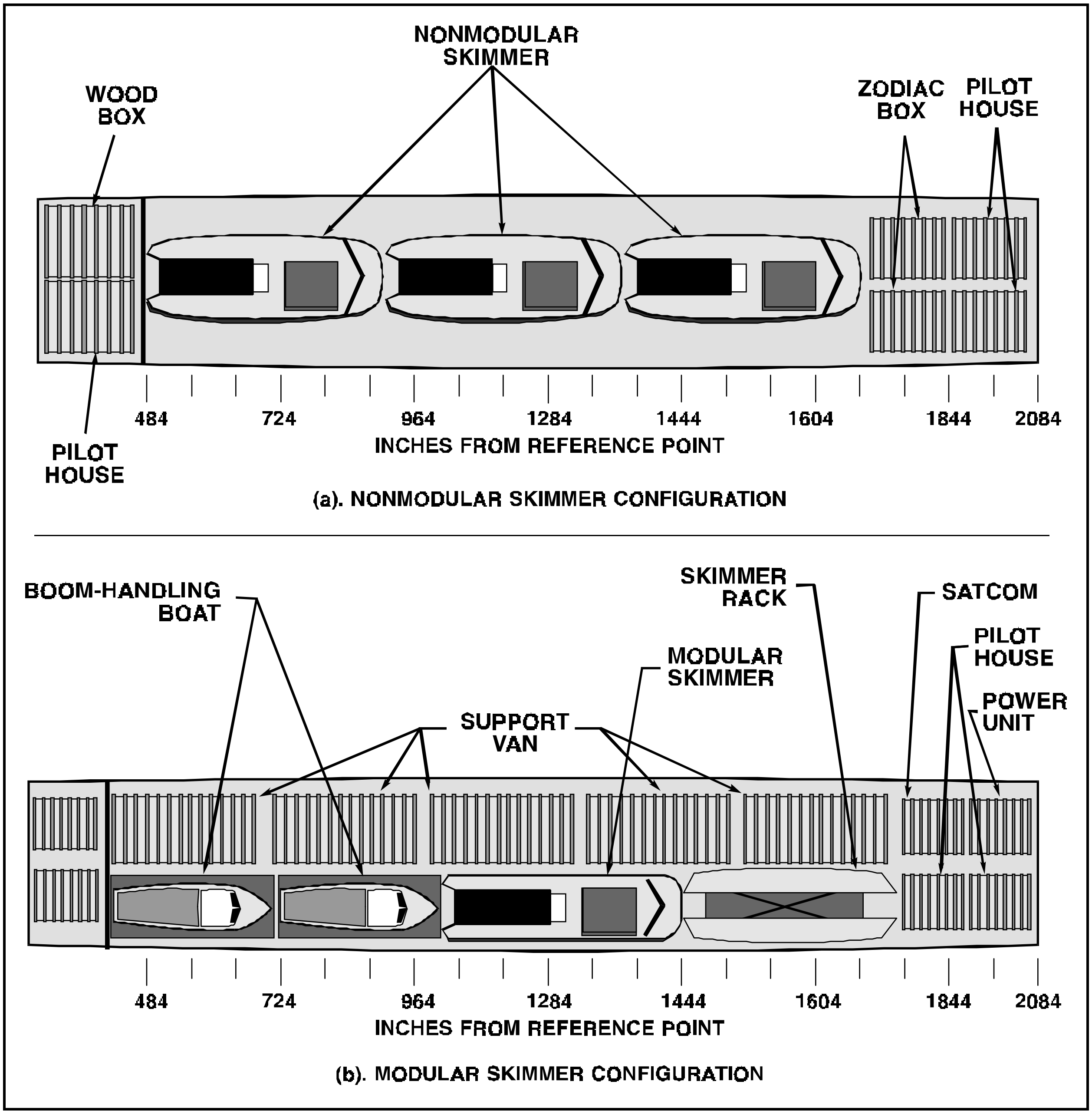


Figure 3-7. Representative Loading Plan for C-5A Aircraft - Modular and Nonmodular Skimmers.

transported by truck, boats, skimmers and other engine-driven equipment can be shipped fueled and ready for immediate operations on arrival.

3-6.2.1 Material Handling Equipment (MHE). Material Handling Equipment (MHE) is crucial to any logistics operation that must function without interruption. MHE and qualified MHE operators are required wherever pollution equipment is deployed. Cranes are necessary to move skimmers, vans, etc., on and off flatbed trucks and to launch skimmers in the water. Similarly, 5- to 6-ton forklifts are needed at staging areas. Special K-loaders must move equipment in and out of large military cargo aircraft. It is sometimes necessary to transport K-loaders to the destination airfield in the first aircraft. The SUPSALV Contingency Planning Guide includes MHE requirements so contingency plans may include them. The 13-ton command van is the heaviest element in the ESSM system. If the MHE at each transshipment point can handle the command van, it can handle all other parts of the system.

3-6.3 Logistics Support. Logistics support for NOSCDR spill responders is provided by Navy and DOD forces in the area, as specified by the applicable contingency plan. Normally, the same units will support SUPSALV contractors and Navy salvage forces tasked to assist the NOSCDR. If necessary, logistics assistance can be sought from adjacent NOSCDRs or the NOSC.

The National Response Team (NRT) supports the Federal On-Scene Coordinator and can provide logistics support to Navy spill response teams, including SUPSALV assets, tasked to participate in a non-Navy spill response. The NRT, made up of officials from 15 federal agencies including DOD, can arrange for aircraft and other assets—a task that may be difficult and time-consuming from the field. NRT organization and membership is discussed in **Chapter 1.**

The Military Airlift Command (MAC), responding directly to SUPSALV or via the Coast Guard, has provided aircraft for logistics support often. Special Assignment Airlift Missions (SAAM) provide dedicated but very expensive air transportation. The urgency of the response and the potential environmental damage that delay could cause may justify the expense of SAAM aircraft. The Supervisor of Salvage office should be contacted both for ESSM equipment and transportation arrangements, including SAAMs.

3-6.4 Ship and Vessel Support. A variety of ships and smaller craft may be required to support large spill response operations. Typical vessel requirements include:

- Working platforms from which boom is deployed and positioned.
- Platforms for vessel of opportunity skimming systems (VOSS).
- Boom and skimmer towing to move and recover oil.
- Personnel and equipment transportation, including towing of smaller craft.
- Towing oil storage bladders or barges.
- Afloat command centers.
- Mobile, afloat maintenance and logistics support for small craft.
- Tending moored boom.
- Spill monitoring and tracking.
- Vessel salvage.

Ships and craft, such as offshore supply vessels, tugs or barges, may be provided by a number of sources, depending on the location of the spill and the nature of the response. Ships and offshore vessels provide convenient mobile command sites; some types of ships are suitable for use as working platforms, for towing boom/skimmer systems or for providing berthing, messing, medical or industrial shop support. Some ship types that are particularly useful during spill response operations include:

- *Offshore supply vessels (OSV).* The relatively small size and maneuverability of these vessels, coupled with a large, low-freeboard working deck and towing capacity, makes these vessels ideal platforms for skimmer support, dracone towing, spill monitoring, personnel and equipment transport and chemical deployment. Many OSVs are equipped with mud tanks and can be used for transporting waste oil. OSVs can be used as mobile command sites, although the smaller vessels may have very limited communications facilities. Most OSVs have berthing for only the normal crew of about five, although vessels designed for anchor-handling or salvage work usually have berthing for an additional 15 to 20 persons. Some OSVs, particularly those set up for salvage work are equipped with light cranes. Except for those equipped with controllable-pitch propellers, most OSVs cannot maintain the one- to two-knot tow speeds required for skimmer operations. The utility of OSVs can be expanded by embarking berthing, communications, work or equipment vans or liquid cargo containers for transporting waste oil.

- *Fishing vessels.* Fishing vessels vary in size and capability. Most have clear working decks aft or amidships and deck winches or capstans. Many have derricks or A-frames that can be used to lift skimmers, boats or oil boom. Most fishing vessels are suitable for towing or deploying boom and for offshore work in rough weather. Boom deployment operations are very similar to some fishing operations and are readily grasped by fishing crews. Fishing vessels of appropriate size can perform most of the tasks listed for OSVs.

- *Tankers and tank barges*. Tank vessels may be required to lighter a stricken tanker that is the source of the spill or to receive waste oil from skimmers or dracones.

- *Other barges.* Hopper barges are good receptacles for oily debris. Flat-decked barges can be moored at convenient locations as floating piers and work platforms to support skimmer and small boat operations.

- *Dredges*. Large liquid storage capacity combined with pumping systems designed to move viscous materials make hopper dredges ideal receiving platforms for heavy or weathered oil. Some dredges are able to skim oil. A Soviet dredge employed on the *EXXON VALDEZ* spill was designed as a trailing hopper dredge with oil recovery capability; several U.S. Army Corps of Engineers dredges were also used in the *EXXON VALDEZ* spill without modification.

- *Tugs.* Harbor tugs can deploy boom, tow boom, skimmers and dracones, transport personnel and equipment, support small boat and skimmer operations, tow disabled response vessels, position barges and assist with salvage operations. Like OSVs, many tugs may not be able to maintain the low towing speeds required for towed skimmer operations.

- *Military vessels.* Navy and Coast Guard ships typically have very good communications facilities and make excellent afloat command sites. Depending on size and configuration, military vessels may be able to provide medical support, messing, berthing and industrial shop support to spill response operations. Patrol craft are well suited for personnel and light equipment transport, spill monitoring and messenger duties. Combatants larger than small patrol craft are of little use as work platforms, but can be very useful in monitoring large spills, particularly those that carry helicopters. The Navy, Coast Guard and Army also operate harbor tugs (YTB, YTM, WYTM, WTGB, ST) and a variety of workboats. Because of their authoritarian nature, Navy and Coast Guard ships are well suited for keeping sightseers and other vessel traffic out of the response area. Certain military vessels described below are well suited to oil spill response work.

- *Salvage vessels (ARS, ATS, ASR, T-ATF).* Navy salvage ships and tugs are well-equipped for boom deployment and boom/skimmer towing operations. With lifting derricks or cranes, they can lift skimmers, boom and workboats to and from piers or transport them to remote areas. Communications facilities and office space are sufficient to allow them to function as command sites. Most salvage ships and tugs are equipped with one or two workboats and one or more inflatable boats. Ex-Navy ARS and ATF Class ships serving as Coast Guard cutters and some Army large tugs (LT) have similar capabilities. The T-ATF-166 design was derived from offshore supply vessel design, giving them many of the same features as described for those vessels. T-ATF-166, ARS-50 and ATS-1 Class ships are fitted with transient berthing for 15 to 20 people.

- *Amphibious warfare ships (LST, LSD, LPD).* Amphibious warfare ships have large messing and berthing capacity and their crews are used to maneuvering in shallow water close to shore. All are equipped with cranes or boom and kingpost systems and have large cargo capacity. As large ships, their communications and administration facilities are commensurately larger than those of salvage ships. LSTs can discharge cargo directly to shore in undeveloped areas, while other types can discharge cargo to shore via landing craft. Ships fitted with well decks can transport boats and skimmers to remote work areas and anchor to serve as a covered boat harbor and work area. Amphibious warfare ships are also well suited to returning response equipment to the ESSM Pools.

- *Buoy tenders (WLB, WLM, WLI).* As robust, relatively small and maneuverable working vessels, the capabilities of buoy tenders with regard to oil spill response is generally similar to that of salvage ships. The well deck amidships provides a good working area and a 30- or 20-ton boom gives a good lift capacity. Operated by the Coast Guard, buoy tender crews are familiar with both inshore and offshore operations and general oil spill response procedures. The Army Corps of Engineers operates vessels of similar size and configuration at a number of ports throughout the U.S.

- *Heavy landing craft (LCM, LCU, LSV).* Large mechanized landing craft are handy, maneuverable workboats, with large working decks suitable for embarking equipment, vans or vehicles. Landing craft are effective platforms for supporting skimmer operations, transporting personnel, equipment, vehicles or oily debris, monitoring spill movement and as general-purpose workboats. Because of their beaching capacity and shallow draft, landing craft are well suited to operations in shallow water and for transporting personnel and equipment to and from remote beaches. Landing craft are operated by Navy assault craft units, Army water transportation units and may be embarked on amphibious warfare ships. Modified landing craft are also operated by naval stations, Mobile Diving and Salvage Units and certain other units as workboats or diving tenders.

For Navy-originated spills, Navy ships and craft may be assigned support duties under fleet or shoreside NOSC contingency operations. Vessel assignments may be defined in NOSC contingency plans or made on request of the NOSC/NOSCDR following a spill. The Navy's *Environmental and Natural Resources Program Manual* (OPNAVINST 5090.1A) states that fleet salvage units should be assigned as fleet NOSCDRs, so it is likely that salvage ships will attend spills to which the fleet NOSC organization responds, as well as spills originating from vessel casualties.

For non-Navy spills, Navy ships and craft may be assigned to support FOSC requirements through regional response team agreements or through the USN-USCG interagency agreement. Commercial vessels may be hired by the spiller or various state and federal agencies as part of the contingency operations.

3-7 SUPSALV ON-SCENE SPILL RESPONSE ORGANIZATION

3-7.1 Command and Control. NAVSEA contracts for maintenance of SUPSALV oil pollution response equipment within the Emergency Ship Salvage Material (ESSM) system. When directed by SUPSALV full-time ESSM operations, maintenance, support and subcontractor personnel mobilize to the spill site. This mechanism enables NAVSEA to carry out Navy responsibilities for oil spill response.

Deployed SUPSALV resources are under the control and direction of the Supervisor of Salvage Representative (SUPSALVREP). The SUPSALVREP reports to the NOSC, NOSCDR or, when ESSM resources mobilize under the interagency agreement, to the predesignated FOSC. The SUPSALVREP is the personal representative of the Supervisor of Salvage and is responsible for:

- Liaison with the customer

- Liaison with government agencies

- Administration of the ESSM contract throughout the operation

- Technical direction and assistance to the ESSM contractor
- Daily contact with the SUPSALV office
- Recommendations about on-scene resource requirements

In practice, most SUPSALV oil spill activities are in response to FOSC needs for SUPSALV expertise and specialized equipment. As a result, SUPSALV and the ESSM system organizations are well known to and highly regarded by the Coast Guard and oil spill response communities throughout the world. Navy participation in any oil spill response activity is always welcome because of the special expertise and experience.

3-7.2 Command Organization. The project manager, the senior contractor charged with hands-on management of the response activity, assists the SUPSALVREP. Project managers are highly skilled oil spill response operators who typically have several years experience working within

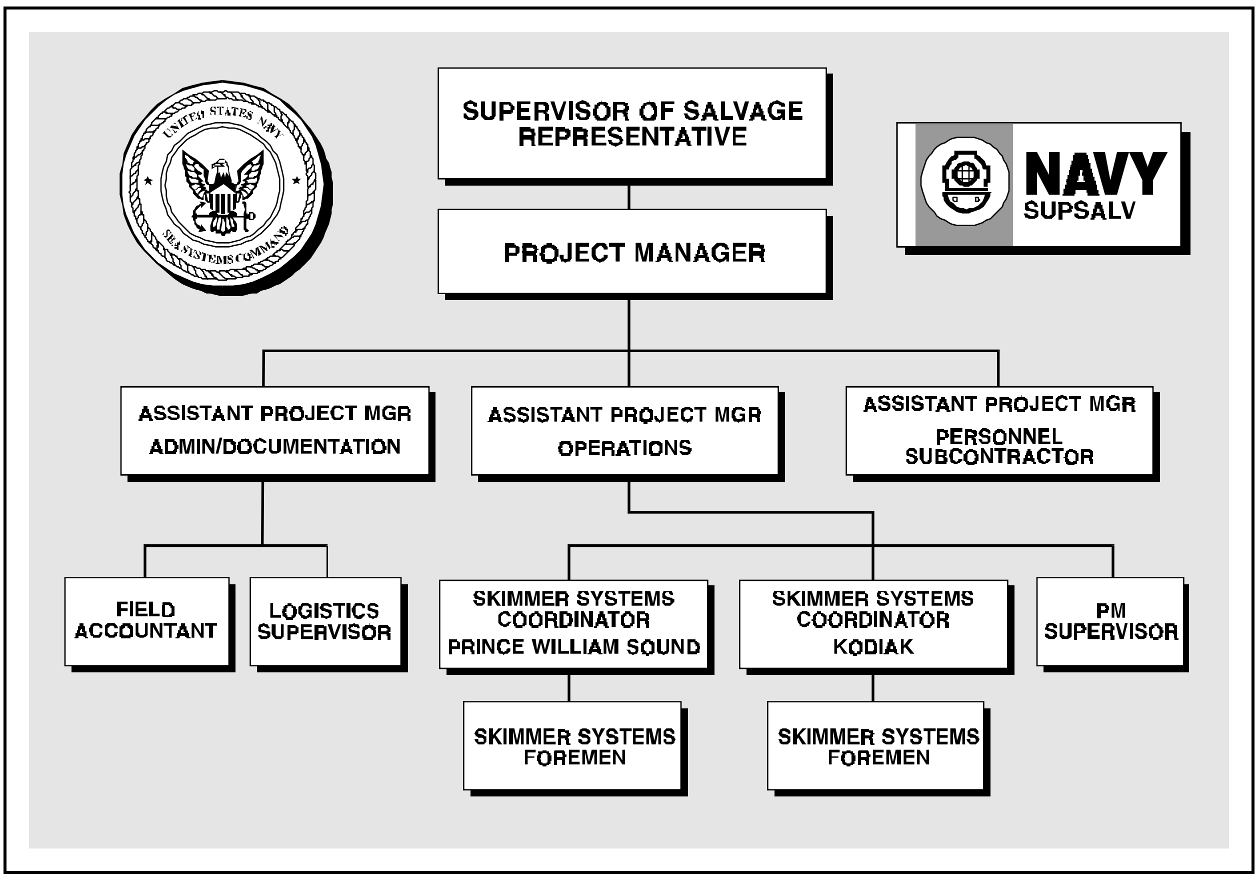


Figure 3-8. Supervisor of Salvage Valdez Spill Response Organization.

the ESSM system. As a result, they are intimately familiar with equipment and material in the ESSM inventory.

Figure 3-8 illustrates a typical deployed SUPSALV organization.

The functional positions for SUPSALV involvement in an oil spill response include assistant project managers for operations, documentation (administration) and personnel:

- Operations Managers are responsible for the resources on-scene, usually including skimmer operations, maintenance and the day-to-day activities of recovering oil and oily debris. The operations manager initiates daily reports.

- Documentation (Administration) Managers are responsible for accounting and report preparation. They also act as the office managers and the logistics coordinator, responsible for getting equipment to and from scene and expediting supplies. Typically, they spend much of their time with communications and handling the myriad of telephone calls that accompany any response operation.

- Personnel Managers are responsible for getting the proper number and mix of people to the right places. A major spill can require hundreds of personnel on-scene, some of whom must travel long distances or work at sites remote from the command center. Transportation, berthing and messing and compensation all require attention to detail to get people assembled and working quickly.

Very high, near frantic activity levels surround oil spill response operations, particularly during the first two or three days. Logistics requirements, people needs, media involvement and technical matters compete for supervisors' time and attention. During this period, people must focus their efforts on the principal objective—to recover oil and minimize damage to the environment. They must be certain their activities contribute to that objective. Without a clear understanding of priorities, inordinate time may be spent on less important matters, slowing the response.

The oil spill response organization can be thought of as an outdoor group (operations) and an indoor group (documentation and personnel). The primary function of the organization is to keep the outdoor group working nonstop. The indoor group furnishes the outdoor group with enough people, equipment and supplies for this to happen. Both groups are necessary for a successful operation. The concept of such an ideal and symbiotic organization helps managers assign priorities, particularly during the initial stages of a response.

3-7.3 Command Center Locations. The command center should be near the principal activity so day-to-day business does not require excessive travel time. Communications, transportation, topography and proximity to the water help determine command centers siting. Communications have the greatest influence. VHF (line of sight) communications work well close to shore and in flat country. In these conditions, support facilities can be spread out. High terrain and islands can block VHF, requiring operating units to remain close together or be supported by a more complex communications system.

A initial or temporary site should have telephones so people can call in reports or for instructions. Cellular telephones allow mobility so an automobile can sometimes serve as a command center for a small spill or as a temporary site. Motel rooms make good temporary command centers because telephones, food and berthing facilities are in a single location. The command center can shift to a more permanent site when the needs of the operation are more fully defined.

The ESSM command van is specifically designed for use as a temporary or mobile command center. Offshore supply vessels are suitable afloat command centers because of the large open deck area for loading vans and equipment. The command center for a major spill may consist of a command trailer and two command vans supported by the communications van and a network of telephone lines and VHF repeater stations. A communications van with a satellite communications capability is included in the ESSM inventory to support command centers in remote or offshore locations.

The command center should serve communication, transportation, and people needs so people can exchange information easily and make timely decisions during the response operation. It is usually convenient to have the assistant project managers located in one place, although there may be situations where collocation is not necessary.

Naval facilities are excellent command centers for nearby spills. The availability of piers, deep water berths, cranes, storage facilities, material-handling equipment, messing and berthing facilities, office space, communications facilities and manpower simplifies startup, coordination and logistics.

3-7.4 Logistics Center. The logistics center receives and handles equipment. The facility—a warehouse or yard—must have material-handling equipment to load and unload trucks and to move equipment from trucks and warehouses to the point of use. A record-keeping system must track equipment ordered, received and deployed. Activity is high until equipment deploys and routine established. It peaks again when units demobilize and equipment is prepared for shipment to storage.

3-7.5 Maintenance Center. The maintenance center assembles and services equipment. Because normal skimming operations occur only in daylight, routine maintenance is done at night when skimmers and boom handling boats are idle. The center must be close to the site of operations to reduce transit time. Offshore support vessels are excellent maintenance centers because their large open decks allow loading special equipment for the operation. Their mobility permits them to go where needed saving skimmer transit time.

3-7.6 Personnel Messing and Berthing. Personnel need food, showers, laundry and a quiet place to sleep. These basic creature comforts must be supplied in any oil spill response of more than two or three days duration. Personnel should be berthed close to operating areas, maintenance bases and their workplaces to reduce transportation requirements. A block of motel rooms will satisfy this requirement well in inhabited areas. In more remote areas, mobile homes can be rented. The ESSM inventory includes berthing vans and personnel support trailers for use when other messing and berthing is not available. Offshore or in remote areas, ships provide personnel support.

3-8 FUNDING AND COST ACCOUNTING

Commercial oil spill response equipment and services command premium prices. Costs are significant for large numbers of people or long-term rentals of equipment. Using equipment and services from other government agencies can reduce costs of oil spill response operations. To expedite arrangements, contingency plans should list federal and state government agency resources and points of contact.

Cost-effective and expedient coordination requires accurate cost documentation and constant communication with the other agencies. Cost documentation is particularly important when funds flow between agencies. There is always risk that an agency will have to terminate an agreement because of changing priorities. Interagency coordination is vital for operations to continue efficiently and to avoid crises.

Appendix C describes the fiscal accounting procedures and reimbursement requirements for SUPSALV assets. Cost accounting for other Navy forces is similar. As a general rule, costs attributed to an oil spill response effort should include all costs that would not normally have been accrued, such as:

- Fuel, lubricants and other consumables used by ships, boats and equipment.
- Personnel travel.
- Per diem, when personnel subsist on the local economy or cost of berthing and messing if provided on site.
- Equipment, aircraft, boat, vehicle and office rental.
- Overtime for civilian government employees and contractor personnel.
- Full wages, including overtime, for any short-term government or contractor personnel hired specifically for the response.
- Equipment mobilization, on-scene maintenance and rehabilitation, including transportation costs to and from the site, replacement of consumables and repair or replacement of items damaged or destroyed during the response.
- Telephone and utility bills.

Daily cost summaries should be provided:

- To the NOSC by the senior SUPSALV representative or salvage officer when ESSM assets or Navy salvage forces are assisting a NOSCDR in dealing with a large Navy-caused spill.

- To the FOSC by the senior Navy or SUPSALV representative when Navy assets are assisting with a federally coordinated spill response.

The daily cost summaries provide the NOSC or FOSC an accurate estimate of costs incurred to date and an opportunity to resolve any questions in a timely manner. Compilation of daily costs also facilitates estimates of total cost necessary for proper budgetary support.

3-9 DEMOBILIZATION

Demobilization, seldom addressed in manuals on oil spill response, requires planning and logistics support to prepare equipment for return to storage. Most oil spill equipment requires special care because it is expensive and designed for several years of service. During demobilization, special attention is paid to cleaning, maintenance, repair, transportation and handling of equipment for return to storage. One goal of demobilization is to return equipment to storage safely at a reasonable cost and within an acceptable period of time.

People’s attention, focused during the initial days of a response, flags during demobilization—activities no longer make daily headlines, people are tired and want to go home. Attention to detail during demobilization reduces repair costs and costs of preparation for the next operation. A demobilization that cleans equipment thoroughly, delineates all maintenance needed and prepares equipment properly for transportation is as much a part of a professional response as skimming.

3-9.1 Demobilization Planning and Logistics. Demobilization planning must begin before the response effort completes. As the response winds down, equipment no longer needed is removed from service, cleaned and made ready for shipment to storage. Incremental demobilization of equipment is a more orderly and effective process than simultaneous demobilization of the entire plant.

Imagination and initiative can reduce transportation costs. Demobilization lacks the urgency of mobilization although equipment must be returned to staging areas and brought to ready-for-issue status quickly. There is usually enough tolerance to permit transportation by inexpensive opportune lifts. Government ships and aircraft are cost-effective transportation. T-AFT-166 Class and LPD/LSD type ships are particularly suited to transporting large, bulky equipment and boats that have not been cleaned to commercial or air transportation standards.

Equipment cleaning is a major part of demobilization. The amount and degree of cleaning depend upon transportation requirements and the costs of field cleaning. Equipment must be clean for commercial transportation, but equipment can be cleaned by experts at ESSM facilities at a very low cost. Cleaning decisions must be made on a case basis. For field cleaning, suitable proper equipment must be staged and delivery of cleaning equipment and protective clothing, arrangements for material handling equipment and disposal of cleaning residue must be planned.

3-9.2 Equipment Cleaning. The ESSM inventory contains a cleaning van equipped for a moderate amount of field cleaning. Large items such as skimmers, boom, boom-handling boats and dracones are cleaned over a pool, much like a shallow swimming pool, to collect residue runoff and direct it to a collection point for disposal. The ESSM system contains two 60- by 40-foot portable boom cleaning pools designed to clean several 55-foot sections of boom simultaneously. Three or

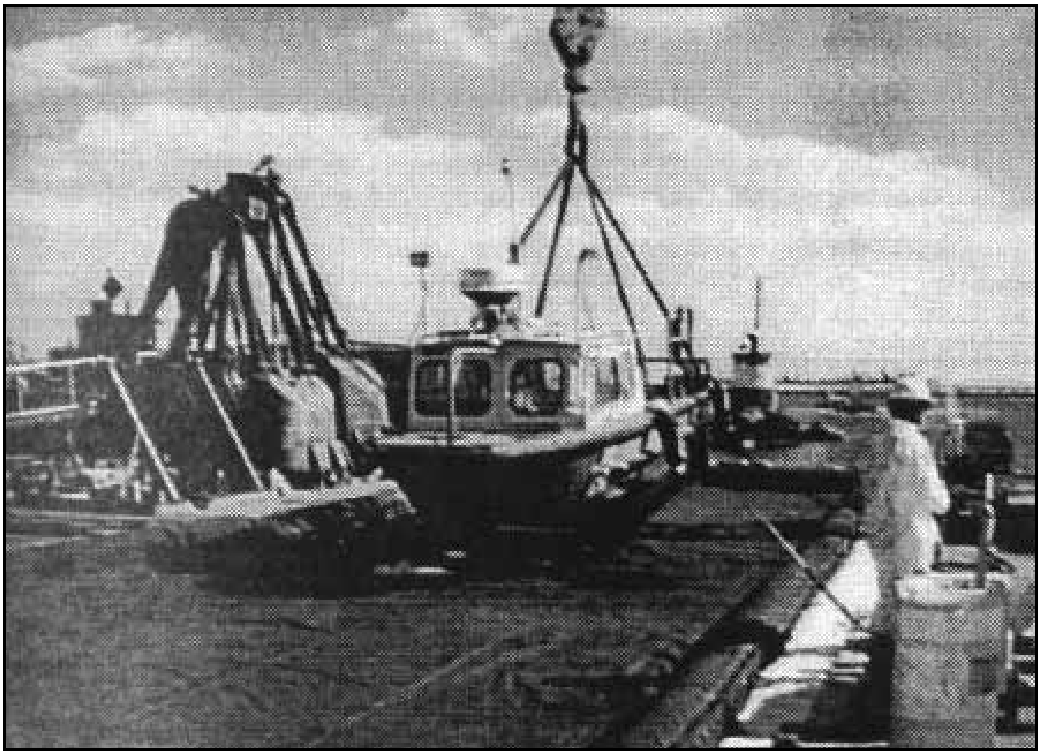


Figure 3-9. Cleaning Pool Operations.

four sections can be laid out in the pool. The pools are constructed of the same durable materials as the SUPSALV open ocean boom and have drains for attaching vacuum truck hoses to remove liquids. The pools act as a reservoir for the cleaning solvent, water and oil mixtures that result from the cleaning process. The reservoir sides are formed by chambers inflated with low-pressure air. The pools are portable, take little equipment to erect and can be set up in any location without digging pits or building berms. **Figure 3-9** shows a cleaning pool in operation.

Cleaning equipment accompanying the portable pools includes high-pressure water and solvent sprayers, air compressors, solvent, sorbent pads and rolls, brushes, scrapers, personal protective clothing and storage vans.

Dracones are difficult to clean in the field because their flexibility makes them hard to handle and drain. The cleaning liquid must be warm enough to keep the oil and debris fluid, but cool enough not to damage the dracone fabric. A marine chemist should be present to test the dracone interior for gases that may present personnel and/or fire hazards.

High-pressure hot water generators are required for efficient cleaning. Cleaning heavy oil residues require water and solvent mixtures heated above 120°F at pressures of 2,000 to 3,000 psi. Many different types of solvents cut oil efficiently. The ratio of solvent to water is usually very low. Although solvents and high-pressure-water washing facilitate cleaning, some manual scrubbing is always required, especially when intricate surfaces have been oiled.

3-9.3 Equipment Handling. Handling mistakes cause much damage to response equipment. Extra measures are needed to prevent equipment damage during demobilization.

Equipment usually is most efficient and is damaged least in its design environment. For example, containment boom, designed to be in the water, is seldom damaged in the water. Damage to boom occurs when it is streamed or retrieved from the water, transported or otherwise moved—most operational damage to boom occurs during demobilization. Boom can be torn when dragged over rocks or when impaled by a careless forklift operator. Equipment damage and the costs associated with repairs or replacement can be reduced by thinking out all equipment-handling operations and eliminating identified hazards. Supervisors must be alert to signs of indifference or haste on the part of operators who are anxious to complete the operation. Equipment should be handled with the same care and given the same protection during demobilization as during mobilization.

CHAPTER 4

CONTROL, CONTAINMENT and PROTECTION

4-1 INTRODUCTION

Spilled oil can be treated while it is floating on the water or after it comes ashore. It is simpler and less expensive to treat the oil while it is on the water surface before it spreads over a wide area. Initial, immediate spill response should focus on stopping or slowing oil flow with concurrent containment actions to limit the spread of already released oil. Measures to protect environmentally sensitive areas should be taken as soon as the direction of oil movement is determined.

Limiting oil spread facilitates recovery, reduces the length of shoreline that will be fouled if the oil slick reaches shore and limits the amount of water and quantity of wildlife exposed to the oil. Short of preventing discharge, containing spilled oil for prompt recovery is the most effective means of minimizing environmental impact of an oil spill.

Securing the source of a major spill can be difficult and time consuming. Unless damage control or oil removal actions can be initiated almost immediately after a ship casualty, initial spill size cannot be limited in most cases. Oil flows out of severely damaged tanks at an extremely high rate until the oil head inside the tank equals the water head outside. If this occurs before all oil flows out the tanks in a stranded ship, additional oil will be lost as the tide falls over the next tide cycle. In the 1989 *EXXON VALDEZ* spill in Prince William Sound, more than 95 percent of the oil spilled was discharged in the first nine hours following the tanker stranding—nearly 50 percent in the first 20 minutes—long before salvage or spill control assets arrived at the scene. Removing oil from damaged tanks can prevent additional oil discharge resulting from fluctuating water levels caused by waves, vessel motions, storms or extreme tides. Oil may be removed from undamaged tanks in a stranded or sunken ship to eliminate the potential for further discharge if the ship suffers additional damage.

Unlike spills from ships, where the spill source is finite, however large, oil well blowouts create a virtually unlimited oil spill source. Securing the source requires the services of specialists and may take months. Until the source is secured, containment is ineffective unless oil can be removed from within the containment barrier as fast as it is released.

The Navy's oil spill response philosophy, parallel to commercial operating procedures, is to capture the spill with containment booms for mechanical removal before oil reaches the shore. When it is not possible to contain spilled oil completely or prevent it from coming ashore, boom can be deployed to protect and divert oil away from sensitive areas or to bring oil ashore at selected locations.

The Navy spill response organization provides equipment and personnel through existing contingency plans. This chapter discusses spill containment equipment in the NOSCDR and SUPSALV inventories and related control and protection methods.

4-2 CONTAINMENT BARRIERS

Containment barriers prevent oil from spreading and contaminating sensitive areas. The most common barriers consist of floating containment boom. Pneumatic, chemical and water barriers can also contain oil, although not as effectively as floating booms.

Barriers are put in place to:

- Keep oil offshore and contained for removal by mechanical skimmers.
- Prevent oil from reaching waterways or other areas where oil spread will be accelerated.
- Keep oil concentrated in a small area to enhance mechanical removal.
- Divert oil into afloat skimmer systems.
- Direct oil onto the shore in selected locations for controlled pickup by manual or vacuum truck collection systems.
- Stop oil from re-entering a body of water from the shore as the tide cycles.
- Divert oil from sensitive areas.
- Establish an in-place, precautionary containment barrier during oil transfer operations.

The COMNAVSEASYSCOM and COMNAVFACENGCOM booms are available for oil spill response at ESSM and NOSCDR storage sites. **Table 4-1** shows the various types of containment boom and the applications for which they are best suited.

4-2.1 Containment Boom. The most common barrier systems are floating containment booms consisting of several sections or one continuous length of material supported by a buoyant system. There are many types of boom, but most include the following features:

- Flotation by air chambers or solid buoyant material.
- A barrier that extends below the buoyant system to prevent the passage of oil.
- Freeboard to prevent or reduce splashover.
- Longitudinal tension member (wire rope, chain or synthetic fiber).
- Ballast weights or chain near the skirt bottom to provide stability.

Boom is constructed with tough, lightweight materials that are durable and abrasion-resistant yet allow ease of handling. It must be flexible enough to perform in widely varying weather, currents,

Table 4-1. Application of Oil Containment Barrier

Operating Areas				Performance		Characteristics		
Barrier Type	Open Ocean Waves <3 ft Current <1 KT	Harbor and Bay Waves <3 ft Current <1 KT	Inshore Waves <1 ft Current <.5 KT	Wave Response	Strength	Handling	Cleaning	Com-pactness
Solid Buoyance	2	1	1	2	1	2	1	3
Inflated	1	1	1	2	1	1	1	1
Self-Inflating	2	1	1	1	3	1	2	1
Sorbent	2	1	1	1	3	1	N/A	2
Air-Water Barrier	3	2	2	2	N/A	N/A	N/A	N/A
Fence	3	2	1	3	2	2	3	3
Net	3	2	1	3	2	2	3	3
1 = Good 2 = Fair 3 = Poor								

temperature and locations. It should be portable and compact for rapid mobilization and demobilization. Boom is normally fabricated in 45- to 60-foot sections with end connectors to facilitate handling, deployment and storage.

Booms range in height from eight inches to 80 inches, measured from the top of the freeboard to the bottom of the skirt. The skirt depth can be up to twice the freeboard height. Most booms are made by fabric layering or double-wall construction for durability against punctures and deep abrasions from rocks, coral, workboats and oil skimmers. Materials are selected to give the boom a wide range of working temperatures. Ultraviolet stabilization in the material slows deterioration of the exposed floating sections from the sun's rays. Heavier boom components are designed to withstand the forces created by high waves or ice flowing against the system. Smooth polyurethane coatings prevent marine growth, keep oil from penetrating deeply into the fabric and facilitate cleaning the boom.

Open ocean boom is constructed with stronger, heavier fabrics, weighs more per linear foot, has higher freeboard and deeper draft than boom used inshore or in harbors. Where surface waves predominate, boom should have splash guards to keep oil from splashing over the barrier. Some ocean barrier booms have weir or suction oil skimming systems installed at the float-skirt interface. Openings in the fabric allow collection of oil. The major components of floating boom-buoyancy system, skirt, ballast, strength members and connecting points are described in the following paragraphs.

4-2.1.1 Buoyancy System. The buoyancy system keeps the barrier afloat. In conjunction with the skirt, the floating barrier stops the flow of oil on the water surface. The buoyancy members range from about four inches freeboard in small harbor systems to over 24 inches for open ocean barriers. Air or solid materials commonly supply buoyancy.

- Air-filled chambers give buoyancy and rigidity to the freeboard fabric. Air is usually supplied by a low-pressure blower. Inflatable boom is compact and relatively easy to handle during deployment, transportation and stowage. However, deployment of inflatable boom is slower than solid buoyant boom because of the time required for inflation and damage can cause loss of buoyancy that may compromise the barrier. Most inflatable booms are supported by compressors, connecting hoses and fill valves that require maintenance to ensure reliability in the marine environment. Some of the newer inflatable boom can be filled with air through a continuous supply line that eliminates delays caused by filling the boom section by section. Some air-buoyant boom is self-inflating. This type of boom has an internal system of coiled wire that causes the fabric to maintain a cylindrical shape. Vents allow air to flow into the float as the spring wire shapes the boom. When stowed, this boom lays flat as the boom is placed back onto the storage reel and air exhausts from free-flowing vents.

- Solid materials are either internal to the fabric making up the boom's freeboard or are attached as flotation devices on both sides of a solid barrier material. Permanently deployed systems can be set up with buoyant-filled boom without worry about sinking due to air loss. Solid buoyant booms can be deployed quickly as inflation is not required. Solid flotation booms require more storage space than inflatable booms and may deform in storage.

4-2.1.2 Skirt. The skirt forms a barrier from the water surface to the bottom of the boom and acts as a keel when the boom is towed. Water-ballasted skirts ensure stability and have a strong, effective underwater shape. When this type of boom is recovered, easy water and air removal facilitates repackaging and transportation. Increasing skirt depth beyond five feet does not necessarily make the boom more effective. The limiting factor in boom design is the flow of current acting against the boom. Generally, oil carry-under or entrainment occurs in currents exceeding 0.7 knots.

4-2.1.3 Ballast. Ballast keeps the skirt and float vertical and adds stability. Ballast is usually lead weight, liquid or permanently installed heavy chain that doubles as a strength member.

4-2.1.4 Strength Members. Strength members carry towing loads and prevent these loads from being carried by the relatively fragile flotation and skirt fabrics. Boom section connecting hardware, towing points and tension members are all designed to protect the float and barrier material from tearing by excessive forces working against the materials. Tension members can be continuous lengths of chain or wire rope fabricated into or attached to the float and skirt material. Boom material strength added to the tension member strength determines the overall boom tensile strength.

4-2.1.5 Connecting Points. The fabric at connecting points usually is reinforced to prevent tearing under strain. End attachments should keep oil from flowing between the boom and shore or ship connecting points. Special end connectors that attach to I-beams, pilings or magnets are common. Other connecting points are located on various parts of the boom for towing, maintaining a

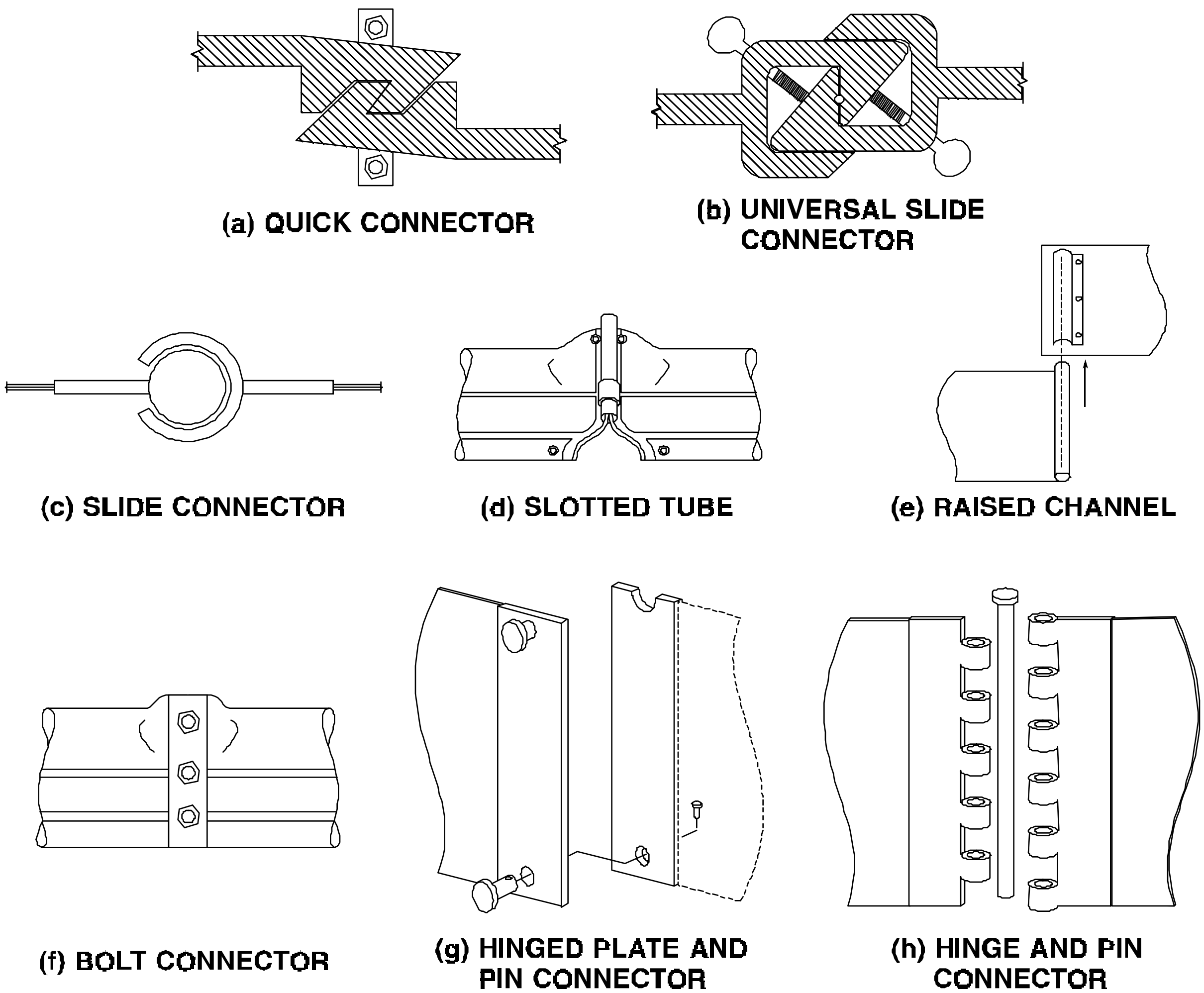


Figure 4-1. Typical Boom Configuration.

specific shape, connecting booms perpendicular to one another, etc. **Paragraph 4-2.3.1** discusses connector hardware in detail. **Figure 4-1** shows several types of boom connectors. Because there are so many types of end fittings available, it is important that replacement and additional boom purchased have compatible connectors so all boom can be joined together.

4-2.2 Types of Boom. Containment boom is classified by flotation method (inflatable or solid flotation) or by construction, application or special features. Some types of special-purpose boom are described in the following paragraphs.

4-2.2.1 Fence Boom. Fence boom consists of a single sheet of material forming both freeboard and skirt; floats and ballast weights are attached at intervals rather than continuously as in solid flotation or inflatable boom. Fence boom requires less storage space than solid flotation boom and has similar advantages. The main disadvantage of fence boom is that long spans of the boom tend to lay over in strong wind or current.

4-2.2.2 Sinking Boom. Construction of sinking boom is similar to that of inflatable boom, but it is usually made in longer sections. Sinking boom is useful when oil containment systems would block shipping traffic and have to be moved to allow ship passage. Heavy chain combination ballast and tension members hold the boom on the bottom when ships are passing. After the ship passes, the flotation cells are filled with air and the boom resurfaces to act as a barrier. In high-traffic areas, this type of boom can be permanently stored on the bottom and inflated when needed to contain an oil spill.

4-2.2.3 Net Boom. Net boom is designed to allow water to pass through the barrier while capturing tar balls and viscous oils. The system stops some of the products from unimpeded spreading and provides excellent containment in conjunction with conventional boom. Net boom is appropriate where products with low pour points are floating in waters subjected to excessive currents; most other types of boom lose effectiveness in currents above 1.5 knots.

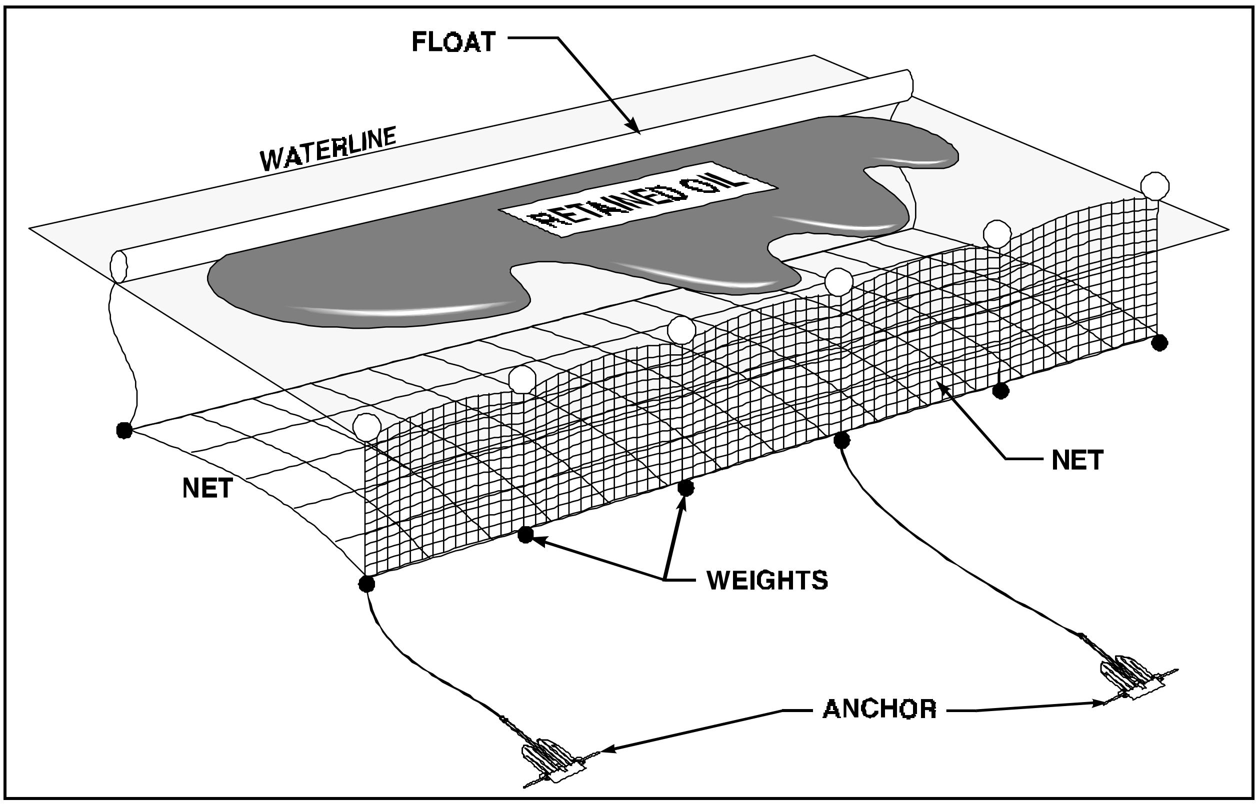


Figure 4-2. Anchored Net Boom.

Net boom has been successful in cold weather spills of heavy oils. Decreasing water and air temperatures increases the oil's viscosity, allowing nets to hold a high percentage of the oil. Deployment of net boom can be easy and quick because it is very lightweight. Net boom is very good for

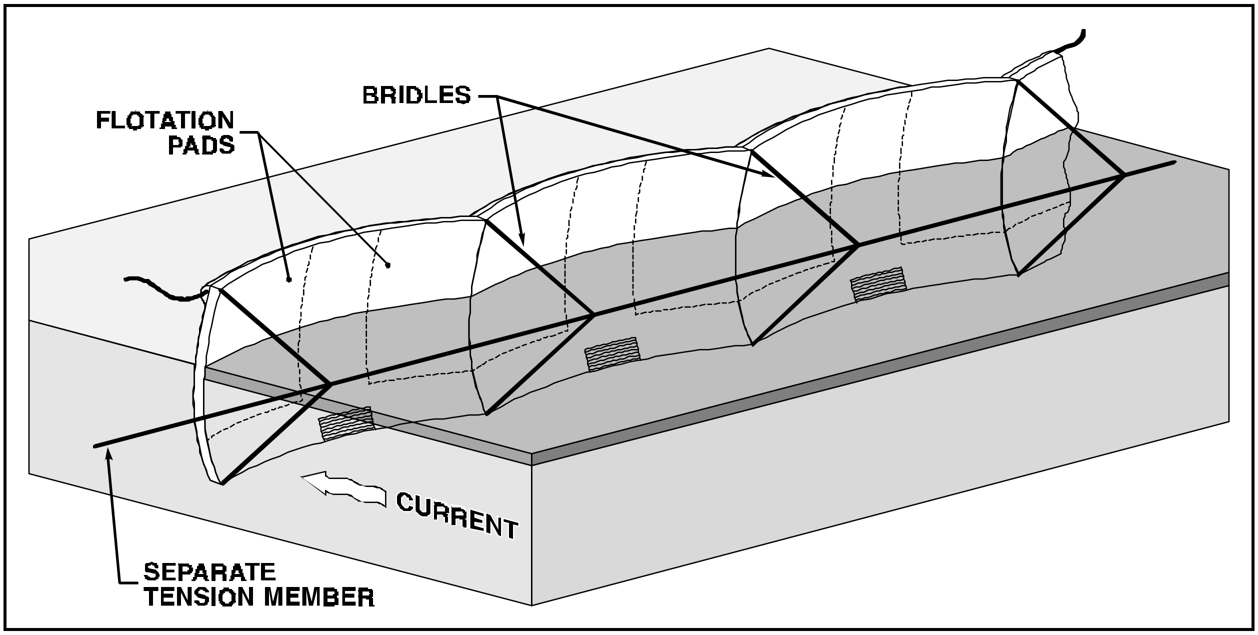


Figure 4-3. External Tension Member Boom.

keeping objects from fouling floating boom and making it ineffective. Net boom operation is shown in **Figure 4-2**.

4-2.2.4 External Tension Member Boom. The tension member of inflatable, solid flotation or fence boom can be rigged externally as shown in **Figure 4-3** to relieve stresses on the boom and improve seakeeping properties.

4-2.2.5 Fire Boom. Fire boom is constructed with components designed to withstand intense, long-burning fires and is used to contain burning oil as well as for conventional containment. Float outer fabric is PVC-based with the inner layers a combination of heat-resistant ceramics and abrasion-resistant stainless steel similar to steel-belted radial tires. Buoyancy is provided by a heat-resistant solid flotation core. Strength members are similar to that used in conventional boom.

4-2.2.6 Sorbent Boom. Sorbent boom is made from oil-sorbent material encased in a netted fiber that keeps the boom intact but allows contact with oil. Most sorbent materials repel water, absorb up to 20 times their own weight in oil, are long lasting and usually do not deteriorate or disintegrate. This boom can be effective for protecting sensitive areas when placed inshore of barrier boom or net boom across small, still waterways. It absorbs sheen and light layers of oil that get past containment boom and keeps contamination from shore plants, beaches and soils.

Sorbent type booms are not designed to contain oil from spreading in open waters like floating barrier booms, nor do they have great tensile strength. Sorbent booms do not have any appreciable draft. When the sorbent has absorbed a sufficient amount of oil, the boom is removed from the water and transported for recycling or disposal.

Sorbent boom can be used in the waterway as an oil collector. The boom is towed through the contained oil, absorbs the maximum amount of oil and is disposed of ashore. Practical applications of sorbent booms include containment and absorption of spills and effluent discharges in small canals, ditches, streams, rivers and around or under terminal docks and piers.

4-2.3 Boom Accessories. Boom accessories are hardware designed to handle, connect, inflate, deploy and retrieve boom. Other accessories are used after a spill to clean, repair, restow and transport boom.

4-2.3.1 Boom Connection Standards. During a large oil spill, several different types of boom may comprise a containment system. Standardized boom connectors are essential to connecting these different boom types. ASTM F 962-86 outlines the design criteria and requirements, desirable features and material characteristics for boom connectors with the following guidelines:

- Universal hook engagement design.
- Connector length not be the limiting factor for freeboard or skirt.
- Minimum tensile strength of 300 lbs/in2 or 54kg/cm2.
- Different length connectors should possess adequate strength, minimize oil spillage, be sexless and directionless, not reduce freeboard, be full boom height, and not impair stability and require no special tools for assembly. **Figure 4-4** illustrates various boom connection fittings.
- Features should include ease of handling, lightweight materials, connectable in the water, easily cleaned, safe and easy to install or remove.
- Materials shall be corrosion-resistant in seawater or designed with galvanic protection and may be of any kind as long as the design criteria, requirements and desirable features are fulfilled.

4-2.3.2 T-Connectors. T-connectors allow boom to be connected at 90-degree angles which gives more flexibility in the configuration of boom in permanently installed pierside boom systems. T-connectors also allow smaller ships requiring boom to attach in the middle of a long run of boom.

4-2.3.3 Sliding Connectors. Sliding connectors compensate for tidal rise and fall. The boom is kept in place with sliding plates or shoes that ride freely up and down stanchions or vertical runners fixed along the pier. Weighted lines attached to the pier and lowered over the floating boom can hold the boom in place effectively during tidal changes.

