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Technology Assessment & Research (TA&R) Project Categories

Mechanical Containment and Recovery

Mechanical containment and recovery is the most commonly used and most environmentally acceptable response technique to cleanup oil spills in the United States. Mechanical spill response uses physical barriers (containment booms) to contain and concentrate floating oil, mechanical devices (skimmers) as well as natural and synthetic sorbent materials to remove oil from the water's surface, and temporary storage devices to store the recovered oil and water until it can be disposed of properly. Where feasible and effective, this technique is preferable to other methods (use of dispersants or in situ burning), since spilled oil is removed from the environment to be recycled or properly disposed. In most instances, the containment and recovery phase of an oil spill proceed simultaneously.

Spilled oil floating on the water's surface is affected by wind, currents, and gravity, all of which cause it to spread, fragment and disperse. The first stage of an effective response is to deploy containment boom to limit further spreading and concentrate the oil for recovery. Containment of an oil spill is the process of preventing its spread by confining the oil to the area where it has been discharged. Containment not only localizes the spill but also facilitates the removal of the oil by causing it to concentrate in thicker layers on the surface of the water.

Oil containment booms are generally the first equipment mobilized at the scene of a spill and the last to be removed. They are used for concentrating oil so that it is thick enough to be skimmed, for keeping oil out of sensitive areas, or for diverting oil into collection areas. When deploying booms and skimmers to recover spilled oil a common difficulty is controlling the movements and activities of vessels and directing them to the thickest areas of the oil slick. This can be overcome by using aircraft equipped with air to sea communications.

Booms come in many different shapes, sizes, and styles ranging from small, lightweight models intended for manual deployment in harbors, to large, robust units which usually need cranes and sizeable vessels designed for the open seas to handle them. Booms vary considerably in their design, but all normally incorporate the following features:

1. Freeboard to prevent or reduce splash-over;
2. Sub-surface skirt to prevent or reduce escape of oil under the boom;
3. Flotation by air or some buoyant material; and
4. Longitudinal tension member (chain or wire) to provide strength to withstand the effects of winds, waves and currents. This is often used to provide ballast to keep the boom upright in the water.

The most important characteristic of a boom is its oil containment or deflection capability, determined by its behavior in relation to water movement. The boom should be flexible enough to conform to wave motion yet sufficiently rigid to retain as much oil as possible. Most booms are not capable of containing oil in currents greater than 0.7 knot (0.35 meter/second) that flow at right angles to the boom, irrespective of boom size or skirt depth. This factor limits the speed at which booms can be towed to less than 0.5 knots (0.26 m/s). The success of containment booming is dependent on currents, wind, and waves. Even minor currents can draw oil under the booms; waves may cause splash-over, and wind and currents may cause the boom to sink or plane. Oil patches or water turbulence appearing on the down-current side indicates that the boom is failing. New open ocean boom designs capable of containing oil as tow speeds greater than 3 knots (15.4 m/s) are becoming commercially available. In Arctic conditions even very low concentrations of ice can seriously affect the performance of most booms. Containment booms will quickly collect ice and subsequently lose oil as flotation chambers are submerged or lifted out of the water. Other important boom characteristics are strength, ease and speed of deployment, reliability, weight and cost.

It is essential that a boom be sufficiently robust for its intended purpose and tolerate inexpert handling, since trained personnel are not always available. Strength is required to withstand the forces of water and wind when being towed. Ease and speed of deployment combined with reliability are very important in a rapidly changing situation and may strongly influence the selection of equipment. Practical limitations of strength, water drag and weight mean that generally only relatively short lengths (tens to a few hundred meters) can be deployed and maintained in a working configuration. Towing booms at sea in “U” or ”J” configurations, is a difficult task requiring specialized vessels. Because of the difficulties of operating multi-ship towed boom systems, specialized ships have been built which incorporate sweeping arms, skimming devices and on board oil storage. The limitations posed by sea conditions still also apply to larger versions of these vessels of which are unable to work in shallow inshore waters. The efficiency of a specialized vessel is mainly determined by the built-in oil recovery system or skimmer which is deployed. Because of the relatively narrow sweep width, these specialized vessels are best suited to recovering oil in ribbons or windrows. Following containment of the oil, the next step in the cleanup operation is physical recovery of the oil from the water’s surface.

Skimmers that are used to recover oil from the water all incorporate an oil recovery element and some form of flotation or support. In addition a pump or vacuum device is necessary to transfer recovered oil and water to some sort of temporary storage device. Because skimmers float on the water surface, they experience many of the same operational difficulties that apply to booms, particularly those posed by wind, waves and currents. Even moderate wave motion greatly reduces the effectiveness of most skimmer designs. In calm waters better performance can be achieved if the skimmer is suited to the viscosity of the oil in question. The simplest skimmers are suction devices which remove oil from the water surface directly or via a weir, although these tend to pick up a lot of water at the same time. More complex units rely on the adhesion of oil to metal or plastic disks, or oleophilic belts or ropes. Still others employ brush systems or are designed to generate vortices to concentrate the oil. The effectiveness of a skimmer is determined by how quickly it can collect the oil, and how well it minimizes the water to oil ratio collected.

Many factors should be considered when selecting skimmers. The intended use and expected operational conditions should first be identified before criteria such as size, robustness and ease of operation, handling and maintenance can be evaluated. The most important factors to consider are the viscosity and adhesive properties of spilled oil, including any change in these properties over time. At oil terminals and refineries where oil type may be predictable, specialized units may be selected. Otherwise it is preferable to retain versatility and select units which can deal with a range of oils. A wide variety of skimmers are available that use different methods for separating oil from water. Vessel-based skimming systems remove oil from open water, while vacuum trucks are often used to remove oil that has collected near the shoreline.

It is also important to recognize the difficulties posed by floating debris, both natural (e.g. sea weeds, sea grasses, trees and branches) and man made (e.g. plastic, glass, timber). Skimmers may need trash screens and regular unblocking where debris is common, such as near urban areas or the mouths of river. In Arctic conditions, even very low concentrations of ice seriously affect the performance of most skimmer systems through plugging and bridging. The skimmers will need continuous maintenance by specially trained staff with a supply of spare parts. Because of the various constraints imposed on skimmers in the field, their design capacities are rarely realized. Experience from numerous spills has consistently shown that recovery rates reported under test conditions cannot be sustained during a spill. It is important not to have unrealistic expectations about what can be achieved.

Oil collected by the skimmer is stored in a containment tank or temporary storage device. It is important to have adequate temporary oil storage facilities available otherwise this becomes a bottleneck to successful oil recovery operations. Temporary storage needs to be easy to handle, and easy