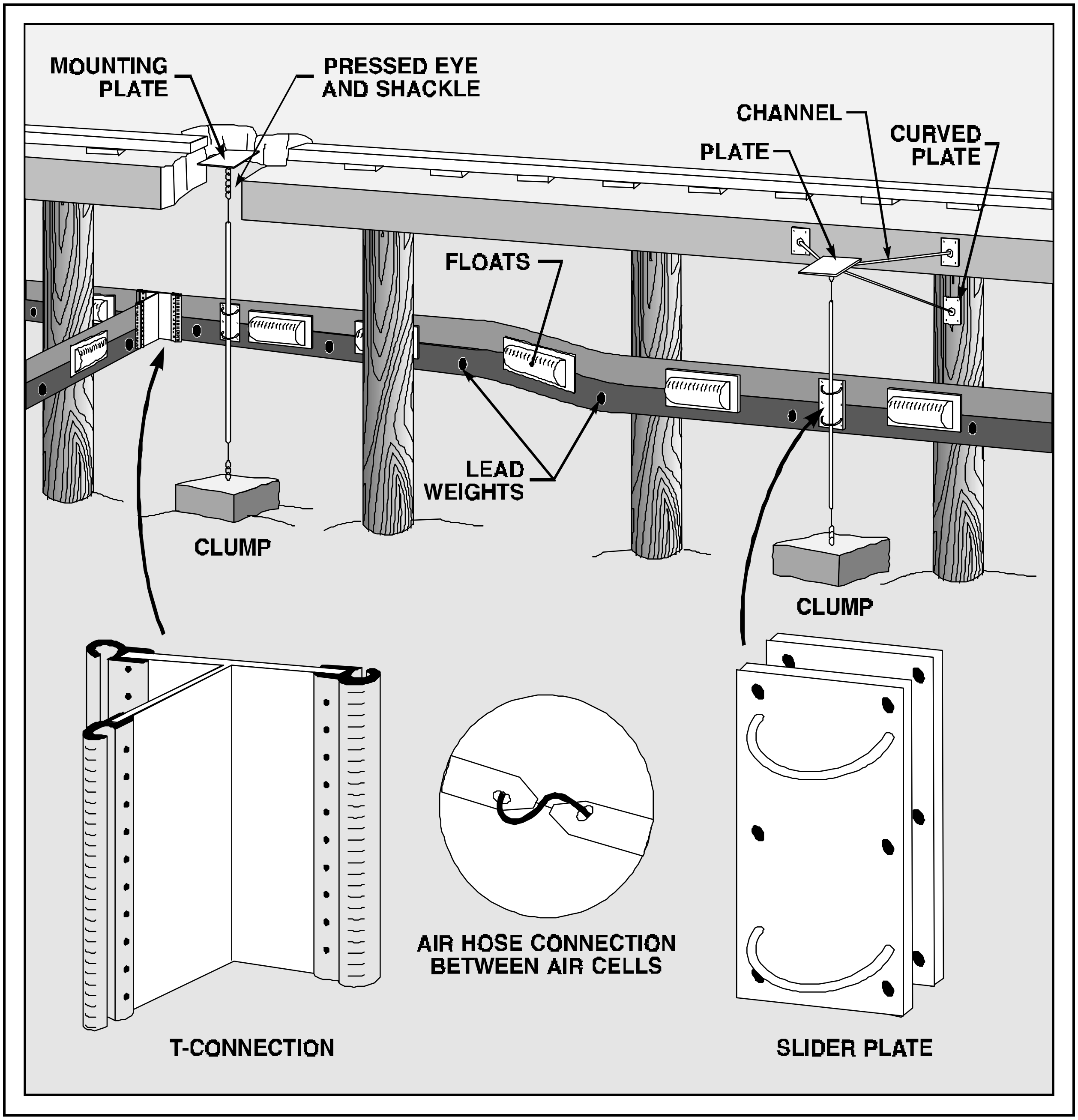


Figure 4-4. Boom Connecting Hardware.

4-2.3.4 Magnetic Connectors. Magnetic connectors are attached to ships' hulls or piers to hold the boom end connection. The connectors move with the ship as the tide changes, but must be moved when attached to a fixed object.

4-2.3.5 Deployment and Recovery Accessories. Deployment and recovery accessories aid in quick boom deployment and protection when moving between land and water. Boom storage and deployment units protect the boom in storage and have roller assemblies that allow easing the boom out with little chafing. Hydraulic or pneumatic storage reels deploy and recover boom at varying rates. These units aid in avoiding damage to attachment points and tearing the boom when small boats haul the boom away from the shore.

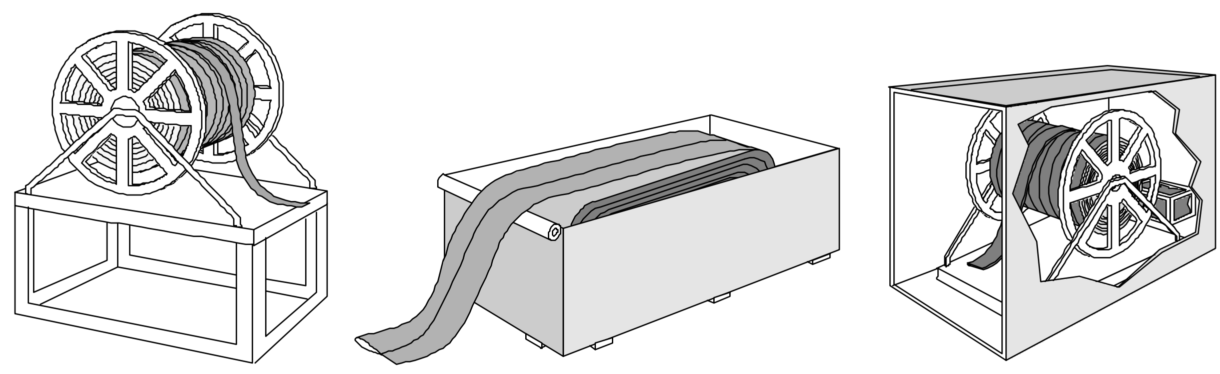


Figure 4-5. Boom Storage and Deployment Systems.

Large boom rollers, fairleads and storage reels should be positioned to avoid objects that can damage boom material. The land-water interface zones at oil spill mobilization sites are usually industrial waterfront areas. The piers or shore often contain objects that tear boom. Simple procedures such as covering sharp rocks and pier edges with heavy rubber sheets will keep boom structure from hanging up and tearing. Deploying and recovering boom from barges also means avoiding working in areas hazardous to the boom. Barges usually have unobstructed, smooth gunwales ideal for deploying the boom. Handling and storage systems are mounted on barges with little difficulty. Typical boom-handling accessories are shown in **Figure 4-5**.

4-2.4 Other Containment Barriers. Alternate containment systems stop oil from migration via small streams, ditches, canals or other avenues from the source to larger and less controllable bodies of water.

- Damming streams stops the spread very effectively, but blocked water accumulates behind the dam and creates problems where flooding is undesirable. Water buildup can be reduced by underflow or drain pipes that pass water in controlled quantities and keeps oil afloat behind the dam.

- Trenching to divert the oil flow when the stream flow is too fast for boom to be effective allows oil to be collected. Reflecting boom or net angled across the stream directs the oil into the diversion trench. The trench is dammed with drainage pipes to allow water flow back into the stream. The oil collects behind the dam for removal by skimmer systems.

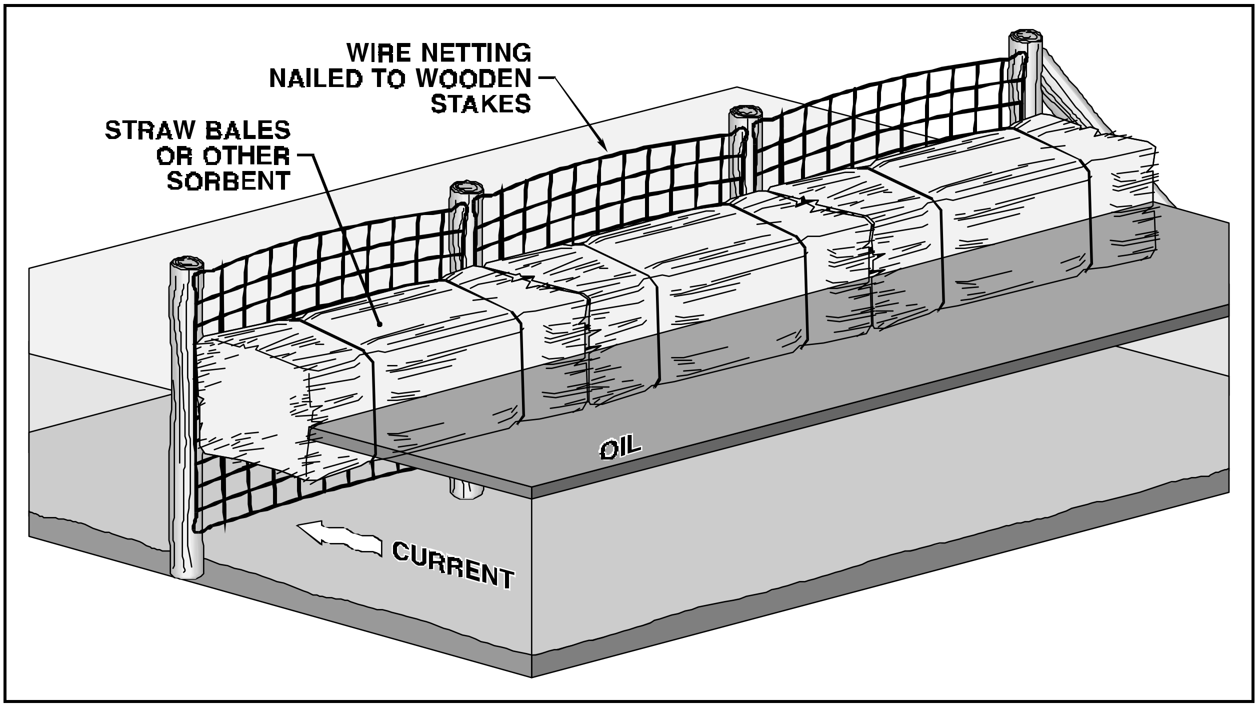


Figure 4-6. Typical Containment Fence.

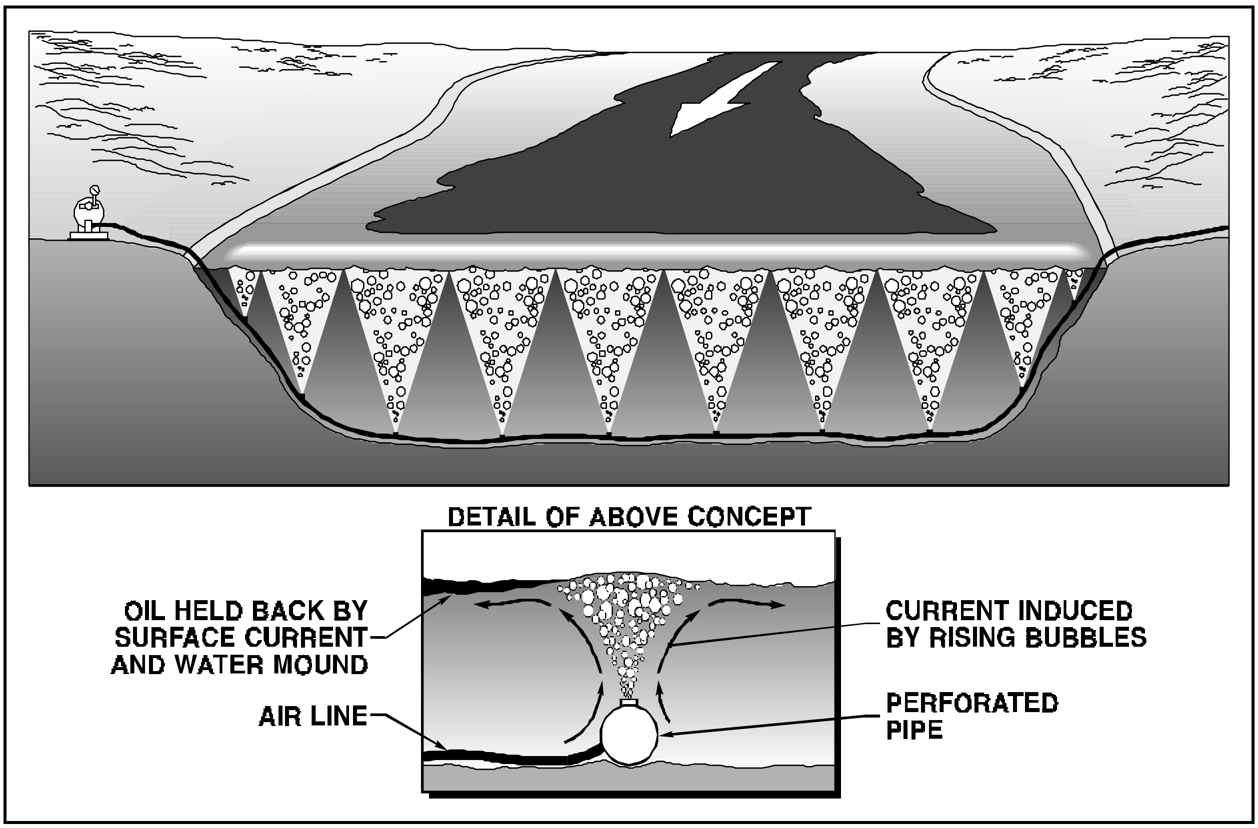


Figure 4-7. Pneumatic Barrier.

- Fences are wooden barriers built across the water flow to hold sorbent materials. The fences are not solid and allow water to pass. Oil is absorbed as it makes contact with the sorbent materials. Sorbent material is removed after it has extracted the oil from the flowing water. Fences do not stop all of the oil from passing; a series of fences improves oil removal efficiency. A typical fence type sorbent barrier is shown in **Figure 4-6**.

- Pneumatic barriers employ a screen of bubbles released below the water surface. The rising air bubbles create an upward water flow. At the surface, the upward water flow creates a slight mound on the water and diverts horizontally to form currents that flow away from the bubble stream as shown in **Figure 4-7**. The water mound and surface current can retain oil in low current areas. The principle advantage of pneumatic barriers is that they are fireproof and do not obstruct ship passage. Their primary disadvantages are the time and effort required to transport and set up air compressors, hose, diffusion piping and other equipment at the spill site and the fact that any malfunction that interrupts air flow will destroy the barrier and allow oil to spread. Pneumatic barriers may be permanently installed at oil terminals or other high traffic areas.

4-2.5 COMNAVFACENGCOM Boom. This boom is maintained and operated by NOSCDRs under the direction of the NOSCs at various locations worldwide. NAVFAC boom is procured by activities under Military Specification MIL-B-28617C. The three classes of boom depend upon the environment for which it is suited:

- Class I - for quiescent water with low currents and waves.

- Class II - for open water harbor environments with moderate waves and currents.

- Class III - for water with high waves.

The MILSPEC requires durability and ruggedness that is available only with closed-cell foam or other puncture-proof materials for flotation. All fabric must be able to pass strength, tear, abrasion and weathering tests. Other features required of boom complying with NAVFAC specifications are:

- Stability and strength during a straight line or U-shaped tow.

- Boom hardware that allows easy connecting and disconnecting in the water.

- Floating single-point tow assembly.

- Sliding bulkhead attachment points.

Table 4-2 shows the three NAVFAC boom measurements and operational ranges.

The Oil and Hazardous Substance Spill Response Activity Information Directory (AID), NEESA Publication 7-021C, lists all of the boom currently held in inventory at Navy facilities.

Table 4-2. NAFAC Boom.

Class*	Skirt Depth (in)	Free-board (in)	Total Height (in)	Current Velocity Perpendicular to Boom (kts)	Wind Velocity Perpendicular to Boom (mph)	Wave Height to Length Ratio	Intended Operating Area
I	8	4	14-18	1.0	15	0.08	Low current/wave height
II	16	8	24-28	1.5	20	0.08	Harbor - moderate current/ waves
III	24	12	36	2.0	25	0.08	Open water - high waves
*Boom sections are 500 feet long							

4-2.6 COMNAVSEASYSCOM Boom. SUPSALV maintains Class III type boom for use in the open ocean where choppy seas, high winds and strong currents can be expected. This boom is extremely durable and has proven to be effective in many oil spill cleanup operations from the Arctic to the Antarctic. The boom is maintained and operated through the ESSM system contractor at Cheatham Annex, Virginia and Stockton, California. The boom is described in **Table 4-3** and illustrated in **Figure 4-8**. A more complete equipment description and operations and maintenance procedures are given in *Operation and Maintenance Manual with Parts List for Oil Containment Book and Boom Mooring System,* NAVSEA S9597-AC-MMO-010.

Table 4-3. NAVSEA Oil Containment Boom (FUG, FUG-1)

GENERAL INFORMATION

The FUG and FUG-1 booms consist of 55-foot inflatable sections. For containment, a standard boom consists of 18 sections (990 feet). Two six-section booms (330 feet) are used in conjunction with the NAVSEA-towed skimmer system (see Figure 5-15). Boom sections are stored and shipped in standard 20-feet ISO freight containers, along with compressor, inflation equipment, sorbent pads and boom, marker lights, bridle and span lines, repair tools and spare parts. The boom sections are assembled for operation, connected in legs of six assemblies and stowed on pallets with two legs per pallet. Two pallets (four legs) are configured for skimming operations and one pallet (two legs) for containment. Mooring systems are stored and shipped separately.

SECTION/ASSEMBLY DESCRIPTION

Manufacturer	Goodyear Aerospace Corp.	Lifting Points	4
FSCM	56221	Inflation Chambers	
Models	FUG Standard, Full Bridle FUG-1 Bridle	Number Length	5 10 ft
Length (approx)	55 ft	Inflated Diameter	14 in
Freeboard	12-1/2 in	Buoyancy (approx)	615 pounds
Skirt (draft)	24 in	Container	
Weight	484 lbs	Dimensions (LxWxH)	20 x 8 x 8 ft
Strength		Weight, empty	4,973 lbs
Working	62,402 lbs	Weight, full	28,260 lbs
Proof	96,644 lbs	Door Opening	92 x 84 in
Ultimate	133,608 lbs	Pallet Size	52 x 78 in
Tension Member	Kevlar		

MOORING SYSTEM DESCRIPTION

Anchor	500- or 1,000-lb STATO with folding stabilizers	Accessories	Marker lights, crown buoy, floats 5/8-in wire rope, 6-in and 1-1/2 in polypropylene rope.
Holding Power	500-lb Anchor	1,000-lb Anchor	
Mud	8,800 lbs	17,600 lbs	
Sand	12,500 lbs	25,500 lbs	
Mooring Buoy	Foam	Shipping Container	Steel mesh or extruded aluminum panel.
Weight	700 lbs	Dimensions (LxWxH)	103 x 48 x 41-1/2 in. (mooring buoy stowed atop container adds 40 in to height).
Buoyancy	5,000 lbs		
Rated Throughpull	10,000 lbs		
Dimensions (dia x length)	48 x 88 in	Cube	110 ft^3 (without buoy) 275 ft^3 (with buoy)
Chain	2-1/4 or 2-5/16 in Stud-Link	Weight	
Length	90 ft	Empty	1,598 lbs
Weight	4,250 lbs	Full w/500-lb Anchor	7,600 lbs
		Full w/1,000-lb Anchor	8,340 lbs

REQUIRED SUPPORT EQUIPMENT

Boom roller.
Crane with 25-ton capacity at 15-foot outreach.
40,000-lb K-Loader for air transport.
9,000-lb forklifts.
Boom-handling boats (towing vessels) with minimum 3,000-lb bollard pull.

Boom-tending boat (small launch or inflatable boat.
Deployment vessel for mooring system (should be 40-ft work-boat or larger).
Marker buoys.
Rigging gear.

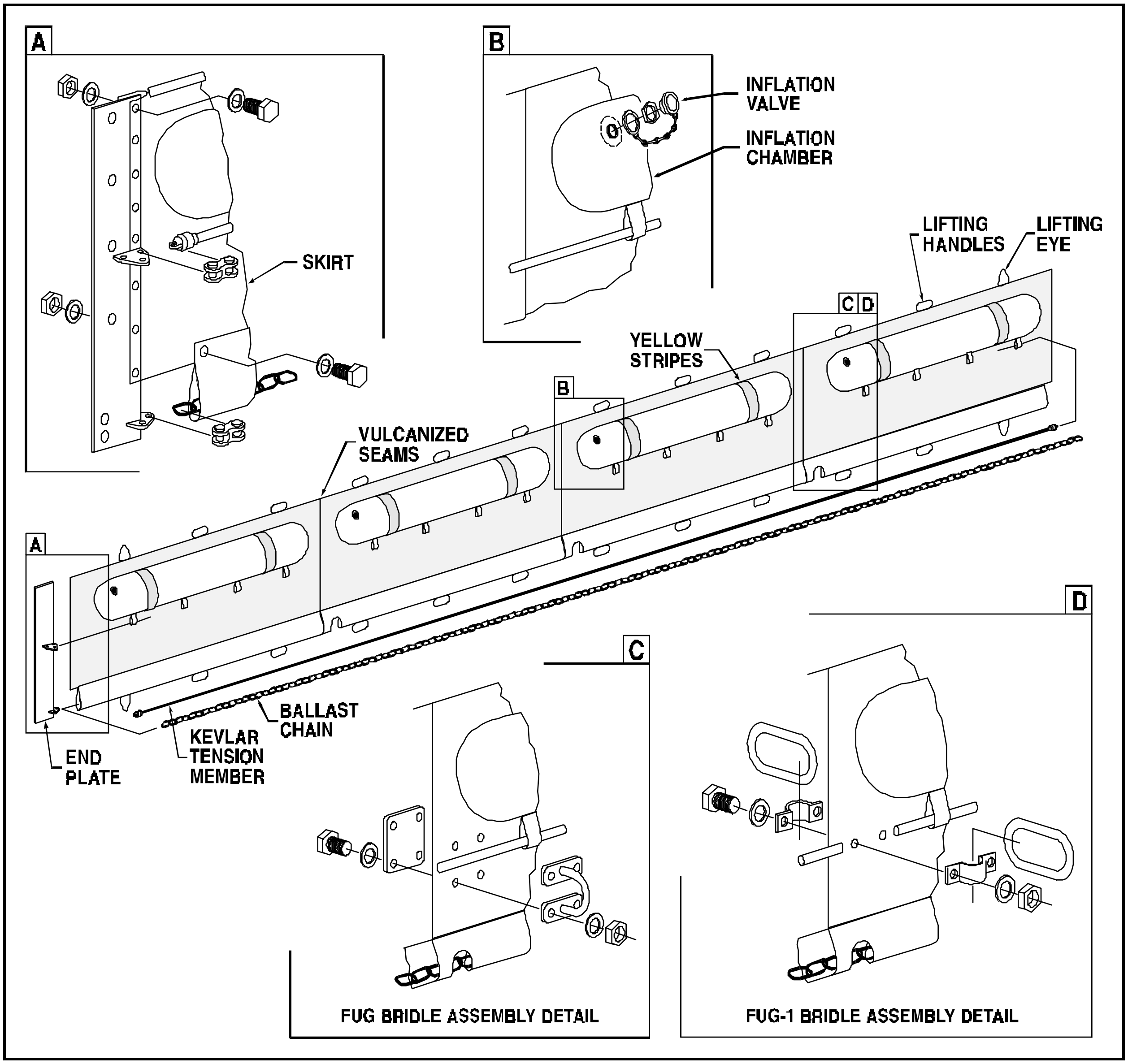


Figure 4-8. NAVSEA (ESSM) Oil-Containment Boom.

4-3 BOOM DEPLOYMENT

Boom should be deployed as rapidly as possible after the spill or when there is a threat of an oil spill. Permanently deployed boom is one of the best preventive measures against oil spill damage. The condition of deployed boom should be checked routinely to ensure constant effectiveness. All booms must be inspected for proper configuration and preventative maintenance. If the boom is not performing as intended, then it must be adjusted or modified. Similarly, all boom support components and mooring systems are inspected to avoid oil breaching the barrier because of inadequacies.

4-3.1 Deployment Methods. Optimum boom deployment depends on weather, sea state, proximity of land, water depth, shoreline topography, length of boom and number of handling boats available and other factors. Typical deployment can be categorized as:

- Encircling
- Waylaying
- Deflection
- Oil collection by towing
- Free drift containment
- Multiple setting
- Deployment in channels and rivers

4-3.1.1 Encircling. Oil can be contained by encircling if the slick has not grown too large to be surrounded with available boom. In some instances, ship hulls or shoreline can form part of the encircling containment barrier as shown in **Figure 4-9**. When a ship is to be completely encircled, boom length should be approximately three times the ship's length. The boom must be held away from the vessel's side with mooring systems, small craft or spacers to prevent chafing. If the ship is anchored, the boom must be anchored to leave sufficient room for the ship to swing with tide and wind changes. More permanent boom systems can be moored around stranded vessels. The containment system must allow for passage and operation of salvage ships and small craft.

4-3.1.2 Waylaying. When available boom length is not sufficient to encircle an oil slick, oil is waylaid by placing boom across the likely paths of floating oil, as shown in **Figure 4-10**. Booms are laid at some distance from the spill source to intercept the approaching oil. In tidal waters, booms should be laid on both sides of the spill sources to catch oil as tidal currents reverse.

4-3.1.3 Diversion. When spilled oil cannot be contained at the spill site, it can sometimes be diverted away from sensitive areas. It is sometimes possible to divert oil to a location where oil recovery can be accomplished more effectively, such as a sheltered bay. In some instances, it may be desirable to divert oil onto a carefully chosen shoreline location to prevent oil from coming ashore at more sensitive or more difficult to clean locations. Diversion should be toward skimmers or vacuum trucks or to the least environmentally sensitive areas. Diverting the oil ashore causes damage to the shoreline but eliminates oil that could spread to more environmentally sensitive areas. Before this procedure is put into practice, however, it is recommended that technical guidance be sought from the Scientific Support Coordinator or other similarly qualified personnel.

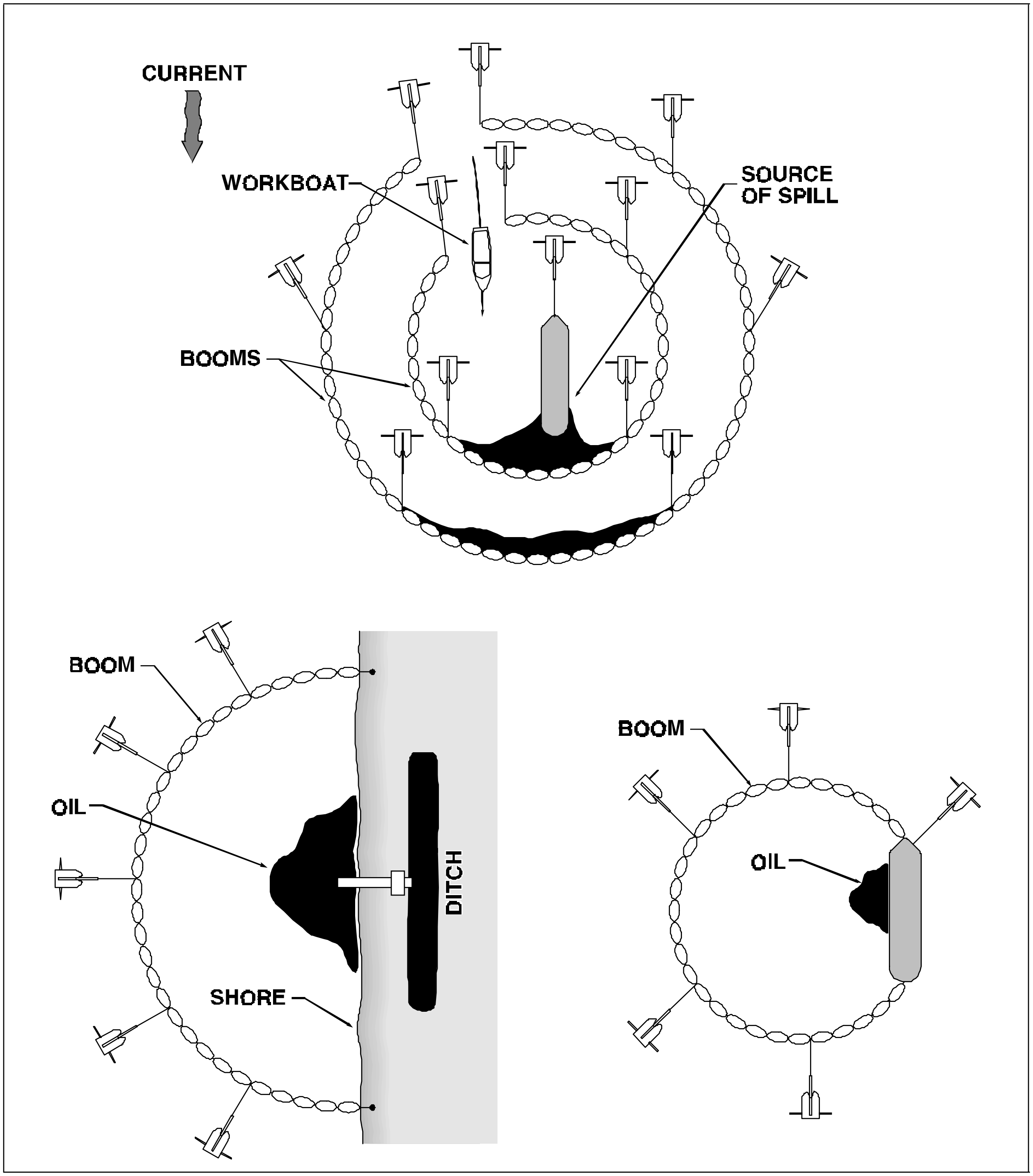


Figure 4-9. Encircling.

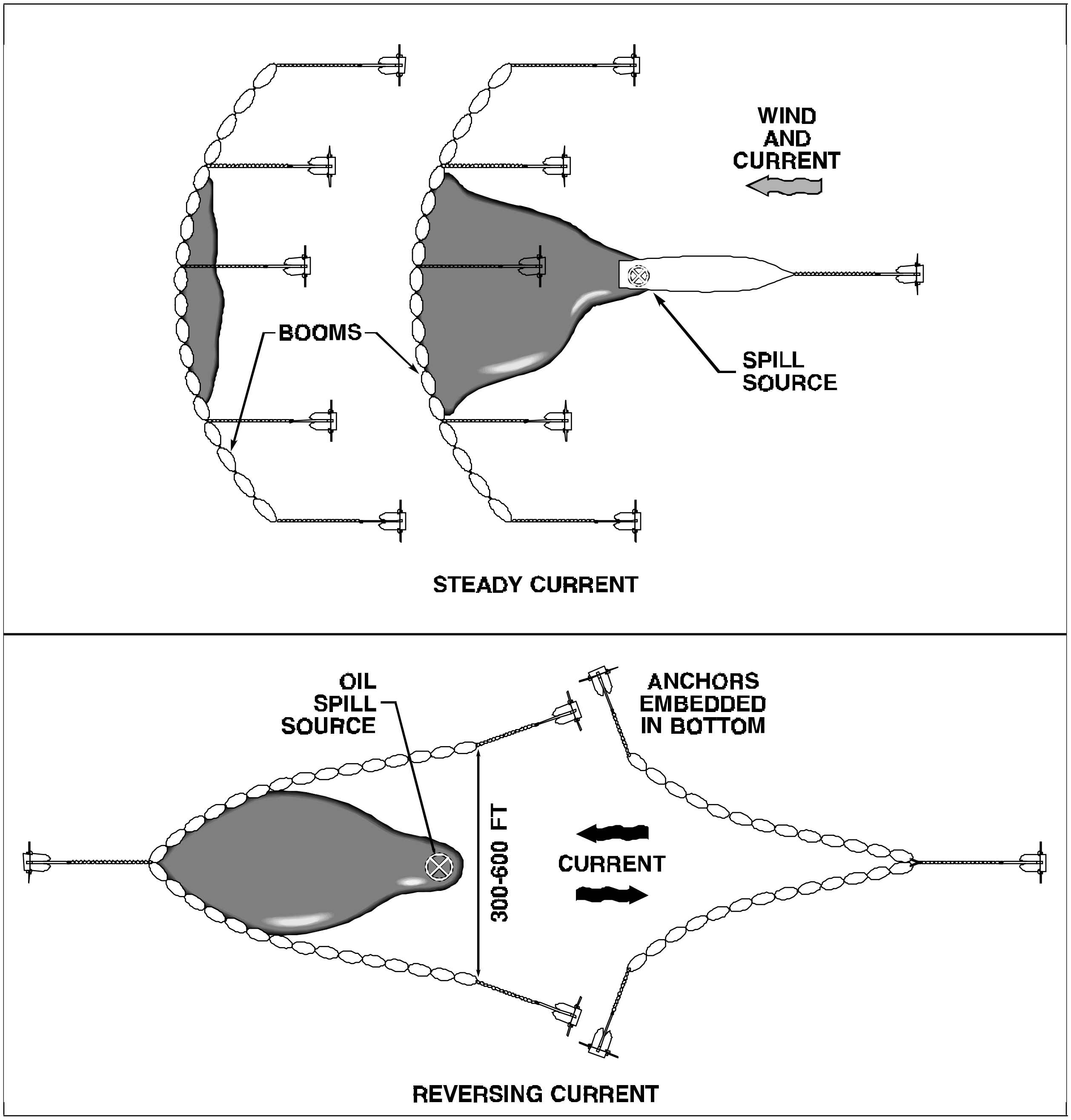


Figure 4-10. Waylaying.

Diversion is accomplished by laying boom at an angle to the current. Oil flowing unimpeded moves the same speed as the current. Diverting oil reduces the effective speed at which the oil flows. Diversion boom 70 degrees to the current reduces the effective oil movement to 85 percent, 60 degrees to 77 percent, 45 degrees to 55 percent, etc. Current effects on boom are discussed in **Paragraph 4-5.1**.

Diversion boom does not maintain nor should it be rigged to keep a straight-line shape. A straight-line boom is not desirable, as it tends to roll over and lose oil through entrainment. The force of the current naturally causes the boom to take a J-shape. The J-shape occurs toward the downstream end of the boom. Oil will eventually entrain under the center in the J-shape or around the end of the boom. This oil can be collected by a second boom and skimmer arrangement located downstream but away from the shore.

Large forces created by the boom trying to hold flowing water are reduced as the boom is moved to parallel the water flow. Mooring diversion boom in planned positions based on current and tidal flow directions makes the boom more effective.

Where the geography permits, multiple diversion booms may be rigged. Multiple booms—known as cascading booms—divert oil sequentially in the desired direction, as shown in **Figure 4-11**.

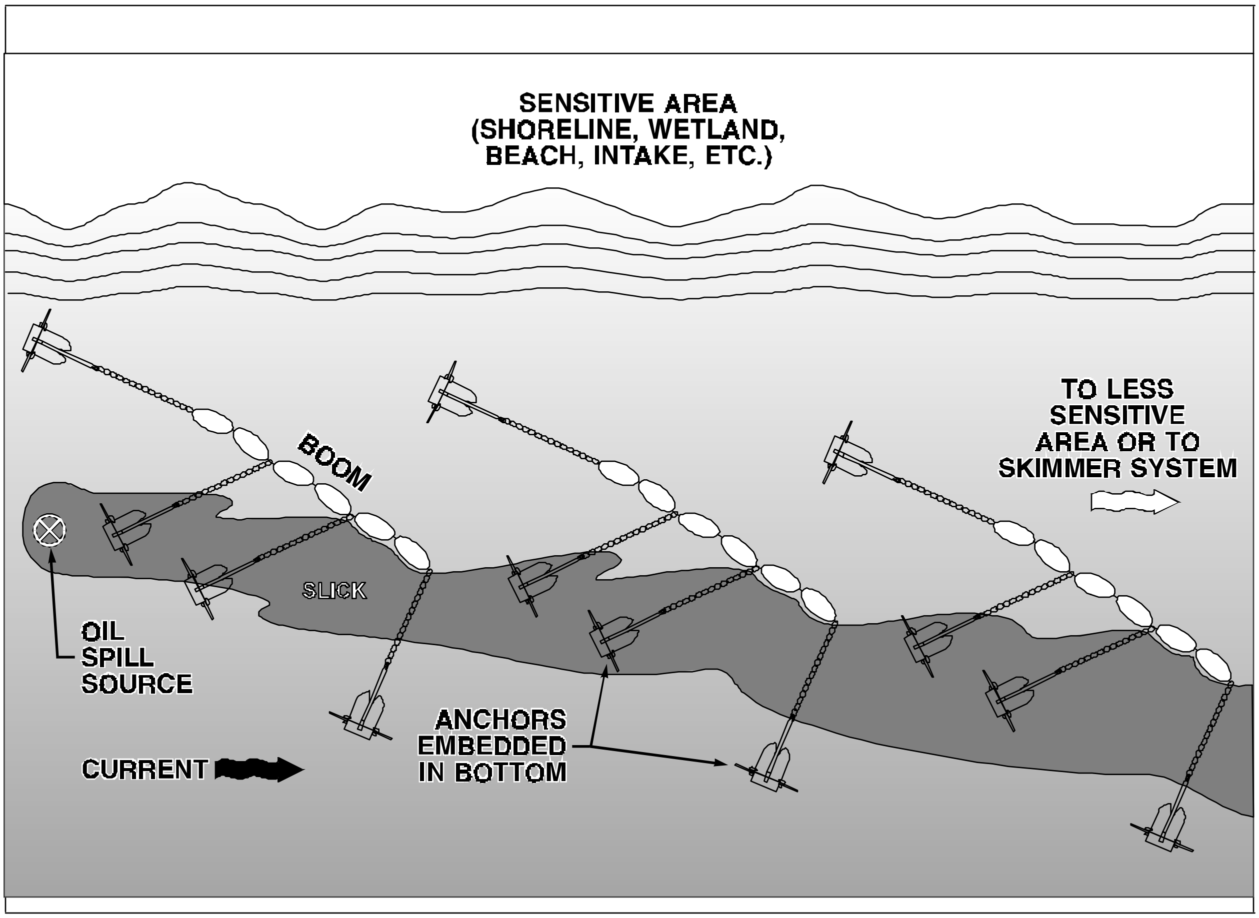


Figure 4-11. Cascading Oil with Boom (Plan View).

Oil spilled in waterways subject to fast-moving currents will spread over wide areas unless it is deflected ashore for manual and vacuum pickup. Oil may be deflected into slower moving currents. The primary purpose of deflecting oil into slower moving currents is so it can be dealt with more easily. Diversion boom can also divert oil past marina entrances, environmentally sensitive areas, water intakes and other areas of concern. In tidal waters, booms must be adjusted or secondary booms used to divert oil as it moves with tide change. The boom and skimmers used to pick up the diverted oil can be moved to continue recovery operations.

4-3.1.4 Towed Boom. Boom is towed to collect oil for recovery or to funnel oil directly into skimmers operating on the open water. **Figure 4-12** shows how lengths of boom are towed in a U-shape by two boats to collect oil and bring it to skimmers or other recovery devices.

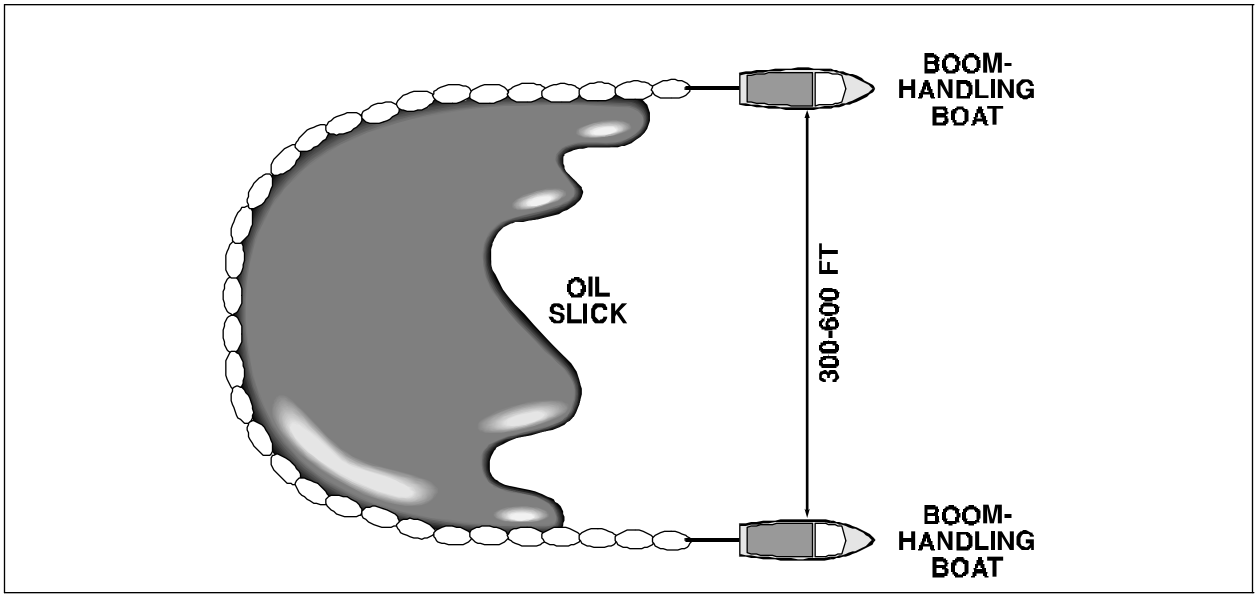


Figure 4-12. Towed Boom.

Sweeping or collector boom consists of sections of floating boom attached between an oil skimmer to a towing boat or boats. The boom directs the oil into the mouth of the skimmer for pickup or concentrates the oil in a small area where the skimmer operates. **Paragraph 5-3.4** describes skimming and sweeping operations with towed boom. Long boom distances between skimmer and towboat allow great surface areas of water to be skimmed.

4-3.1.5 Free Drift Containment. If boom cannot be moored because of current velocity or water depth, oil can be encircled by freely drifting boom to concentrate the oil for recovery. Drift rate of the boom and encircled oil can be slowed by attaching sea anchors or trailing chain in shallow water.

4-3.1.6 Multiple Setting. Oil can escape encircling or waylaying boom for a variety of reasons. Setting additional booms separated by 3 to 15 feet increases the amount of oil contained for subsequent recovery.

4-3.1.7 Deployment in Channels and Rivers. Oil can be kept from spreading in narrow channels by laying boom at appropriate angles, depending on current velocity, as shown in **Figure 4-13**. A limited opening can be left to permit vessel traffic.

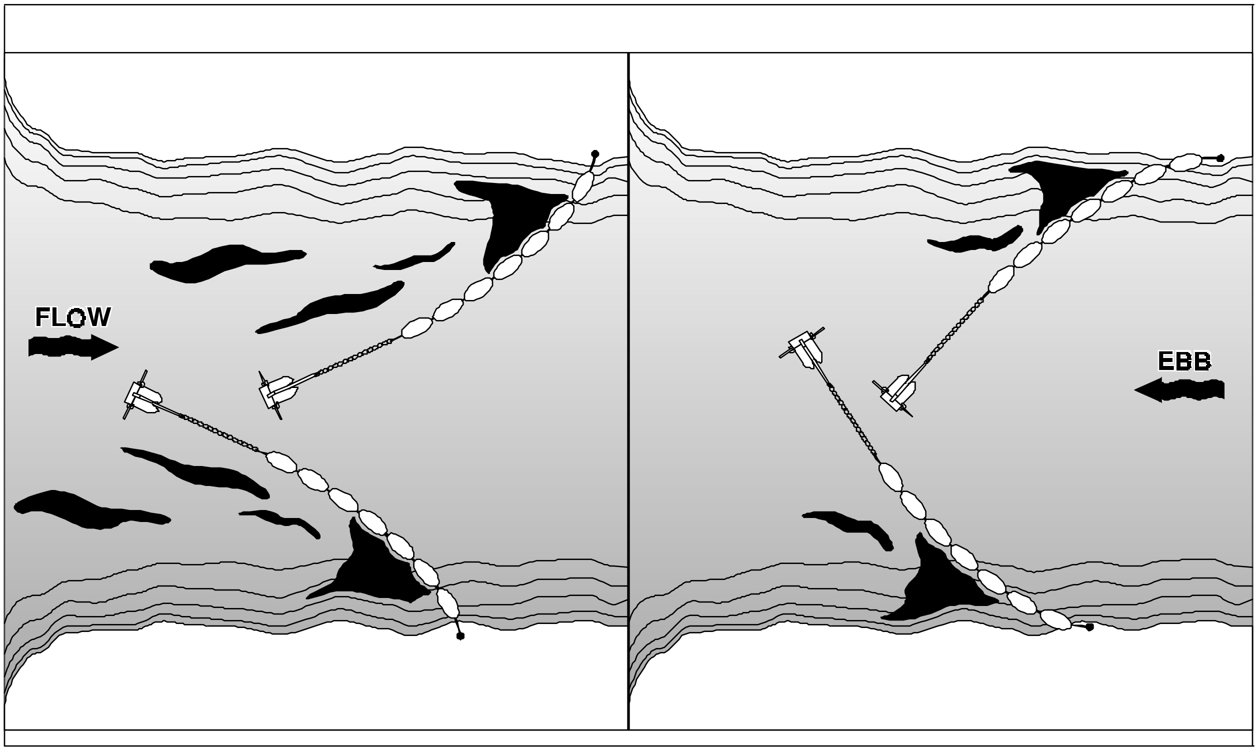


Figure 4-13. Staggered Boom Deployed Across a Channel.

Boom can be laid across slow-moving streams leading to open waterways to prevent oil spilled upstream from spreading into the waterway. The boom can be permanently deployed as a preventive measure against spilled oil flowing uncontrolled from the source. This barrier provides a suitable collecting point for shore-based vacuum trucks or portable skimmer systems for quick removal of the oil. If not predeployed, then the boom can be located ready for deployment at predetermined sites. Following a spill, personnel should be dispatched quickly to place the boom into the most effective position. Contingency plans should identify the areas where predeployed booms are to be located, how they should be deployed and with what equipment.

Diversion of oil from a river into the open sea may lessen the impact on sensitive estuaries and should be considered as an alternative. When oil is diverted into the open ocean by current, it may dissipate in the water column or evaporate. Diversion into open water may be desirable when the environmental impact is considered, especially if water depths increase rapidly offshore and prevailing currents will carry the oil offshore.

4-3.1.8 Beach Interface Boom. Beach interface boom acts as a barrier to oil as the tides rise and recede. Air-floated, water-ballasted boom is very effective in this application. Because the skirt is water-ballasted, the boom sits upright on the ground when the tide recedes. During flooding, a seal between the ground and boom is provided by the weight of the water-filled skirt pressing against the ground. As the water rises with the incoming tide, the float barrier and water skirt rise with the water level. The vertical barrier between the oil and beach is never interrupted. More conventional floating boom might allow oil to get past the skirt during the time the nonsealing skirt is laying lazy and not perpendicular to and in close contact with the ground.

4-3.2 Deployment Procedures. Deploying boom is a coordinated effort between boat operators and personnel aboard barges, skimmers or ashore. Efficiency in this evolution is gained through regular team training. Procedures that help successful boom deployment are:

- Assemble boom before launching or as the boom is hauled into the water. Attaching boom from small craft is dangerous, difficult and slow.
- Launch boom *into—**not** across* current. Towboats should have sufficient power to maintain headway into the current.
- Moor booms at one end and stream them with the current.

Most importantly, successful deployment of oil containment boom requires judicious use of common sense. Every boom deployment is different because of geography, environmental conditions and experience levels of people involved. Important ingredients for success are good seamanship and small boat handling. Persons in charge should discuss the evolution with their people prior to actual deployment to achieve desired results and assure safety.

4-4 BOOM MOORING SYSTEMS

Boom mooring systems should keep the boom in place in the maximum current and tide in a specific area. Boom cannot be expected to be effective at right angles to the current. Good boom system design provides a method to slack the boom to an aspect more parallel than perpendicular to the current during high-current periods.

Oil spills in ports and other inland waterways are frequently close enough to the shore to allow one end of the boom to be anchored ashore. Several anchors secured to buoys and lines at regular intervals along the boom are necessary to eliminate the belly caused by the forces acting against the boom skirt and floats. Mooring systems should be laid out, assembled and tested before they are needed. Ad hoc mooring systems improvised in the field have proven to have a low potential for success.

4-4.1 Selecting Mooring Anchors. The anchor must secure the boom against wind- and current-generated forces. The total force can be estimated by applying formulae for wind and current forces and summing the results. Anchor holding power must be greater than the total force. **Appendix E** describes boom mooring calculations.

Water depth and combined current and wind forces determine the anchor size and optimum anchor chain scope to keep the system in place. Buoys between the anchor chain or line and boom help maintain the correct aspect of the boom. The scopes of line from the boom tension member, buoy and anchor varies with the forces against the boom. Normally, scopes of at least five times the depth are needed. A shot of chain between the anchors and mooring line adds weight to the moor, increases bottom contact and friction and holds the anchor shank and pull on the anchor parallel to the bottom—all these increase the efficiency of the moor. A typical mooring leg is shown in **Figure 4-14**. **Appendix G** of the ***U.S. Naval Salvage Manual, Volume 1***, S0300-A6-MAN-010, provides an in-depth discussion of anchor performance.

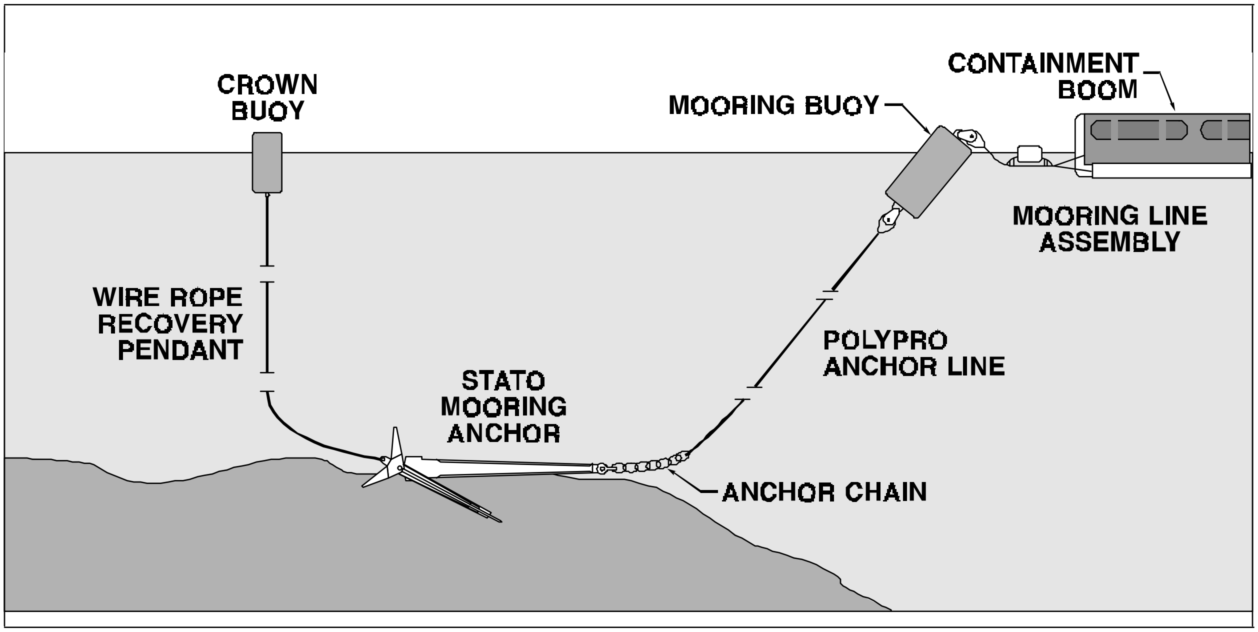


Figure 4.14. SUPSALV Mooring System, Oil Boom Recovery System.

4-5 BOOM BEHAVIOR

Bad weather often makes a boom useless. Wind, waves, currents and ice all decrease boom effectiveness. Booms made ineffective by weather should be left in place whenever possible. An efficient boom remains perpendicular to the water surface. Changing the boom's aspect reduces the forces affecting it and makes the boom partially effective until the weather subsides.

The ability of a boom to retain oil depends on its size, profile and ability to conform to waves. The ways in which oil escapes a containment boom are shown in **Figure 4-15**. In addition, oil can escape through poor connections between boom sections.

4-5.1 Current Effect on Boom. Oil entrainment or underflow occurs when the boom skirt is no longer vertical; oil flows down the face of the skirt and under it as the current increases. Tests show that boom subjected to perpendicular current entrains oil at about 0.7 knots. **Figure 4-16** shows maximum deployment angle to keep the component of current velocity perpendicular to the boom skirt below 0.7 knots for different current speeds.

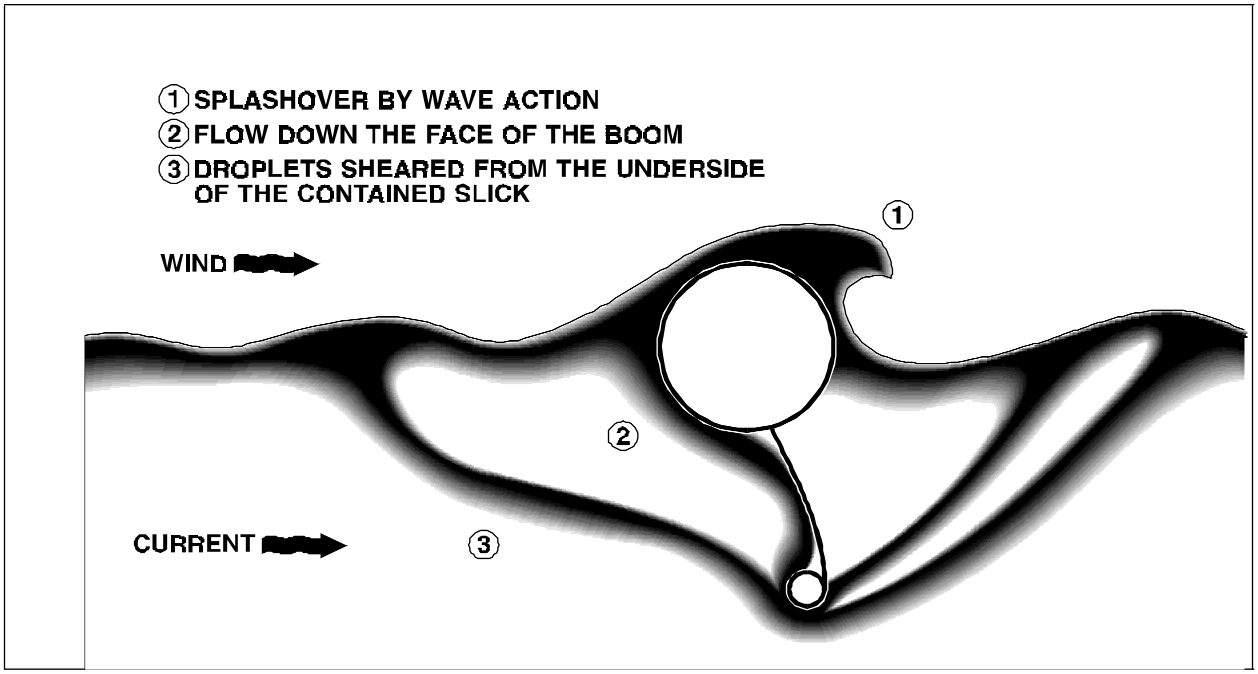


Figure 4.15. Escape of Oil from a Boom.

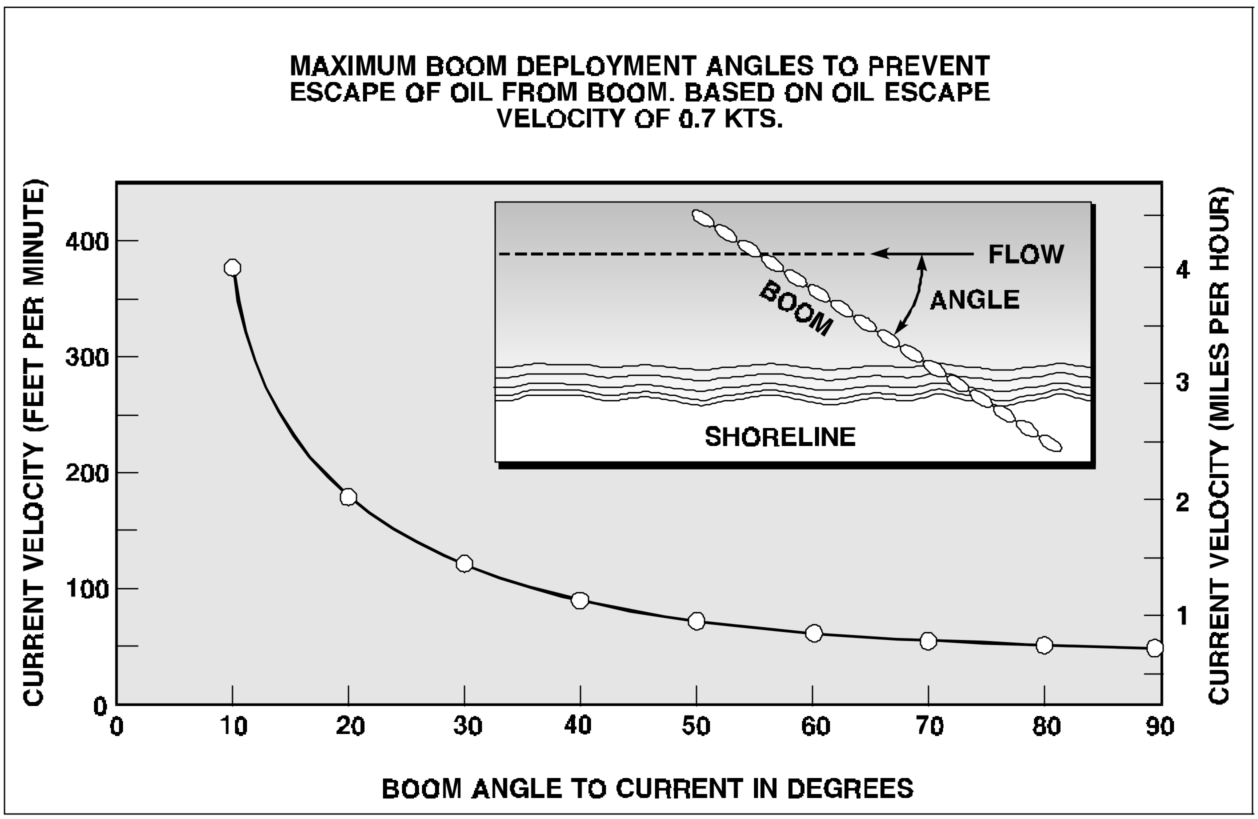


Figure 4.16. Boom Deployment Angle vs. Current Speed.

4-5.2 Wind Effect on Boom. High winds can create surface waves that can in turn cause oil overflow or splashover and reduce boom effectiveness. Wind tends to lay the boom over in the direction of the wind and lessens boom efficiency. High winds can cause a mooring system or boom-handling boat system to drag.

Wind can generate waves that carry oil over the barrier. To prevent this, some boom is constructed with splash guards located near the top of the float and extending outward. As waves attempt to wash over the float, the splash guards deflect the oil and water backward.

4-5.3 Wind and Current Combinations. Wind and current acting on a boom from the same direction tend to keep the boom upright. The freeboard and skirt flair in the same direction.

Conversely, wind and current acting on the boom from opposite directions tend to roll the boom over because the freeboard and draft flare in opposite direction.

4-5.4 Ice and Boom. Ice moved by current can drag anchoring systems, roll boom over, damage the flotation cells and skirt or completely destroy the system. Boom intended for ice-laden waters requires upgraded strength members. Most boom skirt and float materials are damaged by exposure to heavy ice for prolonged periods. When ice is anticipated, heavy and durable boom systems should be used.

The SUPSALV boom has been subjected to ice conditions in Alaskan waters and performed well. The boom retained its shape and remained intact even though the mooring anchors were dragged as the ice moved. In some instances, the best procedure is to disconnect the boom and trail it from one anchoring point until the moving ice has passed. Some commercial booms have been successful in ice, but most existing booms show instability in ice.

If ice movement is slowed by conventional boom, spreading oil is delayed in reaching sensitive areas. Net boom positioned between the ice and containment boom can protect the boom from damage or fouling by ice. The ice acts as a barrier to oil, but becomes oiled and must be disposed of as part of the cleanup.

4-6 BOOM DEMOBILIZATION

Demobilizing boom after the spill can be time consuming, tedious and difficult. All oil residue must be removed before repacking the boom for transportation. Factors such as temperatures at the cleaning site, duration of exposure to oil and oil viscosity determine cleaning efficiency. Boom cleaning usually takes longer than the cleaning of the other response equipment because of the large amount of surface area. Experience has shown that most of the operational damage to boom occurs during demobilization. Most of the damage is caused by rough, careless handling by tired people. Supervisory personnel must ensure that boom is handled with the same care and given the same protection during demobilization as during mobilization.

4-6.1 Facility Support Equipment. Boom rollers, chafing gear, crane support, forklifts, portable lights, lined dumpsters and vacuum trucks are necessary support equipment for cleaning boom. Sufficient equipment must be available to support 24-hour cleaning operations. Giving material and equipment supply and transportation companies as much lead time as possible eliminates work stoppages. Twenty-four hour work schedules during large spill operations stretch the availability of lights, dumpsters, vacuum trucks and other equipment in the immediate area.

If one cleaning station operates efficiently with two high-pressure hot water cleaners, at least one spare should be available to ensure continuous operation. One vacuum truck can usually support multiple cleaning pools, but a relief truck should be on scene well before the first truck is full.

4-6.2 Boom Cleaning Procedures. Cleaning procedures are usually the same regardless of the type of cleaning facility. General cleaning procedures are:

- Towing the boom to the cleaning site. Boom is detached from the skimmers or mooring systems and brought to a holding area near the cleaning facility.

- Booming off the oil soaked boom. Oil continues to bleed off of the boom as long as it remains in the water. Containment and sorbent booms must be deployed around the boom to be cleaned to prevent further pollution.

- Hauling the boom ashore. Cleaning sites are usually located near the same areas from which boom and skimming equipment are deployed. These areas should be selected with ease of hauling equipment in and out of the water as a criteria.

- Lifting the boom into the cleaning facility. Boom manufactured in short sections should be broken into manageable lengths while it is in the water. Sections should be short enough to fit into the cleaning pool, berm or pit. Cranes lift the boom section clear of the water and into the cleaning facility. Cranes reaching a few feet longer than the boom section facilitate the operation.

- Presoaking with solvent, scrubbing and water cleaning the boom. Boom sections are flaked out in the pool for cleaning. Both sides are sprayed with a solvent, scrubbed and blasted with hot water and cleaner.

- Final cleaning with hot water and solvent. The boom is attached to the crane and lifted. As the boom is lifted straight up, high-pressure water is applied to remove all cleaning residue. When the boom is lifted clear of the pool floor, it should be clean enough to restow.

- Cleaning the pool. The cleaning facility should be kept as oil-free as possible. Spraying the liner with solvent and hot water between cleaning boom sections keeps excess oil to a minimum. Before the next boom sections are put in, the pool should be emptied by vacuum trucks. Liquid pumped from the cleaning pool must be disposed of properly and documentation must be prepared to satisfy, federal, state and local requirements. These procedures should be addressed in the cleaning plan as a part of any demobilization.

- Restowing the boom. The crane moves the suspended boom sections away from the cleaning pool to a clean area where the boom is repalletized or restowed in containers for shipment back to the storage area. Forklifts are helpful for moving the re-packaged boom sections to their shipping destination.

4-6.2.1 Cleaning Equipment. High-pressure hot water generators are mandatory for removing oil. Cleaning heavy oil residues requires water and solvent mixtures heated above 120 °F at pressures of 2,000 to 3,000 psi. Many different types of solvents that are available cut oil efficiently. The ratio of solvent to water is usually very low.

Before applying high-pressure water, cleaning solvent should be sprayed directly onto the boom and the boom scrubbed briskly with stiff brushes. The scrubbing process breaks the oil down for more efficient water cleaning.

Solvent and high-pressure water remove most of the oily residue. However, there is no substitute for manual scrubbing to remove oil—especially when tension or ballast chain is oily.

4-6.2.2 Cleaning Safety Precautions. Many solvents are hazardous to personnel involved in the cleaning or can be destructive to the boom fabric. Some solvents may require respiratory equipment as well as full suits of protective rubberized clothing, boots and gloves.

OSHA requires Material Safety Data Sheets (MSDS) to be posted at the cleaning site. The hazards and minimal protective requirements are listed on the MSDS. As cleaning boom requires personnel to work with hazardous substances, they must receive training on respiratory protection, MSDS information and safe cleaning techniques and procedures.

Figure 4-17 is a sample MSDS sheet. **Appendix F** contains MSDSs with information on some of the more common fuels.

Flinn Scientific, Inc.

MATERIAL SAFETY DATA SHEET

CHEMICAL NAME & SYNONYMS	FLINN CATALOG NUMBER
MAGNESIUM	***

FORMULA	ATOMIC WEIGHT (A.W.)	CAS NO.
Mg	24.31	7439-95-4

PHYSICAL DATA (DENSITY, SOLUBILITY, ETC.)

Specific Gravity: 1.74
Insoluble in water. Soluble in acids.
Melting Point: 651˚C

APPEARANCE AND ODOR

Silvery-white, odorless, metal, powder, granular, turnings or ribbon.

COMPATIBLE CHEMICAL FAMILY	DOT CLASS	REACTIVITY
Inorganic #1 See Flinn Chemical Catalog/Reference Manual	Flammable Solid	Will react with water and acids to release flammable hydrogen.

CONDITIONS TO AVOID (IF ANY):

Avoid any open flame, spark, or other source of ignition.
Avoid contact with water or acids. Avoid contact with chlorine, bromine, iodine or oxydizing agents. Store away from other combustibles or flammables, preferably in a flammables cabinet.

HEALTH HAZARDS (IF ANY):	TOLERANCE LIMIT VALUE (TLV) (IF ESTABLISHED)
Toxic as dust or fume. Not all health aspects of this substance have been fully investigated.	As fume 5mg/M^3

FIRE HAZARDS (IF ANY):

Flammable solid; avoid contact with acids or water. Do not use a hydrous (like CO_2) extinguisher.
Use dry sand or Class D extinguisher like Flinn #SE3004.

SPILLS AND LEAKS:	DISPOSAL NO.
Sweep up and place in a suitable container. Follow suggested disposal method at right.	26a See Flinn Chemical Catalog/Reference Manual 1987

SPECIAL PRECAUTIONS (IF ANY):

Chemical gloves and goggles. Fume hood. Avoid directly viewing burning magnesium. Intense white flame may cause eye injury. Wear face protection.
Prudent laboratory practices should should be observed.

FIRST AID (IF SUBSTANCE DANGEROUS):

External: Wash affected areas with copius amounts of water.
Internal: See physician immediately. For eyes: Wash continuously for 15 minutes; see a physician. Respiratory: Transport to fresh air; see a physician.

Consult your copy of the Flinn Chemical Catalog/Reference Manual
for even more information about laboratory chemicals.

Figure 4-17. Flinn Scientific Material Safety Data Sheet.

CHAPTER 5

OIL RECOVERY SYSTEMS

5-1 INTRODUCTION

Following an oil spill, environmental damage is minimized by recovering and removing oil quickly, preferably before it reaches shore. Navy policy emphasizes recovery by skimmer systems. Navy salvors and spill responders have access to a variety of skimmers and recovery systems, including self-propelled skimmers, in the ESSM System or at NOSCDR facilities.

Like every piece of equipment used in salvage, oil recovery systems have their limitations. Regardless of manufacturer's claims, every system reaches a point of nonproductivity as weather and sea state increase. There are no charts or formulae to indicate the sea state at which recovery becomes unproductive. Because weather conditions are unpredictable and because oil becomes more difficult to recover as it weathers and spreads and may come ashore as time passes, quick-starting, continuous recovery efforts are more likely to succeed. Slow starts caused by poor planning, lack of equipment or limited operations result in fouled shorelines and a lengthy cleanup. An excessively long cleanup may delay or prevent vessel salvage.

COMNAVSEASYSCOM (SUPSALV) and COMNAVFACENGCOM planned and developed Navy skimmers, as they did the Navy boom described in **Chapter 4**. The COMNAVFACENGCOM-procured skimmers are placed at naval facilities throughout the world as the Navy's first line of defense in oil pollution abatement. SUPSALV skimmer systems are stored and maintained at ESSM pools and bases in CONUS and Hawaii and may be staged at other ESSM bases when deemed prudent. When required, NOSCs request ESSM augmentation directly from the SUPSALV (Operations Branch). **Appendix C** describes procedures for requesting ESSM pollution control equipment and operators. NEESA *AID Publication 7-021C* contains NOSC and NOSCDR telephone numbers.

For major oil spills associated with a serious Navy accident, salvage forces and spill responders can request assistance and equipment from the nearest USCG Marine Safety Office, USCG National Strike Force, nearby NOSCDRs or local commercial spill cooperatives.

As discussed in **Chapter 4**, spill response efforts must recover or otherwise remove persistent oils because containment methods cannot protect sensitive environments indefinitely. Oil is recovered primarily to protect the environment and manmade structures, although recovered oil may have economic value. Oil recovery should begin as soon as personnel and equipment can be made available. If sufficient assets are available, oil recovery efforts can begin at the same time as action to secure the spill source and contain spilled oil.

This chapter discusses:

- General mechanical recovery systems and their operating principles.

- Specific recovery systems found in the Navy's inventory.

- Oil recovery equipment in the ESSM System.

In situ burning, dispersing, bioremediation and other viable means of oil control and removal are discussed in **Chapter 6**. NOSC contingency plans address alternative abatement methods and list the primary skimmers available to salvors.

5-2 OIL RECOVERY SYSTEMS AND PRINCIPLES

Recovery devices vary widely in size and the principles employed to remove oil from the water. In general, oil recovery devices can be grouped in five basic groups:

- Mechanical devices using oleophilic materials (belts, ropes, drums, disks or brushes).

- Suction devices.

- Induction devices (weirs and inclined planes).

- Oleophilic materials (sorbents) placed on the water surface or oil-fouled shore and recovered by manual or mechanical means.

- Devices using other principles (nets, screw pumps, vortex skimmers, mechanical grabs, manual recovery).

Recovery systems that remove oil from the water surface in an essentially continuous process are called skimmers. Skimmers may be built into self-propelled or towed vessels or configured as portable equipment to be operated from shore, pier or vessel of opportunity.

Some skimmer systems have semirigid short boom sweeps attached to the side of the skimmer craft and supported by outriggers or kept taut by towboats and span wires. The boom directs the oil flow into the skimmer mouth or vessel side openings for pick up by belt, disc, bristles or decanting recovery systems.

Recovery rate is generally taken as the rate at which the oil-water mixture is recovered by the device or system, regardless of the relative oil and water proportions. Recovery efficiency is the ratio of oil to water in the recovered oil-water mixture.

Recovery efficiency depends on oil viscosity, water and air temperature, sea and wave conditions, the degree of oil weathering and operator skill. Many mechanical recovery systems do not operate well through the entire range of environmental conditions. This is especially true of weir systems operating in heavy weather; too much mixing at the oil-water interface reduces recovery efficiency. The range of oil properties and sea conditions in which a skimmer operates effectively is commonly called the skimmer's recovery window.

Recovery efficiency increases with oil layer depth for all recovery methods. The sooner oil recovery starts after a spill, the less the oil has spread and the more efficient the recovery. Wherever possible, oil should be contained or collected to thicken the oil layer and enhance recovery, as well as to protect the environment.

5-2.1 Oleophilic Devices. Oil is removed from the water by oleophilic devices when oil adheres to moving oleophilic belts, ropes, drums, disks or brushes. The oil is subsequently scraped, wrung or squeezed from the material for collection in a receptacle. The oil is diverted to a holding sump until it is offloaded. Oil recovered with oleophilic materials can have a water content of less than two percent, but the water content depends upon many factors, including the operator and the environment.

Cold can cause certain oils to adhere to the oleophilic material so strongly that they cannot be readily scraped or squeezed into the reservoir. Under these conditions, steam lances and solvents enhance removal of the oil from ropes and belts.

Dispersants reduce the efficiency of oleophilic materials. Oleophilic materials exposed to dispersants should be cleaned thoroughly before reuse.

5-2.1.1 Belt Skimmers. Belt skimmers use an endless belt running continuously through the oil layer as shown in **Figure 5-1**. The belt may or may not be oleophilic. Belt systems may be permanently installed on either self-propelled vessels or on nonself-propelled units operated from a pier or vessel.

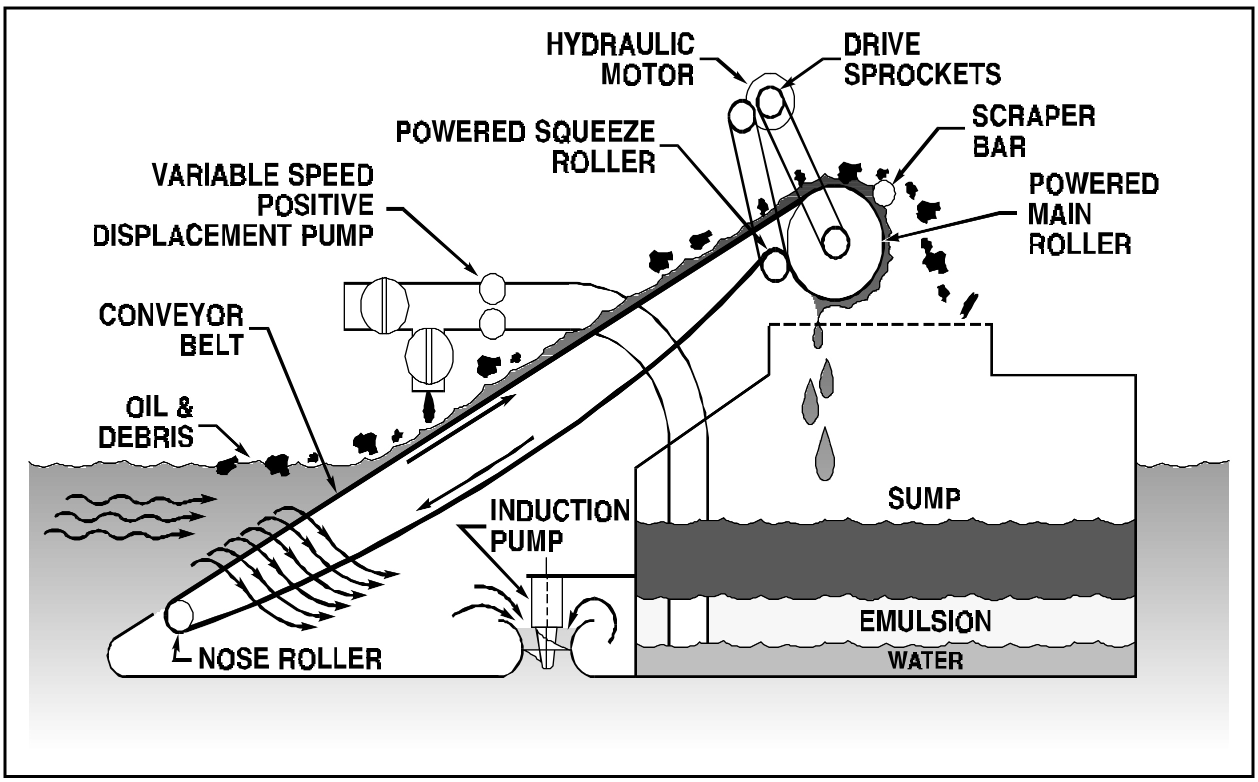


Figure 5-1. Belt-Type Skimmer System.

Unless very heavy with large pieces, floating debris does not usually hinder belt skimmers. The moving belt will carry debris to the top of the plane and onto gratings installed above the oil sump where it is removed easily. Wire mesh or netting placed before the belt prevents trash and debris from entering the recovery mechanisms. Since the debris is usually oil-soaked, it should be kept on board for eventual disposal. This will require manual intervention and may require frequent removal if there is little storage space on the skimming vessel.

5-2.1.2 Rope Mops. Rope mops, shown in **Figure 5-2**, consist of an endless loop or loops of oleophilic material that is continuously drawn across the water surface between a collection device and pulleys held by moorings. Collected oil is squeezed out of the oil into a reservoir by rollers in the collection device. Rope length can be adjusted to suit the location. Rope mops usually pass through debris with little fouling and can be used in very shallow water. The collection device can be mounted on shore or on a vessel. Some systems are designed to be suspended above the sea by a crane with multiple mops hanging into the water from the collection device. Rope mops have high recovery efficiency and are relatively easy to deploy and maintain.

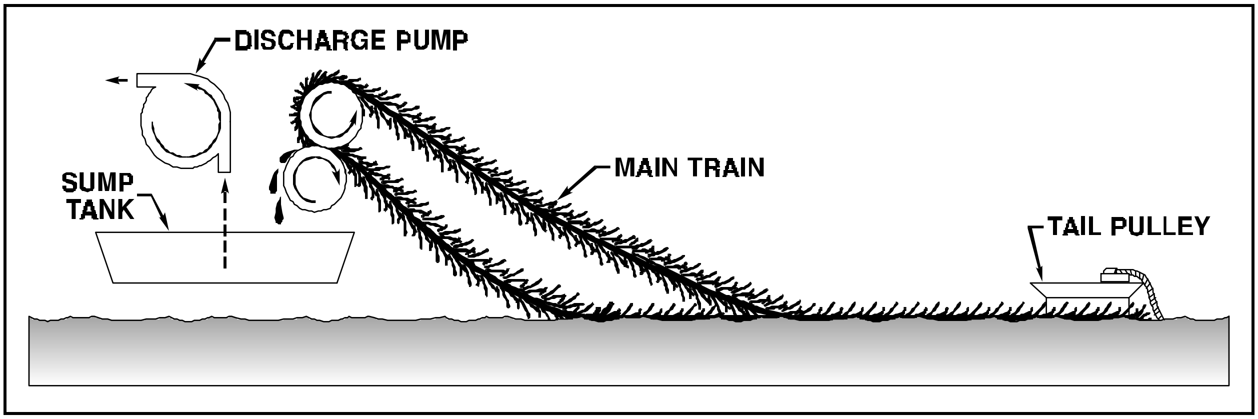


Figure 5-2. Rope Mop-Type Skimmer System.

5-2.1.3 Oleophilic Drum, Disk, Bristle and Brush Skimmers. The oleophilic property of the polymer, aluminum or stainless steel components of drum, disk, bristle and brush skimmers attract oil in the same manner as the oleophilic materials in the belt or rope skimmers. Oil adheres to the oleophilic material as it rotates through the oil-water interface. The oil is removed from the smooth disk or drum surfaces with scrapers and diverted to a sump.

Likewise, rotating drums or belts with brushes or bristles attached attract oil as the oleophilic material passes through it. The oil collects at the ends of the brushes and bristles where removal is easy. Bar- or comb-type scrapers remove the oil before the oleophilic material enters the oil again.

Figure 5-3 shows various oleophilic disk, drum and brush devices and how they operate. Because of the large vertical dimension of the disks, disk skimmers are relatively effective in waves. They are, however, easily clogged by debris. Disk skimmers do not work well with very viscous oil and are ineffective on mousse. Some disk skimmers incorporate intermeshing toothed disks to improve performance in viscous oils. Efficiency and applicability of drum systems is generally similar to that of belt skimmers.

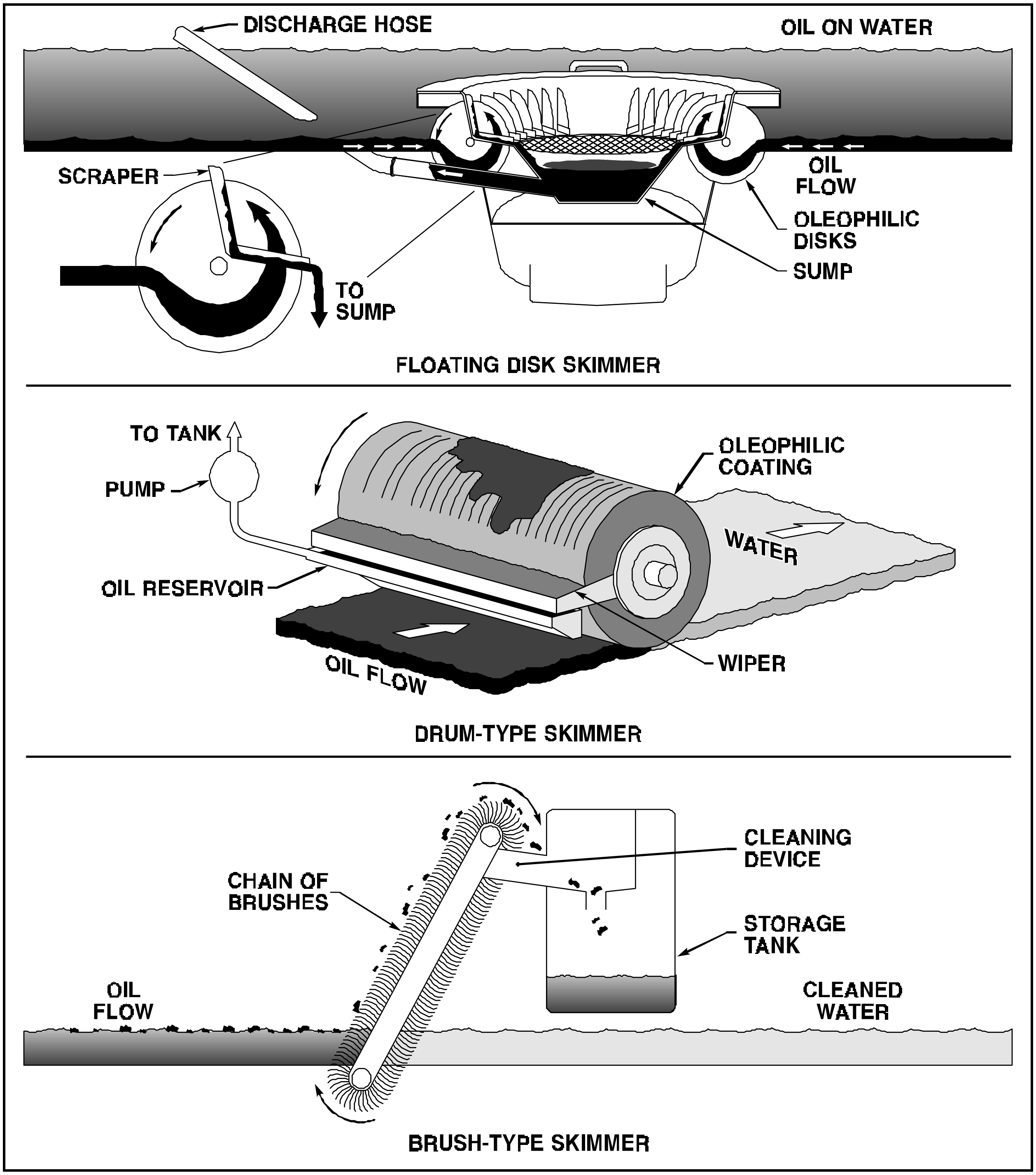


Figure 5-3. Disc, Drum and Brush Recovery Systems.

5-2.2 Suction Devices. Suction devices operate by drawing oil through a restricted opening designed to limit the quantity of water drawn in with the oil. The system consist of an inlet head, a pump and a storage tank. The inlet head should be positioned so that oil can enter but water is excluded, but this is not always possible because oil layer thickness varies and waves can swamp the head. To minimize wave effects, inlet heads are designed to float at the oil-water interface with minimum inertia. A number of specially designed inlet heads are available, such as the adjustable weir skimmer shown in **Figure 5-4**.

Figure 5-4. Self-Adjusting Skimmer/Inlet.

Oil and water can be separated at the interface because of the differences in viscosity and specific gravity between oil and water. Oil floats on water because of its lower specific gravity. Because of the difference in viscosity between oil and water, there is a natural shear in a flowing mixture of the two liquids. The more viscous oil can be induced to flow at a faster rate over or under a barrier or weir, placed at the oil-water interface by forces created by pump suction. The weir height is adjusted to allow only oil to flow over the weir and into the pump. The pump also transfers the oil from the weir into holding tanks or bladders.

Suction devices are manufactured in a wide variety of sizes, from small portable units to large systems incorporated into vessels. Modified or unmodified suction dredges can skim oil by holding the drag head at the water surface.

Suction-weir-type skimmers are easily clogged by debris. Small units do not function well with high-viscosity and emulsified oils. Suction skimmers generally have a high recovery rate but low recovery efficiency because they do not discriminate well between oil and water.

5-2.3 Induction Devices. Induction systems are usually built into vessels. The vessel moves into the oil slick so that oil flows into an enclosed area where the effects of waves and current are reduced. Oil is separated at the interface or from the water surface with the following general types of systems:

- Inclined plane
- Multiple weir
- Hydroclone

5-2.3.1 Inclined Plane Skimmers. Inclined plane skimmers operate by forcing oil downward with an adjustable inclined plane under the skimmer well, where the oil rises into a sump and the water is allowed to escape. The oil is drawn from the top of the sump for transfer to a holding tank. The gravity separation of oil from water in the sump may be enhanced by flow across underflow weirs as shown in **Figure 5-5**. Flow across the weirs may be induced by a pump suction or vessel motion.

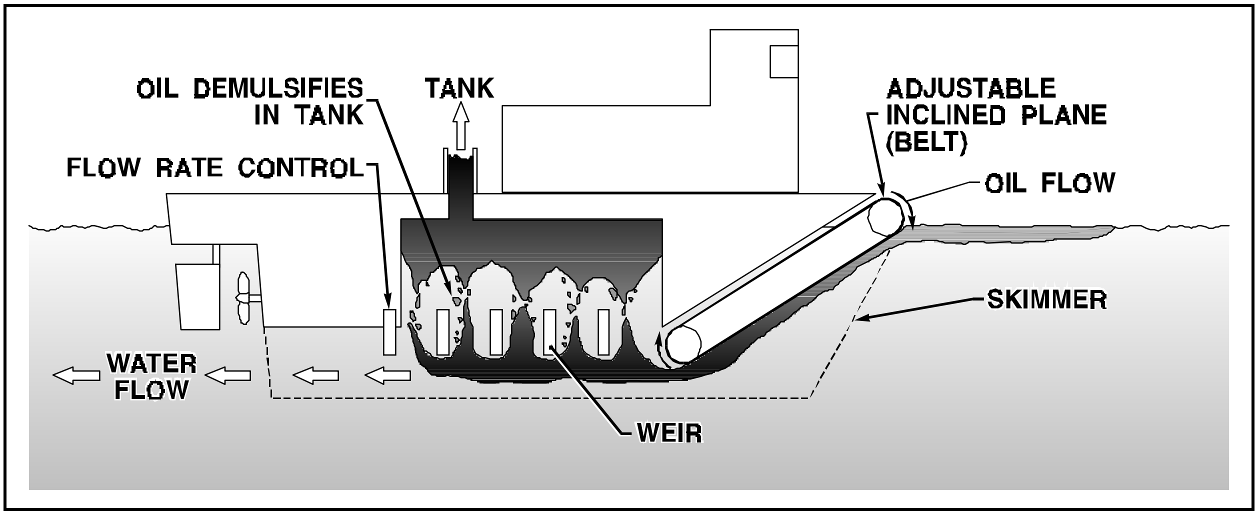


Figure 5-5. Inclined Plane Skimmer.

Flow down the inclined plane is created by the rotating movement of the belt and/or the forward motion of the vessel driving through the water. Because the belt drive direction is opposite of the vessel's movement, relative motion between the belt and the oil is low and little turbulence is generated as the liquids come into contact with the belt. Lack of turbulence reduces mixing of oil and water. Most inclined plane belt speeds and angles are adjustable to change oil pickup rates to fit the situation. The aspect of the belt as it moves through the water is the opposite of belt-driven oleophilic systems discussed in **Paragraph 5-2.1.1**. Induction pumps can also create additional flow down the inclined plane as the skimmer operates.

There is usually an oil-water interface within the tank or sump. Most systems have electronic interface and quantity indicators. As the interface level drops as the oil rises in the decanting tank, pumps transfer the oil to holding tanks. The transfer pumping induces a flow within the sump that assists oil entry.

5-2.3.2 Multiple Weir Systems. Weir systems are either underflow or overflow design. Overflow weir float systems operate on the shear principle discussed in **Paragraph 5-2**. Weir height can be fixed or adjustable. Adjustable weirs allow vertical movement that causes shearing at the optimum point of the oil-water interface. As the oil flows over the weir by gravity, it collects in the weir holding tank until offloaded by pumps. In some systems, the oil cascades over a series of weirs and into a holding sump. After the sump fills, the oil is pumped off. The water flows under the weir and away from the skimmer. **Figure 5-6** shows how the weir recovery systems operate.

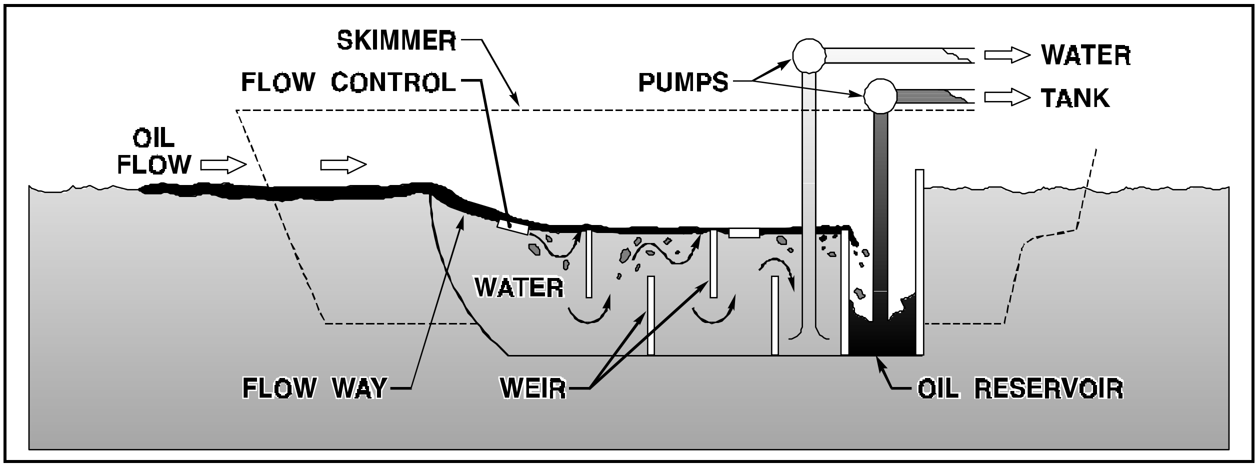


Figure 5-6. Weir Recovery System.

Underflow weir float systems cause the same action as the inclined plane on surface oil. They force oil below the float toward a collection sump. The floating weir is attached to a skimming vessel that maneuvers through the oil. Forward motion forces oil down the float's face to an open tank or sump similar to the inclined plane system. The oil floats to the top of the tank because of its lower specific gravity. When enough oil collects, it is pumped off. Because the floating weir is stationary, the relative velocity between the float face and oil is greater than with a moving belt inclined plane system. This higher velocity may cause turbulence and emulsification, reducing recovery efficiency.

5-2.3.3 Hydroclone Skimmers. The hydroclone systems separates oil and water with centrifugal force in much the same manner as a centrifugal fuel purifier. The skimmer is held next to a support vessel as shown in **Figure 5-7**. As the vessel moves through the oil slick, oil and water are forced into a chamber where they rotate at high speed. The denser water is forced outward where it escapes through an opening at the bottom of the chamber. Oil, lighter than water, moves to the center of the vortex where it is drawn off by a pump. The stability of the vortex is affected to some extent by waves. Efficiency decreases as oil density approaches that of water.

5-2.4 Sorbents. Sorbents are oleophilic materials used to recover oil and oil-like liquids through absorption, adsorption or both. In absorption, oil is distributed throughout the body of the material; in adsorption oil is distributed over the surface of the material. ASTM standards F716 and F726 define sorbent types based on the form in which the sorbent is manufactured. The sorbent types are listed in **Table 5-1**; the various forms are shown in **Figure 5-8**.

Oil sorbents range from sawdust to expensive sorbent mats. Three different kinds of materials are used as sorbents:

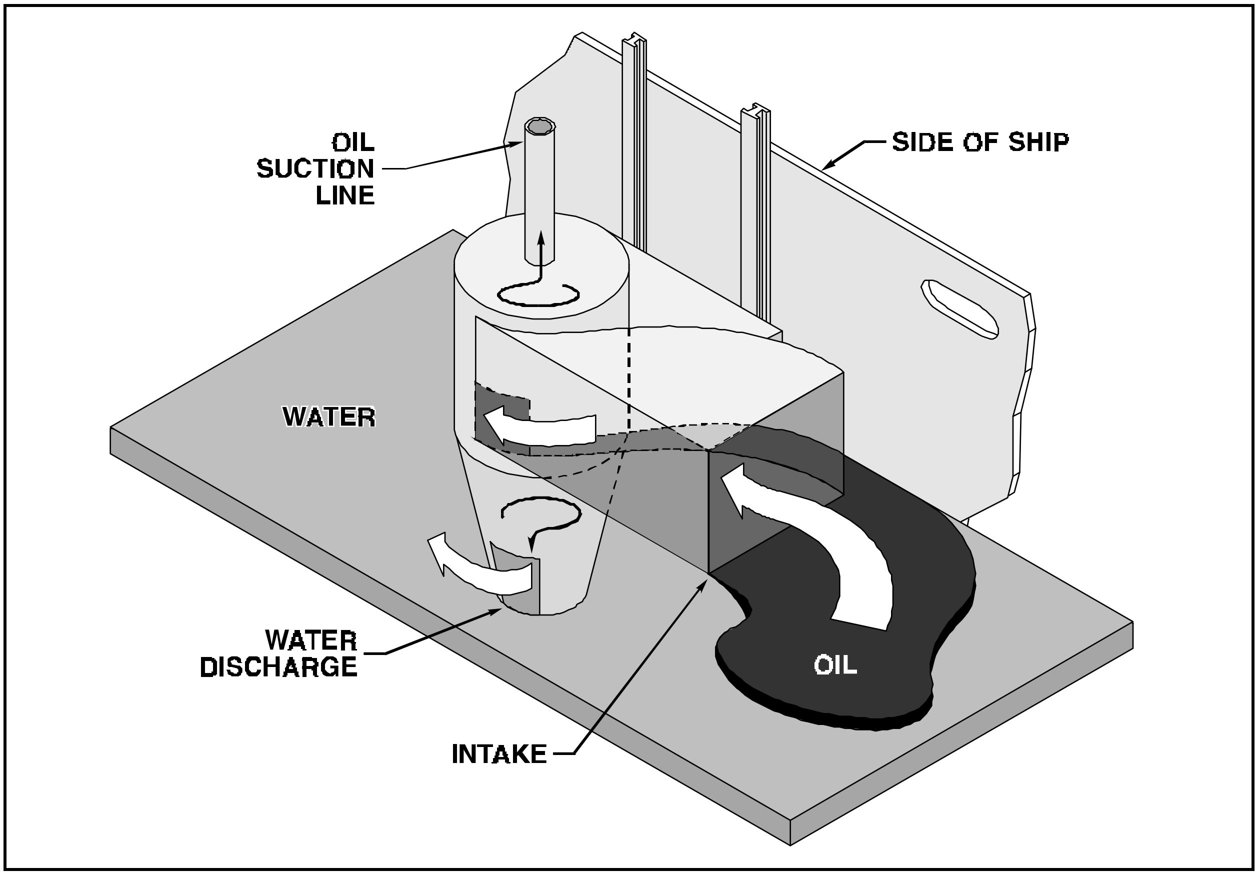


Figure 5-7. Hydrocyclone.

- Inorganic materials, such as vermiculite or volcanic ash.
- Synthetics, such as polypropylene fiber.
- Natural organic materials such as peat, cotton, pine bark, etc.

Sorbent performance is defined as the ratio of the weight of oil picked up to the weight of the sorbent. **Table 5-2** describes some of the available sorbents.

Use of sorbents is generally manpower-intensive—sorbents are generally distributed by hand. The sorbent is left in contact with the oil long enough to become saturated with oil before it is collected—again, usually by hand. Belt skimmers will recover floating sorbent as debris which must be manually removed. Towed nets can collect large quantities of oil-soaked sorbent which can then be removed from the water by hand or mechanical grab. Sorbents that sink must be left long enough to collect oil, but not long enough to sink. Like skimmers, the recovery rate of sorbents diminishes as the oil layer thins. Oil should be contained to thicken the oil layer and increase recovery rate.

Table 5-1. Oil Sorbent Types.

Absorbent types:	
Type I (loose)	Unconsolidated particulate material without sufficient form or strength to be handled as a single unit. May be blended with absorbents for specific applications.
Type II (roll, sheet, pad, pillow, web)	Material has form and strength sufficient to be lifted and handled when saturated without tearing.
Type III (booms)	Absorbent material in a form whose length substantially exceeds other dimensions. Booms are provided with connector units so they may be coupled with other booms.
Absorbent types:	
Type I (roll, sheet, blanket, pad, web)	Material with length and width much greater than thickness and strength to be lifted and handled either saturated or unsaturated.
Type II (loose)	Unconsolidated particulate material without sufficient form or strength to be handled as a single unit.
Type III (enclosed)	
Type IIIa (pillow)	Absorbent material with an outer fabric or netting that is permeable to oil but with sufficiently small openings that the sorbent materials is substantially contained.
Type IIIb (boom)	Absorbent material contained as Type IIIa in form with length substantially greater than other dimensions, and with strength member running parallel to length. Booms are provided with end connections for coupling end to end.
Type IV (agglomeration unit)	An assemblage of strands, open netting or other physical forms with an open structure that minimally impedes intrusion into itself of high viscosity oils. Oils are held within the structure so the oil can be handled as a unit.

Sorbents are excellent devices to remove the sheen from the water during the final stages of cleanup. Sorbent booms, used in conjunction with sorbent pads and other sorbent materials are very effective in keeping sheen from small inlets etc. Sorbent pads are also excellent for cleaning boats, skimmers and other oil-contaminated equipment.

After recovery, sorbents must be stored and possibly transported for eventual disposal in a landfill or by incineration or for separation of oil and sorbent for re-use. Arrangements for storage and transportation should be made as soon as recovery begins or before. Complete separation of oil and sorbent is technically difficult and generally not a good option. If the sorbent is to be re-used immediately, incomplete separation by wringing or squeezing may be acceptable.

In most operations, oil is recovered primarily by skimmers or other recovery vessels, with sorbents used as an alternative or complement to skimming. Sorbents are especially useful in confined areas or shallow water where skimmers may not be able to operate and to recover small quantities of oil. In calm water, sorbents can be deployed as a barrier to protect sensitive areas. It will be necessary to replenish the sorbent as it becomes oil-logged to prevent oil from breaching the barrier. Sorbents can also be applied to contained oil within booms or other barriers; one

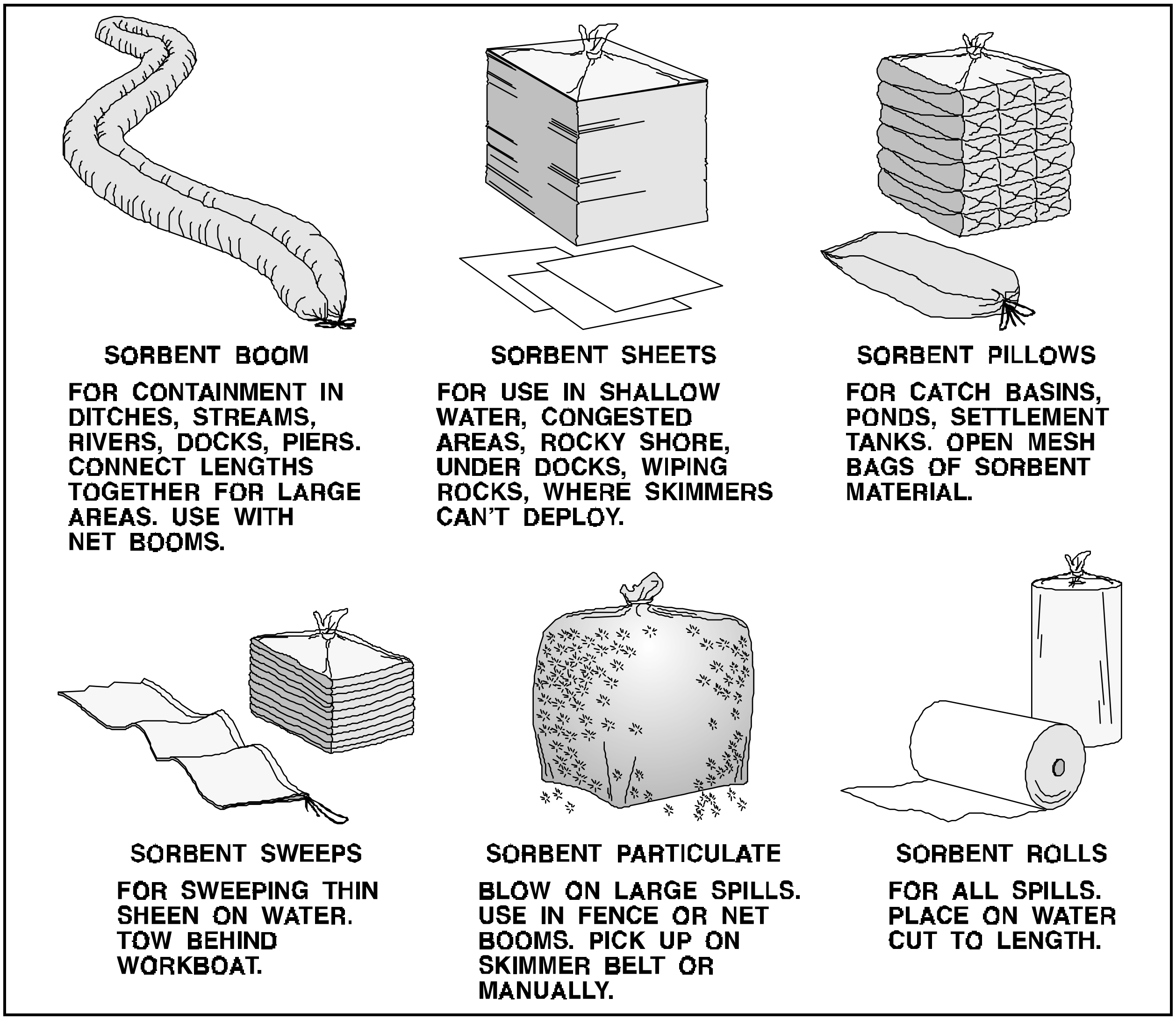


Figure 5-8. Sorbent Material Characteristics.

effective method is to deploy containment and sorbent boom together. Sorbents applied to contained oil can suppress waves and help prevent oil from splashing over booms.

5-2.5 Other Recovery Methods. Other recovery methods and devices include vacuum systems, nets, mechanical grabs, manual recovery, vortex skimmers and screw pumps.

5-2.5.1 Vacuum Systems. Vacuum tank trucks like those used to collect industrial, agricultural or sewage sludges can pickup oil effectively when significant quantities of oil can be reached from piers or shorelines that the trucks can drive along. Vacuum trucks or systems can be mounted on boats or barges to access oil further from shore.

Most vacuum systems can draw oil through hoses directly from the water into the tanks. Vacuum systems are subject to the same restrictions as discussed for suction devices in **Paragraph 5-2.2** and can be clogged by debris. Large amounts of water will be picked up along with the oil, especially in choppy water, because the suction hose does not always remain in oil, but primary oil-water separation can take place in the tank, with water drained from the bottom of the tank periodically.

Table 5-2. Sorbent Performance.

Sorbent	Maximum Oil Absorbing Capacity		Buoyancy After Prolonged Contact with Oil on Water
	High Viscosity Oil (3,000 cSt at 25 °C)	Low Viscosity Oil (5 cSt at 25 °C)	
Inorganic:			
Vermiculite	4	3	Sinks
Volcanic Ash	20	6	Floats
Glass Wool	4	3	Floats
Synthetic:			
Polyurethane Foam	70	60	Floats
Urea Formaldehyde Foam	60	50	Floats
Polyethylene Fiber	35	30	Floats
Polypropylene Fiber	20	7	Floats
Polystyrene Powder	20	20	Floats
Natural:			
Corn Cob	6	5	Sinks
Peanut Husks	5	2	Sinks
Redwood Fiber	12	6	Sinks
Wheat Straw	6	2	Sinks
Peat Moss	4	7	Sinks
Wood Cellulose Fiber	18	10	Sinks

Specialized inlet heads are required for thin oil layers. These devices can recover oil in water as shallow as three inches or from the bottom of storage tanks. They operate on the fixed-weir principle and have quick connection points for standard 3- and 5-inch vacuum hoses.

5-2.5.2 Nets. Nets can be used to collect nearly solid emulsions, tar balls and oil-soaked debris or sorbents. Seine-like nets are towed by two vessels or set across currents. Trawl-like nets can be towed by a single vessel. Fine-mesh fishing nets can be used, but purpose-built oil collection nets are available. Nets are well suited for containing loose particulate or matted sorbent such as straw, cotton, peat, vermiculite or synthetics. The oil is absorbed while the water passes through the nets. Some materials lose their buoyancy after soaking in oil and must be removed from the nets without delay. Because water can pass through nets, current drag is lower than booms and they can be moored across currents that might carry booms away. If current or towing speed is too great, however, oil and collected sorbents may be forced through the net.

Grabs, clam shell buckets, power shovels, drag lines or back hoes can remove viscous or weathered oil, oily debris or oil-saturated sorbents pooled or collected near shorelines and piers.

Oil that has washed ashore and contaminated the shoreline is nearly impossible to remove with the skimmer systems unless it is very plentiful in deep pools or layers. Once ashore, oil usually is removed by personnel operating mechanized or manual equipment. Heavily soaked beaches can be cleaned by removing the oil-soaked sand with front-end loaders, graders, dump trucks and bulldozers. Grabs and backhoes are excellent tools for picking up oil-covered rocks that are too heavy to be moved by hand. Shoreline cleanup is addressed in greater detail in **Chapter 7**.

5-2.5.4 Vortex Skimmers. Vortex skimmers draw oil and water over a weir into a separation chamber by creating a vortex with a rotating paddle. Some water separates from the oil as it passes over the weir. Additional water is separated from the oil by centrifugal force and gravity as the water is forced to the outside of the separation chamber, while the oil rises and moves to the center of the chamber to be drawn into a storage tank. Vortex skimmers work best in calm waters where wave action is minimal. **Figure 5-9** shows a typical vortex skimmer system.

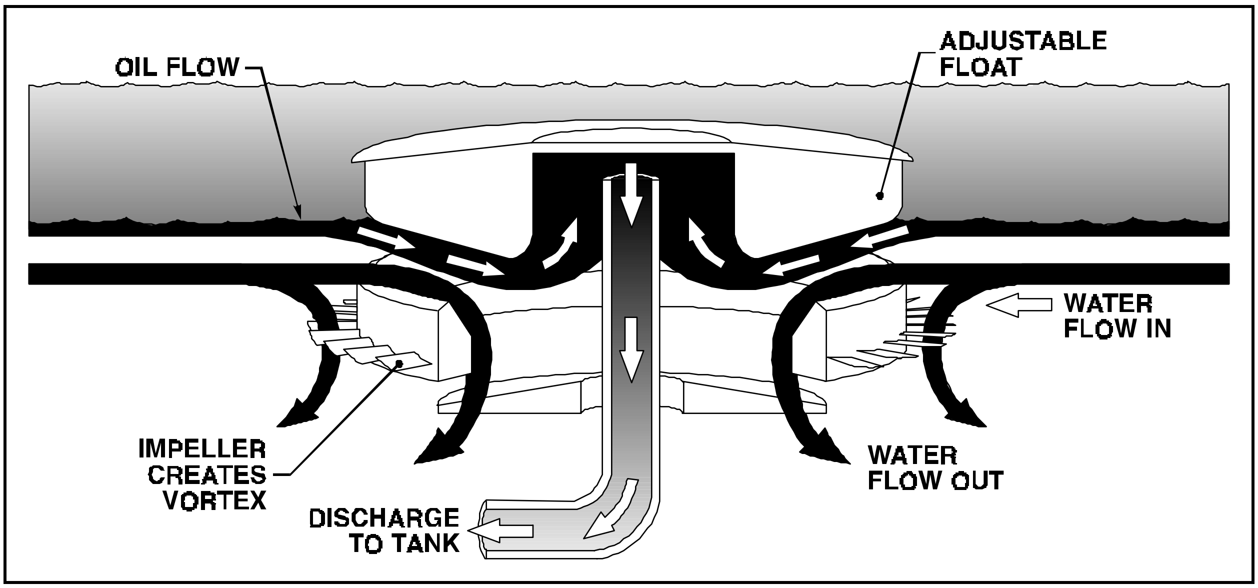


Figure 5-9. Vortex Skimmer.

5-2.5.5 Screw Pumps. Screw pump skimmers like those shown in **Figure 5-10** are used primarily to recover viscous oils. The adjustable float keeps the weir inlet at the oil-water interface. Screw pumps tolerate debris but are quite sensitive to wave action.

5-3 OIL RECOVERY OPERATIONS

The choice of recovery devices and methods depends on oil characteristics, spill size and location, weather, sea conditions, shoreline geography and, above all, availability. Skimmer performance varies widely with oil viscosity. Most skimmers have a range of viscosities for which they are most effective. General skimmer applicability is shown below:

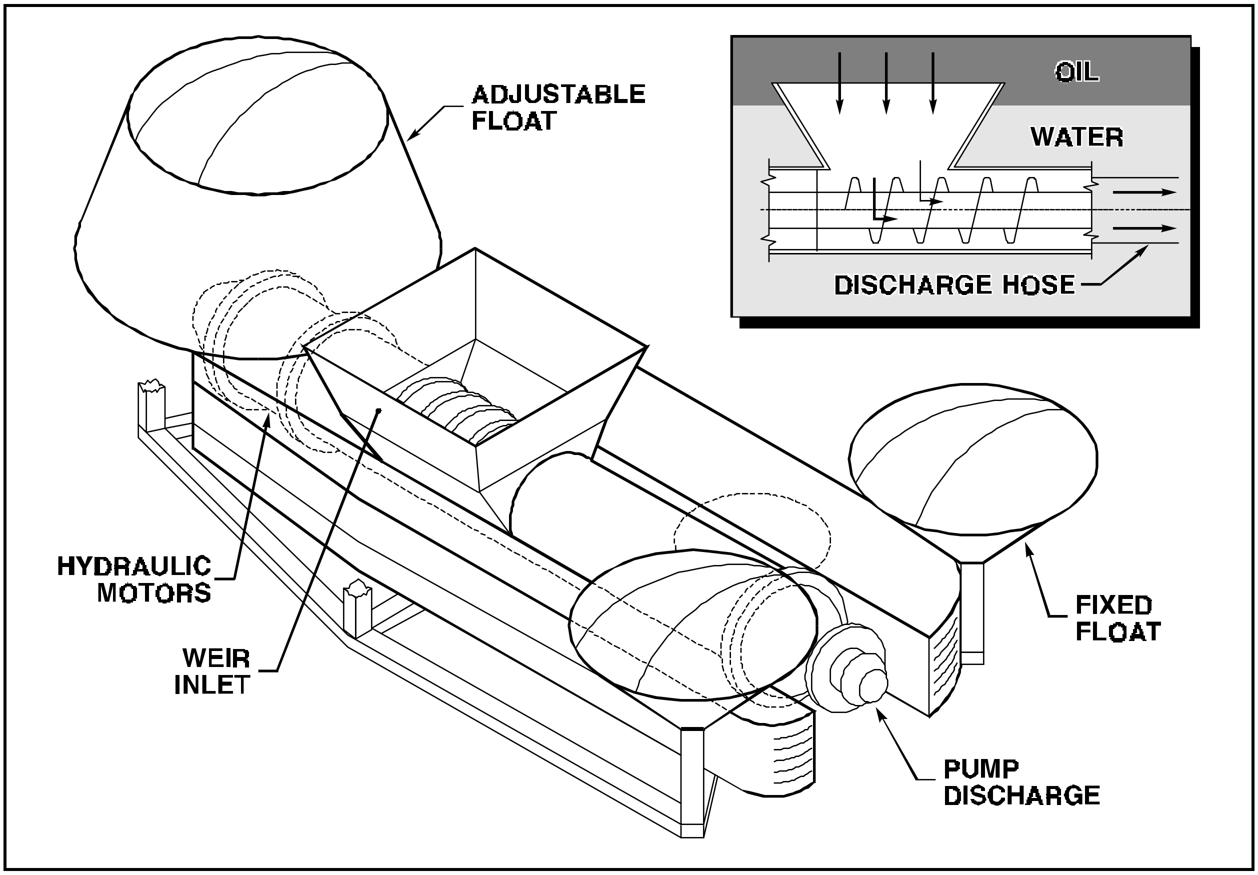


Figure 5-10. Screw Pump.

- Light oils - Weir, suction, inclined plane, hydroclone, vortex.
- Medium oils - Rope mop, oleophilic types, inclined plane, vortex.
- Heavy oils - Oleophilic belt, rope mop, weir.

Induction types are not effective for recovering small slicks spread over a wide area.

In general, even the most rugged recovery equipment is not effective in waves greater than six feet, winds greater than 20 knots or currents greater than one knot. Average wind and current conditions in many U.S. ports approach these limits.

5-3.1 Spill Containment. As mentioned previously, recovery devices are more efficient in thicker oil layers. Booms and other barriers can collect or guide oil into smaller areas to increase layer thickness or to guide oil directly into recovery systems.

5-3.2 Storage of Recovered Oil. Oil recovery systems can remain in operation only so long as there is someplace to store the recovered oil for eventual disposal or recycling. Oil can be stored in tank barges, oil storage bladders, small tankers, shore facilities or portable tanks on barges or ashore. Storage vessels should be sited near skimmer operating areas to minimize lost skimming time. Most skimmers have only a limited storage capacity. To avoid frequent trips by skimmers to the storage vessel, oil storage bladders (dracones) can be towed by the skimming vessel. Workboats can shuttle empty bladders to skimmers and full bladders to central storage or discharge points. Alternatively, small coastal tankers can accompany skimming vessels to receive skimmed oil.

It is often difficult to find adequate barge or lightering vessels at remote locations. Transportable ESSM oil storage bladders are a method of augmenting barges and tank storage ashore. In long-term, large-scale operations, it may be necessary to dispose of some of the recovered oil while recovery operations are still ongoing, to free storage space, rather than dealing with disposal after recovery and cleanup operations are finished.

5-3.3 Oil-Water Separation. Because skimmers recover a sometimes-emulsified oil-water mixture, it is desirable to remove water from the recovered mixture to conserve storage space.

5-3.4 Skimming and Sweeping. Spilled oil can be recovered by skimmers operating inside containment barriers. For effective recovery of oil spread over a wide area, recovery systems consisting of boom and skimmer combinations or specialized large recovery vessels concentrate and recover oil from broad areas.

5-3.4.1 Single-Vessel Sweep System. A single-vessel sweep system consists of a vessel equipped with special booms or sweep arms extended from one or both sides of the vessel by rigid arms or bridles. Oil encountered by the vessel is concentrated by the extended sweep arms and recovered by skimmers built into the vessel hull or sweep arms or operated from the vessel deck.

5-3.4.2 Two-Vessel Sweep System. Two-vessel sweep systems consist of a length of boom, a boom-towing vessel and a skimming vessel. The vessels operate in one of the two configurations shown in **Figure 5-11**. Recovered oil is stored aboard the skimming vessel, a towed bladder or an accompanying vessel.

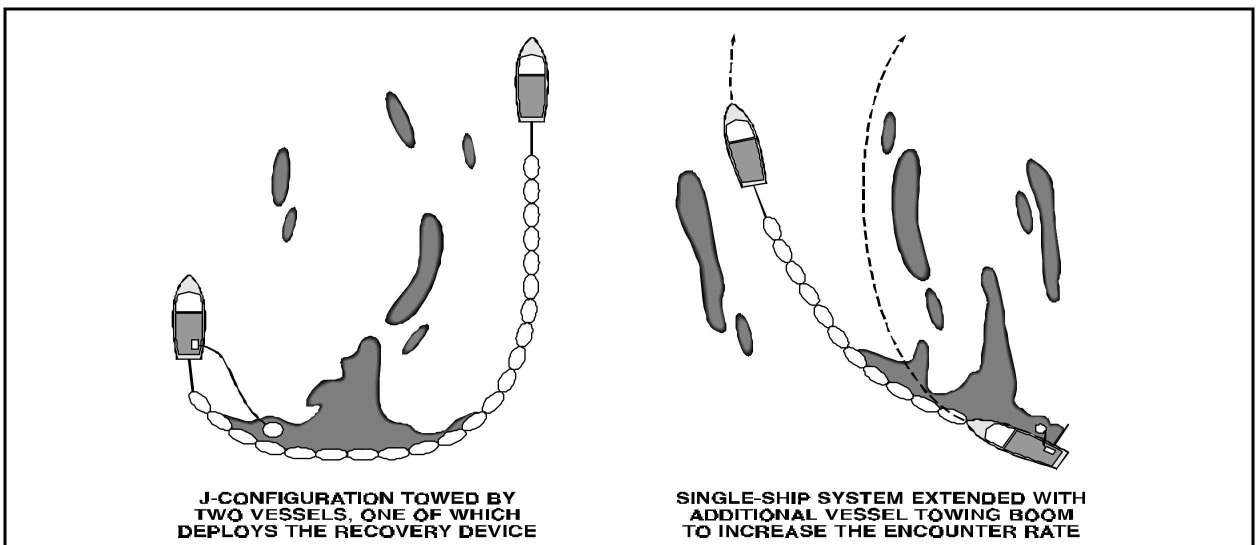


Figure 5-11. Two-Vessel Sweep System.

5-3.4.3 Three-Vessel Sweep System. Three-vessel sweep systems consist of one or two lengths of boom, two boom-towing vessels and one skimming vessel deployed in one of the configurations shown in **Figure 5-12**:

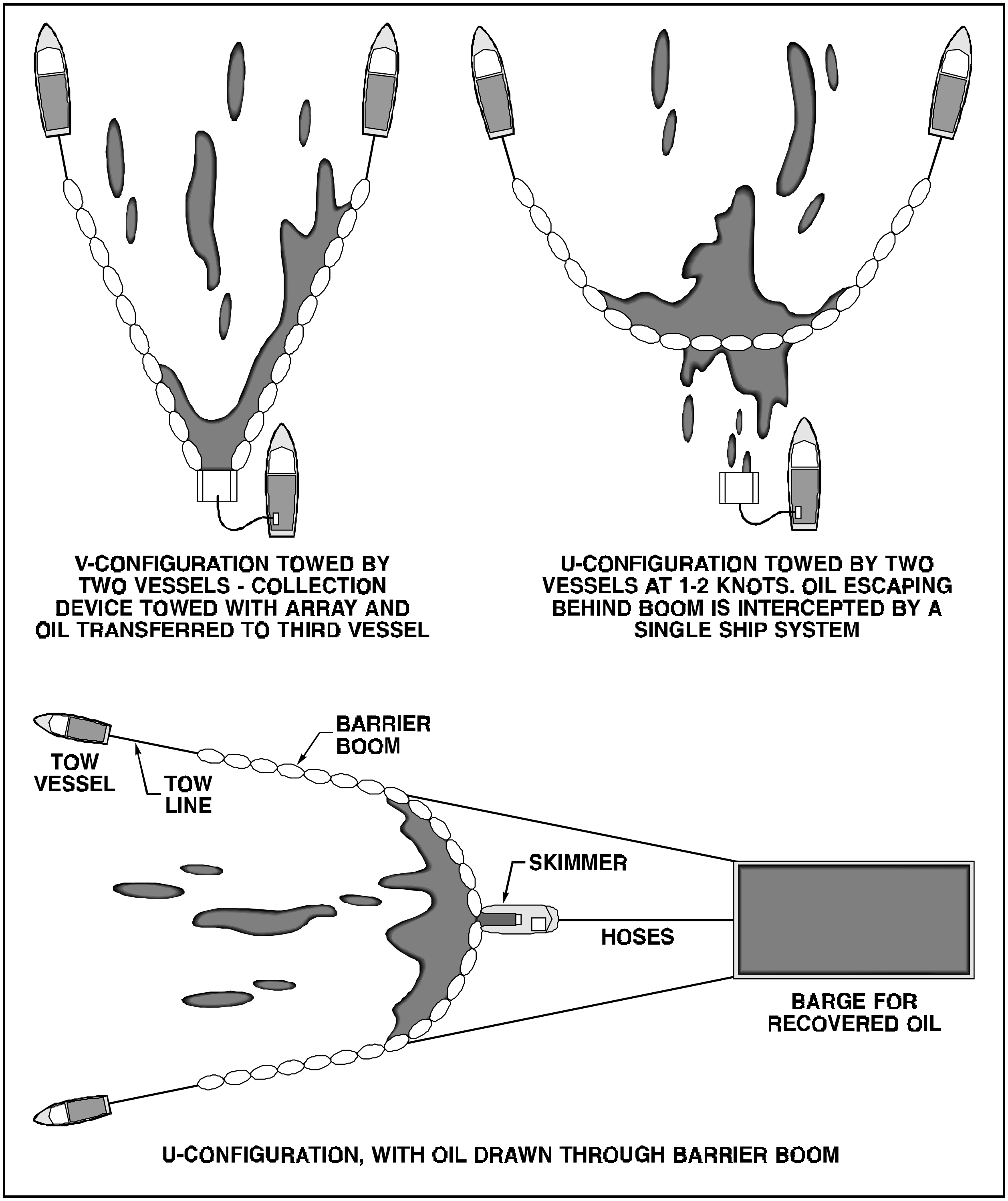


Figure 5-12. Three-Vessel Sweep Systems.

- The boom is towed in a V-configuration with a skimmer or skimming vessel at the apex. Collected oil is pumped into another vessel or towed barge or bladder.

- A specially designed boom is towed in a U-configuration. Oil collected at the apex of the boom is drawn through integral manifolds in the boom and pumped into a receiving vessel.

- Two vessels tow a boom in a U-configuration. Oil concentrates at the apex and eventually escapes to be recovered by a following single-vessel sweep system. The system is most effective if the boom is constructed with opening to permit controlled escape of the oil through a narrow aperture.

5-4 NAVY OIL RECOVERY SYSTEMS

Navy oil recovery systems are basically commercial or modified commercial skimming systems. A variety of skimmers are maintained in the SUPSALV and NOSCDR inventories.

SUPSALV Class V and VB oil recovery skimmers are transportable and responsive to spills throughout an extremely wide environmental range. The Class V and VB skimmers are operated and maintained by contractors as part of the ESSM System.

NAVFAC skimmers are the primary oil recovery skimmer systems operated and maintained by NOSCDRs. They are either large, self-propelled oleophilic-belt-configured skimmers or small, nonself-propelled weir and belt units. NAVFAC dynamic inclined plane (DIP) skimmers and small weir skimmers are intended for harbor spills but are suitable in some open sea situations.

Salvors can request skimmer support directly from SUPSALV or from the NOSC in whose area the salvage-related spill has occurred. The NOSC contingency plan lists non-Navy skimmer assets that are available if the NOSC is involved in the operation.

5-4.1 SUPSALV Class V and Class VB Skimmers. The SUPSALV Class V and VB skimmers are the most utilized, effective and durable vessels ever built for oil recovery. SUPSALV procured the first order of these commercially produced skimmers in the mid-1970s. The basic hull was modified to SUPSALV specifications for operational improvement and rapid movement in response to remote oil spills. The modified Class V skimmer is designated Class VB.

Class V and VB skimmers are used most effectively as part of a three-vessel V-boom skimming system. Boom-towing boats, oil storage bladders and oil boom are deployed with the skimmers. There are only enough boom-towing boats in the ESSM system to support half of the Class V skimmers, so boats must be obtained from other sources if more than half the ESSM skimmers are mobilized.

The hull of the Class VB has been modularized so the sides may be removed for transportation. Removal of the sides reduces the hull width from 12 to 8 feet. The narrower width eliminates the need for wide-load permits when trucking the skimmers and facilitates loading the vessels in aircraft. Ancillary equipment is carried in racks with each Class VB (modular) hull.

The operating principles, procedures and capabilities of both classes of skimmer is the same. The Class V oil recovery system can operate in conditions up to sea state three or four and recover oil at rates up to 300 gallons per minute. At this recovery rate, the skimmer sump will be filled in a few minutes. Without a towed bladder or other oil receiving vessel, skimming operations will have to cease until the oil can be offloaded. The skimmer may be maneuvered independently with a hydraulically powered 360-degree rotatable thruster or towed with one or two ESSM System boom-handling boats. The skimmer is built for high-speed towing to reach distant skimming areas quickly. The pilothouse contains communications equipment. The vessel can be operated by as few as two people, but more are required when the skimmer operates in the boom and bladder configuration.

These skimmers recover oil by inducing oil onto a rotating sponge-like filter belt that picks the oil up and transfers it to a sump. The filter belt is composed of reticulated polyurethane foam with large cells. Like the general belt designed recovery systems discussed in **Paragraph 5-2.1.1**, this material is oleophilic and hydrophobic. That means oil is attracted to the belt material and water is repelled. The oil remains on the belt and water passes through it. The belt can work with or without the polyurethane foam depending on the oil's viscosity. The foam belt is for light and medium viscosity oils. The foam is removed and the filter backing used for skimming high-viscosity oils. As the belt moves through the oil-water interface, the oil adheres to it and moves to the top of the belt where it is scraped off—squeezed off the foam belt—into a sump.

Hydraulically powered transfer and offloading pumps and hoses are required for continuous recovery because the onboard storage capacity of the skimmers is only 32 or 43 barrels, depending on the class of skimmer. Pumping recovered oil into barges or bladders accompanying the skimmer permits continuous operation.

In a free-skimming mode, the sweep width is increased from 3 feet to 12 feet by deploying aluminum sweep arms on both sides of the bow. Sweep coverage may be improved significantly by attaching containment boom to the skimmer and towing the boom and skimmer as a single unit through the oil. Connecting hardware for skimmer and boom configurations always is deployed with the boom and skimmer equipment. **Figure 5-13** illustrates the modular characteristics of the Class VB skimmer. **Figure 5-14** shows the skimmer belt operating specifications of the Class V and VB skimmers. **Figure 5-15** shows the V-boom skimming configuration.

5-4.2 SUPSALV Vessel-of-Opportunity Skimming Systems. Vessels with good tank capacity or deck space for portable tanks, but without installed skimming systems, can be outfitted with vessel-of-opportunity skimming systems (VOSS). The ESSM-stored VOSS system is a floating, vertically adjustable weir-type recovery system. Oil flow over the weir is enhanced by a screw pump that moves the oil from the weir sump to a storage tank. Debris passes through the pump easily after passing through a cutting blade.

The Class XI oil recovery system is another ESSM vessel of opportunity skimmer system. The oil recovering apparatus is the same as the Class V and VB skimmers. The oleophilic pickup filter belt, induction pump and offload pump make up the portable oil skimmer. The unit is attached to the side of the ship and operated by hydraulic fluid from an accompanying portable hydraulic pump. The system is handled by a portable crane or other suitable lifting system. The operating

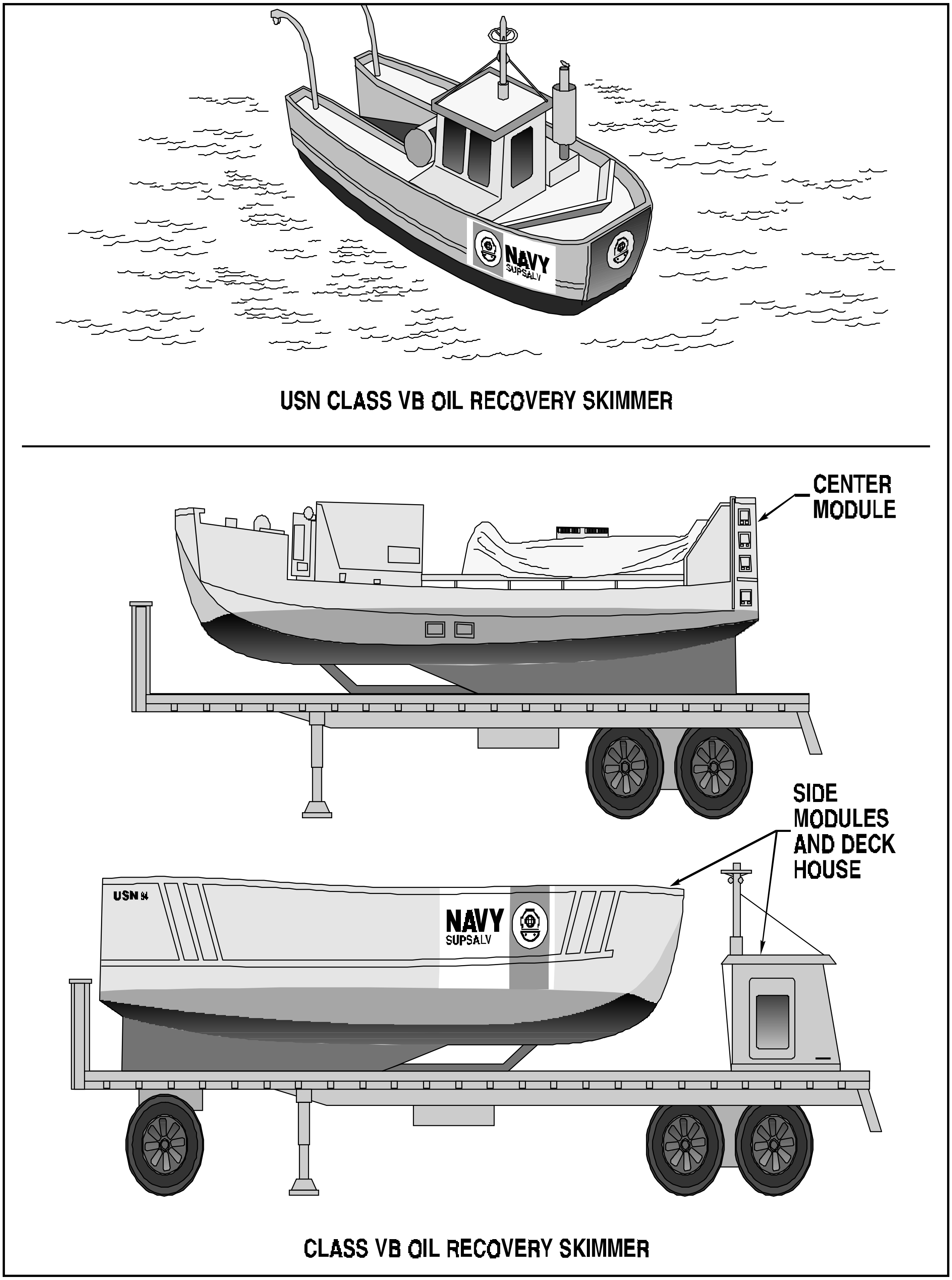


Figure 5-13. Class V and VB Oil Recovery Skimmers.

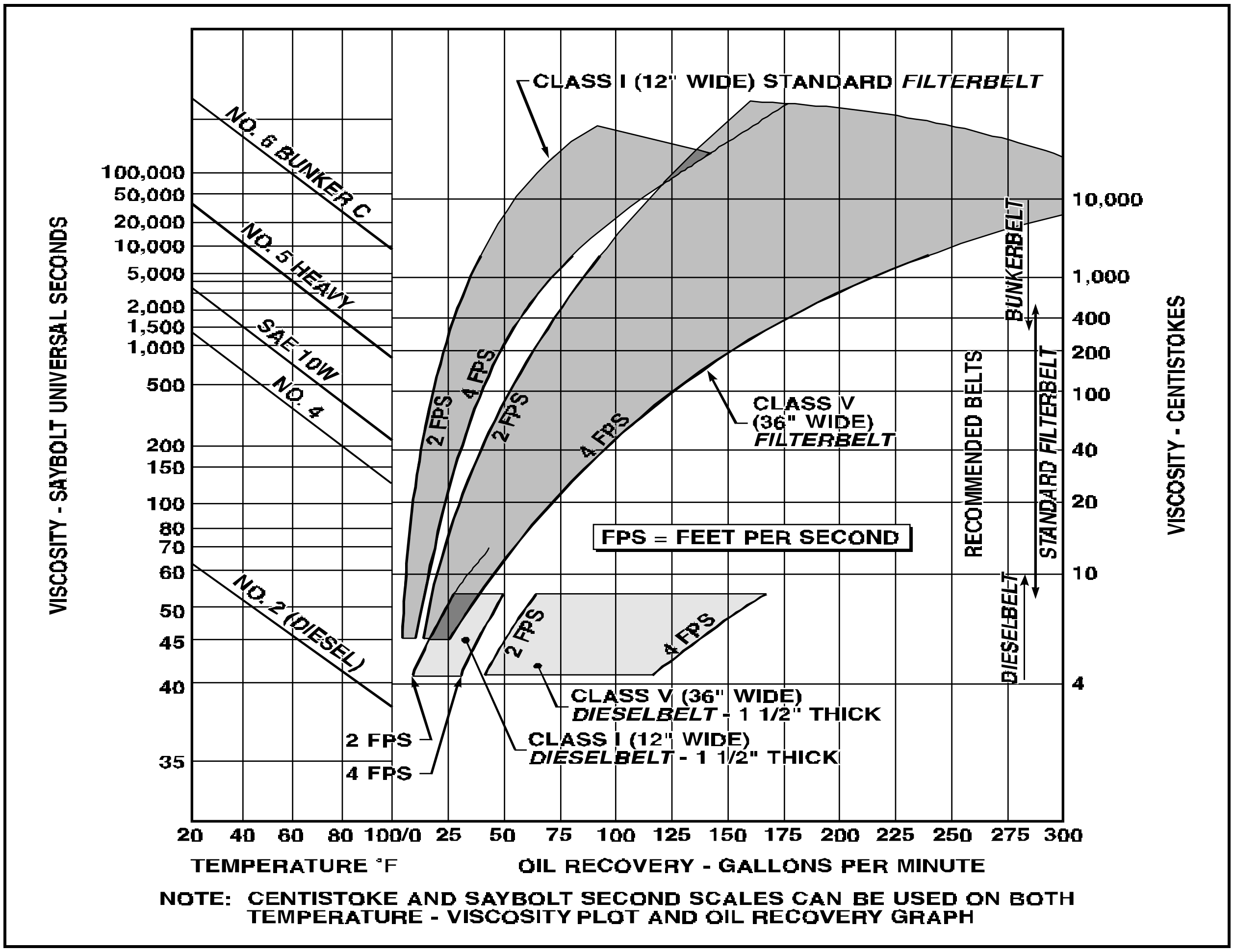


Figure 5-14. SUPSALV Mooring System/Oil Boom Recovery System.

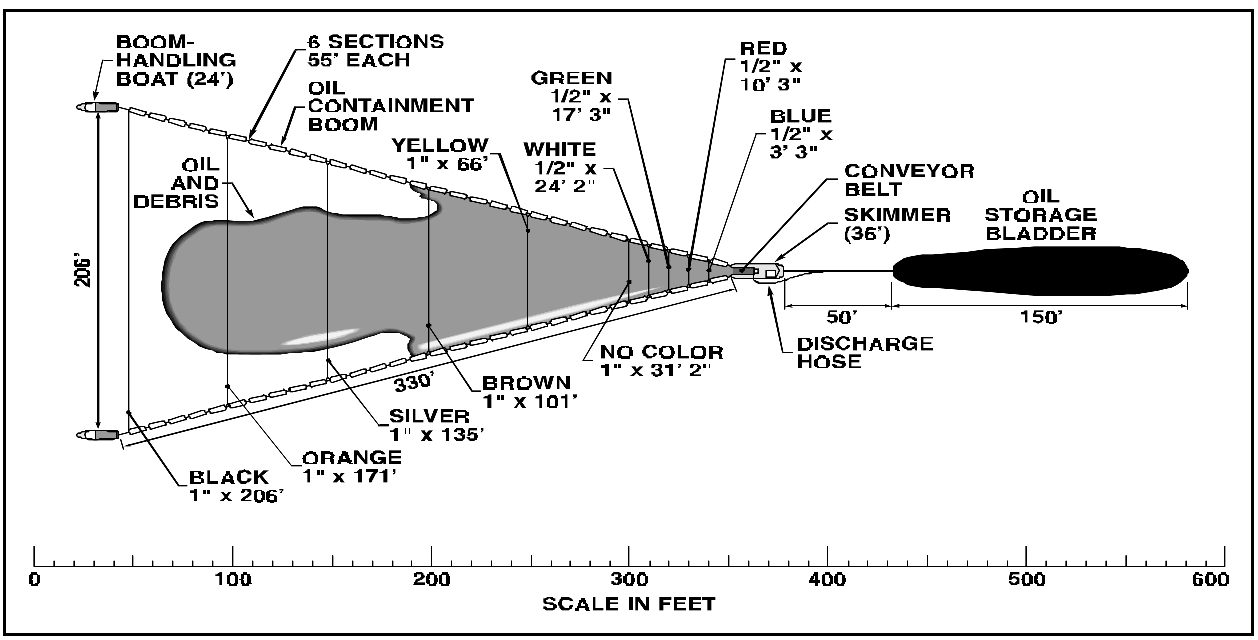


Figure 5-15. Boom Configuration Showing Span Lines.

parameters and pickup rate are the same as those of the self-propelled Class V skimmers. The Class XI may be attached to either side of the vessel of opportunity. Containment boom is attached to the skimmer to direct oil toward the filter belt induction pump, as shown in **Figure 5-16**.

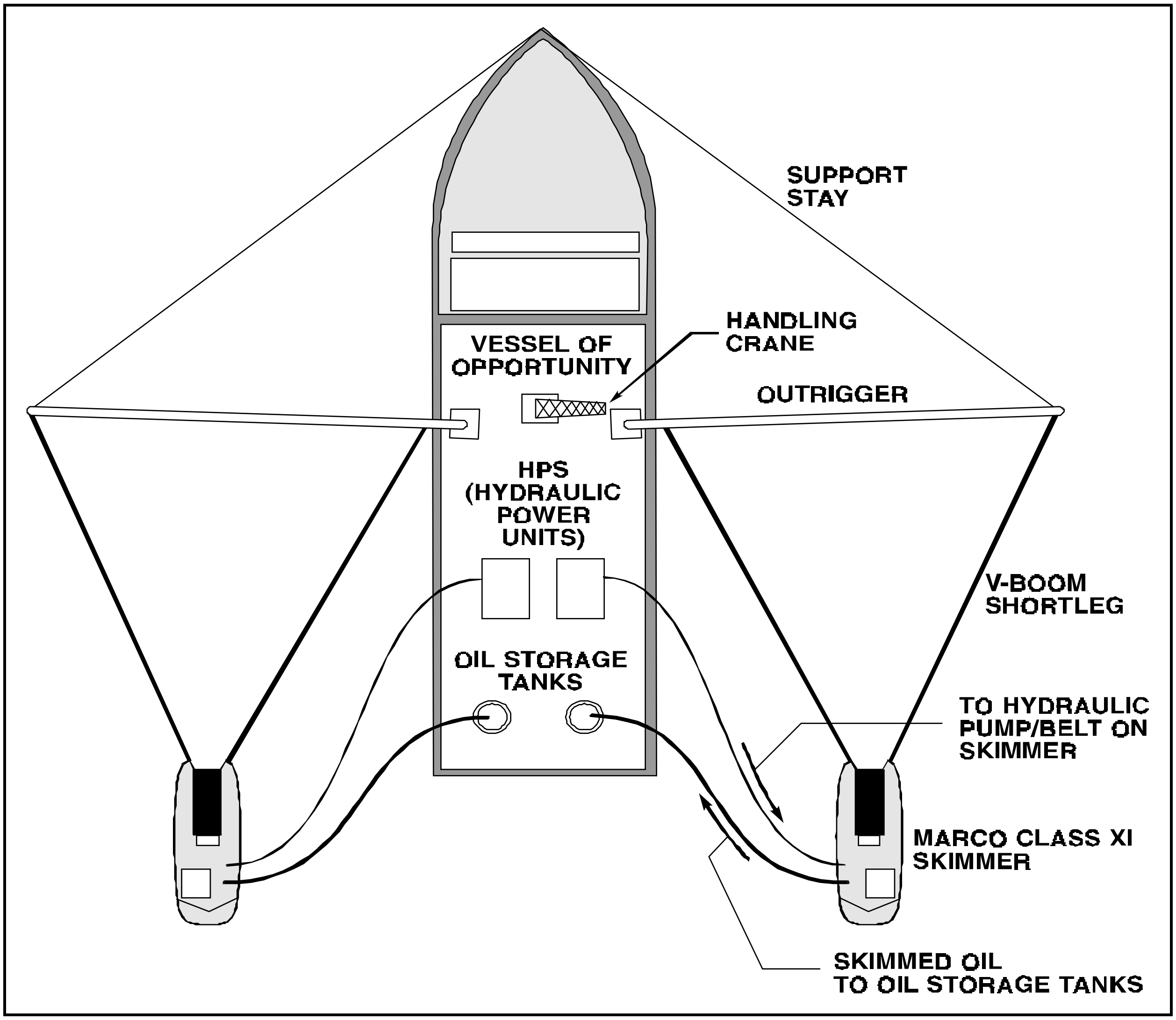


Figure 5-16. ESSM Class XI VOSS OIL Recovery Systems.

5-4.3 NAVFAC Skimmers. Four different COMNAVFACENGCOM skimmer models have been provided to the NOSCDRs. The NEESA Activity Information Directory (AID) lists the skimmer systems held by each NOSCDR. NAVFAC skimmers are categorized as:

- Small - Two small types are in inventory—a floating weir and a floating belt mop-type. The floating weir operated skimmers were issued to Navy activities before 1986, primarily for sheltered harbors alongside piers. After 1986, 30 belt mop-operated skimmers were issued.

- Medium - The Dynamic Inclined Plane (DIP) 2001 system is being replaced by the small belt mop skimmer. The medium skimmer is intended for sheltered harbors alongside or away from piers.

- Large - DIP 3001 is a self-propelled vessel with a rotating belt system for large open harbors.

5-4.3.1 NAVFAC Small Skimmer. NAVFAC small skimmers originally procured for the NOSCDRs are being replaced with more advanced skimmers. Before Fiscal Year 1986, the skimmer procured was a small floating oil and water separator weir model for small harbor spills, shown in **Figure 5-17**. A diesel-driven pump, connecting hose and 300-gallon storage bag assembled pierside allowed oil transfer from the floating oil and water separator to the storage bag. This two-man-operated system is most effective when used for small spills alongside a pier. High waves significantly reduce the effectiveness of this system.

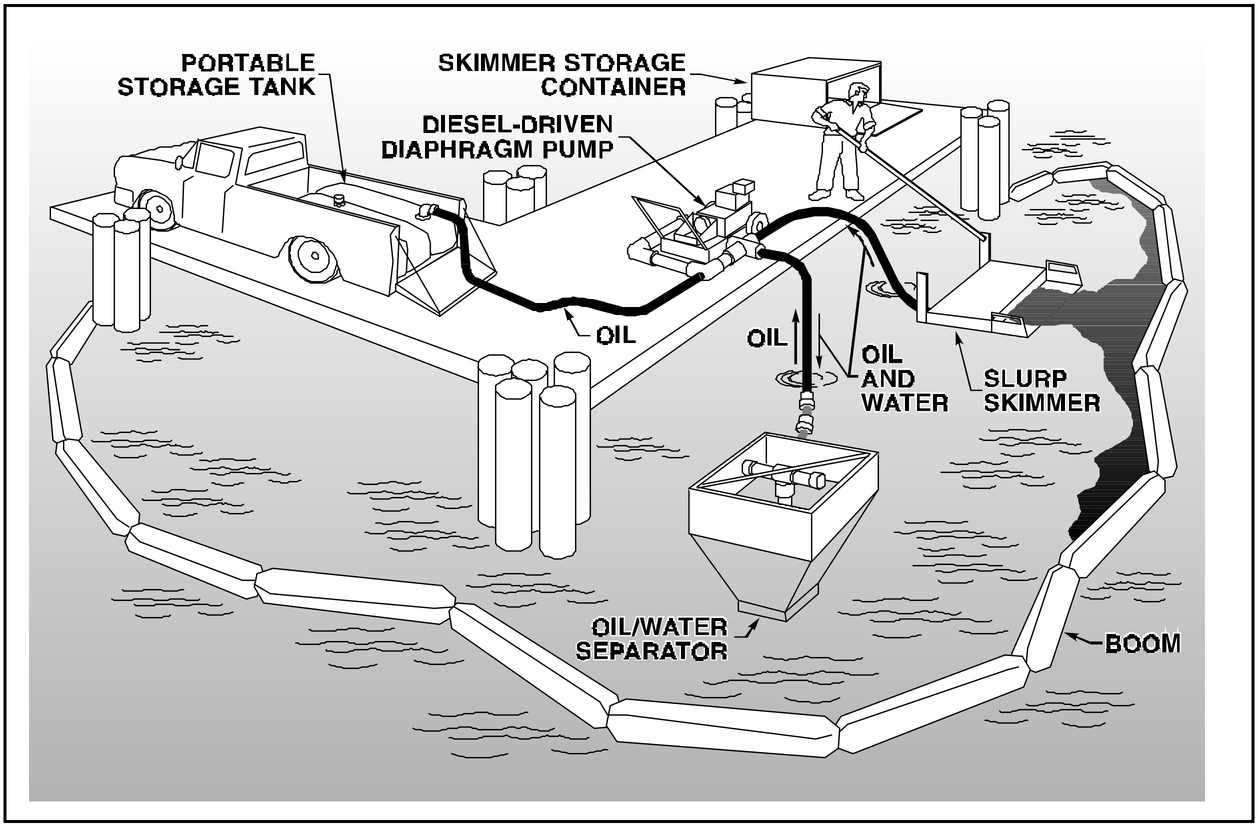


Figure 5-17. NAVFAC Small Skimmers.

The small skimmer system delivered to the NOSCDRs after FY 1986 is a rotating belt mop device intended to be more effective than the older model. The rope mop is made from oleophilic polypropolene fibers that attract oil as the rope passes through the oil-water interface. The oil passes through a set of wringer rollers and then into a storage tank. A transfer pump maintains a constant suction on the storage tank to transfer the recovered oil into a 300-gallon holding bag on the pier. This holding bag can be emptied into other larger storage tanks or into vacuum trucks by the same transfer pump.

Although effective, this replacement system has not proven to be a complete answer to small spills. A NEESA study is underway to identify a new self-propelled, belt-operated skimmer vessel for small spills. This skimmer will be procured by NEESA for NOSCDRs.

5-4.3.2 NAVFAC Medium Skimmer. The Dynamic Inclined Plane (DIP) 2001 medium skimmer is no longer procured for NOSCDR use. The new small skimmer system discussed in the previous paragraph is intended to replace the medium skimmer. NOSCDRs will continue to use the DIP 2001 medium skimmers until they are no longer in inventory. The new skimmers procured by NEESA will eventually replace the medium skimmers.

The DIP 2001 is a self-contained portable system that is moved by truck to the spill site. A DIP 2001, air compressor, skimmer-handling boom, 400-gallon storage tank and 200 feet of containment boom are included in this system. The system is designed to move surface oil down the underside of the inclined plane to an open area beneath the skimmer. Like the other DIP-operated skimmers, the oil rises and fills the tank above the open area. The skimmer is moved in the oil manually with a control wand. The 22-foot-long wand also contains hose for pumping recovered oil from the skimmer to the 400-gallon tank on the pier. A control box held on the pier or shore operates the skimmer systems and controls the belt speed.

DIP 2001 systems are intended for small to medium spills occurring in harbors and other still water areas. The skimmer remains stationary and the oil is brought to the rotating inclined plane with an artificial or natural force. The apex of the skimmer and boom configuration is located downwind or downcurrent. The surface oil should flow into the skimmer mouth. Oil movement can be enhanced with water and air jets, prop wash, pusher boats or firefighting monitors. Universal boom fittings allow boom to be added if the spill is larger than the area covered by the initial 200 feet of boom.

5-4.3.3 NAVFAC Large Skimmer. The DIP 3001 shown in **Figure 5-18** is intended for medium and large spills in open harbors. The operating principle for this skimmer is the same as the DIP 2001. However, the DIP 3001 has a wider belt and, thus, a higher recovery rate. The DIP 3001 is a self-contained, 26-foot vessel, manned by a crew of two and capable of operating in three-foot waves. Open water operations are possible in good weather. The skimmer has two oil containment sweeps that funnel oil toward the dynamic inclined plane. Water enhancement jets push oil into the recovery plane. A debris rake in front of the inclined plane keeps out large pieces of debris. Smaller debris that ends up in the oil collection well is removed by a hydraulically operated basket system.

Containment boom attached to the skimmer's bow and towed by two vessels increases the sweep width and recovery rate. With the sweep boom attached, the skimmer-boom-towboat makeup is maneuvered slowly through the oil spill by using a combination of boat and skimmer propulsion. Skillful manipulation of boats and skimmer keep oil flowing into the inclined plane mechanism.

The DIP 3001 can recover up to 60 gallons per minute operating at one to two knots. Water percentage in the recovered oil is usually less than one percent. The on board storage capacity is 1,500 gallons. Continuous recovery and offloading is possible if a bladder or barge is brought to the skimmer.

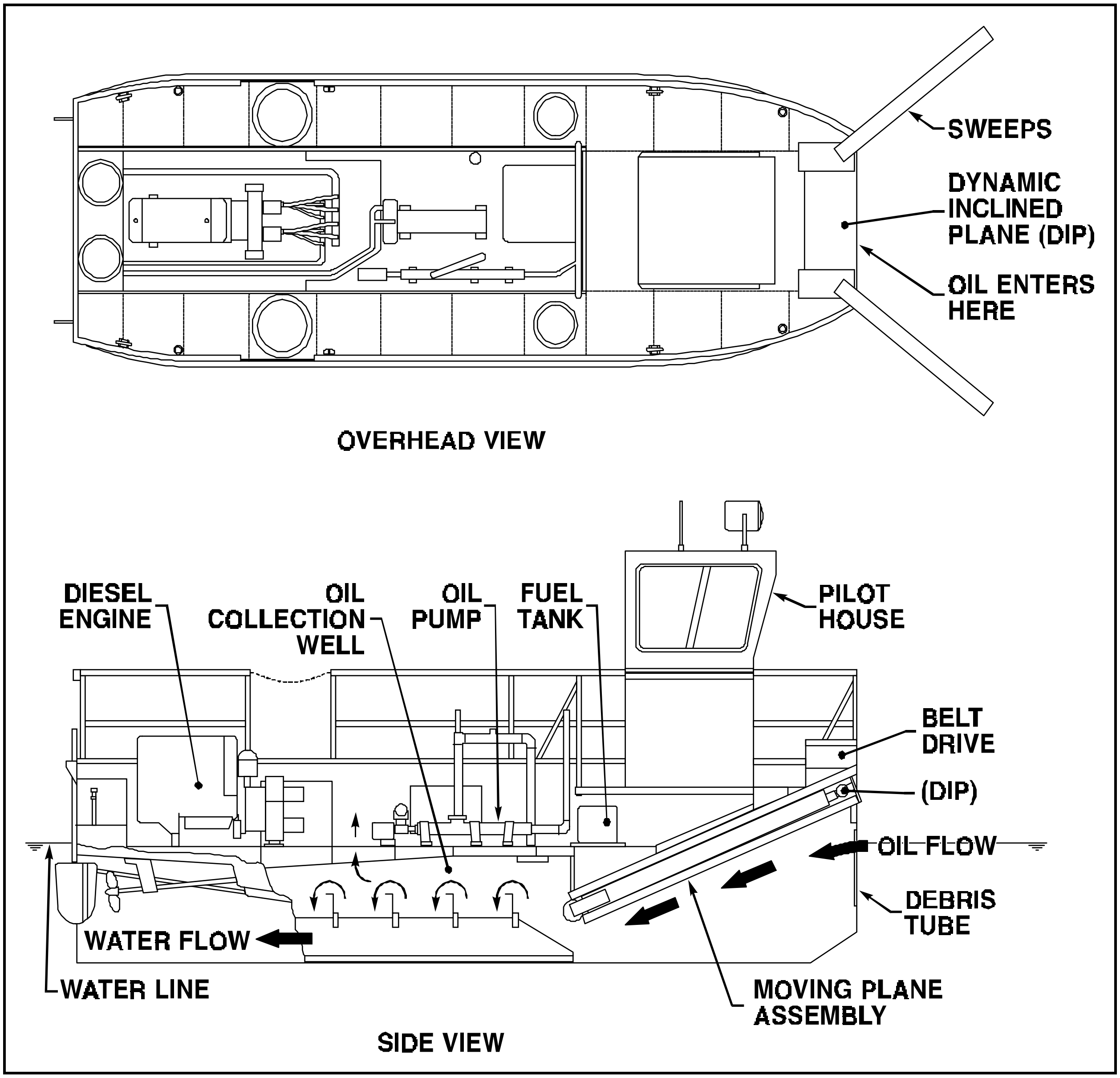


Figure 5-18. NAVFAC Large Skimmer.

5-4.4 Other Navy Oil Recovery Equipment. Basic skimming systems should be augmented to improve the recovery rate. Descriptions of available SUPSALV ancillary oil recovery equipment can be found in the *U.S. Navy ESSM Catalog*, NAVSEA 0995-LP-017-3010 and in the *Activity Information Directory (AID)* NEESA Publication 7-021C. Skimmers are not always the critical piece of operating equipment during recovery operations.

Hydraulic submersible, positive-displacement and axial flow pumps are available in the ESSM System. The pumps can transfer oil directly from tanks to barges or lightering ships or can be placed in the spilled oil to recover oil. The DOP-250 pump can pump the heaviest crude in cold weather at very high rates. **Figure 5-19** shows the pump's performance curves.

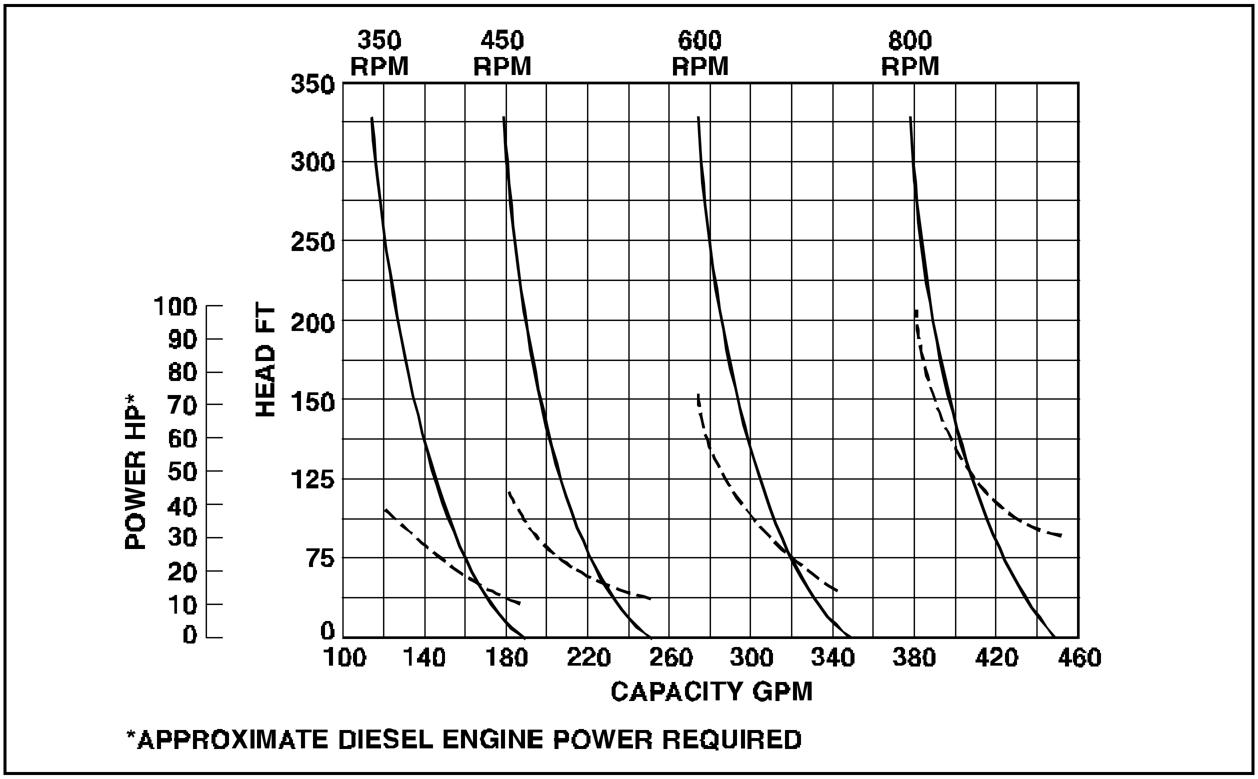


Figure 5-19. DOP-250 Flow Rates.

Other ESSM System oil recovery support equipment includes:

- Large fenders for barge and ship lightering operations.
- Command vans that provide office space, galley equipment and personnel shelter.
- Rigging vans that contain expendable materials like line, wire rope, shackles, spare parts and tools for rigging the skimmers, boom and support equipment.
- Workshop vans that contain power tools, a 30KW generator, spare parts and hand tools.
- Tyvek suits, gloves, boots, hand cleaners, solvents and other consumables carried in the inventory of the various vans.

NAVFAC support equipment listed in the AID publication includes waste oil rafts (donuts), ship's waste offload barge (SWOB) and workboat platforms. These items are not intended for deployment to remote places as readily as the ESSM support equipment. They are primarily for service in harbors that homeport fleet units.

Open and closed-bottom waste oil rafts (donuts), shown in **Figure 5-20**, are suitable for temporary storage of oil received from skimmers. The closed-bottom donut is preferred because the open donut can spill oil if oil is pumped into it too fast or when towed too fast. There is little

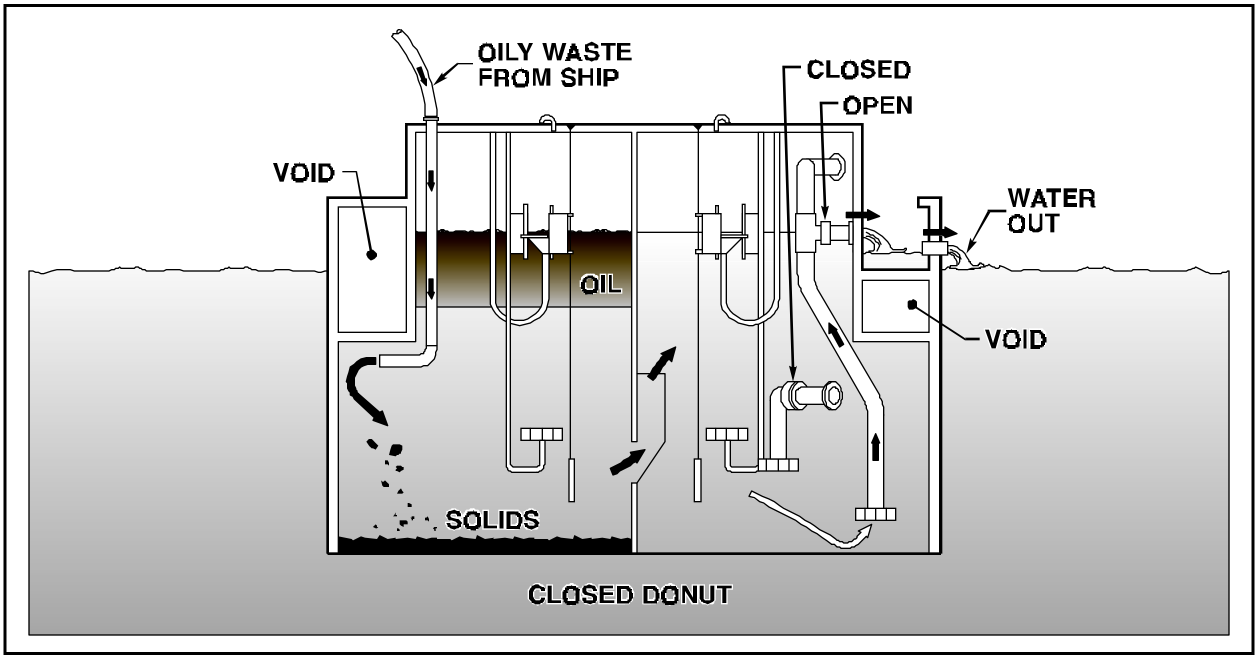


Figure 5-20. Waste Oil Rafts (Donuts).

chance of oil spillage from a closed-bottom donut. Both donuts are effective for decanting oil-water mixtures.

SWOBs are intended to collect ship-generated oily wastes but are excellent receivers for skimmer-recovered oil. The barges can handle more oil at a much higher flow rate than donuts can. These nonself-propelled barges can be towed to the skimmer or rigged astern of the skimmer. The onboard pumping systems are for offloading product only. Portable vacuum pump systems can be deployed to offload skimmers or to suck up oil directly.

5-5 COMMERCIAL SYSTEMS

When the local Navy On-scene Coordinator assists salvors in combating an oil spill, significant additional oil containment and recovery resources become available. Through the DOD member of the Regional Response Team, the NOSC has access to commercial cooperatives through existing contracts or memorandums of understanding. If there is a specific requirement for equipment not held by U.S. Navy NOSCDRs assisting in the spill, the NOSC can request that equipment from other members of the RRT. Inventories of available commercial assets are not readily available to salvors but are an integral part of shoreside and Fleet NOSC/NOSCDR contingency plans.

Commercial assets from various sources include state-of-the-art oil skimmers, support equipment and highly qualified personnel. Some commercial skimmers are much larger than Navy skimmers and have multiple skimming capabilities. Their size, up to 150 feet long, permits operations in higher sea states in the open ocean. Many cooperatives have been formed in the port cities of the U.S. and in foreign countries. Requesting their assistance is prudent when large amounts of skimming equipment is needed early in a spill response to prevent oil from fouling the shore.

CHAPTER 6

DISPERSANTS AND OTHER CHEMICALS

6-1 INTRODUCTION

Navy policy advocates the mechanical recovery of spilled oil over the use of dispersants or other chemicals. Because oil spill response chemicals may be environmentally damaging and do not remove oil from the environment, their use is strictly controlled or forbidden by regulatory agencies, particularly in the United States.

Although mechanical recovery is usually preferable, chemical application is sometimes the best response option and is deployed by the spiller or host government. Pollution control plans, therefore, may require immediate availability of dispersants during salvage and emergency POL off-loading operations.

Several types of chemicals can lessen or alter the environmental impact of spilled oil:

- *Dispersants* that disperse slicks into small droplets of oil in the water column.
- *Surface collecting agents* that enhance mechanical recovery.
- *Biological additives* that encourage biodegradation.
- *Burning agents* that facilitate in situ burning.
- *Sinking agents* that cause oil to settle to the seafloor.

The Navy does not stockpile nor recommend initial response with dispersants or other chemicals, however, salvage officers should recognize situations that favor chemical application over other response options. Although not responsible for deploying chemicals, Navy salvors should have enough technical knowledge to coordinate salvage activities and mechanical spill response measures with the application of dispersants or other chemicals.

6-2 DISPERSANTS

The first large application of dispersants was in response to the spill from the oil tanker *TORREY CANYON*, following her grounding and the release of 14,000 tons of crude oil off the coast of Cornwall, England in 1967. Approximately 10,000 tons of dispersant were applied during this response. These early dispersants were essentially degreasers made for tank and bilge cleaning and consisted of extremely toxic surfactants and solvents. While effective in removing visual evidence of spilled oil, these first-generation dispersants were harmful to organisms in shallow water and along the shoreline. In many cases, the dispersants were more harmful than the spilled oil.

As a result of the *TORREY CANYON* experience, dispersants are applied very conservatively to combat oil spills, especially in the United States.

Second-generation dispersants, also containing hydrocarbon solvents, were less toxic but also less effective. Third-generation dispersants consist mostly of surfactants formulated with relatively little alcohol or glycol solvent. The dispersants are supplied in concentrated form that is diluted with seawater as they are applied. Third-generation dispersants are less toxic to marine life than earlier dispersants.

The following terms are necessary to understanding dispersants:

- *Surfactant*. Surface-acting agent, sometimes called a detergent. Contains molecules with both water-compatible and oil-compatible portions.

- *Hydrophilic*. The water-compatible portion of a surfactant molecule.

- *Hydrophobic* (also called *lipophilic*). The oil-compatible portion of a surfactant molecule.

- *Interfacial Tension*. Surface tension existing at the oil-water interface. Surfactants reduce interfacial tension.

- *Micelles*. *Micelles* are ordered aggregates of surfactant molecules. *Critical Micelle Concentration (CMC)* occurs when so many surfactant molecules are added that they no longer accumulate only at the oil-water interface.

6.2.1 Dispersant Composition. Dispersants consist of surfactants dissolved in a solvent. When dispersants are applied to an oil slick, the surfactant reduces the surface tension of the oil to break up the oil into droplets. The solvent helps the surfactant to penetrate the oil. The oil droplets are dispersed throughout the water column, where natural degradation takes place. Dispersants do not make oil go away; they only change it from a slick on the surface to tiny droplets suspended throughout the water column. Dispersal helps prevent emulsification and enhances oxidation, biodegradation and dissolution.

Dispersants are classed as water-based, hydrocarbon-solvent-based or concentrate. Water-based dispersants can be applied by eduction into a water stream. Hydrocarbon-based dispersants are formulated to enhance mixing and penetration of the surfactant into viscous oils. Concentrated dispersants disperse a higher volume of oil per volume of dispersant than conventional dispersants and are suited for discharge from aircraft, where weight is an important factor.

6.2.2 Surfactants. Surfactants have two roles: first, to penetrate the oil slick and break it into droplets and second, to shield individual oil droplets to prevent emulsification and immediate coalescence into another oil slick.

Surfactants become aligned to the oil-water interface when dispersants are applied to an oil slick. The hydrophilic portions of the surfactant molecules are attracted toward water and lipophilic portions of the molecules are attracted toward oil, forming a layer of micelles on the oil surface. Figure 6-1 illustrates this mechanism.

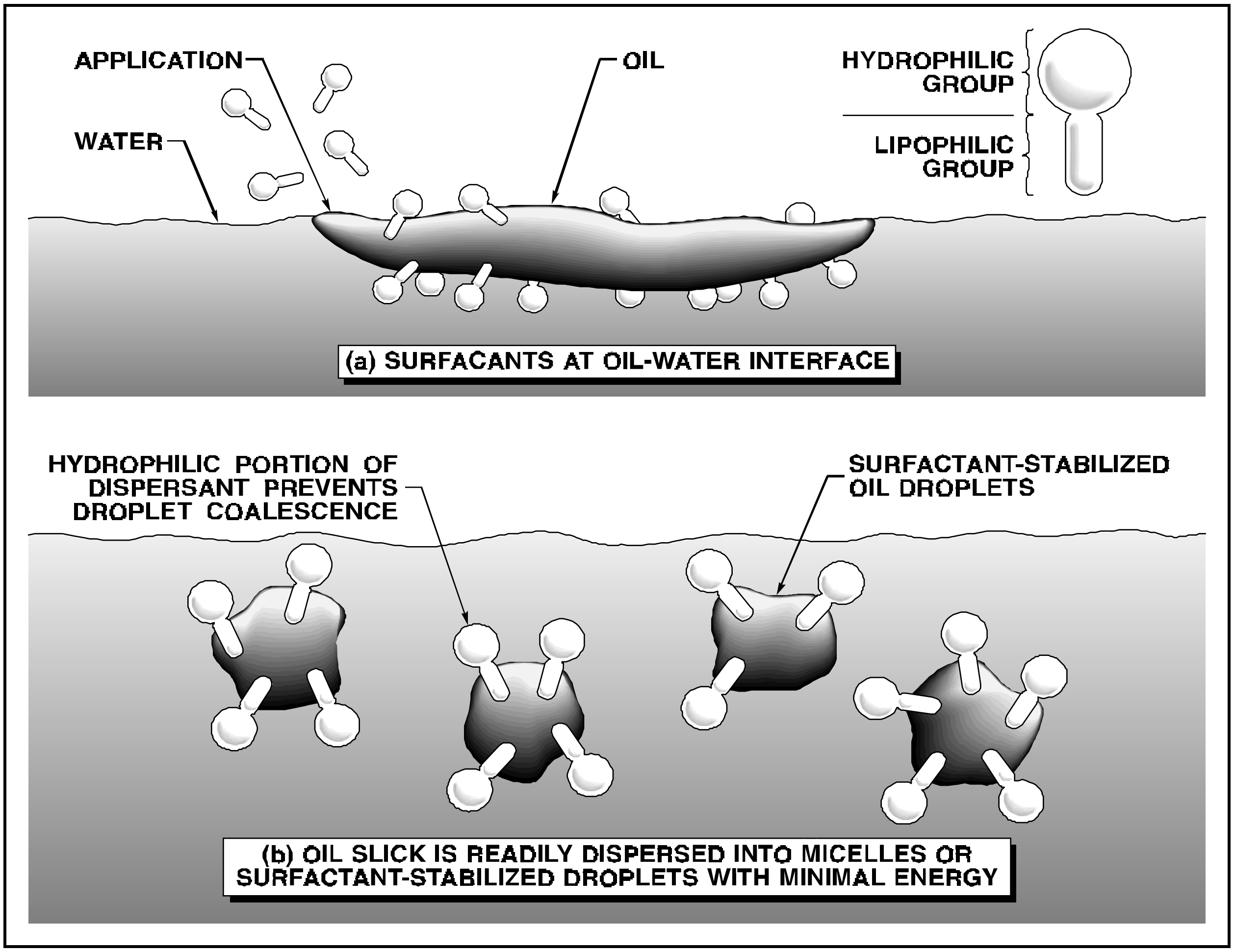


Figure 6-1. Mechanism of Chemical Dispersion.

Dispersants reduce the interfacial tension between oil and water, weakening the cohesiveness of the oil slick, so that external energy, such as wave action, breaks up the oil slick into droplets. Once oil is in droplets, it disperses naturally throughout the water column. The layer of micelles covering the oil droplets, with hydrophilic portions outward, helps prevent the oil droplets from coalescing into another slick.

Surfactants have varying degrees of hydrophilic and lipophilic behavior, depending upon their chemistry. The range of hydrophilic-lipophilic balance (HLB) is measured on a scale of 1 to 20, with 1 being most lipophilic and 20 being most hydrophilic. A surfactant having an HLB of 1 to 4 is very lipophilic and does not mix with water. A surfactant having an HLB of 17 to 20 is very hydrophilic and mixes readily with water. Surfactants in oil spill dispersants are hydrophilic, with HLB numbers ranging from 8 to 18 and are formulated to stabilize oil-in-water emulsions.

6.2.3 Considerations for Employing Dispersants. Dispersants are effective only under proper conditions. Substantial portions of very light oils, such as Diesel Fuel, Marine (DFM), evaporate within a few hours, so there is little need to apply dispersants to light oils except to prevent a fire or fume hazard. Lubricating oils are usually difficult to disperse chemically because of their additives. The type of oil, weathering, method of application and environment all influence dispersant performance.

6.2.3.1 Viscosity. Oils with a viscosity of less than 2,000 centistokes (cSt) react well with chemical dispersants. Dispersants are less effective for oils with viscosities in the 2,000 to 5,000 cSt range. Dispersants are ineffective for oils having a viscosity greater than 5,000 cSt. Oils at temperatures below their pour point become very viscous and are difficult to disperse. **Table 6-1** lists some crude oils that are not amenable to treatment by dispersants in temperate waters because of high viscosity or pour point.

Because viscosity increases as oil cools, dispersants effective in warm weather may be ineffective on the same oil in a cold environment. Oil viscosity also increases with weathering. A dispersant effective shortly after a spill may be much less effective later.

6.2.3.2 Field Testing. Dispersants and oils are chemically complex. Selected dispersants should be tested on the spilled oil to prove the effectiveness of the dispersant and the method of application before large applications are attempted. Testing should take place early in the response to allow large scale application before the oil weathers significantly.

6.2.3.3 Method of Application. Application must be timely and deliver the dispersant in the proper droplet sizes and amounts. Proper application requires great attention to detail. Dispersants may be applied from aircraft or vessels during periods of good visibility.

6.2.3.4 Prevailing Weather. After dispersants are applied, mixing energy is required to complete the chemical reactions that must take place. Wave action generated by winds of Beaufort Force 3 or higher is usually sufficient.

6.2.3.5 Environmental Considerations. Both long-term and short-term environmental impacts must be taken into account in determining if dispersants are appropriate.

Dispersants are recognized as an effective measure to prevent oil from stranding on an environmentally sensitive shoreline. However, the dispersed oil may do more long-term damage than not applying dispersants and allowing the oil to drift ashore.

The **sensitivity** of the local environment where dispersants may be applied must be considered. While such consideration is on a case basis, some generalities are helpful in these evaluations.

- Dispersed oil has the same effects on marine life as nondispersed oil. If oil is dispersed chemically in shallow water, some oil settles on the bottom where it affects marine life adversely. Oil that settles into bottom sediment takes much longer to biodegrade than oil in the water column. Consequently, it impacts benthic organisms for a longer time. Dispersed oil may penetrate beach sand and gravel deeper than nondispersed oil.

- When used to protect a shoreline, dispersants should be applied while the slick is still well out to sea to allow time for the dispersant to take effect and to dissipate and to give maximum time for natural weathering. This is especially true for certain environmentally sensitive areas, such as coastal wetlands, shellfish beds and animal breeding areas. Dispersants and dispersed oil may be toxic to certain fish and other organisms and affect breeding adversely, particularly if dispersed oil remains in the water column for a longtime. The environmental gains of increased weathering of the oil may be offset by the toxicity of the oil and dispersants made available to the organisms in the water column.

- Dispersants are most effective in regions where dispersed oil becomes highly diluted and is subject to regular flushing activity. Dispersants should not be employed where prevailing winds, currents or shoreline topography will concentrate the dispersed oil. Dispersants are more appropriate for application in deeper water and long distances from shore.

In essence, use of dispersants is a tradeoff. In some instances, damage to an aquatic environment is accepted to prevent damage to a shoreline. In others, short-term catastrophic impact is traded for less traumatic, but longer term effects.

6.2.3.6 Wind and Currents. Prevailing wind has a great effect on untreated oil, while prevailing currents have a greater effect on dispersed oil. With knowledge of wind and currents, rough predictions may be made about where either treated or untreated oil can be expected to impact.

6.2.4 Dispersant Application. Subpart J of the *National Contingency Plan* (40 *CFR* 300.900), *Use of Dispersants and Other Chemicals*, sets forth procedures to authorize dispersants.

6.2.4.1 Authorization for Dispersant Use. Dispersants may be applied in certain waters of the United States only when authorized by the Federal On-Scene Coordinator (FOSC). The FOSC must have concurrence from Environmental Protection Agency (EPA) and the Regional Response Team (RRT) representative from the states having jurisdiction over affected waters before granting permission for dispersant application. In addition, the Department of Commerce or Department of Interior is to be consulted when resources are involved for which those agencies have responsibility.

Dispersants authorized by the FOSC must be listed on EPA's *NCP Product Schedule*. The product schedule contains a list of dispersants, surface collecting agents, biological additives and miscellaneous oil control agents that are approved by the EPA. The schedule is maintained by the EPA Emergency Response Division and is revised periodically.

The FOSC may authorize dispersants, including those not on the EPA Product List, without concurrence from other jurisdictions when, in the judgement of the FOSC, the dispersants are necessary to prevent or substantially reduce hazard to human life.

6.2.4.2 Preapproval. Because of the lengthy approval process, authorization for dispersants is often gained by preapproval with the RRT as the decision-making forum. The object of such arrangements is twofold—first, to identify environmentally sensitive areas where dispersant use is appropriate and second, to determine appropriate conditions for dispersant application. By this contingency planning, an RRT, in response to an actual spill, makes a timely recommendation to the FOSC about dispersants, so that the dispersants will have a high probability of being effective. Without preapproval, the time spent by the RRT discussing dispersants may extend beyond the time that dispersants can be effective.

There are several models that can assist in deciding whether dispersants are an applicable response tool. Two primary models are the EPA *Computerized Spill Response Decision Tree* (**Figure 3-1**) and the American Petroleum Institute *Oil Spill Control Decision Diagram* (**Figure 3-2**).

Other models usually consider specific activities, such as offshore drilling or oil terminal operations and areas to be protected. They also provide information about effectiveness of various spill response options.

6.2.5 Field Application of Dispersants. Dispersants may be applied by hand, from vessels or from aircraft. Time, cost and environmental considerations dictate the choice of method.

In general, dispersants must be applied shortly after an oil spill. If the spill is miles at sea, aircraft are often the most effective response vehicle. Vessels may be utilized to apply dispersants to spills close to shore.

The costs of using dispersants include transportation to deployment site, labor, training and deployment of the application system and demobilization of the system. Although dispersant application by boats is less expensive, it is also less effective than by aircraft, particularly if the spill covers a large area or if the dispersant must be applied quickly to protect an environmentally sensitive area.

Prevailing weather may either dictate the method of application or prohibit dispersants. Small boats are ineffective in rough weather. Spotters in aircraft require good visibility to see spilled oil.

6.2.5.1 Theory of Application. A sufficient volume of dispersant in properly sized droplets must be applied. Ideal droplet diameter is 300 to 1,000 microns. Smaller droplets turn to mist and drift with the wind. Larger droplets tend to pass through an oil slick without dispersing it. Nozzle diameter and air shear generated by aircraft are the major influences on droplet size. Other factors influencing droplet size include dispersant viscosity, system flow rate and operating pressure. A proper dispersant spray system takes these factors into account.

6.2.5.2 Application Rates. First- and second-generation hydrocarbon-solvent-based dispersants are applied undiluted at a ratio between 1:1 and 1:3—one part dispersant to one to three parts oil. Third-generation dispersants are highly concentrated and may be applied undiluted or mixed with seawater. Typical dose rates for concentrated dispersants range from 1:5 to 1:30—one part dispersant to 5 to 30 parts oil.

Table 6-1. Crude Oils with High Viscosities or Pour Points.

Crude Name	Loading Port	Country	Gravity °API	Viscosity cSt 100°F 37.8°C	Pour Point	
					°C	°F
Amna	Ras Lanuf	Libya	36.1	13	18	65
Arjuna	SBM, Java Sea	Indonesia, W. Java	37.7	3	27	80
Bahia	Salvador	Brazil	35.2	17	38	100
Bass Strait		Australia	46.0	2	15	60
Boscan	Bajo Grande	Venezuela	10.3	>20,000	15	60
Bu Attifel	Zueitina	Libya	40.6	-	39	102
Bunyu	Bunyu	Indonesia, E. Kalimantan	32.2	3	17.5	63
Cabinda	SPMB-Landana	Angola	32.9	20	27	80
Cinta	SBM, Java Sea	Indonesia, W. Java, Sumatra	32.0	-	43	110
Gamba	SPMB-Gamba	Gabon	31.8	38	23	73
Gippsland Mix	Western Port Bay	Australia	44.4	2	15	60
Handil	SBM, Handil	Indonesia, E. Kalimantan	33.0	4.2	29	85
Jatibarang	SBM, Balongan	Indonesia, W. Java	28.9	-	43	110
Jobo/Morichal (Monagas)	Puerto Ordaz	Venezuela	12.2	3,780	-1	30
Minas	Dumai	Indonesia, Sumatra	35.2	-	32	90
Panuco	Tampico	Mexico	12.8	4,700	2	35
Pilon	Carpito	Venezuela	13.8	1,900	-4	25
Rio Zulia	Santa Maria	Columbia	40.8	4	27	80
San Joachim	Puerto La Cruz	Venezuela	41.5	2	24	75
Shengli	Qingdao	P.R. China	24.2	-	21	70
Taching	Darien	P.R. China	33.0	138	35	95
Tia Juana Pesada	Puerto Miranda	Venezuela	13.2	>10,000	-1	30
Zaire	SBM	Zaire	34.0	20	27	80
Zeta North	Puerto La Cruz	Venezuela	35.0	3	21	70

6.2.5.3 Application Ashore. Dispersants are applied along shorelines by individuals equipped with backpack units with self-contained pumps and applicators or from vehicles fitted with tanks, pumps and spray arms, hose lines or monitors.

Dispersants are most effective for cleaning remaining oil after the shoreline has been cleaned by other means. Dispersants should be applied about an hour ahead of an incoming tide, to allow penetration of the remaining oil before it is mixed with seawater. Dispersed oil must not be allowed to filter into the soil and create environmental damage. To prevent environmental damage, some authorities have special standards for dispersant application along shorelines.

6.2.5.4 Application from Vessels. Usually, vessels of opportunity are fitted with a self-contained spray unit to apply dispersants. These units consist of a pump with prime mover, dispersant tanks and spray booms fitted with piping and nozzles. Some ports and terminals may have dedicated spill response vessels with installed dispersant application systems.

The most effective shipboard units are mounted at the bow where the high freeboard permits the longest extension of the spray booms and the widest encounter width of dispersant. Application of dispersant before the oil slick is displaced by the bow wave enables bow wave energy to aid in mixing dispersant with the oil. Otherwise, the bow wave tends to move oil away from the ship, reducing the effectiveness of the dispersant. Bow systems allow the ship to operate at higher speeds than with systems rigged elsewhere. While ships can carry large quantities of dispersant, some may be limited, primarily by deck area. An unlimited supply of saltwater makes vessels ideal for applying dispersants that must be diluted during application.

Spotter planes may assist ships in locating the areas where application of dispersants is most desirable and in determining the effectiveness of the applied dispersant.

6.2.5.5 Application from Aircraft. Helicopters, small fixed-wing airplanes and large transport aircraft have applied dispersants. Aircraft are best suited for spraying dispersant concentrate because they need not be pre-mixed with water and depend only upon wave energy for mixing. With a speed advantage over ships, aircraft are often the best means to apply dispersant to large or widely separated slicks or slicks some distance offshore. Spotter aircraft can supportdispersant-application aircraft by directing them to areas where the dispersant can be most effective.

To apply dispersants effectively, aircraft should be able to operate at low altitude, at speeds of 50 to 150 knots and have good maneuverability and large payload capacity.

Aircraft equipped for spraying agricultural chemicals (crop dusting) or equipped for forest fire-fighting water/fire-retardant chemical spray support are usually suitable for applying dispersants. In general, dispersant spray systems have greater application rates and generate larger dispersant drop sizes, so agricultural chemical spray systems must be modified before spraying dispersants.

Aircraft support facilities are required for resupply of dispersant, refueling, crew changes and minor maintenance. Because payloads are weight-limited, aircraft normally make several flights to apply dispersants.

Dispersants have a strong degreasing action that may contaminate lubricants, such as those in helicopter tail rotor assemblies and may damage exposed rubber parts. Aircraft applying dispersants require special maintenance.

6.3 SURFACE COLLECTING AGENTS

Surface collecting agents absorb, congeal, trap, fix or make the mass of oil more rigid or viscous, which enhances mechanical removal. Surface collecting agents are applied to the surface or along the periphery of an oil slick. Surface collecting agents include elastomers, gelling agents and herding agents.

6.3.1 Elastomers. Elastomers are the most promising surface collecting agent. An elastomer—usually a powder formulated from a nontoxic polymer (polyisobutylene)—gives a visco-elastic property to spilled oil and makes the oil somewhat adhesive to oil spill recovery equipment.

Tests show that elastomers are effective on a wide range of oils. Effectiveness is increased by mixing and high temperatures. Under good mixing conditions, oils exhibit some degree of elasticity within 15 minutes of application, with maximum elasticity being achieved after one hour. Weathering increases the elasticity of treated oil, thus adding to the productivity of elastomers.

6.3.2 Gelling Agents. Gelling agents cause oil to become solid or semisolid. While gelling agents may control a spill, gelled oil is difficult to handle with conventional response equipment. The large amount of gelling agent required—up to 40 percent of the volume of spilled oil—makes gelling agents impractical for most spills.

6.3.3 Herding Agents. Herding agents stop oil from spreading by pushing oil films together. They function best on small spills in absolutely calm water and, therefore, have little overall utility.

6.3.4 Approval. Procedures for gaining permission to apply surface collecting agents are the same as those for dispersants. Approved surface collecting agents are included in the EPA National Contingency Plan Product Schedule.

6.4 BIOLOGICAL ADDITIVES

Biological additives are microbiological cultures, enzymes or nutrient additives, deliberately introduced into an oil spill for the specific purpose of encouraging biodegradation to mitigate the effects of the spill. Because natural biodegradation is a slow process, degradation of oil by biological means—or bioremediation—has not been a primary means of removing oil from contaminated sites. Only recently has bioremediation received significant attention as a response mechanism.

Biological additives were applied effectively in response to the oil spills from *EXXON VALDEZ* in Alaska in 1989 and from *MEGA BORG* in the Gulf of Mexico in 1990. In Alaska, bioremediation cleaned oil from several miles of contaminated beaches. In the *MEGA BORG* spill, biological additives were applied to the light Angolan crude oil at sea.

6.4.1 Biodegradation. Biodegradation of oil is the process of biological oxidation, similar to that utilized in municipal sewage treatment plants. There are over 200 natural micro-organisms—bacteria, yeast and fungi—that are able to metabolize hydrocarbons. The organisms require oxygen and proper proportions of carbon, nitrogen and phosphorus. Because oil has compounds containing carbon, oil is consumed when encountered by the organisms. The products of the biodegradation process are a stable biomass, water and carbon dioxide. Natural biodegradation of spilled oil is a slow process. Colonization of bacteria typically takes from one to two weeks and then biodegradation of the oil can take up to two to six months or more.

6.4.2 Enhanced Biodegradation. The biodegradation process is enhanced by adding a nutrient containing the proper proportions of nitrogen and phosphorus to the oil slick. A compound containing carbon may also be added to “jump start” the bacterial process. Laboratory tests show the biodegradation process can be made up to four times more efficient by the application of nutrients similar to agriculture fertilizers.

The nutrient must not be soluble in water and must be oleophilic, so that it is available to the oil at the oil-water interface. A nutrient typically may consist of oleic acid for introduction of carbon, a phosphoric ester for phosphorus and a compound containing nitrogen. Nutrients sometimes are made as micro-emulsions to aid retention at the oil-water interface.

6.4.3 Application. Biological additives are applied at a rate of about one part nutrient to 10 parts oil. Bioremediation is particularly appropriate in remote areas where support of personnel and equipment is difficult, because the process is self-sustaining and requires only periodic monitoring. Biodegradation is effective in cold climates, although microbial action is slowed as temperature decreases. Biodegradation makes a slow, but significant contribution to the removal of oil from marine environments. As bioremediation cannot remove a spill in a short time, it is of use principally as a supplement to mechanical removal.

6.4.4 Approval. Procedures for gaining permission to use biological agents for response to an oil spill are the same as the procedures for dispersants. Approved biological additives are included in the EPA National Contingency Plan Product Schedule.

6.5 BURNING AGENTS

Burning agents are additives that physically or chemically improve the combustibility of the materials to which they are applied. Most burning agents function as wicking agents—that is, they enhance movement of oil to an igniter or source of combustion to sustain burning. Wicking agents such as polyurethane foam also insulate oil from cold seawater to enhance combustion. Other burning agents increase the surface area of oil, add catalysts, oxidizers and low-boiling volatile components and absorb and entrap oil.

6.5.1 Burning Operations. Free oil in a slick less than about 0.12 inches thick does not sustain combustion because of cooling from seawater. Thicker oil slicks usually support combustion until only a thin layer that is too cold to burn remains. Combustion is greatest where oil is the thickest. As oil warms, it flows outward, reducing slick thickness so combustion is sustained only toward the center of the slick. The inward flow of air caused by rising heat slows the outward flow. A greater portion of oil burns when it is contained by boom, ice, etc.

Light, volatile oils burn more readily than heavy oils. Ignition and sustained combustion is difficult to achieve in weathered oil because light components have evaporated. Some refined oils sustain combustion on the water surface only when aided by a burning agent. Oil slicks do not burn completely; residue must be removed mechanically. Removal by burning is a tradeoff between removing oil pollution from the water and releasing combustion products into the atmosphere. Research by the U.S. Department of Commerce indicates that the combustion products are no more hazardous than the gases released by evaporating oil. Despite this evidence, the smoke and visible air pollution are objectionable to most communities. Open *in situ* burning of oil and oily debris is therefore used most often in remote areas.

Oil contained in cargo or bunker tanks of a ship supports combustion much more readily than free oil. A rule of thumb is that at least ten percent of the area over the oil in a cargo or bunker tank must be open to the atmosphere for sustained combustion. It is difficult to burn oil completely from deep cargo tanks that are not open to the sea. As oil is consumed, the oil level and consequently the combustion zone, falls within the tank. As the burning oil surface falls deeper into the enclosed tank, it becomes more difficult for air to reach the fire. The fire becomes very smoky and may go out altogether. The sides of the tank must be opened to admit air if the burning is to continue, a difficult and dangerous proposition on a hot and fire-weakened structure. In tanks open to the sea on stranded vessels, the oil level falls only slightly as oil is burned off because water flows into the tank to compensate for the reduced weight of oil.

6.5.2 Approval. The National Contingency Plan requires burning agents to be approved by the FOSC, with concurrence from RRT representatives from the EPA and states with jurisdiction over the navigable waters threatened by the oil. Consultation is also required with the Departments of Commerce and Interior when natural resources for which they have trustee responsibility are threatened. Approval for burning agents is given on a case basis, with no pre-approval. The EPA does not include burning agents on the National Contingency Plan Product Schedule.

6.6 SINKING AGENTS

A sinking agent is an additive applied to oil discharges to sink floating pollutants below the water surface. Sinking agents are made from the dust of dense materials with a high absorption capacity. Cement, coal dust, chalk and clay are such materials. When the dust is spread on an oil slick, it bonds to oil and settles to the bottom in small globules.

Sinking agents neither remove oil from the water nor change the form of oil to enhance its degradation by natural means. The application of sinking agents merely substitutes one form of environmental impact for another. For instance, an offshore seabed can be sacrificed to protect shorelines, adjacent areas of seabed or water areas that are deemed more sensitive for environmental or commercial reasons. Sinking agents do biological harm by suffocating bottom dwelling (benthic) organisms on the seabed. Once oil is moved to the seabed by a sinking agent, there is a risk that some oil may return to the surface. Sinking agents should be applied in the water deep enough that the bottom is unaffected by wave surge, which tends to resurface the oil. Because sinking agents merely move oil to the bottom, where it is least vulnerable to natural degradation and may do grave harm to the environment, regulatory authorities seldom permit sinking agents for oil spill response.

The National Contingency Plan (NCP) states that sinking agents shall not be authorized for application to oil discharges, thus sinking agents shall not be used for any oil spill response on waters where the NCP is applicable.

CHAPTER 7

SHORELINE CLEANUP

7-1 INTRODUCTION

It is easier and less costly to retrieve floating oil with boom and skimmers than it is to clean up oil that has fouled a shoreline. The Navy's strategy for spill response recognizes the benefits of skimming free oil and, building around the self-propelled Class V skimmer, SUPSALV has assembled one of the most effective oil spill response systems in the nation. However, no matter how well-prepared a response organization, some oil will probably impact the shoreline, forcing cleanup by methods other than skimmers and booms.

This chapter discusses strategies and methods that have been proven effective in cleaning oiled shorelines. Good management is important to successful shoreline cleanup operations. Shoreline cleanup is manpower-intensive and, therefore, very expensive. Diligence is necessary to prevent well-meaning response personnel from causing inadvertent environmental harm. Spill response managers must recognize and address safety aspects of shoreline cleanup of an oiled environment. Recovered oil and contaminated debris must be disposed of properly. A particular challenge to the management of shoreline cleanup is developing positive performance from the constant interaction among persons representing groups with diverse interests and objectives.

Salvage officers may face a shoreline cleanup as a result of salvage-related work or in response to a Navy oil spill. In either case, they must be prepared to implement oil-removal procedures that are safe, technically correct, environmentally sound and effective.

7-2 SHORELINE SURVEY

A survey that defines the nature and extent of shoreline oiling must be conducted as soon as possible so that proper cleanup measures may be implemented quickly. The most effective surveys sight and photograph the oil areas from aircraft. Telephone or radio reports from individuals at vantage points along the coast are also helpful in defining the extent of the oiled shoreline.

The type of oil and its viscosity, pour point and other physical characteristics should be identified. Knowledge of the source of spilled oil will aid in identification. A sample of the oil should be taken and preserved for chemical analysis and possible matching to the origin of the spill.

7-3 CLEANING STRATEGY

Formulation of a shoreline cleaning strategy—an integral part of the response operation—should follow the initial survey. Cleaning strategy may be: no cleaning, removal of all contamination or a position between the two extremes.

While agreement to respond initially to gross contamination is easy, agreement on a specific strategy and on how far to proceed is harder. The larger agreement depends upon factors such as economic impact as well as environmental sensitivity. Resolution often derives from trying to answer, “How clean is clean enough?”

7-3.1 No Cleaning. No cleaning is sometimes a proper response. Response personnel and equipment may damage some environments, particularly wetlands, so severely that an attempt to remove oil by mechanical means is inappropriate. The decision to not clean should be made with advise from the Scientific Support Coordinator (SSC), EPA Environmental Response Team (ERT) or similarly qualified personnel.

The decision to clean a contaminated area or to leave it alone should be made after considering the:

- Impact of oil on the environment.
- Persistence of the oil.
- Impact of oil on economic value of the contaminated area.
- Natural processes, such as surf, that may enhance cleaning.
- Likelihood of oil recontaminating the area.
- Likelihood of oil refloating and contaminating other areas.
- Environmental or economic impact of cleanup operations.
- Probability of successful cleanup.

Federal, state and local regulations may influence the nature and scope of the cleaning response.

7-3.2 Cleaning Sequence. Shoreline cleaning is usually separated into primary and final cleaning phases.

7-3.2.1 Primary (Gross) Cleaning. Removal of gross contamination includes removing floating oil and responding only to heavily contaminated areas. Moderately contaminated or stained areas are left alone. Heavily contaminated areas to be considered for immediate cleaning include seaweed, saturated sand beaches, etc., that contain enough oil that some is refloated and spread by waves and tides.

7-3.2.2 Final Cleaning. Removal of moderate contamination usually follows removal of gross contamination. Sand beaches with oil in sediment, under rocks, etc., are typical moderately contaminated areas. A moderately contaminated beach, while not fit for recreation, is not a significant source of oil pollution. Oil must be removed from a moderately contaminated shoreline to restore the utility and ecological systems of the shoreline.

Sometimes termed rock polishing, stain removal is the final step taken to eliminate all visual evidence of oil contamination. There is considerable controversy within the scientific community as to whether rock polishing causes more harm than good. The potential harm or benefit of rock polishing varies depending on the ecosystems involved. Policy concerning rock polishing will be set by the FOSC or Remedial Program Manager on advice from the NOAA Scientific Support Coordinator or EPA Environmental Response Team.

7-4 CLEANING ORGANIZATION

Cleaning is a part of oil spill response and the cleaning organization is a part of the oil spill response organization. Navy personnel or contractors engaged in cleaning usually are formed into a two-tier organization. One tier of the organization consists of the Navy-On Scene Coordinator (NOSC) and the staff. The other tier consists of people directly engaged in field operations.

The NOSC and staff personnel are located near the scene at a command post with transportation and communications facilities. Staff personnel are concerned with planning, funding, securing response equipment, logistics, personnel support, safety, collection of data, media response and the proper flow of information. Field operations personnel are engaged directly in the removal of oil from the shoreline.

7-5 CLEANING METHODS

After a cleaning strategy has been adopted, cleaning methods are implemented.

7-5.1 No Cleaning. No cleaning does not mean no action. No cleaning in one area may require cleaning or other response in another area. For example, if an oiled marsh or grassy area is left alone, oil must migrate freely from the contaminated area and not be trapped within the environmentally sensitive area. The objective is for oil to pass through and be collected where people can work without trampling and damaging sensitive wetlands.

Properly placed diversion booms sometimes permit this tactic. Contingency plans should indicate where booms must be placed to prevent oil from entering an environmentally sensitive area and how to divert oil to an area where it can be controlled.

7-5.2 Floating (Free) Oil. Heavily contaminated shore areas should be boomed or otherwise isolated so that oil running off or refloated by tide or surf does not impact adjacent clean shoreline or recontaminate cleaned areas. Boomed oil can be recovered and transferred to holding tanks as explained in **Chapter 5.**

7-5.3 Shoreline Cleanup Methods. There are numerous methods for collecting stranded oil and cleaning shoreline features. The different methods are not equally effective on all types of shoreline. Some are quite destructive to certain types of environment and therefore not applicable in those environments. **Table 7-1** describes oil behavior on some basic shore types. **Table 7-2** shows applicability of various cleanup methods to different shore types.

Table 7-1. Behavior of Oil on Some Common Types of Shoreline.

Type	Size Range	Comments
Rocks, boulders and artificial structures	>250 mm	Oil is often carried past rocky outcrops and cliffs by reflected waves but may be thrown up onto the splash zone where it may accumulate on rough or porous surfaces. In tidal regions, oil collects in rock pools and may coat rocks throughout the tidal range. This oil is usually rapidly removed by wave action but is more persistent in sheltered waters.
Cobbles, pebbles and shingles	<2-250 mm	Oil penetration increases with stone size. In areas experiencing strong wave action, surface stones are cleaned quickly by abrasion whereas buried oil may persist for some time. Low-viscosity oils may be flushed out of the beach by natural water movement.
Sand	0.1-2 mm	Particle size, water table depth and drainage characteristics determine the oil penetration of sand beaches. Coarse sand beaches tend to shelve more steeply and dry out at low water enabling some degree of penetration to occur particularly with low-viscosity oils. Oil is generally concentrated near the high water mark. Fine-grained sand is usually associated with flatter beach profiles remaining wet throughout the tidal cycle so that little penetration takes place. However, some oil can be buried when exposed to surf conditions.
Mud (mud flats, marshes and mangroves)	0.1 mm	Extensive deposits of mud are characteristics of low-energy environments. Little penetration of the substrate by oil occurs because the sediment is usually waterlogged, but oil can persist on the surface over long periods. If the spill coincides with a storm, oil can become incorporated in the sediment and persist indefinitely. Animal burrows and plant root channels can also bring about oil penetration.
Corals		Most corals are submerged at all stages of the tide and so are unlikely to be affected by floating oil, but, in some parts of the world, corals dry out at low water. In such cases, oil adheres in much the same way as for rocky coasts, resulting in serious damage to the coral and reef communities. However, the strong currents and wave conditions associated with coral reefs are likely to bring about rapid cleaning.

7-5.3.1 Pumping and Skimming Trapped Oil. Pumping liquid oil is the easiest collection method. Vacuum devices are most effective because the oil, which usually contains sand and debris, does not come into contact with the pump. Special flattened suction heads can be used to enhance the recovery of thin layers of oil. Recovery efficiency can be increased by draining or scraping oil into trenches before picking it up.

7-5.3.2 Mechanical Removal of Oiled Sand, Gravel or Soil. Industrial and agricultural earth-moving machinery such as graders, bulldozers, scrapers and front-end loaders can physically remove oiled material from smooth shorelines. On large accessible beaches, such equipment can remove up to 250 cubic yards of material per day, but less than five percent of the removed material is oil in typical situations, particularly if oil layers are thin. The passage of heavy machinery may drive oil deeper into the soil or mix it with soil at the surface. This is especially true of tracked vehicles. In most cases, removed material should be replaced with clean material to restore the shoreline to pre-spill conditions. Excessive removal of beach material can cause unacceptable beach erosion. In general, mechanical removal is not recommended for environmentally sensitive areas, but may be an appropriate cleanup option for heavily oiled recreational or commercial beaches.

Table 7-2. Application of Techniques to Different Shoreline Types.

	Primary Cleanup					Final Cleanup					
	Pumping/ Skimming	Mechanical Recovery	Manual Recovery	Natural Recovery	Comments	Low-Pressure Flushing	High-Pressure Washing/ Sand-blasting	Dispersants	Natural Organic Sorbents	Natural Recovery	Comments
Rocks, boulders and artificial structures	V	N/A	V	+	Poor access may prevent pumping/skimming. Exposed/ remote shorelines best left to natural recovery.	N/A	V	+	+	V	Avoid excessive abrasion of rocks/artificial structures. Cleanup of boulders difficult and often gives poor results.
Cobbles, pebbles and shingles	V	X	V	+	Exposed/ remote shorelines best left to natural recovery.	V	X	+	+	+	If load-bearing character good, consider pushing oiled material to surf zone to enhance natural recovery.
Sand	V	+	V	+	Heavy equipment only applicable on firm beaches.	V	X	V	N/A	+	Solid oil can be recovered using general beach cleaning machines. Enhance natural recovery by plowing/ harrowing.
Mud flats, marshes and mangroves	+	X	+	V	Operations preferably carried out on the water from small, shallow-draft vessels.	+	X	X	+	V	Operations should preferably be carried out on the water from small, shallow-draft vessels.

V = Recommended
\+ = Possibly Useful
X = Not Recommended
N/A = Not Applicable

7-5.3.3 Specialized Collection Equipment. Specialized devices for picking up stranded oil have been developed. Three main principals are utilized:

- Adhesion - oil is picked up on a roller surface.
- Scraping - an oiled surface layer of beach is removed with a blade.
- Scooping - an elevating belt lifts the oil from the beach or shallow water.

These devices are effective on smooth, sandy beaches. Oil is separated from the collected material by sieving (tar balls/sand) or by gravity (oil/water).

7-5.3.4 Manual Removal of Oil and Oily Debris. As a cleanup technique, manual collection of oily debris can be employed on almost any type of shoreline, but is particularly applicable to environmentally sensitive or inaccessible areas. Oiled debris and sorbents are collected with rakes, shovels and similar handtools into suitable containers for transportation by vehicle or by hand. Human workers are more selective and less destructive than heavy machinery, but much less productive (about two cubic yards per person per day). Recovery of manual-cleaned areas is typically more rapid than that of areas cleaned by other methods because of the lower degree of physical disturbance.

7-5.3.5 Washing in the Surf Zone. Lightly contaminated boulders, cobbles, pebbles and gravel can be cleaned by pushing them into the surf where wave action and abrasion will remove and dissipate the oil. Material pushed into the sea will be returned to the beach eventually by wave and tidal movements, but beach profile may be altered. This method is especially effective during or immediately prior to seasons of heavy storms and surf are likely.

7-5.3.6 Beach Cleaners. Beach cleaning machines are specially designed for cleaning recreational beaches of litter and solid debris. Most operate by removing the top layer of sand and separating the litter from the sand by sieving. They are suitable for the collection of solid oil (tarballs and lumps) or oil-soaked debris and sorbents. Beach cleaners typically operate at speeds of two to six miles per hour, corresponding to coverage of 5,000 to 15,000 square yards per hour.

7-5.3.7 Low-Pressure Flushing. Liquid oils can be floated from practically any type of beach with a high water table by flooding. Water is applied at low pressure to avoid eroding the soil, forcing the oil into the beach or damaging plants and animals. Flushing should begin at the highest contaminated point and proceed to the water's edge. The displaced oil can contaminate other areas, so it should be contained or channeled to collection sumps and recovered. If operations can be conducted so that soil substrata are not disturbed, low-pressure flushing is a good means of cleaning environmentally sensitive shorelines.

7-5.3.8 Aeration. Oil on lightly contaminated beaches without recreational value or on recreational beaches that are not in use, can be left to degrade naturally. If the beach is not environmentally sensitive, the rate of natural degradation can be increased by aeration. Agricultural harrows are used to evenly mix the contaminated top layer of soil with clean substrata. The mixing should be repeated from time to time. This method is applicable only on beaches that can support agricultural machinery.

7-5.3.9 Sorbents. Sorbents are effective means to recover thin layers of oil on beach soil, rocks or water. They are also used to protect shorelines from incoming oil or to collect oil dislodged by washing. Sorbents and their use are discussed in **Paragraph 5-2.4**.

Sorbents are spread and collected manually or by special application equipment. Loose sorbents can be worked into an oiled beach by harrows or plows and collected by agricultural rakes or beach cleaners.

7-5.3.10 High-Pressure Hot Water Washing. High-pressure hot water can remove weathered or congealed oil from hard surfaces. Typical equipment supplies water at 1,200 to 2,200 psi and 140 to 200°F. Use of seawater is not recommended, so a plentiful supply of fresh water is required. Some equipment also delivers steam at 300° and 300 psi, but steam cleaning is usually less effective than hot water washing. High-pressure washing should be employed only on rock, stone and artificial structures, such as concrete or steel piers. Washing should begin at the top of the surface to be cleaned and proceed towards the bottom. Berms, trenches or boom should be used to concentrate the resulting oil and water mixture for collection and to prevent it from contaminating clean areas. Misdirected high-pressure or high-temperature water jets can cause severe injury, so personnel must be trained in their operation and equipped with protective clothing.

High-pressure water blasting and steam cleaning destroy most marine life in addition to removing oil contamination from rocks and boulders, creating an environmental trade-off. This phenomenon was reaffirmed during studies conducted following the *EXXON VALDEZ* spill. As a consequence, these methods should be utilized only when recommended by the scientific support coordinator or similarly qualified person.

7-5.3.11 Sand or Grit Blasting. Grit blasting can clean hard, smooth surfaces, such as rock or concrete, by removing stains and moderate contamination. This method is appropriate where all evidence of oil contamination must be removed. The blasting grit will be become oil-contaminated and should be collected for disposal. Collection of blasting grit on a rocky shore or pebble beach is very difficult. Grit blasting poses some occupational hazards, including the risk of silicosis and can damage structures, so operators must be trained and equipped with proper protective gear. Like high-pressure water washing, grit blasting will destroy marine life on the surfaces clean and should be utilized only when recommended by the scientific support coordinator or similarly qualified authority.

7-5.4 Removal of Contamination. The type of shoreline determines cleanup methods. In general, shorelines are classified as large rocks and boulders, cobbles and pebbles, sand and mud.

- Large rock and boulder surfaces can be cleaned by hand or by water or steam wash. Rocks and boulders that have cracks and crevices that hold oil and must be cleaned by vacuum hoses or by hand with buckets. Wave action removes some oil, particularly during storms when wave action is most severe. In protected areas, wave action has no significant effect.

- A sand and pebble beach is the most difficult to clean. Cracks and crevices between stones provide a path for oil that is difficult to penetrate with cleaning equipment. Passage on beaches is difficult for tracked vehicles and heavy equipment. A rising tide lifts low-viscosity oils to the surface and cleanses surface stones, but buried oil remains for some time.

- All other conditions being equal, coarse sand beaches are typically steeper than beaches of fine sand. Water moves through and drains coarse sand quickly, leaving it dry much of the time. Oil penetrates dry sand more readily than wet sand. Water retained on wet fine sand beaches keeps oil at the surface so that the oil runs off with the tide. Storms drive oil into sand so oil contaminates sand beaches more deeply in foul weather. **Figure 7-1** illustrates the behavior of oil on sand beaches.

Fine sand supports heavy machinery better than coarse sand, but heavy vehicles increase the depth of contamination in sand by driving the oil into the substrata. Therefore, the benefits of

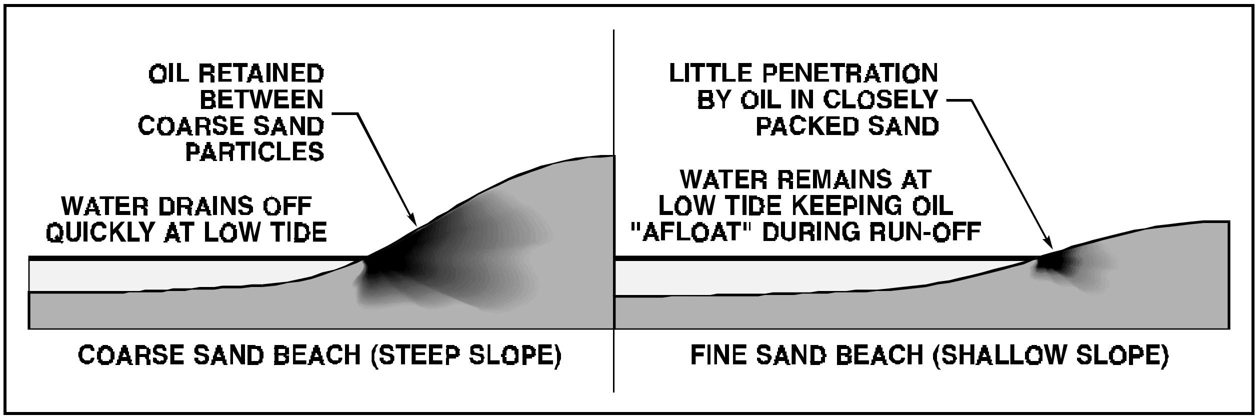


Figure 7-1. Oil Behavior on Beach Surfaces.

vehicles and heavy equipment should be weighed against the increased contamination of shoreline material.

The best method of gross cleaning of sand is to skim the surface layers from the beach for removal to a proper disposal site.

- Mud shorelines are easily damaged by crossing personnel or vehicles. Allowing oil to drain across or through a muddy shore is preferable to attempting cleanup.

Personnel working from shallow draft boats at high water can cut and remove vegetation to help oil flow across the shoreline. Low-pressure water flow from hoses can flush oil from wetlands.

7-5.5 Cleaning of Moderate Contamination. Cleaning of moderate contamination is the most difficult and time-consuming work of an oil spill response. It is labor-intensive and, depending upon the local environment, can be dangerous for personnel. To be effective, cleaning methods for removal of moderate oil contamination must be well thought out.

7-5.5.1 Rocks and Boulders and Artificial Structures. High-pressure water and steam remove moderate oil contamination from rocks and boulders. Oil flowing from contaminated objects must be collected quickly so additional areas do not become contaminated. Strategically placed containment booms or sorbents can collect runoff from final cleaning.

Local climate and weather determine the best measures for cleaning moderate contamination from rocks and boulders. In hot climates, oil bakes onto rocks and boulders, requiring high water pressures and temperatures for removal. Hot water and steam are also necessary for cleaning in Arctic or very cold regions because oil becomes very viscous or solidifies at low temperature.

Viscosity and weathering influence removal. Because of their resistance to flow, high-viscosity and weathered oils are more difficult to remove than low-viscosity oils.

Sandblasting can clean rocks and boulders by removing stains and moderate contamination. This method is appropriate where all evidence of oil contamination must be removed.

7-5.5.2 Cobbles, Pebbles and Shingles. High-pressure water can flush oil towards open water for collection by booms or sorbents. However, some oil remains beneath the top layers of stones. This remaining oil, difficult to remove, leaches out for long periods.

The wind and waves of winter storms clean stone beaches. Protected stone beaches are not subject to this natural cleaning action.

Heavy machinery can move beach material to expose oil and facilitate cleaning. Material must be handled so clean areas are not recontaminated by new material being overturned. Properly done, this is a rapid means of cleaning. Moving beach material to a shoreline where storms clean the contaminated material is a much slower but sometimes effective measure.

7-5.5.3 Sand Beaches. Hand labor or heavy machinery, such as front-end loaders, may clean moderate oil contamination from sand beaches.

Removing moderate contamination by hand is slow, but sometimes most efficient. People remove less material from the beach than machines do and less beach material must be replaced at the end of the cleanup.

7-5.5.4 Mud. Natural recovery is recommended over mechanical removal on muddy shorelines such as tidal flats and wetlands. Muddy areas not only pose often insurmountable problems for machinery, but mechanical cleaning may create new channels that increase erosion and retard natural recovery of plants and animals.

7-6 CARE OF BIRDS AND MAMMALS

The principal goal of bird and mammal cleaning is to remove oil from these animals, restore them to proper health and return them to their natural environment. The care of oiled birds and mammals is a specialized activity that must be done by experts at a dedicated cleaning station. Oil spill contingency plans should address bird and mammal cleaning.

Oiled birds and mammals should receive humane treatment. To many persons, the quality of the overall oil spill response is measured by the treatment given to oiled birds and mammals. Media personnel often report a bird count and gather television footage of oiled animals as a news item, usually on the first day of any spill. This high visibility can be an immediate positive or negative stroke for response personnel, depending upon the care given to oiled birds and mammals. Media relations are discussed in **Paragraph 3-5.5**.

Periodic overflights of the impacted area and local residents locate oiled birds and mammals. Only trained personnel should handle oiled birds and mammals. Bites and scratches from wild animals can cause serious injury.

The NOSC should designate space for a proper cleaning station. Water—both hot and cold—heat, electrical power, telephones and other support services are needed. Space and equipment to capture animals, clean them, observe them while in captivity and means to release them to the wild are needed. Animal cleaning can take from a few days to many weeks, depending upon the number of contaminated birds and mammals.

There is a nationwide network of experts who are highly skilled at cleaning oiled birds and mammals. They have gained their skills from experience. This is not a field where persons equipped only with good intentions can be successful. The best that can be done for oiled birds and animals is to get experts on-scene quickly and fully support them.

7-7 DISPOSAL OF OIL AND OILY DEBRIS

The proper disposal of oil and oily debris is the last phase of a shoreline cleanup and is sometimes the most difficult task. Ideally, disposal of oil and oily debris takes place at the rate at which oil and oily debris is retrieved. If the disposal process slows, eventually the retrieval process also slows as temporary storage capacity for oil and oily debris becomes full. Otherwise good response efforts come to a halt when skimmer operators have no place to dispose of skimmed oil. Likewise, beach cleanups stop with when long lines of filled vacuum trucks must wait for disposal facilities. The final disposal of oil and oily debris may be the most difficult evolution of a beach cleanup operation. A proper contingency plan addresses disposal of oil and oily debris.

A shoreline cleanup can generate several types of material requiring proper disposal. These include oil, oil and water emulsions, oiled vegetation, dirt and sand contaminated with oil and oiled beach debris.

The National Contingency Plan requires that:

- Oil and contaminated materials recovered in cleanup operations shall be disposed of in accordance with the Regional Contingency Plan (RCP) and On-Scene Coordinator (OSC) Contingency Plan and any applicable laws, regulations or requirements.

- Oil and oily debris removed from a beach cleanup must be classified, transported and disposed of in conformance with federal, state and local standards. Disposal options include recycling, placement in a landfill and incineration. The properties of the material to be disposed of, the facilities available to receive the material and cost of disposal determine the disposal method. **Figure 7-2** illustrates options available for disposal of oil and oily debris.

7-7.1 Classification of Material. A determination must be made if the recovered oil or oily debris is a hazardous waste as defined by federal or state standards. The standard of care for a hazardous waste is greater than for a material that is not a hazardous material.

The Resource Conservation and Recovery Act of 1976 (RCRA) and the Hazardous and Solid Waste Amendments of 1984 contain standards for the treatment, containment, transportation and disposal of hazardous wastes in the United States. Title 40 of the *Code of Federal Regulations* contains implementing federal regulations. The Environmental Protection Agency is the federal agency responsible for implementation and enforcement of the Federal Hazardous Waste Regulatory Program.

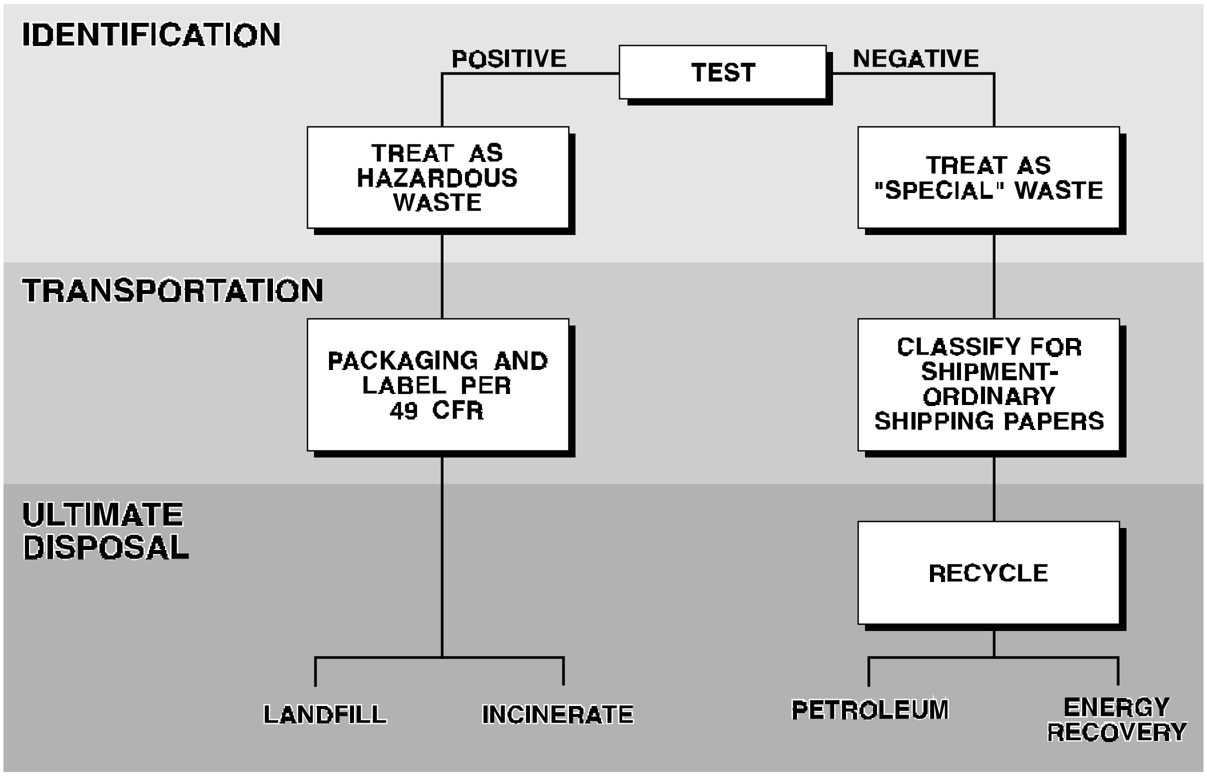


Figure 7-2. Decision Tree for Treatment of Recovered Oil and Oily Debris.

Four characteristics—toxicity, ignitability, reactivity and corrosivity—determine if a material is hazardous waste. The criteria for toxicity (test for metals) and ignitability (test for flashpoint) are more applicable to oil than the tests for reactivity and corrosivity. The Toxicity Characteristic Leaching Procedure (TCLP) determines toxicity.

If an oil tests positive in any characteristic it is treated as a hazardous waste and RCRA standards apply. If the oil tests negative, the oil is not considered a hazardous waste by RCRA standards but may be treated as such by state standards.

Without on-scene testing, persons should apply any information or knowledge available to identify oil. A Material Safety Data Sheet (MSDS), shipping papers, bills of lading, etc., may provide information to identify a particular oil.

In addition to federal standards, most individual states have laws, rules and regulations that are more stringent than federal standards. For example, a state may classify certain waste oil as a hazardous material, while federal regulations provide for a less stringent standard.

7-7.2 Transportation. Oil and oily debris must be packaged properly, documented and labeled when transported. In the interest of protecting public health and the environment, the FOSC may direct waste material be transported to a designated site for temporary storage before its final disposal. A vacuum truck, tank truck or other appropriate vehicle displaying the appropriate placards must transport the material.

If the material is a hazardous waste, documentation, including a hazardous waste manifest, must be prepared. It is possible for a substance that is not considered hazardous for disposal to be considered hazardous for transportation. 49 *CFR* 172.101 lists materials considered hazardous for transportation, including petroleum and petroleum products. The intent of documentation is to provide accountability for the material from the origin to the place of final disposal. Some states have their own versions of these forms along with an indexing system to further refine accountability. The documentation process requires that a copy of the manifest be sent to the appropriate regulatory agency each time the material is shipped from one handler to another. This procedure creates a paper trail so the material may be traced from origin to final disposal.

If the material is to be recycled or is not a hazardous waste, preparation of regular shipping papers that identify ownership, quantity and destination is sufficient. Materials that are not hazardous wastes require no paper trail.

7-7.3 Methods for Disposal of Non-Hazardous Oils. Waste oil and oily debris should be recycled whenever possible. Recycling, usually the least expensive method of disposal, is encouraged by regulatory agencies to reduce the rate at which materials are deposited in landfills and to prevent ground water contamination. Waste oil may be recycled into another petroleum product or as an energy source.

7-7.3.1 Recycled Oil. Federal regulations consider oil that is not a hazardous waste as used oil. Used oils are recycled by blending with other oils for fuels or by utilizing them in the manufacture of asphalt. Much used oil is combined and blended with other oils.

Oil pumped from skimmers and containment booms to tank barges and vacuum trucks contains varying amounts of water, often as an emulsion. As a rule of thumb, recycling facilities accept oil-water mixtures that contain more than five percent oil. Therefore, reducing the amount of water contained in recovered oil enhances the opportunity for recycling.

Regional and local contingency plans should contain information about facilities equipped to recycle oil. Federal and state environmental officials also have this information.

7-7.3.2 Energy Recovery. Waste oil destined for burning as fuel in furnaces or boilers is treated as used oil fuel. Like recycled oil, it is often blended with other fuels before marketing. In some cases it is burned directly, as are some used engine oils.

7-7.3.3 Recycle as Asphalt. Asphalt plants accept a wide range of oils. They are excellent places to dispose of oil and some oily debris. The plants may recycle emulsified oil and some compacted oily debris and usually accept oily sand removed from contaminated beaches.

7-7.3.4 Incineration. It is sometimes advantageous to burn oil-contaminated debris at the spill site. Determining factors for this method of disposal include the type of debris, type and amount of pollutants generated from combustion, remoteness of the site and viability of other options for disposal. Incineration is appropriate for burning relatively small amounts of oily debris in a remote areas where smoke may not be objectionable.

Incineration of large quantities of material may not be feasible. Although oiled logs and organic debris have been burned on remote shorelines in Alaska, following the *EXXON VALDEZ* spill, oiled sorbents were transported to CONUS for disposal in a landfill. Disposal by incineration was not viable because of pollutants generated by combustion of inorganic materials.

Complete combustion of weathered oil is difficult in the field because not all the oil burns. An objectionable tarry mass that is difficult to remove remains after combustion.

Small amounts of oiled debris are easier to burn on site than huge volumes because they may be handled more efficiently. Portable combustion units aid in maintaining high-temperature fires required for proper incineration of some debris. Portable incinerators have been developed that are capable of burning oil from sand, leaving the sand clean enough to be returned to the beach.

7-7.3.5 Municipal Solid Waste Landfill. Oiled debris such as vegetation, logs and dirt may be acceptable for a municipal solid waste landfill. These facilities often accept oiled debris as a cover layer. Municipal solid waste landfills are subject to state and local standards.

7-7.3.6 Landspreading. Oil as sludge may be tilled into the soil where it is broken down by bacteria and sunlight. Landspreading exposes sludge to mixes of oxygen, water and nutrients that enable it to degrade into the environment. The sludge is tilled over in the soil periodically to enhance exposure to air and sunlight. This procedure, sometimes termed sludge farming or land farming, is done where topography and soil conditions permit. Landspreading is no longer a primary means of oil disposal because of the risk of ground water contamination.

7-7.4 Methods for Disposal of Oils Determined to be Hazardous. Hazardous oils must be disposed of without risk to people or the environment. Two methods are available—high-temperature incineration and disposal in a waste management facility.

7-7.4.1 High-Temperature Incineration. Certain hazardous wastes may be incinerated at high temperatures—a thermal oxidation process that alters the chemical nature of the materials leaving only harmless products of combustion. The process with temperatures in the range of 2,000°F is common for destroying oils containing PCBs. High-temperature incineration facilities are suitable for disposal of oiled sorbents, boom and impregnated materials. There are few of these facilities in the United States.

7-7.4.2 Disposal in Hazardous Waste Facility (Landfill). Disposal in a hazardous waste facility is the method of last resort. Hazardous waste facilities operated in compliance with standards set by the Resource Conservation and Recovery Act (RCRA) are called RCRA facilities.

RCRA facilities operate in accordance with terms and conditions of their EPA permits. EPA enforces regulatory standards for RCRA sites and states operate municipal solid waste landfills to EPA standards.

Materials sent to a RCRA facility must be identified, packaged properly, labeled and shipped with a hazardous waste manifest. Oily wastes are packaged in drums designed for landfill disposal.

Hazardous waste management facilities are specially constructed to receive certain materials. Construction details include proper siting, soil conditions, means for control of leachate and continuous monitoring of deposited material.

7-8 PERSONNEL SAFETY

Oil is present in nearly every inhabited place on earth. Consequently, spills may occur in a variety of environments requiring exposure of U.S. Navy personnel to a wide range of conditions, some quite severe. Personnel must have adequate protection and training to work safely in the spill environments.

Beach cleanup exposes individuals to several hazards: the product being cleaned may be hazardous, footing is often slippery making injuries from falls likely and weather adds risk of hypothermia, dehydration or sunstroke. Working outdoors for extended periods can be physically exhausting, particularly for persons who are not well acclimated.

7-8.1 Personnel Health and Safety Standards. The Occupational Safety and Health Administration (OSHA) has set worker protection standards and training requirements for persons in hazardous waste operations and emergency response. OSHA standards for oil spill cleanup work are given in **Appendix G**. Because some oils meet criteria for hazardous materials, U.S. Navy response activities should meet these standards. Items addressed for each response activity include: identification of the oil being removed, personal protective clothing, personal care, task hazards and response to emergencies. Material Safety Data Sheets (MSDS) are an excellent source of information to identify the health and safety risks of handling known materials.

7-8.1.1 Personnel Protective Clothing. Persons must be protected both from the environment they are working in and from the materials being handled. Personnel protective clothing includes boots, hats, gloves, coveralls, Tyvek suits and sometimes face shields and respiratory equipment. Cold weather work requires additional protective equipment—safety-toed rubber boots, insulated coveralls, and wool hats and gloves with waterproof covers under Tyvek coveralls.

7-8.1.2 Personal Care. Workers must have food, water, berthing, sanitary and washing facilities and training in recognition and response to the medical problems of hazardous materials. They must deal with wind, rain and extreme temperatures. Small items—sunscreen, chapped lip balm, etc.,—become very important.

7-8.1.3 Task Hazards. Spill response operations are dangerous. The work is intense; work days are long—particularly at the beginning. Fatigue is always an issue. Rotating machinery, weight handling equipment, slippery footing and heavy physical work are inherent hazards.

7-8.1.4 Emergencies. Workers must know the chain of command and what to do when hazardous materials emergencies or medical emergencies occur. Summoning help often requires communications equipment.

APPENDIX A

DOCUMENTATION MATRIX

A-1 PURPOSE

The purpose of this matrix is to provide the user of this manual with a listing of additional reference documentation. This is given by reference manual and topic area.

A-2 REFERENCE DOCUMENTS

The following manuals/publications are referenced on the matrix (**Table A-1**):

- SAFETY MANUAL - *U.S. Navy Ship Salvage Safety Manual* (S0400-AA-SAF-010)
- SALVAGE MANUAL - *U.S. Navy Ship Salvage Manual*

  Volume 1 Strandings (S0300-A6-MAN-010)
  Volume 2 Harbor Clearance (S0300-A6-MAN-020)
  Volume 3 Firefighting and Damage Control (S0300-A6-MAN-030)
  Volume 4 Deep Ocean (S0300-A6-MAN-040)
  Volume 5 POL Offloading (S0300-A6-MAN-050)
  Volume 6 POL Spill Response (S0300-A6-MAN-060)

- SALVOR’S HANDBOOK - *U.S. Navy Salvor’s Handbook* (S0300-A7-HBK-010)
- UNDERWATER CUT & WELD - *U.S. Navy Underwater Cutting and Welding Manual* (S0300-BB-MAN-010)
- ENGINEER’S HANDBOOK - *U.S. Navy Salvage Engineer’s Handbook*

  Volume 1 (S0300-A8-HBK-010)
  Volume 2 (S0300-A8-HBK-020)

- TOWING MANUAL - *U.S. Navy Towing Manual* (SL740-AA-MAN-010)
- ESSM MANUAL - *Emergency Ship Salvage Material Catalog* (NAVSEA 0994-LP-017-3010)
- EXPLOSIVES MANUAL - *Technical Manual for Use of Explosives in Under-water Salvage* (NAVSEA SW061-AA-MMA-010)

Table A-1. Salvage Documentation Matrix.

		SALVAGE MANUAL								ENGINEER'S HANDBOOK				
TOPIC AREA	SAFETY MANUAL	VOLUME 1	VOLUME 2	VOLUME 3	VOLUME 4	VOLUME 5	VOLUME 6	SALVOR'S HANDBOOK	UNDERWATER CUT & WELD	VOLUME 1	VOLUME 2	TOWING MANUAL	ESSM MANUAL	EXPLOSIVES MANUAL
DAMAGE CONTROL				●				●		●				
STABILITY		●				●		●		●	●			
SHIP STRENGTH		●				●		●		●	●			
RIGGING	●	●	●		●	●	●	●		●		●		
ANCHORS	●	●					●	●		●			●	
STRANDING		●				●		●		●	●			
PULLING SYSTEMS	●	●						●		●			●	
SAFETY	●	●	●	●	●	●	●	●	●	●		●		●
MACHINERY	●							●		●		●	●	
EXPLOSIVES			●					●		●	●			●
HAZMAT	●					●	●	●		●			●	
POL	●					●	●	●		●				
OFF-SHIP FIREFIGHTING	●			●		●		●					●	
TOWING: POINT-TO-POINT						●						●		
RESCUE				●				●				●		
PATCHING		●	●	●				●		●				
COFFERDAMS								●		●				
LIFTING SYSTEMS	●		●		●			●		●			●	
POLLUTION CONTROL	●					●	●	●		●			●	
PONTOONS			●		●			●		●			●	
SALVAGE PLANNING	●	●	●		●	●	●	●		●				●
PROPERTIES OF MATERIALS		●				●		●		●		●		●
CONVERSION FACTORS		●						●	●	●				
COMPUTER PROGRAMMING											●	●		
DEEP WATER RECOVERY					●			●					●	
CUTTING	●		●						●					●
WELDING	●								●					
CARGO OFFLOAD	●	●				●	●	●		●				

APPENDIX B

NAVY AREA AND ON-SCENE COORDINATORS DIRECTORY

Table B-1. Environmental Coordinators (Area Coordinators).

CINCPACFLT

Commander in Chief, Pacific
U.S. Pacific Fleet
Pearl Harbor, HI 06860-7000
ATTN: Code 444

COMM: (808) 471-9751
AUTOVON: (315) 471-9751

CINCUSNAVEUR

Commander in Chief
U.S. Naval Forces Europe
FPO New York, NY 09510
ATTN: Code N431

AUTOVON: Washington, D.C. Operator 937-1550; ask for 235-4266

CNET

Chief of Naval Education and Training
Naval Air Station
Pensacola, FL 32508-5000
ATTN: N-44
COMM: (904) 452-4096
AUTOVON: 922-4096

COMUSNAVCENT

Commander
U.S. Naval Forces Central Command
Pearl Harbor, HI 96860

CINCLANTFLT

Commander in Chief, Atlantic
U.S. Atlantic Fleet
Norfolk, VA 23511-6001
ATTN: Code N4423

COMM: (804) 444-6139/6805
AUTOVON: 564-6139/6805

COMNAVRESFOR

Commander
Naval Reserve Force
4400 Dauphine Street
New Orleans, LA 70146-5000
ATTN: Code 823

COMM: (504) 948-5084
AUTOVON: 363-5084

NAVDISTWASH

Commandant
NAVDIST Washington, D.C.
Washington Navy Yard
Washington, D.C. 20374-2121
ATTN: Code 01

COMM: (202) 433-3760
AUTOVON: 288-3760

Note: Listings current as of March 1990. Check current *Oil and Hazardous Substance Spill Response Activity Information Directory (AID)*, NEESA publication 7-021 (series) for most up-do-date listings.

Table B-2. Shoreside Navy On-Scene Coordinators.

CINCPACFLT

Commander
Naval Base
San Diego, CA 92132-5100
ATTN: Code 024

COMM: (619) 532-2454
AUTOVON: 522-2454

Commander
Naval Base San Francisco
Naval Station Treasure Island
San Francisco, CA 94130-5018
ATTN: Code N4

COMM: (415) 395-3915
AUTOVON: 475-3915

Commander
Naval Base
Pearl Harbor, HI 96860
ATTN: Code N30

COMM: (808) 471-3084
AUTOVON: 471-3084

Commander
U.S. Naval Forces, Marianas
FPO San Francisco 96630-0051

Commander
U.S. Naval Forces, Philippines
Box 30
FPO San Francisco 96651-0051

Commander
U.S. Naval Forces Yokosuka, Japan
FPO Seattle 98762-0051

Commander
U.S. Navy Support Facility
Diego Garcia
FPO San Francisco 96685-2000

Commander
Naval Base
Seattle, WA 98115-5012
ATTN: Code N3

COMM: (206) 941-3225
AUTOVON: 941-3225

Commander
Naval Forces Korea
FPO San Francisco 96301-0023

CINCLANTFLT

Commander
Naval Base, Building G-6
Philadelphia, PA 19112-5098
ATTN: Code N3

COMM: (215) 897-8730
AUTOVON: 443-8730

Commander
Helicopter Wings Atlantic
Naval Air Station
Jacksonville, FL 32212-5000

COMM: (904) 774-2114
AUTOVON: 942-2114

Commander
Submarine Group TWO
Naval Submarine Base New London
Groton, CT 06349-3976

COMM: (203) 449-3976
AUTOVON: 241-3976

Commander
Fleet Air, Keflavik
FPO New York 90571

Commanding Officer
U.S. Naval Facility, Argentina
FPO New York 09597
ATTN: Code N6

COMM: (709) 227-8542
AUTOVON: 568-8542

Commander
Patrol Wings Atlantic
Naval Air Station
Brunswick, ME 04011

Commander
Naval Base, Building N-26
Norfolk, VA 23511-6002

COMM: (804) 444-2590
AUTOVON: 564-2590

Commander
Naval Base
Charleston, SC 294068-5100
ATTN: Code N31

COMM: (803) 743-4961
AUTOVON: 563-4961

Commander
COMFAIRCARIB Roosevelt Roads
Fleet Air Caribbean
FPO Miami 34051-8000

Table B-2 (continued)**. Shoreside Navy On-Scene Coordinators.**

CINCUSNAVEUR

Commander
Fleet Air Mediterranean
FPO New York 09521

Commander
U.S. Naval Activities United Kingdom
FPO New York 09510-1000

CNET

Chief of Naval Education and Training
Naval Air Station
Pensacola, FL 32508-5000
ATTN: Code N-44

COMM: (904) 452-5000
AUTOVON: 922-4096

Commander
Naval Training Center
Building 1, Room 207
Great Lakes, IL 60088-5000
ATTN: Code N-53

COMM: (312) 688-4818
AUTOVON: 792-4818

Chief of Naval Air Training
Naval Air Station
Corpus Christi, TX 78419-5100
ATTN: Code N-61

COMM: (512) 939-2121
AUTOVON: 861-2121

Chief of Naval Technical Training
Naval Air Station Memphis
Millington, TN 38054-5056
ATTN: Code N-8

COMM: (901) 873-5951
AUTOVON: 966-5951

NAVDISTWASH

Commandant
NAVDIST Washington, D.C.
Washington Navy Yard
Washington, D.C. 20374-2121
ATTN: Code 01

COMM: (202) 433-3591
AUTOVON: 288-3591

COMNAVRESFOR

Commanding Officer
Naval Support Activity
4400 Dauphine Street
New Orleans, LA 70142-5000
ATTN: Code N5

COMM: (504) 948-2783
AUTOVON: 363-2783

Table B-3. Fleet Navy On-Scene Coordinators.

Commander
SEVENTH Fleet
FPO San Francisco 96601-6003

Commander
THIRD Fleet
FPO San Francisco 96601-6001

Commander
SECOND Fleet
FPO New York 09506-6000

Commander
SIXTH Fleet
FPO New York 09501-6002

Commander
Middle East Force
FPO New York 09501-6008

APPENDIX C

NAVSEA SUPERVISOR OF SALVAGE (SUPSALV) ASSETS

C-1 INTRODUCTION

This appendix provides detailed information regarding SUPSALV response assets and procedures, as well as oil spill contingency planning and is derived from the document Supervisor of Salvage, U.S. Navy, Contingency Planning Information for Offshore and Salvage-Related Oil Spill Response Operations, 1992. Requests for this document can be forwarded to Commander, Naval Sea Systems Command (Code 00C25), Washington, D.C. 20362.

C-1.1 SUPSALV Points of Contact. Table C-1 provides a list of SUPSALV points of contact.

Table C-1. SUPSALV Points of Contact.

Points of Contact:			
Primary:	NAVSEA 00C25	First Alternate:	NAVSEA 00C2
Address:	Commander	Second Alternate:	NAVSEA 00C24
	Naval Sea Systems Command Code 00C Washington, D.C. 20362		
Telephone:	Commercial: (703) 607-2758 AUTOVON: 227-2758		
SUPSALV Assistance **for Informal Liaison and "Heads-Up" Notification:**			
Working Hours:		Non-Working Hours (NAVSEA Duty Officer)	
	Commercial: (703) 607-2758 AUTOVON: 227-2758		Commercial: (703) 602-7527 AUTOVON: 222-7527 (Duty Officer will relay caller's message to appropriate SUPSALV personnel for a return call.)
for Official Requests for SUPSALV Response:			
	24 Hours CNO Duty Captain: Commercial: (703) 695-0231 AUTOVON: 225-02331		
Note:	Early alert, "heads-up" calls to SUPSALV are encouraged and appreciated even if the extent of the response has not been determined		

C-1.2 SUPSALV Oil Spill Response Equipment Inventory. Table C-2 provides a list of equipment in the SUPSALV Oil Spill Response Inventory.

Table C-2. SUPSALV Oil Response Equipment Inventory.

Equipment Description	Williamsburg, VA	Stockton, CA	Pearl Harbor, HI
Spilled Oil Recovery			
Skimmer Vessel System (36° Aluminum Hull)	12	11	1
Skimming System (Sorbent Belt VOSS*)	1	1	0
Skimming System (Screw Pump VOSS*)	2	2	0
Skimmer Sorbent Rope Mop (36″)	2	1	0
Boom Vans (42″ x 1980′ Boom)	6	7	0
Boom Mooring System	37	34	4
Boom-Handling Boat (24′ 260-HP Diesel)	8	6	2
Boom-Tending Boat (19′ & 23′ Inflatable)	2	2	1
Boom-Tending Boat (18′ Rigid Hull)	4	4	1
136K Oil Storage Bladder, Type L	6	4	0
26K Oil Storage Bladder, Type E	4	3	1
50K Oil Storage Bladder, Type F	2	2	0
290K Oil Storage Bladder, Type O	2	0	0
Casualty Offloading			
Pump System POL 6″ Submersible	11	8	2
Floating Hose (6″ x 100′)	65	0	0
Hot Tap System	4	3	0
Boarding Kit	1	2	0
Firefighting System	3	2	0
Fender System (8′ x 12′ Foam)	16	4	0
Fender System (14′ x 60′ LP Air)	8	0	0
Fender System (10′ x 50′ LP Air)	24	0	0
Ancillary Equipment			
Command Trailer (40′ Communications & Command Center)	1	1	0
Command Van (20′ Communications & Command Center)	3	2	0
Shop Van	3	2	0
Rigging Van	2	3	0
Personal Bunk Van	3	0	0
Beach Transfer System (4WD Vehicles)	1	0	0
Communication System (SAT Phone Land)	1	0	0
Communication System (SAT Phone Ship)	1	0	0
Oil-Water Separator (Parallel Plate 100 GPM)	2	1	0
Cleaning System Van	1	2	0

*VOSS = Vessel of Opportunity Skimmer System

C-2 EMERGENCY RESPONSE PROCEDURES

C-2.1 Emergency SUPSALV Support Requests. The SUPSALV equipment listed in **Table C-2** and described throughout this appendix is available to Navy On-Scene Coordinators (NOSCs) or Navy On-Scene Commanders (NOSCDRs) with operators and maintenance support, on a cost-reimbursable basis. Formal requests for SUPSALV assistance must be made through the Chief of Naval Operations, Navy Command Center, in Washington, D.C. However, an initial call directly to SUPSALV can help ensure a more rapid and appropriate response.

SUPSALV mobilization can be initiated by a telephone call from CNO, after CNO receives the NOSC/NOSCDR's request for SUPSALV response. The message should:

- Be addressed to CNO WASHINGTON DC for action, COMNAVSEASYSCOM WASHINGTON DC for info, with passing instructions CNO FOR OP64 AND OP45, NAVSEA FOR CODE 00C.

- Describe the nature of the pollution incident.

- Request SUPSALV (NAVSEA 00C) assistance and state that the originator (NOSC or NOSCDR) will reimburse NAVSEA for all SUPSALV operational costs incurred in the incident response. An initial maximum cost liability may be stated based on a SUPSALV preliminary cost estimate. The maximum liability can later be amended when better cost estimates can be provided.

- Provide an equipment shipping address and the name for receiving officer point of contact (POC) with 24-hour telephone number(s).

- Provide the name and 24-hour telephone number(s) for the originator's on-scene operations POC.

- Provide the name and office telephone number(s) for the originator's fiscal representative.

- Provide any other information deemed important for SUPSALV mobilization.

A sample request message is provided in **Figure C-1**.

FROM: (COGNIZANT NOSC OR NOSCDR)
TO: CNO WASHINGTON DC
INFO: COMNAVSEASYSCOM WASHINGTON DC
(OTHER ADDEES AS APPROPRIATE)
UNCLAS //N05090//
SUBJ: REQUEST FOR SPILL RESPONSE ASSISTANCE
A. (INITIAL MSG REPORT OF SPILL FROM SPILLER)
B. INITIAL NOTIFICATION PHONCON WITH SEA 00C REPRESENTATIVE)
1. (PASSING INSTRUCTIONS) CNO FOR OP64 AND OP45, NAVSEA FOR CODE 00C.
2. REF A REPORTED SIGNIFICANT DETAILS OF SUBJECT SPILL (IF CNO AND NAVSEA WERE NOT REF A ADDEES ORIGINATOR SHOULD REPORT THE FOLLOWING:)
A. (DATE AND TIME SPILL OCCURRED)
B. (SPILL LOCATION - GEOGRAPHIC NAME AND/OR LATITUDE/LONGITUDE)
C. (SPILL SOURCE)
D. (SPILL CAUSE)
E. (TYPE OF PRODUCT SPILLED)
F. (QUANTITY SPILLED)
3. AS DISCUSSED IN REF B, NAVSEA 00C SPILL RESPONSE ASSISTANCE IS REQUESTED. ORIGINATOR WILL REIMBURSE NAVSEA FOR ALL NAVSEA 00C OPERATIONAL COSTS INCURRED IN SUBJ SPILL RESPONSE. ORIGINATOR'S INITIAL MAXIMUM LIABILITY BASED ON REF B COST ESTIMATE IS $_____ . (AMOUNT IN DOLLARS)
4. A SUITABLE STAGING AREA FOR RESPONSE EQUIPMENT HAS BEEN SELECTED. THE EQUIPMENT SHIPPING ADDRESS IS: ___. THE RECEIVING OFFICER IS (NAME) AT ____. (24-HOUR TELEPHONE NUMBER(S)).
5. ORIGINATOR'S ON-SCENE OPERATIONS REPRESENTATIVE IS (NAME) AT ____ . (24-HOUR TELEPHONE NUMBER)
6. ORIGINATOR'S FISCAL REPRESENTATIVE IS (NAME) AT _____. (OFFICE TELEPHONE NUMBER)

Figure C-1. Sample Message Request for Spill Response Assistance.

To request SUPSALV support for emergency response, on-scene technical expertise or simply advice over the phone, SUPSALV should be contacted at the following numbers:

- For informal liaison and "heads-up" notification during working hours, commercial (703) 607-2758 or AUTOVON 227-2758; during nonworking hours, the NAVSEA Duty Officer should be called, commercial (703) 602-7527 or AUTOVON 222-7527. The NAVSEA Duty Officer will relay the caller's message to appropriate SUPSALV personnel for a return call.

- Official requests for SUPSALV response should be directed to the CNO Duty Captain, commercial (703) 695-0231 or AUTOVON 225-0231.

- Early alert, "heads-up" calls direct to SUPSALV are encouraged and appreciated even if the extent of the response has not been determined.

- Non-Navy requests for emergency assistance should be directed through the Regional Response Team in accordance with the National or Regional Pollution Contingency Plan.

- Coast Guard requests can be initiated in accordance with the Navy/Coast Guard inter-agency agreement.

- In all cases, when in doubt, a call to SUPSALV will facilitate an appropriate request for SUPSALV assistance.

C-2.2 SUPSALV Pollution Response Equipment Support Requirements. SUPSALV is prepared to provide personnel and equipment which are as nearly self-supporting as transportation permits. The requesting activity should be aware that the following support element must be provided from local sources. These requirements must be addressed in local and area contingency plans. Descriptions of SUPSALV equipment can be found in **Chapters 4** and **5** of this manual, Chapter 3 of the SUPSALV document, *Contingency Planning Information for Offshore and Salvage Related Oil Spill Response Operations* and the *U.S. Navy Emergency Ship Salvage Material Catalog*, NAVSEA 0994-LP-017-3010.

C-2-2.1 Staging Area. The staging area for a spill response operation is that location where equipment from all sources is assembled and held pending deployment to the spill site. During prolonged spill control operations, equipment maintenance and repair may be accomplished in the staging area. Contingency plans must include provisions for setting up staging areas satisfying the following requirements:

- A surfaced area large enough for interim storage of all equipment deployed to the spill site. Covered storage is desirable but not essential except under extreme weather conditions.

- Close proximity to the spill site to minimize transit time for equipment called to the scene. This is especially important for near-shore operations when the staging area at pierside replaces the offshore support platform as the focal point for daily operations.

- Ready access to piers capable of accommodating support vessels and other involved vessels. Pier size, capacity, strength to support equipment, limiting draft and access to the spill site must be considered.

- Ready accessibility of material-handling equipment (MHE), i.e., cranes and forklifts, for offloading trucks and vessels on short notice. Paragraph C-2.2.2 provides additional guidance on MHE requirements.

- Security against theft and vandalism. A fenced staging area or security patrols may be required.

- Sanitary facilities within reasonable distance of the work area.

Local contingency planning conducted under the direction of predesignated NOSCs should designate a staging area for each potential spill site; the staging area requirements listed above should be considered. The SUPSALV pollution control response team can lease or subcontract facilities as noted above, but commercial sources should be identified in local contingency plans.

Since all spill response costs, including SUPSALV costs, are borne by the spilling activity, the use of Navy staging area facilities would generally be most cost effective. However, the potential disruption of Navy local operations by the long-term requirement for a staging area during major spill control operations must be considered. The use of commercial staging area facilities may be more cost effective during such prolonged spill response operations.

C-2.2.2 Material-Handling Equipment (MHE). MHE will be needed for offloading/onloading trucks and vessels on short notice. Also, MHE may have to be placed on board large support vessels to launch recovery equipment. Flatbed trucks and tractors are needed for moving equipment from the staging area to the pier if the two are not adjacent. MHE may be leased by the SUPSALV response team from commercial sources if government-owned equipment is not readily available. Sources must be identified in the contingency plan.

A large mobile crane is usually adequate to support staging area operations. The 10-ton SUPSALV skimmer vessel will generally be the largest single spill response equipment item to be handled. However, it may be necessary to offload the skimmer from the center of the support vessel. This would necessitate a 10-ton lift at a 35- to 40-foot reach, requiring a large mobile crane. In addition, a 5- or 6-ton forklift is needed at the staging area and at any other equipment-handling locations. During peak activity periods, several forklift trucks may be required.

C-2.2.3 Support Vessels

- V-Boom Towboats. Sources of locally available towboats should be identified in the contingency plan. The ESSM inventory does not include enough towboats to support its entire inventory of skimmers and boom. Additional boats will be required to support major deployments of SUPSALV equipment. Towboats must be suitable for local conditions. They must be sufficiently seaworthy to ride out rough weather and prevailing sea conditions or they must be recoverable onto the deck of a large support vessel. The SUPSALV towboats, for example, are intended to recover oil in sea state 3 and survive sea state 5 and can be recovered onto the support vessel if necessary.

  Locally available boats must have a substantial tow point forward of the rudder(s) to ensure high maneuverability while towing. They must have a bollard pull of at least 3,000 pounds and must be capable of prolonged towing at approximately one knot with as little as 500 pounds drag from one-half of a towed boom, skimmer, bladder configuration. They must have a minimum 10-hour endurance at operating speeds between refueling.

  Most offshore tugs and supply boats would make good recovery system towboats. But, unless these vessels are equipped with variable-pitch propellers, they generally cannot sustain the low speed (one to two knots) required for spilled oil recovery operations. Local fishing vessels may be excellent recovery system towboats.

  All vessels must be equipped with marine radios. A VHF marine radio with appropriate operating frequencies is a minimum requirement.

- Large Support Platforms. Unless the SUPSALV spilled oil recovery equipment system is operated within five miles of a pier-side staging area, a large support vessel is needed. The support vessel should provide a command post, communications center, messing, berthing, equipment repair facilities, large deck area for equipment and a crane with a minimum capacity of 10 tons. A crane of at least 20 tons is highly desirable offshore for recovering the 10-ton SUPSALV skimmer vessel on deck for repairs or for heavy weather.

- Other Support Vessels. If both the spilled oil recovery system tow vessels are small, large towing vessels will be needed to move the system at eight to ten knots in a transit towing mode to the spill area. Such vessels may also function as logistics support vessels for functions such as refueling the smaller vessels, crew transport and towing barges or bladders of recovered oil. Small, high-speed vessels are also desirable for crew transport and oil spill surveys. The number of additional recovery system barges or bladders and towboats needed will depend upon the transit distance between recovery operations and the oil disposal site.

  Barges and tank vessels for recovered oil storage and transport are described in Paragraph C-2.2.5.

C-2.2.4 Aircraft Support. Helicopter and/or fixed-wing aircraft support is essential in major spill oil recovery operations. The aircraft are required for spilled oil tracking, surveys and vectoring recovery systems to key areas. In addition, equipment and personnel transfer to stranded vessels in bad weather may be necessary.

Such operations are most safely accomplished by vertical replenishment (VERTREP). VERTREP specialists must be made available to the NOSC and identified in the contingency plan. Helicopter support areas or platforms for emergency landings, refueling and maintenance must be identified in the contingency plan.

C-2.2.5 Storage and Disposal of Recovered Oil. Temporary storage and final disposal of recovered oil have been found to be among the most difficult aspects of spill control operations. Local and regional contingency plans must include storage and disposal facilities. The Coast Guard, Environmental Protection Agency (EPA) and local environmental officials should be contacted for planning guidance.

The SUPSALV spilled oil recovery systems and petroleum oil and lubricants (POL) pumping systems can use locally available barges or tank vessels to receive the recovered or transferred oil. Such oil storage components are often difficult to procure locally. The SUPSALV storage bladders can provide storage pending the arrival of large-capacity-tank vessels. Locally procured tank vessels should be equipped with pumps, lighting for night operations, anchoring system, a winch and related tackle for hose recovery and shelter for the crew. If required, these barge support element (pumps, lighting, etc.) can be provided from the SUPSALV Emergency Ship Salvage Material (ESSM) inventory.

C-2-2.6 Personnel. The following manpower may be required to support SUPSALV efforts during pollution operations:

- A ready supply of riggers and laborers to support MHE, particularly during start-up and demobilization phases of the operation/exercise. Riggers and laborers for MHE can be locally hired by the SUPSALV response team if local Navy personnel are not available.

- On-site shipping and receiving official with office and telephone for larger operations. If government facilities are not readily available, a SUPSALV command van or a locally leased office trailer may be set up at the staging area.

- Each SUPSALV spilled oil recovery system (skimmer, oil boom, bladder and towboats) typically requires a minimum of eight operators per shift.

- The POL pumping system needs a minimum of four operators initially per shift. For 24-hour per day operations, at least two shifts per system would be required.

SUPSALV provides operators for all deployed ESSM equipment for all shift operations. Other experienced supervisory and administrative personnel are available to support the operating field personnel. If necessary to supplement SUPSALV response team personnel, experienced seamen can be hired from local sources or mobilized from forces under the NOSC's control. To reduce costs, SUPSALV can provide only a nucleus of operators that can then be supplemented by local Navy personnel.

C-2.2.7 Personnel Support Services. The efficiency and success of a large spill response operation depends on the physical efforts of the equipment operators. Adequate personnel support services are therefore an essential part of planning for pollution response. SUPSALV does not deploy equipment or personnel for these support services. The following items must be addressed in the contingency plan:

- Messing. Meals must be provided for all working personnel on board the large support platform, at remote work sites and at the staging area. The SUPSALV response team can purchase meal services from locally identified sources, commercial or military.

- Sanitary. Fixed or portable sanitary facilities, showers and a laundry will be needed both on board the support platform and within a reasonable distance of the staging area. Portable toilets will be needed for remote area operations.

- Transportation. Vehicles or small boats for personnel transportation and equipment support will be needed throughout the spill operations. Sources for commercial truck/car rental or military vehicles/buses should be included in the contingency plan.

C-2.2.8 Emergency Medical Services. The requesting activity for SUPSALV services will be expected to provide 24-hour medical support. This support will differ depending on the type of operations conducted. The following medical support services must be addressed in the contingency plan:

- Medical Personnel. First aid support by qualified Navy corpsmen or doctors will be needed on board the support platform. The requesting activity will be expected to assign such personnel for deployment with the support vessel. Also, emergency medical support must be quickly available to the staging area.

- Emergency Communications. The requesting activity will be expected to maintain 24-hour communications with all remote operating platforms and staging areas. Radio frequencies will be established for emergency communications between all deployed units.

- Evacuation Plan. In the event of an emergency, a medical emergency evacuation plan must be established. The execution of the plan will be under the control of the NOSCDR or the requesting activity. The plan must include:

  (1) Ambulance availability.

  (2) Helicopter medical evacuation.

  (3) Fast boat transportation.

- Hospitals. A list of civilian and military hospitals that will provide emergency services to the SUPSALV response team (including contractor personnel) must be identified in the contingency plan and given to the SUPSALV representative upon his arrival.

C-2.2.9 Water, Fuel, Lube and Hydraulic Oils. The SUPSALV equipment is not deployed with sufficient fuel and consumables for prolonged operations. These items must be available at the staging area upon arrival of the equipment. Upon deployment of the equipment from the ESSM base, SUPSALV will notify the requesting activity of the initial and daily requirements, for the following:

- Water - Potable water for personnel; water for equipment cleanup and maintenance.

- Fuel - Diesel fuel #2 and gasoline for outboards.

- Oils - Lubricating and hydraulic oils.

Most miscellaneous maintenance items such as belts and filters are shipped with the equipment. However, contingency plans should identify local industrial and marine suppliers. Consumables can be open-purchased by the SUPSALV response team directly from commercial sources. Locally available government fuels and consumables should be provided, whenever possible, to reduce costs.

C-2.2.10 Transportation. The SUPSALV ESSM equipment will be deployed to the spill area from the ESSM base by the most appropriate transportation method. These methods include truck, air cargo and ship/barge transportation. The most appropriate transportation mode will be determined by SUPSALV on the basis of distance, the time available and the equipment needed.

The requesting activity must provide a contact for all transportation coordination with a 24-hour phone number. A complete shipping address for the delivery site must be provided to SUPSALV before shipment of the equipment from the ESSM warehouses.

C-3 FUNDING, COST ACCOUNTING and REIMBURSEMENT

The Navy's inventory of offshore spill response equipment has been procured by SUPSALV and is maintained and operated by SUPSALV personnel and SUPSALV contractor personnel within the SUPSALV ESSM system. SUPSALV pays for equipment storage and maintenance within the ESSM bases. All operational costs for response to Navy spills (including SUPSALV/ contractor costs) must be funded by the fleet commander in chief for vessel spills and by the major claimant for facility spills. These funding requirements are established in OPNAVINST 5090.1 (series).

SUPSALV operational costs include SUPSALV personnel travel, per diem and overtime; and all contractor costs for equipment mobilization, on-scene operation and maintenance, demobilization and rehabilitation. This includes replacement of consumables and/or repair or replacement of equipment damaged or destroyed while under the operational control of the NOSC. Shipping costs are funded separately by NAVSEA Transportation Accounting Code (TAC) number. Prior to an official NOSC/NOSCDR request for SUPSALV assistance, SUPSALV representatives can be reached by telephone to provide a daily cost estimate for response based on the agreed-upon level of response (i.e., number of skimmer systems, quantity of boom, personnel requirements, etc.).

When the NOSCs or NOSCDRs request SUPSALV to respond to a pollution incident (through CNO) they must state that they will reimburse NAVSEA for all SUPSALV operational costs incurred in the incident response. Shortly after SUPSALV mobilization, SUPSALV fiscal representatives will contact the NOSC's fiscal agent to explain and discuss appropriate reimbursement procedures.

The on-scene SUPSALV representative will present to the NOSC daily cost summaries of all expenses incurred as the operation progresses. The daily cost summaries provide the NOSC with a daily summary of deployed SUPSALV assets, an accurate estimate of SUPSALV costs incurred to date and an opportunity to resolve any SUPSALV cost questions in a timely manner. An example of the daily cost summary is presented in **Figure C-2**. Navy contingency plans must address on-scene fiscal and accounting requirements and ready availability of funding for prompt payment of NAVSEA billings.

NAVAL SEA SYSTEMS COMMAND (SUPSALV)
DEPARTMENT OF THE NAVY
WASHINGTON, D.C. 20363
TELEPHONE (703) 607-2758
TELEX: 899182

Contractor:	Contractor Account Number:	
Delivery Order Number:	Date:	Contract Number:

DAILY OPERATIONAL COST SUMMARY REPORT

OPERATION: ______________________________	Cost This Date	Cumulative Cost
1. SCHEDULED LABOR (Attach list of personnel with regular and overtime rates, including travel time. Include personnel not on-scene, i.e., logistics expeditors.)		
2. SCHEDULED EQUIPMENT (Identify equipment used and rate per day.)		
3. NONSCHEDULED LABOR (Attach list of personnel with regular and overtime rates, including travel time. Include not on-scene.)		
4. NONSCHEDULED EQUIPMENT (Identify equipment used and rate per day.)		
5. SUBCONTRACTED SERVICES (Attach additional sheet as required identifying type of service and cost.)		
6. PERSONNEL TRANSPORTATION (Include itemized air fares, number of rental cars with cost estimate, etc.)		
7. EQUIPMENT TRANSPORTATION (List equipment transported and mode.)		
8. PER DIEM (For all scheduled and nonscheduled personnel incurring lodging and subsistence costs; identify number of people and per diem rate [in accordance with JTR]).		
9. PURCHASED MATERIAL/MISCELLANEOUS COSTS (Itemize purchase[s] in excess of $100.)		
10. MATERIAL HANDLING _____% (Items 4, 5, 7 & 9)		
11. (G & A) AT _____% ESTIMATED) (Items 3 through 10)		
12. AWARD FEE (__________% ESTIMATED) (Apply maximum fee to lines 3 through 11)		
13. CONTRACTOR RENTAL EQUIPMENT		
14. CONTRACTOR INTERDIVISIONAL PERSONNEL TRANSFER		
15. TOTALS		

Maximum Liability of Task	
Funds Remaining in Task	
Estimate to Complete	

Reviewed by Contractor Representative ______________________________	Date
SUPSALV Representative ______________________________	Date

Figure C-2. Sample Cost Form.

APPENDIX D

INTERAGENCY AGREEMENT BETWEEN THE U.S. NAVY AND THE U.S. COAST GUARD

INTERAGENCY AGREEMENT (IAA) BETWEEN THE UNITED STATES NAVY AND THE UNITED STATES COAST GUARD FOR COOPERATION IN OIL SPILL CLEAN-UP OPERATIONS AND SALVAGE OPERATIONS

I. PURPOSE: To specify for U.S. Coast Guard and U.S. Navy application:

A. Conditions and procedures under which the U.S. Coast Guard can request and the U.S. Navy will provide oil spill clean-up and/or salvage equipment and services to support the U.S. Coast Guard in non-Navy oil spills and other operations requiring salvage expertise.

B. Conditions and procedures under which the U.S. Navy can request and the U.S. Coast Guard will provide equipment and services to support the U.S. Navy in salvage operations and in response to oil spills which are caused by facilities or vessels under Navy jurisdiction.

C. Reimbursement procedures and policies.

II. BACKGROUND: The National Oil and Hazardous Substances Pollution Contingency Plan, promulgated under the authority of the Federal Water Pollution Control Act, (FWPCA) (33 USC 1251, et. seq.) confers on the Coast Guard (or the Environmental Protection Agency in designated areas) responsibility for designating Federal On-Scene Coordinators (OSC) to coordinate Federal agency resources in cleaning up any oil or hazardous substance discharged in U.S. navigable waters, the contiguous zone or waters beyond the contiguous zone up to approximately 200 miles. In addition to having the responsibility and expertise to respond promptly in cases of discharges from Navy operated or supervised ships and facilities, the Navy is also the governmental agency possessing expertise in ship salvage and salvage-related operations. The OSC, may access this expertise for the cleanup and control of any oil spill. The Coast Guard may also access the Navy's salvage expertise to assist during other operations conducted by the Coast Guard. Alternatively, the Navy may access the Coast Guard's expertise in oil spill control and other assets for salvage operations.

III. RESOURCES: Under the terms of this Agreement, the following resources may be provided:

A. When requested by the U.S. Coast Guard pursuant to Section V herein, the U.S. Navy will furnish to the U.S. Coast Guard the following resources consistent with availability and operational commitments as determined by the Navy:

(1) Salvage equipment and specialized oil spill control and clean-up equipment.

(2) Salvage, diving and oil spill control consultation, evaluation, planning and operational services.

(3) Naval Craft, vessels and aircraft.

B. When requested by the U.S. Navy pursuant to Section VI herein the U.S. Coast Guard will furnish to the U.S. Navy the following resources consistent with availability and operational commitments as determined by the Coast Guard.

(1) Oil spill consultation, evaluations, planning and operational services

(2) Specialized oil spill control and clean-up equipment.

(3) Coast Guard craft, vessels and aircraft.

IV. FEDERAL ORGANIZATION AND RESPONSIBILITIES: U.S. Navy response to U.S. Coast Guard Federal On-Scene Coordinator (OSC) requests for services and equipment in non-Navy oil spills will be provided in accordance with the National Contingency Plan (Part 1510, Chapter V, Title 40 CFR) and the terms of this IAA.

The Coast Guard OSC will coordinate and direct Federal oil spill control and cleanup efforts in the event of an incident in his area of responsibility. In the event that commercial resources and/or expertise are not available to carry out the required cleanup, the OSC will arrange for the use of Federal and/or State resources. Unless prearrangements have been made, the OSC will seek the assistance of the Regional Response Team in accessing the needed advice and/or resources.

U.S. Navy Salvage operations, conducted in support of other coast Guard activities, will be coordinated by the Coast Guard On-Scene Commander or Coast Guard Officer-In-Charge of the operation, subject to the operational and technical control of the Navy Salvage Officer.

V. COAST GUARD REQUESTS FOR NAVY ASSISTANCE:

A. When local or regional interagency contingency plans contain adequate provision for identification, deployment of, and reimbursement for locally available Navy pollution control assets OSC requests for such assets will be made through the Navy or DOD member of the RRT. The Navy (or DOD) member will have prearranged with the Navy supplier activity commander for authority to commit these resources to the OSC with the utmost expediency. It shall be the responsibility of the OSC to follow up such a request with a confirming message to the supplier activity and Navy Area Coordinator referencing the request and citing pertinent operational and funding information. Requests forwarded by OSCs shall include the following information:

(1) Circumstances of the spill, e.g., locations, quantity and

(2) Extent of assistance required.

B. When adequate local activity assets are not available, or difficulties arise in arranging for their deployment and cannot be resolved on the RRT level, the matter shall be referred to the National Response Team (NRT) for resolution. Requests forwarded by RRTs shall include the information called for in V.A. above.

(1) The Coast Guard NRT representative or National Response Center (NRC) Duty Officer will relay all requests for assistance from the OSC/RRT to the Chief of Naval Operations Navy Department Duty Captain (OP-641/642) for action, (24-hour telephone: 703-695-00231). Such referrals will specify the above mentioned information relating to the conditions and circumstances of the oil spill.

(2) All Coasts Guard telephonic requests for assistance referred to in paragraph (1) will be followed promptly by a documenting message from the Coast Guard. This message will reference and detail the initial OSC request and must include accounting data identification for reimbursement to the Navy of the costs identified in Section VIII of this Agreement. The message shall be addressed to CNO, Washington, D.C., Attn: OP-64/45/223/37; to CHNAVMAT, Washington, D.C. Attn: MAT-044; to COMNAVSEASYSCOM, Washington, D.C., Attn: NAVSEA-00C; to COMNAVFACENGCOM Alexandria, VA; to CINCLANTFLT, Norfolk, VA., or CINCPACFLT, Pearl Harbor, HI., (as appropriate); and to Commandant, U.S. Coast Guard and the NRC (as appropriate). The Navy will properly document increases in the projected cost of its assistance and will so inform the OSC by message referencing the Coast Guard's message.

C. If NAVSEASYSCOM assistance is anticipated OSCs may, prior to formal tasking, directly communicate with NAVSEASYSCOM at 703-607-2758 (normal workday), other times 703-607-7527 for technical matters.

D. In oil spill related cases where it becomes necessary to assist the Coast Guard by mobilizing Navy forces other than Navy pollution control assets, the Coast Guard representative to the NRT or the Coast Guard NRC Duty Officer will relay requests received from the Coast Guard OSC via the RRT to the Navy Department Duty Captain (OP-641/642) outlining the specific circumstances of the request. Each request for such assistance will contain the information set forth in paragraph V.A. of this agreement.

E. For purposes of this Agreement items are to be considered under the administrative control of the OSC from the time they are delivered for his use, whether such delivery is made at the scene of the incident or to a representative of the OSC at a location other than at the scene, through the time the item is redelivered to the Navy or its representative.

F. All Coast Guard requests for salvage assistance in other Coast Guard operations will be relayed by the appropriate Coast Guard Headquarters authority to the Navy Department Duty Captain. The request shall include information similar to that called for in V.A. of this Agreement.

VI. NAVY REQUESTS FOR COAST GUARD ASSISTANCE:

A. Coast Guard resources will be provided, subject to their availability, to assist Naval Activities in responding to pollution discharges caused by facilities or vessels under Navy jurisdiction. Requests for such assistance shall be relayed by the Navy representative to the NRT or to the National Response Center. Reimbursement will be made in accordance with the guideline established in Section VIII of this Agreement.

B. Coast Guard resources will be provided, subject to their availability, to assist the Navy during salvage operations. Requests for such assistance shall be relayed by the cognizant Navy Commander to the Coast Guard Commander Atlantic Area (Aom) for resources located on the Atlantic and Gulf Coasts and to Commander Pacific Area (Pom) for resources located on the Pacific Coast. Reimbursement will be made in accordance with the guidelines established in Section VIII of this Agreement.

C. For purposes of this Agreement items are to be considered under the administrative control of the Navy from the time they are delivered to the location and/or representative specified by the Navy, through the time the item is redelivered to the Coast Guard or its representative.

VII. LOCAL ARRANGEMENTS FOR ASSISTANCE:

Coast Guard OSC’s and local Naval commands, having oil spill cleanup capabilities, are encouraged to enter into agreements for the utilization of those capabilities to respond immediately to discharges of oil occurring within or in threatening proximity of, the waters of a U.S. Naval base or facility regardless of whether the Navy is responsible for the discharge. Wherever such agreements are reached, the Coast Guard will reimburse the Navy for Navy costs incurred in undertaking such actions as per Section VIII of this Agreement, unless it is subsequently determined that the Navy was responsible for discharge.

VIII. REIMBURSEMENT PROCEDURES AND POLICIES:

A. The Federal On-Scene Coordinator is responsible for insuring that proper cost documentation records are maintained.

B. Navy and Coast Guard activities providing advice and assistance are responsible for providing OSCs with supporting documentation for cost accounting.

C. Navy and Coast Guard activities providing assistance in support of the cleanup operation as requested by an OSC are entitled to reimbursement for the following items:

(1) Travel, per diem and overtime costs for personnel.

(2) Rental costs, as approved by the parent agency, for nonexpendable equipment provided.

(3) Replacement costs for expendable materials provided and utilized

(4) Replacement or repair costs for nonexpendable equipment which is damaged while under the administrative control of the OSC.

(5) Transportation costs incurred in delivering items to and from the scene.

(6) Incremental operating and contract costs incurred as a result of providing assistance to OSCs.

D. Normal salary costs of government employees in positions that are not normally intended to provide services in support of response operations are reimbursable. Salaries of reserve personnel called on active duty specifically to assist in a Federal response activity are reimbursable.

E. The fiscal agent for the U.S. Navy under Section V.A. of this Agreement will be the local activity Commanding Officer and under V.B. will be the Commander, Naval Sea Systems Command (NAVSEA-01), Washington, D.C. 20362.

F. The fiscal agent for the U.S. Navy under Section V.A. of this Agreement will be the local activity Commanding Officer and under V.B. will be the Commander, Naval Sea Systems Command (NAVSEA-01), Washington, D.C. 20362.

G. Subject to the Coast Guard’s ultimate collection responsibility for services and operations provided by the Navy under this agreement, NAVSEA-01 of the local activity, depending on the applicability of V.A. or V.B., shall be responsible for making collections from the Coast Guard and shall make appropriate disbursements of transfer of funds within the respective Navy organizations.

H. Paragraphs A through G above apply only to the reimbursement of costs to the Navy in connection with FWPCA response actions. Paragraphs E and F apply to all reimbursements covered by this Agreement. Normal accounting procedures (interagency transfers) apply (1) to reimbursements not related to FWPCA response actions and (2) to reimbursements to the Coast Guard for the use of their equipment and services in a FWPCA response action conducted by the Navy.

IX. NOTIFICATION: The terms of this Agreement, amplifies as necessary to provide detailed guidance and procedures for reimbursement, will be promulgated to components of the Coast Guard and the Navy.

APPENDIX E

BOOM MOORING

E-1 INTRODUCTION

To form an effective barrier to oil movement, containment booms must be held stationary, except when towed or employed in the free-drift containment mode. To prevent movement, deployed booms must be secured at each end and usually at several locations along their length. Booms are secured to the seabed by clumps and ordinary drag embedment anchors and to conveniently located piers, dolphins or other structures by assorted fittings. The relative merits of different types of anchors in different seafloors is discussed in **Appendix G** of the ***U.S. Navy Ship Salvage Manual, Volume 1***, S0300-A6-MAN-010. The ESSM system maintains 500-pound STATO anchors for boom mooring. STATO, LWT, Danforth, stockless, mushroom or other type anchors of various sizes may be available from the ESSM system and other Navy, Coast Guard, other government agency or commercial sources. The size, type and number of anchors or other attachments required to restrain a given length of boom depends on the current and wind forces acting on the boom, the configuration desired and on the seafloor composition when anchors or clumps are used.

E-2 MOORING BOOMS WITH ANCHORS

Mooring leg tension at the anchor should be nearly parallel to the seafloor. Upward forces will tend to break most anchor types out of the seafloor, allowing them to drag. Mooring leg lengths of five times the water depth are usually sufficient to ensure tension parallel the seafloor when nonbuoyant materials, such as wire rope, chain, nylon or manila are used. When buoyant lines, such as polypropylene or polyethylene are used, a short length of chain should be attached between the anchor and the mooring rope to ensure the mooring leg lies parallel to the seafloor at the anchor. Chain should also be used in conjunction with nonbuoyant fiber line mooring ropes on rock, shingle or coral seafloors to prevent chafing.

It is important that the mooring leg provide horizontal restraint to the boom, without vertical tension that will tend to submerge the boom and allow oil to escape. A buoy installed in the mooring leg 10 to 12 feet from the boom, as shown in **Figure E-1**, can help prevent vertical tension on the boom. Mooring legs along the length of a boom should be attached by two leg bridles to avoid causing the boom to layover in strong current or wind. The restraint of a single point attachment forms a rotating couple with the current drag, as shown in **Figure E-2**, if not attached precisely at the center of lateral resistance.

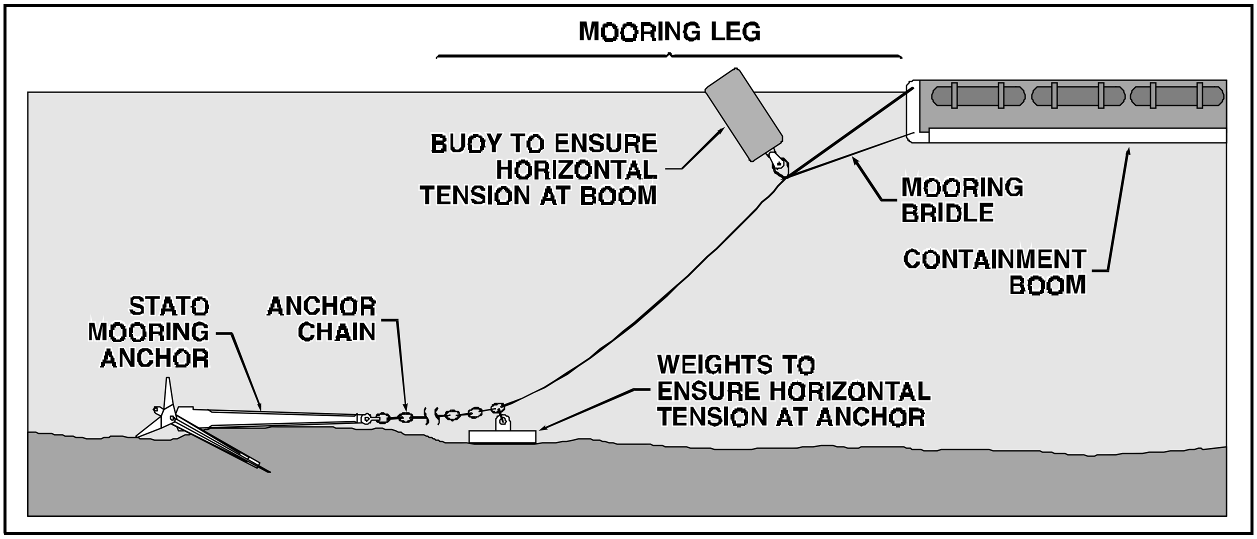


Figure E-1. Typical Mooring Arrangement.

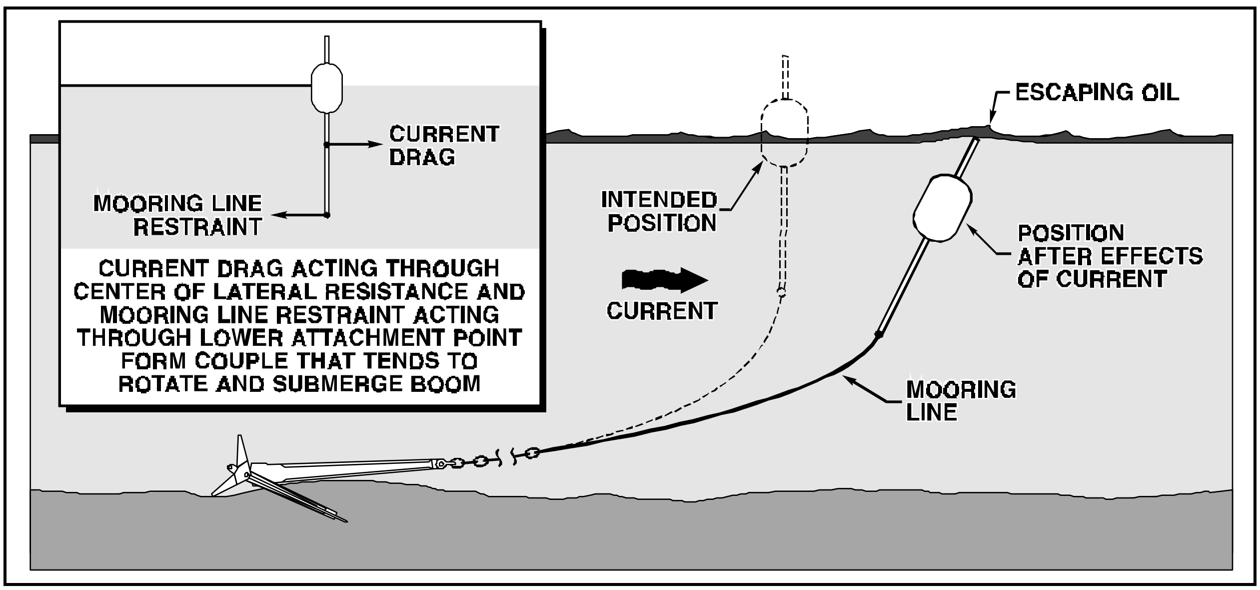


Figure E-2. Boom Submergence by Improper Mooring.

The total holding power of the anchors or anchoring points securing a boom must equal or exceed the wind and current generated drag forces acting on the boom. Current drag force can be estimated by:

$$Fc = 5.33 A_s V_c^2 \quad \text{(English units)}$$

$$= 26 A_s V_c^2 \quad \text{(Metric units)}$$

where:

F_c = current drag force, lb or kg

A_s = area of the skirt and other submerged portions of the boom, ft^2 or m^2

$V_c^{\,2}$ = current velocity, kt

Wind force can be estimated from:

$$F_C = 5.33 A_f \left(\frac{V_W}{40}\right) \quad \text{(English units)}$$

$$= 26 A_f \left(\frac{V_W}{40}\right) \quad \text{(Metric units)}$$

where:

F_w = wind drag force, lb or kg

A_s = area of the boom freeboard, ft^2 or m^2

$V_w^{\,2}$ = wind velocity, kt

It is prudent to assume that wind and current will act in the same direction at least part of the time and base anchor selection on the combined drag force resulting from wind and current. The drag force formulae are based on the assumption that the boom is a rigid barrier perpendicular to the wind or current direction. In most situations, two factors cause drag forces on booms to be somewhat less than calculated:

- Booms are flexible and assume curved shapes when acted on by wind and current.
- Booms are usually oriented at an angle to current flow.

Use of the formulae without modification provides a substantial safety factor in the selection of anchors and mooring hardware.

The total holding power of the anchors or anchoring points selected must equal or exceed the combined wind and current drag. The number of anchoring points actually used will depend on the boom configuration desired and above all, the availability of suitable anchors. Holding power, as a multiple of the anchors weight, for various anchor types can be estimated from **Table E-1**.

Table E-1. Anchor Holding Power.

Anchor type	**Holding power as a multiple of dry weight**	
	Soft soils (soft clays and slits)	**Hard soils (sands and stiff clays)**
1,000-lb anchors:		
Danforth/LWT	10.5	20
STATO/NAVMOOR	24	22-29
Navy Stockless	2.9	7
500-lb anchors		
Danforth/LWT	11	23
STATO/NAVMOOR	25	23-30
Navy Stockless	3	8
100-lb anchors		
Danforth/LWT	12.6	31.6
STATO/NAVMOOR	27.7	25-33
Navy Stockless	3.5	11

E-3 SECURING BOOMS TO PIERS AND OTHER STRUCTURES

In addition to the end connections described in **Paragraph 4-2.3**, it is often necessary to secure boom along its length to maintain a desired configuration or provide additional restraint against wind and current force. Near piers or other manmade structures, it may be more convenient or workable to secure boom to the structure than to lay anchors. If the boom is fitted with mooring leg attachment points along its length, guy lines can be run from these points to cleats, bollards or similar fittings on the pier. If there are no mooring leg attachments on the boom, weighted guy lines can be thrown over the boom as shown in **Figure E-3**. The boom is pulled into the desired position and the guy lines secured to cleats or other fittings on the pier.

The end connections described in **Paragraph 4-2.3** provide an oil-tight connection to a seawall or ship's hull, but may not have sufficient strength to withstand the tension resulting from wind, wave or current forces. Stress on the end connector can be alleviated by rigging guy ropes as shown in **Figure E-4**.

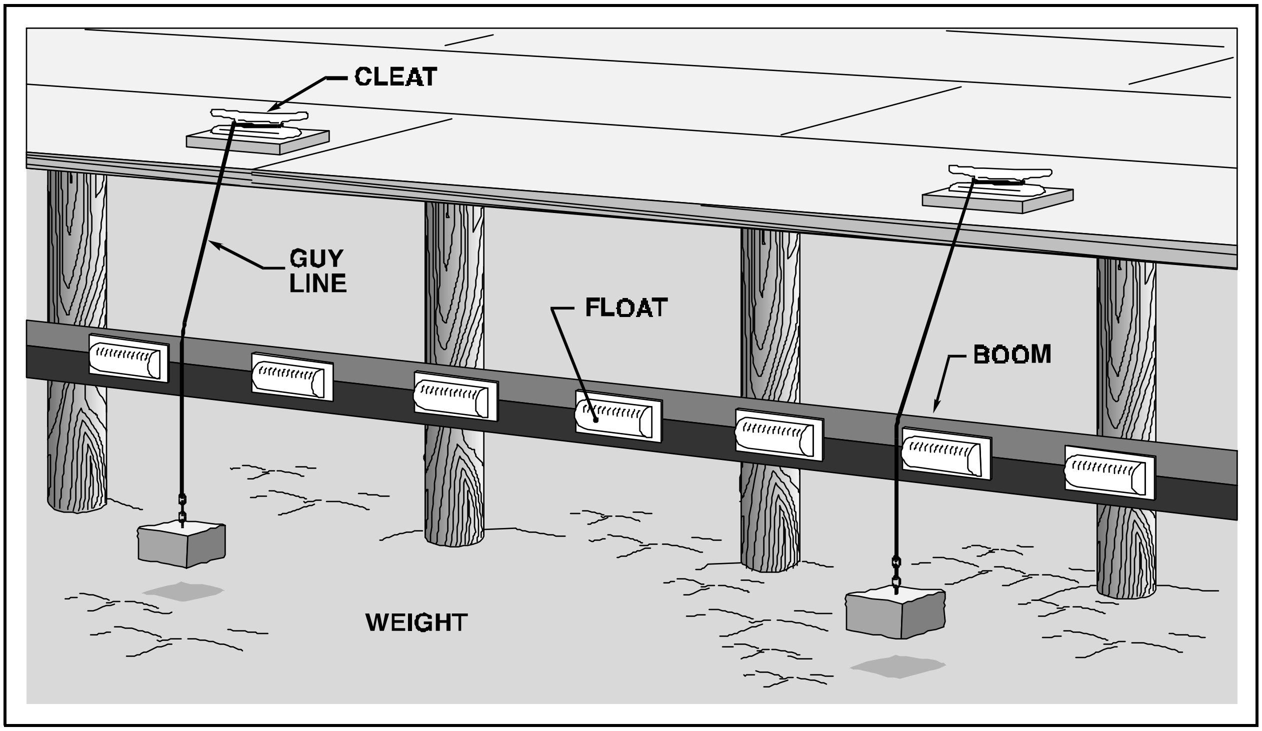


Figure E-3. Boom Mooring With Weighted Guy Lines.

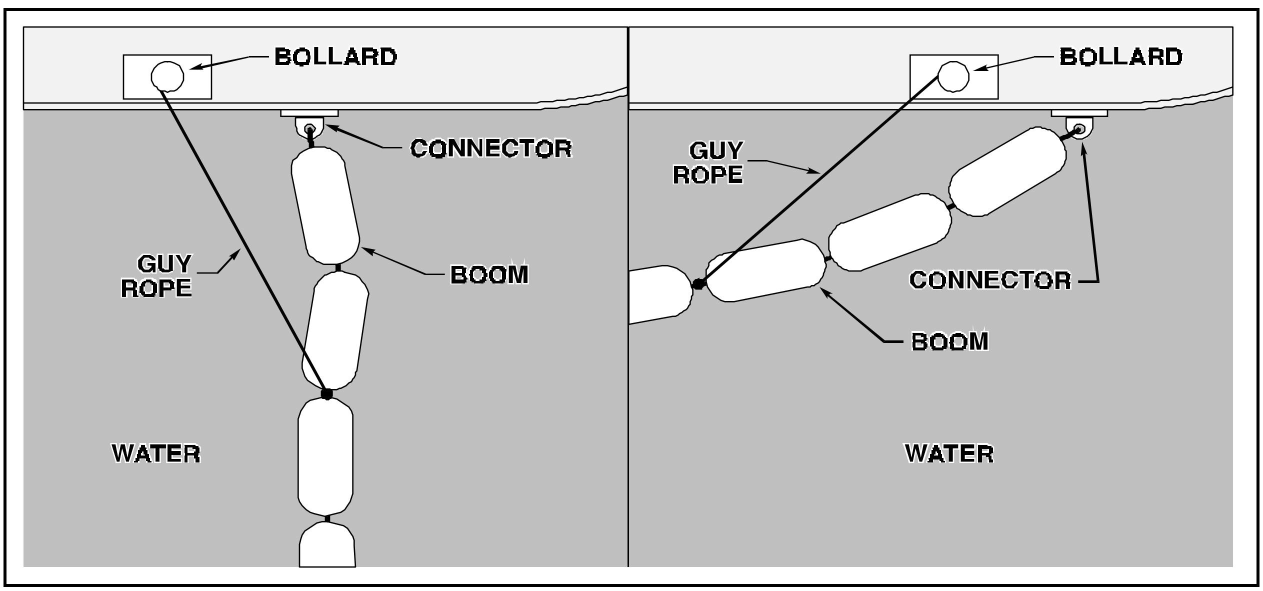


Figure E-4. Guy Ropes to Relieve Stress on End Connectors (Plan Views).

APPENDIX F

OIL CHARACTERISTICS

F-1 INTRODUCTION

Paragraph 2-2 defined the physical and chemical properties of oils pertinent to spill response and described the factors exerting a general influence over those properties and the petroleum distillation refinement process. The following tables, figures and text describe characteristics of specific petroleum products, nonpetroleum oils and crude oils.

F-2 OIL CHARACTERISTICS TABLES AND FIGURES

The following tables and figures provide data on physical characteristics of selected crude oils, petroleum products and nonpetroleum oils. **Tables F-1** through **F-3** give properties of refined oils, while **Tables F-4** through **F-6** give properties of various crude oils. **Table F-7** and **Figures F-1** and **F-2** provide data on the behavior of crude and refined oil exposed to the environment.

Table F-1. General Oil Classifications.

Light Distillates (Boiling Point-BP-Range from 95°F to 572°F)	
A.	Motor Gasoline (BP Range 156.2°F to 388.4°F)
B.	Jet Fuel (BP Range 350.6°F to 550.4°F)
C.	Kerosene (BP Range 372.2°F to 572°F)
D.	Naphtha (BP Range 95°F to 572°F)
Heavy Distillates and Residuals (Boiling Point-BP-Range over 370.4°F)	
A.	Diesel Fuel Oil (BP Range 399.3°F to 719.6°F)
B.	Number 1 Fuel Oil (BP Range 370.4°F to 624.2°F)
C.	Number 2 Fuel Oil (BP Range 429.8°F to 633.2°F)
D.	Number 4 Fuel Oil (BP Range 494.6°F to 800.6°F)
E.	Bunker Fuel Oil (BP Range over 600.8°F)
F.	Number 6 Fuel Oil (BP Range 541.4°F to 1,261.4°F)

Table F-2. Common Designations of Refined Products.

Group	Common Designations
Gasoline	Gasoline; Aviation Gasoline; JP-4; Jet B
Aircraft Turbine Fuel	JP-1; JP-3; JP-4; JP-5; JP-6; JP-7; JP-8; Jet A, A-1, B, C
Kerosene	Kerosene; No. 1 Fuel Oil; Range Oil; Jet A, A-1, C; JP-5; Aircraft Turbine Fuel; Aviation Kerosene
Diesel Fuel Oil	No-1D; No-2D; No-4D; Gasoil; Marine Diesel Type I: No-1D, Type II: No-2D, Type III: Heavy Distillate or Marine Diesel, Type IV: Residual and Distillate
Distillate Heating Oils	No. 1 Grade; No. 2 Grade
Residual Fuel Oils	No. 4; No. 5; No. 6; Navy Special; Navy Heavy; Bunker A, B, C

Table F-3. Generalized Physical Properties of Crude Oil.

Properties	Range
Gravity	
API	13 to 57
Specific Gravity	0.73 to 0.98
Sulfur Content, Percent	0 to 5.0
Asphaltene Contents, Percent	0 to 5.8
Wax Content, Percent	0 to 27
Pour Point,°F	-23.2°F to 69.8°F
Viscosity @ 100.4°F	1.6 to 739
Distillation Rate, Percent	
to 300°F	3 to 54
to 449.6°F	7 to 84
to 649.4°F	23 to 100
to 699.8°F	27 to 100

Table F-4. Properties of Fuels and Oils.

Liquid	Saturated Liquid Density (Lb/ft^3 at 60°F)	Viscosity (Units Centipoise @ 60°F unless specified)	Flash Point (°F)	Vapor Press. (psia @ 70°F)	Flammable Limit (% in air)	Specific Gravity @ 60°F
DIESEL FUELS						
DFM	52.63		160	Low		0.844
DF1	52.43	11.95 @ 100°F	100	.042	1.3-6.0	.840
DF2	52.43	11.95 @ 100°F	125	.042	1.3-6.0	.840
DFA	51.13		100	0.5		.820
Kerosene	49.90	1.32	100	.041	0.7-5.0	.800
JET FUELS						
JP-4	50.49	.829 @ 70°F	-51	2.3-2.9	1.3-8.0	0.809
JP-5	51.46	2.28	140-150	.101 @ 130°F	0.6-4.6	0.825
JP-8	50.50		100			0.810
Naphtha (Solvent)	53.06	7.12	>100	.094 @ 90°F	0.8-5.0	0.850
FUEL OIL						
1-D	50.53	1.32	100	.041	1.3-6.0	0.810
2	54.74	2.13	136	.489		0.877
4	56.18	14.50 @ 100°F	>130	.042	1.0-5.0	0.900
5	58.36	43.50 @ 100°F	>130	.042	1.0-5.0	0.935
6	60.30	493.50 @ 100.42°F	>150	.042	1.0-5.0	0.966
LUBE OIL						
9250	52.43	275.00 @100°F	275-600	.042		0.840
SAE 10w/30	54.81	224.5	383			0.878
Used 10w/30	55.21	175.2				0.885
Gear Oil (EP)	55.1	975	379-511			0.883
Electrical Lube 27"	54.5	144	>230			0.873
GASOLINE						
MOGAS <4.23g Pb/gal	45.85	.475	.36		1.4-7.4	0.735
AVGAS <4.86g Pb/gal	44.26	.440	-50		1.2-7.1	0.709
MISCELLANEOUS OILS						
Coconut Oil	57.07 @90°F	32.59 @90°F	420 (crude) 580 (refined)			0.915
Cottonseed Oil	57.71	2,356.00	486	.41		0.925
Fish Oil	58.33	2,356.00	420	.41		0.935
Linseed Oil	58.52	56.03	535			0.938
Olive Oil	57.39	116.29	437	0.41		0.920°F
Palm Oil	56.17 @100°F		373			0.906 @100.4°F
Safflower Oil	57.90					0.928
Soybean Oil	56.46	2,356	540	.41		0.905
Sperm Oil	54.93	17.150 @100.42°F	42 (#1) 460 (#2)	.42		0.880
Veget. Oil	57.71	2,356.00	610	.41		0.925
Electrical Insulating	54.6	18.5	304			0.874

* Marine fuels may also be designated by International Fuel Oil Numbers in the format IFO-XXX, Where the last 3 digits indicate viscosity in cSt at 60°F.

Table F-5. Typical Ultimate Analyses of Crude Oils and Petroleum Products.

	Carbon	Hydrogen	Sulphur	Nitrogen	Oxygen
Pennsylvania Crude	86.06%	13.88%	0.06%	9.99%	0.00%
Texas Crude	85.05	12.30	1.75	0.70	0.00
California Crude	84.00	12.70	0.75	1.70	1.20
Mexican Crude	83.70	10.20	4.15	-	-
Oklahoma Crude	85.70	13.11	0.40	0.30	-
Kansas Crude (Towanda)	84.15	13.00	1.90	0.45	-
Kansas Residuum	85.51	11.88	0.71	0.32	0.63
Healdton (Oklahoma) Crude	85.00	12.90	0.76	-	-
Kansas Air Blown Residuum	84.37	10.39	0.42	0.21	4.61
Byerlite Pitch	87.61	9.97	0.55	0.29	1.58
Grahamite	87.20	7.50	2.00	0.20	-
Trinidad Asphalt	82.60	10.50	6.50	0.50	-
Commercial Gasoline	84.27	15.73	0.00	0.00	0.00
Kerosene	84.74	15.26	0.01	0.00	0.00
Lubricating Oil (Paraffin)	85.13	14.87	0.01	-	-
Lubricating Oil (Naphthene)	87.49	12.51	-.01	-	-

Table F-6A. Crude Oil Properties, North America and North Sea.

Crude Name	Producing Area	Gravity ° API	Viscosity cSt 60°F (15 °)	Pour Point	
				°C	°F
Alaska North Slope (Sadlerochi, ANS)	Alaska North Slope	26.4	42.40	-18	0
Prudhoe Bay	Alaska North Slope	27.0	75.300	0	32
Kuparuk	Alaska North Slope	23.0	80.00	-48	-55
Granite Point	Cook Inlet, Alaska	42.8	2.00	<-15	<5
McArthur River	Cook Inlet, Alaska	35.4	24.00	-7	19
Middle Ground Shoal	Cook Inlet, Alaska	41.5	6.5	<-15	<5
Swanson River	Cook Inlet, Alaska	29.7	21.00	<-15	<5
Trading Bay	Cook Inlet, Alaska	31.0	12.00	<-15	<5
Koakoak O-22	Beaufort Sea	28.1	22.5	-48	-54
Kopanoar	Beaufort Sea	25.7	36.70	-37	-35
Kopanoar M-13	Beaufort Sea	30.9	26.90	3	37
Mayogiak	Beaufort Sea	37.3	17.00	-30	-22
Mektoralik K-59A	Beaufort Sea, Canada	39.9	1.70	-39	-38
Nerclerk M-98A	Beaufort Sea, Canada	22.3	97.00	-	-
Nerclerk M-98C	Beaufort Sea, Canada	26.4	14.00	-	-
Tarsiut	Beaufort Sea	28.0	8.50	<-60	<-76
Tarsiut A-25	Beaufort Sea	30.8	6.20	-32	-26
Norman Wells	Northwest Territories, Canada	38.4	6.06	-85	-121
Alberta	Alberta	36.8	7.65	-24	-11
Lloydminster	Alberta and Saskatchewan	16.3	69.50	-36	-33
Gulf Alberta L&M	Alberta	35.1	4.8	-27	-17
Rainbow L&M	Alberta	40.7	3.77	3	37
California API 11	California	10.3	34,400.00	0	32
California API 15	California	13.2	6,550.00	-9	16
Synthetic Crude		32.6	5.30	-72	-98
Auk	North Sea, UK	37.2	3.65	9	48
Forties	North Sea, UK	37.0	8.20	-3	27
Piper	North Sea	35.2		-9	16
Statifjord	North Sea, Norway and UK	38.4	7.30	-15	5
Ekofisk	North Sea, Norway	43.0	20.00	-12	10
Gulfaks	North Sea, Norway	28.6	22.70	-45	-49

Table F-6B. Crude Oil Properties, Middle East, South America, and Pacific.

Crude Name	Producing Area	Country	Gravity ° API	Viscosity cSt 60°F (15 °)	Pour Point	
					°C	°F
Amma	Ras Lanuf	Libya	36.1	13	18	65
Arjuna	SBM, Java Sea	Indonesia, W. Java	37.7	3	27	80
Bachequero	La Salina	Venezuela	16.8	275	-23	-10
Bahia	Salvador	Brazil	35.2	17	38	100
Bakr	Ras Gharib	Egypt	20.0	152	7	45
Bass Strait		Austrailia	46.0	2	15	60
Belayim	Wadi Feiran	Egypt	27.5	18	6	43
Boscan	Bajo Grande	Venezuela	10.3	>20,000	15	60
Bu Attifel	Zueitina	Libya	40.6	-	39	102
Bunyu	Bunyu	Indonesia, E. Kalimantan	32.2	3	17.5	63
Cabinda	SPMB-Landana	Angola	32.9	20	27	80
Cinta	SBM, Java Sea	Indonesia, W. Java	32.0	-	43	110
Duri	Dumai	Sumatra	20.6	100	14	57
El Morgan	Shaukeer	Egypt	32.3	9.5	7	45
Es Sider	Es Sider	Libya	37.0	5.7	9	48
Gamba	SPMB-Gamba	Gabon	31.8	38	23	73
Gippslank Mix	Western Port Bay	Australia	44.4	2	15	60
Handil	SBM, Handil	Indonesia, E. Kalimantan	33.0	4.2	29	85
Heavy Lake Mix	La Salina	Venezuela	17.4	600	-12	10
Iranian Nowruz	Bahrgan	Iran	18.3	270	-26	-15
Jatibarang	SBM, Balongan	Indonseia, W. Java	28.9	-	43	110
Jobo/Morichal (Monagas)	Puerto Ordaz	Venezuela	12.2	3780	-1	30
Lagunillas	La Salina	Venezuela	17.7	500	-20	-5
Mandji	Cap Lopez	Gabon	29.0	17	9	48
Merey	Puerta La Cruz	Venezuela	17.2	520	-23	-10
Minas	Dumai	Indonesia, Sumatra	35.2	-	32	90
Panuco	Tampico	Mexico	12.8	4700	2	35
Pilon	Carpito	Venezuela	13.8	1900	-4	25
Qua Iboe	SBM	Nigeria	35.8	3.4	10	50
Quiriquire	Carpito	Venezuela	16.1	160	-29	-20
Ras Lanuf	Ras Lanuf	Libya	36.9	4	7	45
Rio Zulia	Santa Maria	Columbia	40.8	4	27	45
San Joachim	Puerto La Cruz	Venezuela	41.5	2	24	75
Santa Rosa	Puerto La Cruz	Venezuela	49.4	2	10	50
Seria	Lutong	Brunei	36.9	2	2	35
Shengli	Qingdao	P.R. China	24.2	-	21	70
Taching	Darien	P.R. China	33.0	138	35	95
Tia Juana Pesada	Puerto Miranda	Venezuela	13.2	>10,000	-1	30
Wafra Eocene	Mina Saud/Mina Abdulla	Neutral Zone/Kuwait	18.6	270	-29	-20
Zaire	SBM	Zaire	34.0	20	27	80
Zeta North	Puerto La Cruz	Venezuela	35.0	3	21	70

Figures in Table F-6B are from Response to Marine Oil Spills, 1987 (published by Witherby & Co., London, ISBN 0 948691) and are reproduced with the kind permission of the authors, the International Tanker Owners Pollution Federation, Ltd.

Table F-7. Oil-Water Emulsions and Solubility of Distillates.

Types of Oil	Formation of Emulsion	Water % in Emulsion After 5 Days	Solubility of Oil in Water
Light Distillates			
Gasoline	None	-	Fairly soluble in water but evaporates easily
Kerosene	None	-	Fairly soluble in water but evaporates easily
Naphtha	Partially Stable	5 to 10	Fairly soluble in water but evaporates easily
Heavy Distillates			
Diesel	None	-	Soluble in water
No. 2 Fuel Oil	None	-	Soluble in water
No. 4 Fuel Oil	Partially Stable	5 to 10	Little solubility in water
Bunker Oil	Significant	70	Little solubility in water
Crude Oil	Significant	70 to 85	Variable solubility in water

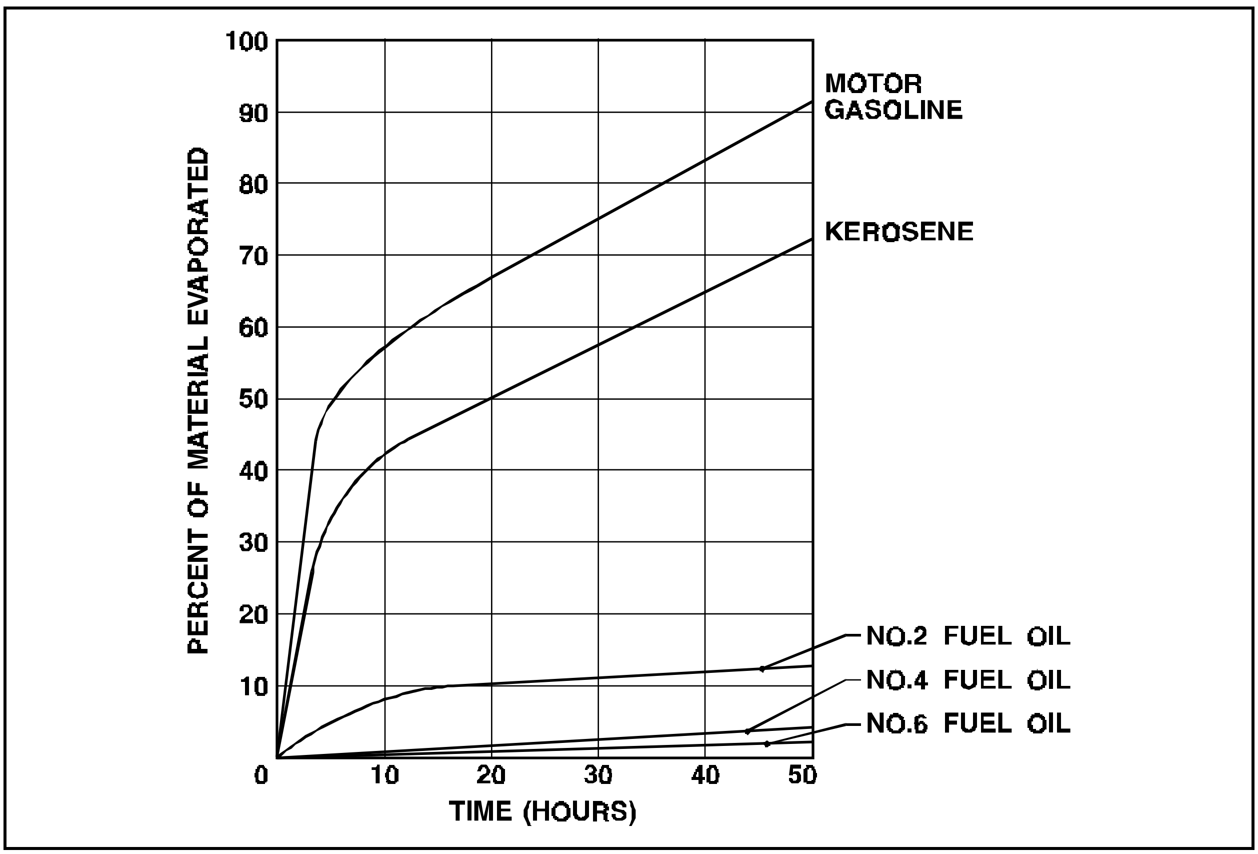
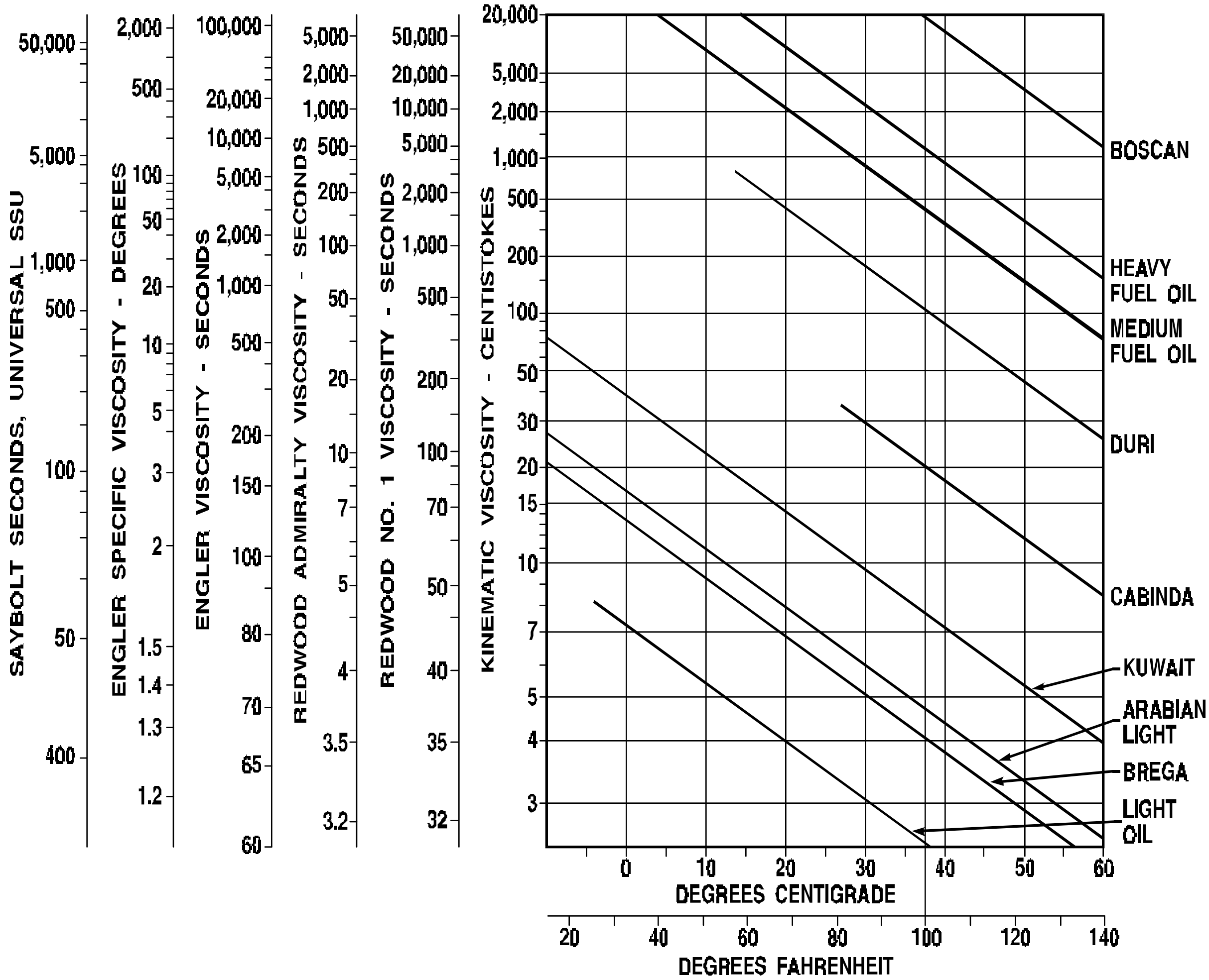


Figure F-1. Theoretical Evaporation Rates of Selected Distillate Fuels.



NOTES:

1. OTHER OILS CAN BE PLOTTED BY ENTERING A KNOWN VISCOSITY VALUE AT THE RELEVANT TEMPERATURE AND DRAWING A LINE PARELLEL TO EXISTING ONES.
2. LIGHT DIESEL IS ALSO KNOWN AS GAS OIL OR NO. 2 FUEL OIL (ASTM NOMENCLATURE) AND RANGES FROM 35-42 SSU AT 100°F.
3. MEDIUM FUEL OIL IS ALSO KNOWN AS N0. 4 FUEL OIL (ASTM NOMENCLATURE) AND RANGES FROM 1,200-2,000 SSU AT 100°F.
4. HEAVY FUEL OIL IS ALSO KNOWN AS BUNKER C OR NO. 6 FUEL OIL (ASTM NOMENCLATURE) AND RANGES FROM 3,500-12,000 SSU AT 100°F.

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Figure F-2. Relationship Between Temperature and Oil Viscosity for Representative Crude and Fuel Oils.

F-3 GENERAL CHARACTERISTICS OF PETROLEUM BY PRODUCING REGION

The major petroleum reserves of the world are found in North and South America, the Persian Gulf area of the Middle East, the Caspian Sea region, North Africa, the North Sea and to a lesser degree, continental Europe and the Malayan region.

F-3.1 North America. The main oil-producing areas of North America have been the Appalachian region (Pennsylvania), the Mid-Continent, the Gulf Coast, California, the Rocky Mountain area, Mexico, Michigan, certain areas of Canada and the North Slope of Alaska.

F-3.1.1 Pennsylvania. The so-called “Pennsylvania” crude, produced from wells in certain areas of Pennsylvania, West Virginia and New York, is a classic paraffin-based petroleum. As the first crude oil produced in quantity, it has become a basis for comparison. Pennsylvania crude is generally light in color, with specific gravity of about 0.81. The crude is virtually free of asphaltic constituents with only traces of sulfur and nitrogen. Gasoline and kerosene fractions may account for up to 60 percent of the volume. The heavy fractions and residuals yield paraffin, petrolatum wax and lubricating oils with relatively flat temperature-viscosity curves and high boiling points. Pennsylvania crude accounts for only a small portion of U.S. production, but the oil continues to be commercially important because of the high quality of lubricants derived from it.

F-3.1.2 Mid-Continent. Mid-Continent crudes are usually darker and heavier than Pennsylvania crude, with higher asphalt and sulfur contents. Specific gravity ranges from 0.81 to 0.93. Sulfur content is generally about 0.5 percent, although sulfur contents of 1.0 to 1.5 percent are not uncommon in West Texas and Arkansas crudes. Most of the crude produced can be classed as mixed base, although relatively paraffinic or naphthenic oils can be identified. Oil from the Oklahoma-Kansas area, considered the classical Mid-Continent crude, are typically high in gasoline content (25 to 40 percent), relatively low in sulfur (0.2 to 0.4 percent) and very asphaltic. The Kansas crudes are higher in sulfur and less paraffinic; the northern, central eastern Texas oils are lower in sulfur and more paraffinic. West Texas and Texas Panhandle crudes are typically high in sulfur (up to 1.5 percent) and of intermediate base, although West Texas crude from deep (Ordovician) formations is very similar to Pennsylvania crude.

F-3.1.3 Gulf Coast. Gulf Coast crudes are heavy oils of intermediate to naphthenic base, with low gasoline content, little or no wax content and high yields of naphthenic lubricating oils. The heavy fractions and residuals are often asphaltic. Deeper formations often yield lighter oils with higher gasoline content and lower sulfur content.

F-3.1.4 California. The typical California crude, produced in the San Joaquin Valley, is heavy (specific gravity around 0.934), low in gasoline and wax content and high in asphalt content. The gasoline has a high octane rating because of a large naphthene content. The Los Angeles area produces a lighter, more paraffinic crude (specific gravity around 0.834), although it still contains asphalt. Gasoline content may be as high as 35 percent and kerosene as high as 15 percent. In some cases, sulfur content may be as low as 0.06 percent. The coastal area north and west of Los Angeles produces oil with qualities between those of Los Angeles and San Joaquin crudes, except that sulfur content is very high—sometimes 2 to 4 percent.

F-3.1.5 Alaska. Alaska's primary oil production areas are the North Slope, including offshore fields in the Beaufort Sea and the areas in and around Prince William Sound in Southern Alaska. North Slope oil transmitted by pipeline and locally produced oil are fed to a large terminal facility at Valdez at the head of Prince William Sound. North Slope oil tends to be heavy, of paraffinic-aromatic base. Total percentage of paraffins and aromatics in a crude oil may exceed 90 percent. Light fractions typically account for less than 20 percent of the total volume. Sulfur content is usually about 1 percent.

Southern Alaska crudes, from the Cook Inlet area, are somewhat lighter than North Slope crudes, with light ends making up 20 to 40 percent of the total volume. Viscosity and pour point are low and sulfur content is extremely low, often less than 0.01 percent.

F-3.1.6 Rocky Mountain. Crudes produced in the Rocky Mountain region are either fairly intermediate crudes or black oils with high sulfur content. Wax content is high and the waxes have unusually high melting points. Gasoline and naphtha content of the intermediate crudes may run as high as 40 percent.

F-3.1.7 Mexico. Mexican crudes are typically heavy, asphaltic, high in sulfur and low in gasoline content. The northern Panuco area, near Tampico, yields oil with specific gravity of about 0.972, sulfur content about 5 percent and gasoline content of 5 to 10 percent. The Tuxpan fields, 50 to 100 miles south of Tampico, yield similar but less asphaltic oil with lower sulfur content (about 3.5 percent) and slightly higher gasoline content (up to 15 percent). Crudes from both Tuxpan and Panuco fields have pour points of about 40°F. The Poza Rica and Tehuantepec fields produce lighter crudes (specific gravity about 0.85) with lighter color, less asphalt and lower sulfur content.

F-3.1.8 Michigan. Michigan crudes are of a paraffin-intermediate type, i.e., the lighter fractions are paraffinic and the heavier fractions naphtenic. The nonvolatile residuum is to asphaltic for lubricant production. The gasoline content of about 25 percent is extremely paraffinic, leading to a low octane number.

F-3.1.9 Canada. Canadian oil production is centered chiefly in Alberta, extending into Saskatchewan, although some oil is produced in New Brunswick and Ontario and offshore fields in the Beaufort Sea and off the east coast. The Alberta fields initially produced primarily natural gas and light hydrocarbons (distillate fields), but later production included intermediate base oils with a significant wax content, up to 40-percent gasoline and about 0.5 percent sulfur. In general, oil from newer, interior fields resembles Mid-Continent crude. Offshore oil from the Beaufort Sea is similar to oil from Alaska's North Slope.

F-3.2 South America. Venezuela is the principal producer of petroleum in South America, with small quantities produced in Columbia Peru, Argentina and Trinidad. Most of the Venezuelan fields are near Lake Maracaibo. The fields immediately adjoining Lake Maricaibo produce crudes very similar to those from the San Joaquin valley in California, while those in eastern Venezuela yield oils resembling the California coastal crudes.

Colombian crude resembles the lighter crudes from the San Joaquin Valley. Gasoline content is about 10 percent and the absence of wax allows the production of lubricants with very low pour points. Peruvian crude is very light, with gasoline content of up to 40 percent and very low sulfur content. Argentina procedures both heavy, intermediate base crude and lighter paraffin-base crudes. Most Trinidad crude is of mixed base resembling the California crudes. There is some variation among the crudes produced, with some resembling the California crudes. There is some variation among the crudes produced, with some resembling Mid-Continent crudes.

F-3.3 The Middle East. The Persian Gulf area possesses the worlds largest known petroleum reserves. There are large producing fields in Iran, Iraq, Saudi Arabia, Kuwait and Bahrain.

Iranian crude oils resemble middle-to low-grade Mid-Continent crudes, with a combined gasoline and kerosene content of about 50 percent, with diesel or gas oil accounting for another 25 percent. Asphalt content is 15 to 20 percent. Sulfur content is generally about 1 to 2 percent and the crudes often lie in proximity to large pockets of natural gas with high hydrogen sulfide content.

Iraqi crudes are generally similar to those of Iran. A typical oil is that from the Kirkuk field which is rather paraffinic with a high wax content in the lubricating oil fractions. Asphalt content is about 35 percent.

Saudi crudes are similar to those of Iraq, but with greater variation in sulfur, asphalt and aromatic content. The Burgan field in Kuwait produces oil with about 2 percent sulfur, 20 percent asphalt and combined gasoline, kerosene and diesel content of up to 50 percent. Bahrain produces a similar crude with a 2 percent sulfur content, 30 percent gasoline content, low wax content and low asphalt content.

F-3.4 Europe. The principal European oil production areas are the North Sea, Rumania and the region between the black and Caspian Seas and the area to the north and east. Small quantities of oil are produced in Austria, Germany, Holland, France, Poland and Czechoslovakia, but little is exported.

The Baku fields in Russia supply mixed-base crudes, low in sulfur and high in resins and asphaltic material. Gasoline content is usually less than 10 percent. In some cases, such as the Surakany field, the oil is more paraffinic.

The crude oils of Rumania are varied in character, but uniformly low in sulfur with a high proportion of aromatics.

North Sea crudes are generally paraffinic- or paraffinic-naphthenic-based. Wax content is usually less than 7 percent and sulfur content generally less than 0.5 percent. The crude tends to be heavy, with heavy distillates and residue accounting for 30 to 80 percent of the total.

F-3.5 The Far East. The crude oils of Borneo, Java, Sumatra, Burma and Assam are generally similar. The shallower formations tend to yield heavy, wax-free oils, some of which require no distillation or other treatment before use as fuel oil. the crudes become lighter as depth of production increases, the deepest oils wax bearing with high gasoline and kerosene content. All Far Eastern crudes are moderately low in sulfur and high in aromatics; most are low in asphalt.

F-4 POL MATERIAL SAFETY DATA SHEETS

The physical characteristics of common fuels salvors can expect to encounter and safety-related procedures to protect against probable hazards are listed in **Tables F-8** through **F-14**. The MSDS information, among other things, details the health hazard data, precautions for safe handling and use, explosive hazards and control measures.

Table F-8. Turbine Fuel, Aviation JP-4.

MANUFACTURER	MSDS DATA
CHEVRON ENVIRONMENTAL HEALTH CENTER P.O. BOX 4054 RICHMOND, CA 94804-0054 (415) 233-3737	Serial Number: BDPGR Spec. Number: MIL-T-5624 Grade JP-4 Hazard Char. Code: GL Container: BULK
PHYSICAL/CHEMICAL CHARACTERISTICS	
Appearance and odor: CLEAR, CLOLORLESS TO AMBER LIQUID, KEROSENE ODOR. Boiling point: 57-274°F Melting point: N/K Vapor pressure (MM Hg/70 F): 2.3-2.9PSI Vapor density (Air=1): N/K Specific gravity: 0.75-0.80 Decomposition temp: N/K Evaporation rate & reference: N/K INSOLUBLE IN WATER. Percent Volatiles by Volume: N/K pH: N/K	
FIRE AND EXPLOSION HAZARD DATA	
Flash points: -51°F/-46°C Flash point method: PM Lower Explosive limit: N/K Upper Explosive limit: N/K [Extinguishing Medis] FOAM, CARBON DIOXIDE, DRY CHEMICAL, WATER FOG. WATER MAY BE INEFFECTIVE AND MAY SPREAD FIRE IF IMPROPERLY USED. [Special Firefighting Procedures] USE SELF-CONTAINED BREATHING APPARATUS, ESPECIALLY IN ENCLOSED AREAS. WATER SPRAY MAY BE USED TO COOL FIRE-EXPOSED CONTAINERS AND EQUIPMENT. [Unusual Fire & Explosion Hazards] VAPORS MAY FORM EXPLOSIVE MIXTURE WITH AIR. SATURATED NEWSPAPERS, RAGS, ETC., MAY UNDERGO SPONTANEOUS COMPUSTION.	
REACTIVITY DATA	
STABILITY - YES [Conditions to Avoid (Stability)] HEAT, IGNITION SOURCES. [Materials to Avoid] STRONG OXIDIZERS [Hazardous Decomposition Products] CARBON DIOXIDE, CARBON MONOXIDE. [Hazardous Polymerization Occur] NO. [Conditions to Avoid (Polymerization)] N/R.	

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Table F-8 (continued). Turbine Fuel, Aviation JP-4.

HEALTH HAZARD DATA
LD50-LC50 - MIXTURE: N/R Route of Entry - Inhalation: YES Route of Entry - Skin: NO Route of Entry - Ingestion: YES [Health Hazards - Acute & Chronic] PRODUCT IS A MILD IRRITANT. MOST HAZARDOUS EXPOSURE; EXPOSURE IS TO AIRBORNE MIST OR OTHER ASPIRATION OF LIQUID INTO LUNGS. PROLONGED/REPEATED OVEREXPOSURE MAY CAUSE LIVER OR KIDNEY DAMAGE. Carcinogenity - NTP: YES Carcinogenity - IARC: YES Carcinogenity - OSHA: YES [Explanation of Carcinogenity] API HAS DONE STUDIES INDICATING THAT REPEATED OVER-EXPOSURE MAY CAUSE CANCER IN MICE. PRODUCT CONTAINS BENZENE [Signs of Symptoms of Overexposure] EYE: MILD IRRITATION. SKIN: DRYING,DEFATTING WITH PROLONGED/REPEATED CONTACT. INHALED; HEADACHE, NAUSEA, CONFUSION, DROWSINESS. ASPIRATION OF LIQUID MAY CAUSE CHEMICAL PNEUMONITIS. INGESTED; G/I IRRITATION, NAUSEA, POSSIBLE VOMITING. [Med. Conditions Aggravated/Exposure] NONE EXPECTED. [Emergency and First Aid Procedures] EYE: FLUSH WITH WATER 15 MIN. SKIN: REMOVE CONTAMINATED CLOTHING (LAUNDER BEFORE REUSE) AND THOROUGHLY WASH AREA OF CONTACT WITH SOAP AND WATER. INHALED: REMOVE FROM EXPOSURE. RESUSCIATE OR GIVE OXYGEN AS NEEDED THEN GET MEDICAL ATTENTION. INGESTED: DO NOT INDUCE VOMITING. GET MEDICAL ATTENTION. IF ANY IRRITATION PERSISTS OR IS SEVERE, GET MEDICAL CARE.
PRECAUTIONS FOR SAFE HANDLING AND USE
[Steps if Material is Released or Spilled] ELIMINATE IGNITION SOURCES. USE APPROPRIATE PROTECTIVE EQUIPMENT. CONTAIN LEAK. PREVENT FROM ENTERING SEWER, WATER WAY, ETC. RECOVER AS LIQUID. REPORT SPILL IF APPROPRIATE. [Neutralizing Agent] NONE. [Waste Disposal Method] DISPOSE I/A/W/FEDERAL, STATE, LOCAL REGULATIONS. INCINERATION IS RECOMMENDED FOR DISPOSAL. [Handling and Storing Precautions] STORE IN COOL AREA AWAY FROM OXIDIZERS AND IGNITION SOURCES. DETACHED STORAGE PREFERRED. GROUND CONTAINERS DURING TRANSFER. [Other Precautions] “EMPTY” CONTAINERS MAY CONTAIN RESIDUE AND/OR FUMES WHICH ARE EXPLOSIVE. DO NOT CUT, WELD, ETC. JP-4 HAS AN EXPLOSION HAZARD SIMILAR TO GASOLINE.
CONTROL MEASURES
[Respiratory Protection] NOT EXPECTED TO BE NECESSARY. USE NIOSH/MSHA RESPIRATOR IF PRODUCT IS MISTED OR IF TLV/PEL IS EXCEEDED. [Ventilation] USE LOCAL EXHAUST TO MAINTAIN EXPOSURE BELOW TLV/PEL IF NORMAL ROOM VENTILATION IS INSUFFICIENT. [Protective Glove] RUBBER, PLASTIC, OR OTHER IMPERVIOUS. [Eye Protection] SAFETY GLASSES OR SPLASH GOGGLES. [Other Prolonged Equipment] WEAR PROTECTIVE CLOTHING AS NEEDED TO PREVENT PROLONGED/REPEATED CONTACT. [Supplemental Safety and Health Data] CONFORMS TO MIL-T-5624L. VAPOR PRESSURE (REID) IS GIVEN AS 2.3 TO 2.9 PSI AT 37.8°C. SPECIFIC GRAVITY RANGE: 0.75 TO 0.80. EXTREMELY FLAMMABLE. HARMFUL OR FATAL IF SWALLOWED.

Table F-9. Turbine Fuel, Aviation JP-5.

MANUFACTURER	MSDS DATA
AMOCO OIL CO. 200 EAST RANDOLPH DRIVE CHICAGO, IL (800) 447-8735 (312) 856-3907	Serial Number: BGXMT Spec. Number: MIL-T-5624 Grade JP-5 Hazard Char. Code: F-4 Unit of Issue: GL BULK CONTAINER
PHYSICAL/CHEMICAL CHARACTERISTICS	
Appearance and odor: CLEAR, CLOLORLESS TO AMBER LIQUID, KEROSENE ODOR. Boiling point: N/K Melting point: N/K Vapor pressure (MM Hg/70°F): N/K Vapor density (Air=1): N/K Specific gravity: <1 Decomposition temp: N/K Evaporation rate & reference: N/K NEGLIGABLE SOLUBILITY IN WATER. Percent Volatiles by Volume: N/K pH: N/K	
FIRE AND EXPLOSION HAZARD DATA	
Flash points: -140-150°F/60-66°C Flash point method: NK Lower Explosive limit: N/K Upper Explosive limit: N/K [Extinguishing Medis] FOAM, CARBON DIOXIDE, DRY CHEMICAL, WATER FOG. WATER MAY BE INEFFECTIVE AND MAY SPREAD FIRE IF IMPROPERLY USED. [Special Firefighting Procedures] USE SELF-CONTAINED BREATHING APPARATUS, ESPECIALLY IN ENCLOSED AREAS. WATER SPRAY MAY BE USED TO COOL FIRE-EXPOSED CONTAINERS AND EQUIPMENT. [Unusual Fire & Explosion Hazards] VAPORS MAY FORM EXPLOSIVE MIXTURE WITH AIR. SATURATED NEWSPAPERS, RAGS, ETC., MAY UNDERGO SPONTANEOUS COMPUSTION.	
REACTIVITY DATA	
STABILITY - YES [Conditions to Avoid (Stability)] HEAT, IGNITION SOURCES. [Materials to Avoid] STRONG OXIDIZERS [Hazardous Decomposition Products] CARBON DIOXIDE, CARBON MONOXIDE. [Hazardous Polymerization Occur] NO. [Conditions to Avoid (Polymerization)] N/R.	

Table F-9 (continued). Turbine Fuel, Aviation JP-5.

HEALTH HAZARD DATA
LD50-LC50 - MIXTURE: N/K Route of Entry - Inhalation: YES Route of Entry - Skin: NO Route of Entry - Ingestion: YES [Health Hazards - Acute & Chronic] PRODUCT IS A MILD IRRITANT. MOST HAZARDOUS EXPOSURE; EXPOSURE IS TO AIRBORNE MIST OR OTHER ASPIRATION OF LIQUID INTO LUNGS. PROLONGED/REPEATED OVEREXPOSURE MAY CAUSE LIVER OR KIDNEY DAMAGE. Carcinogenity - NTP: YES Carcinogenity - IARC: YES Carcinogenity - OSHA: YES [Explanation of Carcinogenity] API HAS DONE STUDIES INDICATING THAT REPEATED OVER-EXPOSURE MAY CAUSE CANCER IN MICE. PRODUCT CONTAINS BENZENE [Signs of Symptoms of Overexposure] EYE: MILD IRRITATION. SKIN: DRYING,DEFATTING WITH PROLONGED/REPEATED CONTACT. INHALED; HEADACHE, NAUSEA, CONFUSION, DROWSINESS. ASPIRATION OF LIQUID MAY CAUSE CHEMICAL PNEUMONITIS. INGESTED; G/I IRRITATION, NAUSEA, POSSIBLE VOMITING. [Med. Conditions Aggravated/Exposure] NONE EXPECTED. [Emergency and First Aid Procedures] EYE: FLUSH WITH WATER 15 MIN. SKIN: REMOVE CONTAMINATED CLOTHING (LAUNDER BEFORE REUSE) AND THOROUGHLY WASH AREA OF CONTACT WITH SOAP AND WATER. INHALED: REMOVE FROM EXPOSURE. RESUSCIATE OR GIVE OXYGEN AS NEEDED THEN GET MEDICAL ATTENTION. INGESTED: DO NOT INDUCE VOMITING. GET MEDICAL ATTENTION. IF ANY IRRITATION PERSISTS OR IS SEVERE, GET MEDICAL CARE.
PRECAUTIONS FOR SAFE HANDLING AND USE
[Steps if Material is Released or Spilled] ELIMINATE IGNITION SOURCES. USE APPROPRIATE PROTECTIVE EQUIPMENT. CONTAIN LEAK. PREVENT FROM ENTERING SEWER, WATER WAY, ETC. RECOVER AS LIQUID. REPORT SPILL IF APPROPRIATE. [Neutralizing Agent] NONE. [Waste Disposal Method] DISPOSE I/A/W/FEDERAL, STATE, LOCAL REGULATIONS. INCINERATION IS RECOMMENDED FOR DISPOSAL. [Handling and Storing Precautions] STORE IN COOL AREA AWAY FROM OXIDIZERS AND IGNITION SOURCES. DETACHED STORAGE PREFERRED. GROUND CONTAINERS DURING TRANSFER. [Other Precautions] “EMPTY” CONTAINERS MAY CONTAIN RESIDUE AND/OR FUMES WHICH ARE EXPLOSIVE. DO NOT CUT, WELD, ETC. JP-5 HAS AN EXPLOSION HAZARD SIMILAR TO GASOLINE.
CONTROL MEASURES
[Respiratory Protection] NOT EXPECTED TO BE NECESSARY. USE NIOSH/MSHA RESPIRATOR IF PRODUCT IS MISTED OR IF TLV/PEL IS EXCEEDED. [Ventilation] USE LOCAL EXHAUST TO MAINTAIN EXPOSURE BELOW TLV/PEL IF NORMAL ROOM VENTILATION IS INSUFFICIENT. [Protective Glove] RUBBER, PLASTIC, OR OTHER IMPERVIOUS. [Eye Protection] SAFETY GLASSES OR SPLASH GOGGLES. [Other Prolonged Equipment] WEAR PROTECTIVE CLOTHING AS NEEDED TO PREVENT PROLONGED/REPEATED CONTACT.

Table F-10. Shell Turbine Fuel, JP-8.

MANUFACTURER	MSDS DATA
SHELL OIL CO. 1 SHELL PLAZA P.O. BOX 2463 HOUSTON, TX 77001 (713) 473-9461 (713) 241-4819	Serial Number: BGXRR Spec. Number: MIL-T-83133 Grade JP-8 Hazard Char. Code: F4 Unit of Issue: GL BULK CONTAINER NCR/State License Number: N/R Net Prollent Weight-Ammo: N/R

PHYSICAL/CHEMICAL CHARACTERISTICS

Appearance and odor: CLEAR, CLOLORLESS TO AMBER LIQUID, KEROSENE ODOR.
Boiling point: 320°F/160°C
Melting point: -58F/-50_C
Vapor pressure (MM Hg/70°F):
Vapor density (Air=1): 1
Specific gravity: 0.81
Decomposition temp: N/K
Evaporation rate & reference: N/K
NEGLIGABLE SOLUBILITY IN WATER.
Percent Volatiles by Volume: N/K
pH: N/K

FIRE AND EXPLOSION HAZARD DATA

Flash points:100°F
Flash point method: TCC
Lower Explosive limit: 0.7
Upper Explosive limit: 5.0
[Extinguishing Medis]
FOAM, CARBON DIOXIDE, DRY CHEMICAL, WATER FOG. WATER MAY BE INEFFECTIVE AND MAY SPREAD FIRE IF IMPROPERLY USED.
[Special Firefighting Procedures]
USE SELF-CONTAINED BREATHING APPARATUS, ESPECIALLY IN ENCLOSED AREAS. WATER SPRAY MAY BE USED TO COOL FIRE-EXPOSED CONTAINERS AND EQUIPMENT.
[Unusual Fire & Explosion Hazards]
WHEN HEATED SUFFICIENTLY, VAPORS MAY FORM EXPLOSIVE MIXTURE WITH AIR. SATURATED NEWSPAPERS, RAGS, ETC., MAY UNDERGO SPONTANEOUS COMPUSTION.

REACTIVITY DATA

STABILITY - YES
[Conditions to Avoid (Stability)]
HEAT, IGNITION SOURCES.
[Materials to Avoid]
STRONG OXIDIZERS
[Hazardous Decomposition Products]
CARBON .
[Hazardous Polymerization Occur]
NO.
[Conditions to Avoid (Polymerization)]
N/R.

Table F-10 (continued). ShellTurbine Fuel, JP-8.

HEALTH HAZARD DATA
LD50-LC50 - MIXTURE: N/K Route of Entry - Inhalation: YES Route of Entry - Skin: NO Route of Entry - Ingestion: YES [Health Hazards - Acute & Chronic] PRODUCT IS A MILD IRRITANT. MOST HAZARDOUS EXPOSURE; EXPOSURE IS TO AIRBORNE MIST OR OTHER ASPIRATION OF LIQUID INTO LUNGS. PROLONGED/REPEATED OVEREXPOSURE MAY CAUSE LIVER OR KIDNEY DAMAGE. Carcinogenity - NTP: NO Carcinogenity - IARC: NO Carcinogenity - OSHA: NO [Explanation of Carcinogenity] API HAS DONE STUDIES INDICATING THAT REPEATED OVER-EXPOSURE MAY CAUSE CANCER IN MICE. [Signs of Symptoms of Overexposure] EYE: MILD IRRITATION. SKIN: DRYING,DEFATTING WITH PROLONGED/REPEATED CONTACT. INHALED; HEADACHE, NAUSEA, CONFUSION, DROWSINESS. ASPIRATION OF LIQUID MAY CAUSE CHEMICAL PNEUMONITIS. INGESTED; G/I IRRITATION, NAUSEA, POSSIBLE VOMITING. [Med. Conditions Aggravated/Exposure] NONE EXPECTED. [Emergency and First Aid Procedures] EYE: FLUSH WITH WATER 15 MIN. SKIN: REMOVE CONTAMINATED CLOTHING (LAUNDER BEFORE REUSE) AND THOROUGHLY WASH AREA OF CONTACT WITH SOAP AND WATER. INHALED: REMOVE FROM EXPOSURE. RESUSCIATE OR GIVE OXYGEN AS NEEDED THEN GET MEDICAL ATTENTION. INGESTED: DO NOT INDUCE VOMITING. GET MEDICAL ATTENTION. IF ANY IRRITATION PERSISTS OR IS SEVERE, GET MEDICAL CARE.
PRECAUTIONS FOR SAFE HANDLING AND USE
[Steps if Material is Released or Spilled] ELIMINATE IGNITION SOURCES. USE APPROPRIATE PROTECTIVE EQUIPMENT. CONTAIN LEAK. PREVENT FROM ENTERING SEWER, WATER WAY, ETC. RECOVER AS LIQUID. REPORT SPILL IF APPROPRIATE. [Neutralizing Agent] NONE. [Waste Disposal Method] DISPOSE I/A/W/FEDERAL, STATE, LOCAL REGULATIONS. INCINERATION IS RECOMMENDED FOR DISPOSAL. [Handling and Storing Precautions] STORE IN COOL AREA AWAY FROM OXIDIZERS AND IGNITION SOURCES. DETACHED STORAGE PREFERRED. GROUND CONTAINERS DURING TRANSFER. [Other Precautions] “EMPTY” CONTAINERS MAY CONTAIN RESIDUE AND/OR FUMES WHICH ARE EXPLOSIVE. DO NOT CUT, WELD, ETC. JP-8 HAS AN EXPLOSION HAZARD SIMILAR TO GASOLINE.
CONTROL MEASURES
[Respiratory Protection] NOT EXPECTED TO BE NECESSARY. USE NIOSH/MSHA RESPIRATOR IF PRODUCT IS MISTED OR IF TLV/PEL IS EXCEEDED. [Ventilation] USE LOCAL EXHAUST TO MAINTAIN EXPOSURE BELOW TLV/PEL IF NORMAL ROOM VENTILATION IS INSUFFICIENT. [Protective Glove] RUBBER, PLASTIC, OR OTHER IMPERVIOUS. [Eye Protection] SAFETY GLASSES OR SPLASH GOGGLES. [Other Prolonged Equipment] WEAR PROTECTIVE CLOTHING AS NEEDED TO PREVENT PROLONGED/REPEATED CONTACT. [Supplemental Safety and Health Data] MSDS NO 52,309 SHELL CODE 23540.

Table F-11. Diesel Fuels Arctic, DFA.

MANUFACTURER	MSDS DATA
MOBILE OIL CORP. 3225 GALLOWS RD. FAIRFAX, VA 22037 (212) 833-4411 EMERGENCY (703) 849-3265 INFO.	Serial Number: BGXGP Spec. Number: W-F-800 Grade GR DF-A Char Code: F4 Unit of Issue: DR 55 GAL DRUM CONTAINER NCR/State License Number: N/R
PHYSICAL/CHEMICAL CHARACTERISTICS	
Appearance and odor: CLEAR, CLOLORLESS TO AMBER LIQUID, KEROSENE ODOR. Boiling point: 300°F -550°F Melting point: N/K Vapor pressure (MM Hg/70°F): 0.5MM Vapor density (Air=1): N/K Specific gravity: 0.82-0.87 Decomposition temp: N/K Evaporation rate & reference: N/K NEGLIGIBLE SOLUBILITY IN WATER. Percent Volatiles by Volume: N/K pH: N/K	
FIRE AND EXPLOSION HAZARD DATA	
Flash points:100°F Flash point method: D-93 Lower Explosive limit: N/K Upper Explosive limit: N/K [Extinguishing Medis] FOAM, CARBON DIOXIDE, DRY CHEMICAL, WATER FOG. WATER MAY BE INEFFECTIVE AND MAY SPREAD FIRE IF IMPROPERLY USED. [Special Firefighting Procedures] USE SELF-CONTAINED BREATHING APPARATUS, ESPECIALLY IN ENCLOSED AREAS. WATER SPRAY MAY BE USED TO COOL FIRE-EXPOSED CONTAINERS AND EQUIPMENT. [Unusual Fire & Explosion Hazards] WHEN HEATED SUFFICIENTLY, VAPORS MAY FORM EXPLOSIVE MIXTURE WITH AIR. SATURATED NEWSPAPERS, RAGS, ETC., MAY UNDERGO SPONTANEOUS COMPUSTION.	
REACTIVITY DATA	
STABILITY - YES [Conditions to Avoid (Stability)] HEAT, IGNITION SOURCES. [Materials to Avoid] STRONG OXIDIZERS [Hazardous Decomposition Products] CARBON DIOXIDE, CARBON MONOXIDE. [Hazardous Polymerization Occur] NO. [Conditions to Avoid (Polymerization)] N/R.	

Table F-11 (continued). Diesel Fuels Arctic, DFA.

HEALTH HAZARD DATA
LD50-LC50 - MIXTURE: N/K Route of Entry - Inhalation: YES Route of Entry - Skin: NO Route of Entry - Ingestion: YES [Health Hazards - Acute & Chronic] PRODUCT IS A MILD IRRITANT. MOST HAZARDOUS EXPOSURE; EXPOSURE IS TO AIRBORNE MIST OR OTHER ASPIRATION OF LIQUID INTO LUNGS. PROLONGED/REPEATED OVEREXPOSURE MAY CAUSE LIVER OR KIDNEY DAMAGE. Carcinogenity - NTP: NO Carcinogenity - IARC: NO Carcinogenity - OSHA: NO [Explanation of Carcinogenity] API HAS DONE STUDIES INDICATING THAT REPEATED OVER-EXPOSURE MAY CAUSE CANCER IN MICE. [Signs of Symptoms of Overexposure] EYE: MILD IRRITATION. SKIN: DRYING,DEFATTING WITH PROLONGED/REPEATED CONTACT. INHALED; HEADACHE, NAUSEA, CONFUSION, DROWSINESS. ASPIRATION OF LIQUID MAY CAUSE CHEMICAL PNEUMONITIS. INGESTED; G/I IRRITATION, NAUSEA, POSSIBLE VOMITING. [Med. Conditions Aggravated/Exposure] NONE EXPECTED. [Emergency and First Aid Procedures] EYE: FLUSH WITH WATER 15 MIN. SKIN: REMOVE CONTAMINATED CLOTHING (LAUNDER BEFORE REUSE) AND THOROUGHLY WASH AREA OF CONTACT WITH SOAP AND WATER. INHALED: REMOVE FROM EXPOSURE. RESUSCIATE OR GIVE OXYGEN AS NEEDED THEN GET MEDICAL ATTENTION. INGESTED: DO NOT INDUCE VOMITING. GET MEDICAL ATTENTION. IF ANY IRRITATION PERSISTS OR IS SEVERE, GET MEDICAL CARE.
PRECAUTIONS FOR SAFE HANDLING AND USE
[Steps if Material is Released or Spilled] ELIMINATE IGNITION SOURCES. USE APPROPRIATE PROTECTIVE EQUIPMENT. CONTAIN LEAK. PREVENT FROM ENTERING SEWER, WATER WAY, ETC. RECOVER AS LIQUID. REPORT SPILL IF APPROPRIATE. [Neutralizing Agent] NONE. [Waste Disposal Method] DISPOSE I/A/W/FEDERAL, STATE, LOCAL REGULATIONS. INCINERATION IS RECOMMENDED FOR DISPOSAL. [Handling and Storing Precautions] STORE IN COOL AREA AWAY FROM OXIDIZERS AND IGNITION SOURCES. DETACHED STORAGE PREFERRED. GROUND CONTAINERS DURING TRANSFER. [Other Precautions] “EMPTY” CONTAINERS MAY CONTAIN RESIDUE AND/OR FUMES WHICH ARE EXPLOSIVE. DO NOT CUT, WELD, ETC. DFA HAS AND EXPLOSION HAZARD SIMILAR TO GASOLINE.
CONTROL MEASURES
[Respiratory Protection] NOT EXPECTED TO BE NECESSARY. USE NIOSH/MSHA RESPIRATOR IF PRODUCT IS MISTED OR IF TLV/PEL IS EXCEEDED. [Ventilation] USE LOCAL EXHAUST TO MAINTAIN EXPOSURE BELOW TLV/PEL IF NORMAL ROOM VENTILATION IS INSUFFICIENT. [Protective Glove] RUBBER, PLASTIC, OR OTHER IMPERVIOUS. [Eye Protection] SAFETY GLASSES OR SPLASH GOGGLES. [Other Prolonged Equipment] WEAR PROTECTIVE CLOTHING AS NEEDED TO PREVENT PROLONGED/REPEATED CONTACT.

Table F-12. Gasoline, Automotive, Regular, MOGAS Leaded.

MANUFACTURER	MSDS DATA
AMOCO OIL CO. 200 EAST RANDOLPH DRIVE CHICAGO, IL 60601 (800) 447-8735 EMERGENCY (312) 856-3907 INFO.	Serial Number: BGWPV Spec. Number: W-G-001690 GRADE GR REGULAR, ALL CLAS Char. Code: F2 NCR/State License Number: N/R
PHYSICAL/CHEMICAL CHARACTERISTICS	
Appearance and odor: CLEAR, CLOLORLESS TO AMBER LIQUID, KEROSENE ODOR. Boiling point: 80-430°F Melting point: N/K Vapor pressure (MM Hg/70°F): N/K Vapor density (Air=1): 3.5 (AIR) Specific gravity: 0.72-0.76 Decomposition temp: N/K Evaporation rate & reference: N/K NEGLIGABLE SOLUBILITY IN WATER. Percent Volatiles by Volume: 100 pH: N/K Auto-ignition Temperature: 495°F	
FIRE AND EXPLOSION HAZARD DATA	
Flash point: -45°F Lower Explosive limit: 1.3 Upper Explosive limit: 7.6 [Extinguishing Medis] DRY CHEMICAL, CARBON DIOXIDE, FOAM, WATER FOG WATER MAY BE INEFFECTIVE AS PRODUCT MAY SPREAD FIRE AND WILL FLOAT. [Special Firefighting Procedures] USE SELF-CONTAINED BREATHING APPARATUS, ESPECIALLY IN ENCLOSED AREAS. WATER SPRAY MAY BE USED TO COOL FIRE-EXPOSED CONTAINERS AND EQUIPMENT. [Unusual Fire & Explosion Hazards] VAPORS MAY FORM EXPLOSIVE MIXTURE WITH AIR. SATURATED NEWSPAPERS, RAGS, ETC., MAY UNDERGO SPONTANEOUS COMPUSTION.	
REACTIVITY DATA	
STABILITY - YES [Conditions to Avoid (Stability)] HEAT, SPARKS AND OTHER IGNITION SOURCES, VAPORS ACCUMULATE. [Materials to Avoid] STRONG OXIDIZERS [Hazardous Decomposition Products] CARBON DIOXIDE, CARBON MONOXIDE. [Hazardous Polymerization Occur] NO. [Conditions to Avoid (Polymerization)] N/R.	

Table F-12 (continued). Gasoline, Automotive, Regular, MOGAS Leaded.

HEALTH HAZARD DATA
LD50-LC50 - MIXTURE: ORAL RAT LD50 18,800 MG/KG Route of Entry - Inhalation: YES Route of Entry - Skin: NO Route of Entry - Ingestion: YES [Health Hazards - Acute & Chronic] PRODUCT IS A MILD IRRITANT. MOST HAZARDOUS EXPOSURE; EXPOSURE IS TO AIRBORNE MIST OR OTHER ASPIRATION OF LIQUID INTO LUNGS. PROLONGED/REPEATED OVEREXPOSURE MAY CAUSE LIVER OR KIDNEY DAMAGE. Carcinogenity - NTP: YES Carcinogenity - IARC: YES Carcinogenity - OSHA: YES [Explanation of Carcinogenity] API HAS DONE STUDIES INDICATING THAT REPEATED OVER-EXPOSURE MAY CAUSE CANCER IN MICE. PRODUCT CONTAINS BENZENE [Signs of Symptoms of Overexposure] EYE/SKIN CONTACT: TRANSITORY EYE IRRITATION. HIHALED: RESPIRATORY IRRITATION, CENTRAL NERVOUS SYSTEM DEPRESSION INCLUDING, EUPHORIA, HEADACHE, DIZZINESS, DROWSINESS, FATIGUE, TREMORS, CONVULSIONS, NAUSEA, VOMITING, DIARRHEA, LOSS OF CONSCIOUSNESS, AND FINALLY DEATH. INGESTED: G/I IRRITATION, PLUS SYMPTOMS SIMILAR TO THOSE UNDER "INHALES". [Med. Conditions Aggravated/Exposure] PRE-EXISTING EYE, SKIN CONDITIONS OR IMPAIRED LIVER, KIDNEY FUNCTION MAY BE AGGRAVATED BY THIS PRODUCT. [Emergency and First Aid Procedures] EYE: FLUSH WITH WATER 15 MIN. SKIN: WASH WITH SOAP AND WATER. INHALED: REMOVE TO FRESH AIR. RESUSCIATE OR GIVE OXYGEN AS NEEDED THEN GET MEDICAL ATTENTION. INGESTED: DO NOT INDUCE VOMITING. GET MEDICAL ATTENTION. IF VOMITING OCCURS, MINIMIZE ASPIRATION-HAZARD.
PRECAUTIONS FOR SAFE HANDLING AND USE
[Steps if Material is Released or Spilled] ELIMINATE IGNITION SOURCES. USE APPROPRIATE PROTECTIVE EQUIPMENT. STOP LEAK AND CONTAIN SPILL. DIKE AS NEEDED TO KEEP SPILL FROMENTERING SEWER, WATER WAY, ETC. WATER FOG MAY BE USED TO REDUCE VAPORS AND PERSONAL HAZARD. REPORT SPILL. [Neutralizing Agent] NONE. [Waste Disposal Method] DISPOSE I/A/W/FEDERAL, STATE, LOCAL REGULATIONS. PRODUCT QUALIFIES AS IGNITABLE WASTE AND CANNOT BE LANDFILLED. IF RECOVERY OR RECYCLE ARE UNACCEPTABLE, INCINERATION IS ACCEPTABLE FOR DISPOSAL. [Handling and Storing Precautions] STORE IN COOL, DRY, ISOLATED, WELL VENTILATED AREA. KEEP IGNITION SOURCES AWAY. GROUND CONTAINERS TO PREVENT STATIC DISCHARGE DURING TRANSFERS. [Other Precautions] FIRE EXPLOSION ARE THE ACUTE HAZARDS OF THIS PRODUCT. TAKE EXTRAORDINARY STEPS TO PREVENT THEM.
CONTROL MEASURES
[Respiratory Protection] NOT EXPECTED TO BE NECESSARY. USE NIOSH/MSHA RESPIRATOR IF PRODUCT IS MISTED OR IF TLV/PEL IS EXCEEDED. [Ventilation] USE LOCAL EXHAUST TO MAINTAIN EXPOSURE BELOW TLV/PEL IF NORMAL ROOM VENTILATION IS INSUFFICIENT. [Protective Glove] RUBBER, PLASTIC, OR OTHER IMPERVIOUS. [Eye Protection] SAFETY GLASSES OR SPLASH GOGGLES. [Other Prolonged Equipment] SAFETY SHOWER/EYE WASH. WORK CLOTHING AS NEEDED TO PROTECT FROM PROLONGED/REPEATED CONTACT.. [Supplemental Safety and Health Data] MSDS NO 02003993.

Table F-13. Marine Diesel Fuel DFM, F-76

MANUFACTURER	MSDS DATA
TEXACO INC. P.O. BOX 509 BEACON, NY 12508-0509	Serial Number: BGXCQ Spec. Number: MIL-F-16884 Char. Code: F4 Issue: GL BULK CONTAINER NRC/State License Number: N/R
PHYSICAL/CHEMICAL CHARACTERISTICS	
Appearance and odor: CLEAR, CLOLORLESS TO AMBER LIQUID, KEROSENE ODOR. Boiling point: 640°F/338°C Melting point: N/K Vapor pressure (MM Hg/70°F): LOW Vapor density (Air=1): N/K Specific gravity: 0.844 Decomposition temp: N/K Evaporation rate & reference: N/K Solubility in Water: N/K Percent Volatiles by Volume: N/K pH: N/K	
FIRE AND EXPLOSION HAZARD DATA	
Flash points: 160°F/71°C Flash point method: PM Lower Explosive limit: N/K Upper Explosive limit: N/K [Extinguishing Medis] DRY CHEMICAL, WATER FOG. WATER MAY BE INEFFECTIVE AND MAY SPREAD FIRE IF IMPROPERLY USED. [Special Firefighting Procedures] USE SELF-CONTAINED BREATHING APPARATUS, ESPECIALLY IN ENCLOSED AREAS. WATER SPRAY MAY BE USED TO COOL FIRE-EXPOSED CONTAINERS AND EQUIPMENT. [Unusual Fire & Explosion Hazards] WHEN HEATED SUFFICIENTLY, VAPORS MAY FORM EXPLOSIVE MIXTURE WITH AIR. SATURATED NEWSPAPERS, RAGS, ETC., MAY UNDERGO SPONTANEOUS COMPUSTION.	
REACTIVITY DATA	
STABILITY - YES [Conditions to Avoid (Stability)] HEAT, IGNITION SOURCES. [Materials to Avoid] STRONG OXIDIZERS [Hazardous Decomposition Products] CARBON DIOXIDE, CARBON MONOXIDE. [Hazardous Polymerization Occur] NO. [Conditions to Avoid (Polymerization)] N/R.	

Table F-13 (continued). Marine Diesel Fuel DFM, F-76.

HEALTH HAZARD DATA
LD50-LC50 - MIXTURE: N/R Route of Entry - Inhalation: YES Route of Entry - Skin: NO Route of Entry - Ingestion: YES [Health Hazards - Acute & Chronic] PRODUCT IS A MILD IRRITANT. MOST HAZARDOUS EXPOSURE; EXPOSURE IS TO AIRBORNE MIST OR OTHER ASPIRATION OF LIQUID INTO LUNGS. PROLONGED/REPEATED OVEREXPOSURE MAY CAUSE LIVER OR KIDNEY DAMAGE. Carcinogenity - NTP: NO Carcinogenity - IARC: NO Carcinogenity - OSHA: NO [Explanation of Carcinogenity] API HAS DONE STUDIES INDICATING THAT REPEATED OVER-EXPOSURE MAY CAUSE CANCER IN MICE. PRODUCT CONTAINS BENZENE [Signs of Symptoms of Overexposure] EYE: MILD IRRITATION. SKIN: DRYING,DEFATTING WITH PROLONGED/REPEATED CONTACT. INHALED; HEADACHE, NAUSEA, CONFUSION, DROWSINESS. ASPIRATION OF LIQUID MAY CAUSE CHEMICAL PNEUMONITIS. INGESTED; G/I IRRITATION, NAUSEA, POSSIBLE VOMITING. [Med. Conditions Aggravated/Exposure] NONE EXPECTED. [Emergency and First Aid Procedures] EYE: FLUSH WITH WATER 15 MIN. SKIN: REMOVE CONTAMINATED CLOTHING (LAUNDER BEFORE REUSE) AND THOROUGHLY WASH AREA OF CONTACT WITH SOAP AND WATER. INHALED: REMOVE FROM EXPOSURE. RESUSCIATE OR GIVE OXYGEN AS NEEDED THEN GET MEDICAL ATTENTION. INGESTED: DO NOT INDUCE VOMITING. GET MEDICAL ATTENTION. IF ANY IRRITATION PERSISTS OR IS SEVERE, GET MEDICAL CARE.
PRECAUTIONS FOR SAFE HANDLING AND USE
[Steps if Material is Released or Spilled] ELIMINATE IGNITION SOURCES. USE APPROPRIATE PROTECTIVE EQUIPMENT. CONTAIN LEAK. PREVENT FROM ENTERING SEWER, WATER WAY, ETC. RECOVER AS LIQUID. REPORT SPILL IF APPROPRIATE. [Neutralizing Agent] NONE. [Waste Disposal Method] DISPOSE I/A/W/FEDERAL, STATE, LOCAL REGULATIONS. INCINERATION IS RECOMMENDED FOR DISPOSAL. [Handling and Storing Precautions] STORE IN COOL AREA AWAY FROM OXIDIZERS AND IGNITION SOURCES. DETACHED STORAGE PREFERRED. GROUND CONTAINERS DURING TRANSFER. [Other Precautions] “EMPTY” CONTAINERS MAY CONTAIN RESIDUE AND/OR FUMES WHICH ARE EXPLOSIVE. DO NOT CUT, WELD, ETC.
CONTROL MEASURES
[Respiratory Protection] NOT EXPECTED TO BE NECESSARY. USE NIOSH/MSHA RESPIRATOR IF PRODUCT IS MISTED OR IF TLV/PEL IS EXCEEDED. [Ventilation] USE LOCAL EXHAUST TO MAINTAIN EXPOSURE BELOW TLV/PEL IF NORMAL ROOM VENTILATION IS INSUFFICIENT. [Protective Glove] RUBBER, PLASTIC, OR OTHER IMPERVIOUS. [Eye Protection] SAFETY GLASSES OR SPLASH GOGGLES. [Work Hygienic Practices] USE GOOD INDUSTRIAL HYGIENE PRACTICE. AVOID UNNECESSARY CONTACT. [Supplemental Safety and Health Data] PRODUCT CODE 00813.

Table F-14. Residual Fuel Oil, Bunker Fuel Oil, Bunker C.

MANUFACTURER	MSDS DATA
COASTAL EAGLE POINT OIL 9-GREENWAY PLAZA HOUSTON, TX 77046 (713) 877-1400 EMERGENCY (713) 877-1400 INFO.	Serial Number: BGWDV Spec. Number: ASTM-D-396 GADE 6 CLAS Char. Code: F4 Net Unit Weight: BULK NCR/State License Number: N/R
PHYSICAL/CHEMICAL CHARACTERISTICS	
Appearance and odor: BLACK LIQUID TO HEAVY PASTE; MILD PETROLEUM ODOR. Boiling point: 500°F/260°C Melting point: -20°F Vapor pressure (MM Hg/70 F): 0.2 Vapor density (Air=1): N/K Specific gravity: 0.97 Evaporation rate & reference: <0.01 (ETHYL ETHER=1) NEGLIGABLE SOLUBILITY IN WATER Percent Volatiles by Volume: 100 Viscosity: <300 SFS pH: N/K Autoignition Temperature: 765°F	
FIRE AND EXPLOSION HAZARD DATA	
Flash point: >140°F/60°C Flash point method: PMCC Upper Explosive limit: 20.1 Lower Explosive limit: 3.9 [Extinguishing Medis] DRY CHEMICAL, CARBON DIOXIDE, FOAM, WATER SPRAY. [Special Firefighting Procedures] USE SELF-CONTAINED BREATHING APPARATUS, ESPECIALLY IN ENCLOSED AREAS. [Unusual Fire & Explosion Hazards] AVOID EXTREME HEAT. FLOWING LIQUID MAY CATCH FIRE.	
REACTIVITY DATA	
STABILITY - YES [Conditions to Avoid (Stability)] HEAT, SPARK FLAME. [Materials to Avoid] STRONG OXIDIZERS [Hazardous Decomposition Products] CARBON DIOXIDE, CARBON MONOXIDE, SULFUR DIOXIDE AND HYDROCARBON. [Hazardous Polymerization Occur] NO. [Conditions to Avoid (Polymerization)] N/R.	

Table F-14 (continued). Residual Fuel Oil, Bunker Fuel Oil, Bunker C.

HEALTH HAZARD DATA
LD50-LC50 - MIXTURE: N/K Route of Entry - Inhalation: YES Route of Entry - Skin: YES Route of Entry - Ingestion: YES [Health Hazards - Acute & Chronic] ACUTE: IRRITATING TO EYES, SKIN, MUCUOS MEMBRANES AND RESPIRATORY TRACT, CNS EFFECTS. DUE TO INHALATION: HEADACHE, DIZZINESS, NAUSEA, VOMITING, LOSS OF COORDINATION. HARMFUL OR FATAL IS INGESTED. CHRONIC: DRYING OF SKIN, DERMATITIS. Carcinogenity - NTP: N/K Carcinogenity - IARC: N/K Carcinogenity - OSHA: N/K [Explanation of Carcinogenity] SHOWS NO DATA. [Signs of Symptoms of Overexposure] SEE HEALTH HAZARDS DATA. [Med. Conditions Aggravated/Exposure] PRE-EXISTING CONDITIONS MAY WORSEN. [Emergency and First Aid Procedures] EYE: FLUSH WITH PLENTY OF WATER FOR 15-20 MIN.; CALL A PHYSICIAN. SKIN: WASH WITH SOAP AND WATER. INHALATION: REMOVE TO FRESH AIR, CALL A PHYSICIAN. INGESTION: DO NOT INDUCE VOMITING, CALL A PHYSICIAN IMMEDIATELY.
PRECAUTIONS FOR SAFE HANDLING AND USE
[Steps if Material is Released or Spilled] USE PROPER PERSONAL PROTECTION; REMOVE ALL IGNITION SOURCES. CONTAIN FREE LIQUID IF POSSIBLE; USE SUITABLE INERT ABSORBENT MATERIAL AND RECOVER FOR PROPER DISPOSAL. [Neutralizing Agent] N/R. [Waste Disposal Method] DISPOSAL OF OR INCINERATE COLLECTED MATERIAL IN ACCORDANCE WITH LOCAL, STATE, AND FEDERAL REGULATIONS. IF RECOVERY OR RECYCLE ARE UNACCEPTABLE,. [Handling and Storing Precautions] STORE IN COOL, DRY, WELL VENTILATED AREA. KEEP AWAY FROM HEAT, OPEN FLAMES; DO NOT USE CONTAMINATED CLOTHES.
CONTROL MEASURES
[Respiratory Protection] USE NIOSH/MSHA APPROVED RESPIRATOR FOR ORGANIC VAPOR/MIST IF ABOVE PEL/TLV OR SCBA IN AN ENCLOSED AREA. [Ventilation] LOCAL/GENERAL TO MAINTAIN PEL/TLV.. [Protective Glove] IMPERVIOUS. [Eye Protection] SAFETY GLASSES/GOGGLES. [Other Prolonged Equipment] IMPERVIOUS APRON; EYE-WASH FACILITIES. [Work Hygienic Practices] AVOID CONTACT WITH EYES AND SKIN; DO NOT BREATHE VAPORS/MIST; WASH THOROUGHLY AFTER EACH USE..

APPENDIX G

HEALTH AND SAFETY STANDARDS FOR OIL SPILL RESPONSE SITES

G-1 INTRODUCTION

The National Contingency Plan, in 40 *CFR* 300.135, states that *The OSC/RPM is responsible for addressing worker health and safety concerns at a response scene*. Crude petroleum and petroleum products are defined as hazardous materials by the transportation section of the *Code of Federal Regulations* (49 *CFR);* oil spill sites are therefore "uncontrolled hazardous waste sites," and safety precautions for hazardous material/waste operations apply to spill cleanup operations. Additional hazards may be presented by spill response chemicals, solvents and detergents used to clean up response equipment, industrial machinery, vessel operations, vehicle traffic and the outdoor environment.

The inherent requirement to provide for worker safety is formalized in 40 *CFR* 300.150 which requires that oil spill response actions comply with the OSHA provisions for the health and safety of workers involved in hazardous waste operations and emergency response as contained in 29 *CFR* 1910.120. 40 *CFR* 300.150 also mandates compliance with all applicable state and Federal workplace safety and health regulations, including but not limited to the OSHA construction standards (29 *CFR* 1926) and general industry standards (29 *CFR* 1910). These requirements apply to government employees, contractors and volunteers. The following paragraphs consist of information extracted from the most pertinent portions of 29 *CFR* 1910.120. Spill response managers should consult the latest edition of the *CFR* to ensure complete compliance with all legal requirements.

G-2 HAZARDOUS WASTE (OIL SPILL) SITE OPERATIONS HEALTH AND SAFETY

Employers of spill response workers are required to develop and implement a written safety and health program. The program shall be designed to identify, evaluate and control safety and health hazards and shall include the following elements:

- An organizational structure
- A comprehensive work plan
- A site-specific safety and health plan
- A safety and health training program
- A medical surveillance program
- The employer's standard operating procedures for safety and health

- Any necessary interface between general program and site-specific activities

Employers shall develop and implement a program as part of the safety and health program to inform employees, contractors and subcontractors of the nature, level and degree of exposure likely as a result of participation in hazardous waste operations at the site.

G-2.1 Organizational Structure. The organizational structure part of the program shall establish the chain of command and specify the responsibilities of supervisors and employees, defining, as a minimum, the following elements:

- A general supervisor with responsibility and authority to direct all hazardous waste operations

- A site safety supervisor with responsibility and authority to develop and implement the site safety and health plan and verify compliance

- All other personnel required for hazardous waste site operations and emergency response and their functions and responsibilities

- Lines of authority, responsibility and communication

The organizational structure shall be reviewed and modified as necessary to reflect the current status of waste site operations.

G-2.2 Comprehensive Work Plan. The comprehensive work program shall:

- Define work tasks and objectives

- Identify methods for accomplishing defined tasks and objectives

- Identify required resources and logistics

- Establish personnel requirements

- Provide for the implementation of the required safety and health training

- Provide for the implementation of the medical surveillance program

- Provide for the implementation of the required informational programs

G-2.3 Site-specific Safety and Health Plan. The site-specific safety and health plan shall be kept on site. The plan shall address the safety and health hazards of each phase of site operation and protective measure, including, at a minimum, the following elements:

- A safety and health risk hazard analysis for each site task and operation found in the comprehensive work plan

- Employee training assignments under the required safety and health training plan
- Personal protective equipment required for each site task
- Medical surveillance requirements
- Required frequency and types of air monitoring, personnel monitoring and environmental sampling
- Site control measures
- Confined space entry procedures
- Decontamination procedures
- An emergency response plan
- A spill containment program for accidental spills of collected oil, fuel, industrial chemicals or other hazardous materials employed or collected at the site

G-2.3.1 Pre-Entry Briefings. The safety and health plan shall provide for pre-entry briefings to be held prior to initiating any site activity and at such other times as necessary to ensure that employees are made aware of the site safety and health plan and conditions at the site.

G-2.3.2 Site Evaluation and Hazard Identification. Hazardous waste sites shall be evaluated to identify specific site hazards and determine appropriate protective measures. A preliminary evaluation shall be performed prior to site entry to aid in the selection of protection measures for the evaluation team. Immediately after initial site entry, a more detailed evaluation will be conducted to identify site hazards and aid in the selection of engineering controls and personal protective equipment for site workers.

Suspected conditions that may pose inhalation or skin absorption hazards shall be identified during the preliminary survey and evaluated during the detailed survey. Examples of such conditions include, but are not limited to, potentially explosive or flammable conditions, visible vapor clouds and confined spaces. To the extent available, the following information shall be obtained prior to permitting site entry by employees:

- Location and approximate size of the site
- Description of the response activity or job tasks
- Duration of planned employee activity
- Site topography and accessibility
- Safety and health hazards expected at the site

- Hazardous substances and health hazards involved or expected at the site and their chemical and physical properties

- Pathways for hazardous substance dispersion

- Present status and capabilities of emergency response teams that would provide assistance to the site

G-2.3.3 Monitoring. Air monitoring shall be conducted when site information is not sufficient to reasonably eliminate the possible presence of combustible gases and airborne toxins or irritants in dangerous concentrations.

G-2.3.4 Employee Notification. Any information concerning the chemical, physical or toxicological properties of substance known or suspected to be at the site that is known to the employer and relevant to employee duties shall be made available to employees before they start work at the site.

G-2.3.5 Site Control. Appropriate site control measures shall be implemented to control employee exposure to hazardous substances and conditions. Elements of a site control program include a site map, use of a “buddy” system in high hazard areas, effective site communications, standard operating procedures for safe work practices and identification of the nearest medical assistance.

G-2.4 Safety and Health Training. All employees working on site (such as, but not limited to general laborers, equipment operators, drivers) who may be exposed to hazardous substances or health or safety hazards and their supervisors shall be trained to recognize and deal with site hazards before they are permitted to engage in or supervise hazardous waste operations. In addition to safety and health training, employees shall be trained and qualified to the level required by their job function and responsibility before participating in or supervising field activities. Training shall thoroughly cover the following topics:

- Names of personnel and alternates responsible for site safety and health

- Safety, health and other hazards on site

- Use of personal protective equipment

- Work practices by which employees can minimize risks from hazards

- Safe use of engineering controls and equipment at the site

- Medical surveillance requirements, including recognition of symptoms and signs which might indicate overexposure to hazards

- The decontamination procedures, confined space entry procedures, emergency response plan and spill containment program from the site specific safety and health plan

G-2.4.1 Training Requirements. General site laborers, equipment operators, supervisors and other personnel engaged in hazardous substance removal or other activities that routinely expose or potentially expose them to hazardous substances and health hazards shall receive a minimum of 40 hours of instruction off the site, followed by a minimum of three days field experience under the supervision of a trained, experienced supervisor.

Workers on site only occasionally, for specific limited tasks and who are unlikely to be exposed to hazardous substances over permissible exposure limits, shall receive a minimum of 24 hours of instruction off the site, followed by a minimum of one day field experience under the supervision of a trained, experienced supervisor.

Workers regularly on site who work in areas where it has been determined by monitoring or other means that exposures to hazardous substances are under permissible limits, that there are no health hazards and that there is no possibility of a hazardous material emergency developing, shall receive a minimum of 24 hours of instruction off the site, followed by a minimum of one day field experience under the supervision of a trained, experienced supervisor.

Following initial training, employees shall receive eight hours of refresher training annually.

G-2.4.2 Equivalent Training. Employees who can document training or work experience equivalent to the required training described above do not require the initial 40- or 24-hour training. However, workers with equivalent training new to a site shall receive appropriate site-specific training before site entry and an appropriate period of supervised field activity at the site.

G-2.5 Medical Surveillance. A medical surveillance program shall be instituted for the following employees:

- All employees who are or may be exposed to hazardous substances or health hazards at or above permissible exposure limits for 30 days or more per year

- All employees who wear a respirator for 30 days or more per year

- All employees who are injured, become ill or develop signs or symptoms due to possible overexposure to hazardous substances

Generally, medical examinations and consultations are required at the following intervals for employees subject to medical surveillance:

- Prior to assignment

- At least annually

- At termination of employment or reassignment to an area or job where the employee would not be subject to medical surveillance

- As soon as possible after an injury or the onset of illness or symptoms

- At additional times or more frequent intervals if recommended by the attending physician

G-2.6 Work Practices and Personal Protection. Employee protection from health and safety hazards is obtained by the use of engineering controls, work practices and personal protective equipment (PPE). Employers may use Material Safety Data Sheets (MSDS), included as **Tables F-8 through F-14**, or other published literature as a guide to selecting appropriate protective measures.

G-2.6.1 Engineering Controls and Work Practices. Engineering controls and work practices shall be instituted to keep employee exposure to hazardous substances at or below permissible exposure limits. Engineering controls include the use of pressurized cabs or booths for equipment operators or the use of remote-operated equipment. Work practices include removing nonessential employees from potentially hazardous work sites, siting employees upwind of possible airborne hazards, limiting the use of open flame and spark-producing equipment, limiting employee stay time on site, wetting down dusty operations and similar measures.

Where it is not feasible to employ engineering controls and work practices alone, any reasonable combination of engineering controls, work practices and personal protective equipment (PPE) shall be used to keep employee exposure below permissible limits.

G-2.6.2 Personal Protective Equipment. Personal protective equipment shall be selected and used as required to protect employees from hazards and potential hazards that cannot reasonably be obviated by engineering controls and work practices. Personal protective equipment selection shall be based on an evaluation of performance characteristics relative to the hazards and potential hazards to which the wearer may be exposed, site conditions, task specific conditions and task duration.

The employer shall establish a written personal protective equipment program, as part of the site specific safety and health plan, addressing the following elements:

- PPE selection based on site hazards

- PPE use and limitations

- Work mission duration

- PPE maintenance and storage

- PPE decontamination and disposal

- PPE training and proper fitting
- PPE donning and doffing procedures
- PPE inspection prior to, during and after use
- Evaluation of the effectiveness of the PPE program
- Limitations during temperature extremes, heat stress and other appropriate medical considerations

Personal protective equipment is divided into four categories—A, B, C and D—based on the degree of protection afforded, with level A providing the most protection. The categories are described fully in Appendix B of 29 *CFR* 1910.120 and Chapter 6 of the *U.S. Navy Salvage Safety Manual,* S0400-AA-SAF-010. For most oil spill response work, level D or perhaps level C protection should be sufficient, although full respiratory protection (SCBA or airline mask) may be required in some situations.

G-2.7 General Workplace (Facilities) Requirements. In addition to standards relating directly to actual or potential exposure to hazardous substances, 29 *CFR* 1910.120 establishes standards for workspace illumination and sanitation.

G-2.7.1 Illumination. Employee areas and work sites shall be lighted to not less than the intensities given in **Table G-1** while work is in progress.

Table G-1. Minimum Employee Area Illumination Intensity.

Area or Operation Description	Illumination Intensity Foot-Candles
General site areas	5
Excavation and waste areas, accessways, active storage areas, loading platforms, refueling areas, field maintenance areas	5
General shops—mechanical and electrical equipment rooms, active storerooms, barracks or living quarters, locker or dressing rooms, dining areas, toilets, indoor workrooms	10
Indoor spaces—warehouses, corridors, hallways, exitways	5
First aid stations, infirmaries, offices	30

G-2.7.2 Material Safety Data Sheets. Personnel such as supervisors, site laborers, equipment operators and others who engage in hazardous substance removal should be familiar with the MSDS applicable to the materials they are expected to handle. This includes any solvents or other chemicals used.

G-2.7.3 Potable Water. An adequate supply of potable water shall be provided at the site. Portable containers used to dispense drinking water shall be equipped with a tap and capable of being tightly closed. Water shall not be dipped from containers. Containers used to distribute drinking water shall be clearly marked and not used for any other purpose. Where single-service cups are provided, both a sanitary container for unused cups and a receptacle for the disposal of used cups shall be provided.

There shall be no connection—open or potential—between systems providing potable and non-potable water.

G-2.7.4 Nonpotable Water. Outlets and containers for nonpotable water, such as firefighting water, seawater or similar, shall be identified to indicate clearly that the water is not safe for drinking, washing or cooking.

G-2.7.5 Toilets. One toilet seat and one urinal shall be provided for each 40 employees if fewer than 200 workers are employed at the site, or for each 50 employees if more than 200 workers are employed. Under temporary field conditions, provisions shall be made to assure that at least one toilet facility is available.

G-2.7.6 Food Handling. All food service facilities and operations shall meet the applicable laws ordinances and regulations of the jurisdiction in which they are located.

G-2.7.7 Temporary Sleeping Quarters. When temporary quarters are provided, they shall be heated, ventilated and lighted.

G-2.7.8 Washing Facilities. The employer shall provide adequate washing facilities for employees engaged operations that may expose them to hazardous substances. Washing facilities shall be near the worksite, but in areas where exposure levels are below permissible limits and shall be equipped to enable employees to remove hazardous substances from themselves.

G-2.7.9 Showers and Change Rooms. When cleanup or removal operations at a site require more than six months, the employer shall provide showers and change rooms for all employees exposed to hazardous substances and health hazards. Showers and change rooms shall meet the requirements of 29 *CFR* 1910.141. If it is not possible to locate showers and change rooms in areas where exposure levels are below permissible limits, they shall be provided with a ventilation system that will supply air with contaminant levels lower than permissible exposure limits. Change rooms shall consist of two separate change areas separated by the shower. One change area with an exit leading off the worksite shall provide employees with an area where they can put on, remove and store street clothing. The second change area with an exit leading to the worksite shall provide employees with an area where they can put on, remove and store work clothing and personal protective clothing. Employers shall ensure that employees shower at the end of their work shift and when leaving the hazardous waste site.

APPENDIX H

CONVERSION TABLES

The following tables include the conversion factors most commonly required in oil spill response operations. See **Appendix B** of the ***U.S. Navy Ship Salvage Manual, Volume 1***, S0300-A6-MAN-010, for more extensive conversion tables.

Table H-1. Metric System.

LENGTH	
1 meter (m)	= 10 decimeter (dm)
	= 100 centimeters (cm)
	= 1,000 millimeters (mm)
1,00 meters	= 1 kilometer (km)
VOLUME	
1 liter (l)	= 1,000 milliliters (ml)
	= 1 cubic decimeter (dm^3)
1 kiloliter (kl)	= 1,000 liters
	= 1 cubic meter (m^3)
1 milliliter (ml)	= 1 cubic centimeter (cc)
MASS	
1 kilogram (kg)	= 1,000 grams (g)
1,000 kilograms	= 1 tonne (metric ton)

Table H-2. Basic Metric/English Equivalents.

MEASURES OF LENGTH			
1 meter	= 39.37 inches	1 inch	= 0.0254 meter
1 meter	= 3.281 feet	1 foot	= 0.3048 meter
1 centimeter	= 0.3937 inches	1 inch	= 2.54 centimeters
1 millimeter	= 0.03937 inches	1 inch	= 25.4 millimeters
MEASURES OF AREA			
1 square meter (m^2)	= 10.76 square feet	1 square foot	= 0.0929 square meter
1 square meter (m^2)	= 1.196 square yards	1 square yard	= 0.836 square meter
1 square centimeter	= 0.155 square inches	1 square inch	= 6.452 square centimeters
MEASURES OF VOLUME			
1 cubic meter (m^3)	= 35.3 cubic feet	1 cubic foot (ft^3)	= 0.0283 cubic meter
1 cubic meter (m^3)	= 1.31 cubic yards	1 cubic yard (yd^3)	= 0.764 cubic meter
1 liter	= 61.023 cubic inches	1 cubic foot (ft^3)	= 28.32 liters
1 liter	= 0.0353 cubic foot	1 cubic inch (in^3)	= 0.016339 liters
1 liter (1)	= 0.264 U.S. gallons	1 U.S. gallon (gal)	= 3.79 liters
1 cubic meter	= 264.17 gallons	1 U.S. gallon	= 0.0038 cubic meter
MEASURES OF WEIGHT AND MASS			
1 kilogram (kg)	= 2.205 pounds	1 pound	= 0.454 kilograms
1 tonne	= 1.1023 short tons	1 short ton	= 0.9072 tonne
	= 2205 pounds		= 907.2 kilograms
	= 0.9842 longs tons	1 long ton	= 1.016 tonne

Table H-3. Common Flow Rate Conversions.

MULTIPLY	BY	TO OBTAIN
Liters per seconds (lps)	15.83 = 16	gallons per minute (gpm)
	2.12	cubic feet per minute (cfm)
Liters per minute (lpm)	0.26 = 0.25	gpm
	0.0353	cfm
M^3/hour	4.4	gpm
	0.588	cfm
	0.278	lps
	1.01 = 1.0	tons seawater/hour
	0.98 = 1.0	tons fresh water/hour
	1.025 = 1.0	tonnes seawater/hour
M^3/second	15850.2	gpm
	2118	cfm
Ft^3/min (cfm)	7.48 -= 7.5	gpm
	0.472 = 0.5	lps
	28.32	lpm
	1.714	tons seawater/hour
	1.671	tons fresh water/hour
	1.741	tonnes seawater/hour
	0.00047 = 0.0005	m^3/second
U.S. GPM	0.134	cfm
	0.063	lps
	3.790= 4	lpm
	0.229 = 0.23	tones seawater/hour
	0.223	tons fresh water/hour
	0.233	tonnes seawater/hour
	0.00006	m^3/sec
	0.228 = 0.23	m^3/hour, tonnes fresh water/hour

Table H-4. Common Pressure Conversions.

MULTIPLY	BY	TO OBTAIN
Feet of seawater	0.445 = 0.45	psi
Feet of fresh water	0.434 = 0.43	psi
Psi	2.25	feet of seawater
Psi	2.31 = 2.3	feet of fresh water
Inches of mercury	0.49 = 0.5	psi
Psi	2.04 2.0	inches of mercury
Psi	0.07	atmoshperes
Atmospheres	14.7 = 15	psi
Atmospheres	10.08 = 10.0	meters of seawater
Bar	14.5 1.02 = 1.0	psi kg/cm^2

Table H-5. Common Density Conversions.

MULTIPLY	BY	TO OBTAIN
Lb/ft^3	16.02	kg/m^3
Kg/m^3	0.0624	lb/ft3
m^3 /tonne	32.87	ft^3 /Iton
ft^3 /Iton	0.279	m^3 /tonne

Table H-6. General Conversion Factors.

MULTIPLY	BY	TO OBTAIN
Atmospheres	33.9 = 34 33.1 = 33 29.92 = 30 14.7	feet of fresh water (ffw) feet of seawater (fsw) inches of mercury (in Hg) lb/in^2 (psi)
Bars	0.987 14.5 10,200	atmospheres psi kg/m^2
Barrels	5.615 42 0.159 159	cubic feet (ft^3) U.S. gallons (gal) kiloliters, m^3 liters
Cubic centimeters	0.0002642 0.0338	gallons (U.S.) ounces
Cubic feet	7.48 = 7.528.32 0.178 1,728 0.02832	gallons liters bbl in^3 m^3
Cubic meters	35.31 264.2 6.29 1,000 1	ft^3 gallons bbl liters kiloliters
Cubic meters/hour	4.4 0.589 = 0.6	gallons/minute ft^3/min
Gallons (U.S.)	0.1337 0.003785 3.785 0.833 231 0.238	ft^3 m^3 liters Imperial gallons in^3 bbl
Gallons (Imperial)	1.201	gallons (U.S.)
Gallons per minute	0.228	cubic meters/hour
Kilograms/m^2	0.00142	lb/in^2 (psi)
Kilometers/hour	54.68 0.5396 0.6214	feet/minute knots mph

Table H-6 (Continued). General Conversion Factors.

MULTIPLY	BY	TO OBTAIN
Kiloliters	1	cubic meters
	6.29	bbl
	264.2	U.S. gal
	220.1	Imperial gal
	35.31	cubic ft
	1.308	cubic yds
Knots	1.8532	kilometers/hour
	1.1516	statute miles/hour
Millimeters of mercury	0.00132	atmospheres
	0.0435	feet of seawater
	0.0446	feet of fresh water
	13.6	kg/m^2
	2.785	lb/ft^2
	0.0193	psi
Newtons	0.225	pounds (lb)
Pounds	0.454	kilograms
Pounds/ft^3	16.02	kilograms/m^3
Pounds/inch^2	703.1	kilogram/m^2
	144	pounds/ft^2
Tons (short)	907.2	kg
	2,000	lbs
	0.8929	long tons
	0.9072	tonnes
Tonne	0.984	long tons
	1.1023	short tons
	2,205	lbs
	1,000	kg

Table H-7 . Power Conversion.

MULTIPLY	BY	TO OBTAIN
Horsepower	0.746	kilowatts
Kilowatts	1.3404	horsepower
Btu	778.3	foot-pounds
Foot-pounds	0.001285	Btu
Btu	0.0003927	horsepower hours
Horsepower hours	2,554.1	Btu
Btu	0.0002928	Kilowatt hours
Kilowatt hours	3,412.75	Btu

Table H-8. Temperature Conversion.

Degrees Fahrenheit (°F) = (9/5 x degrees Celsius) + 32
Degrees Celsius (°C) = 5/9 x (degrees Fahrenheit - 32)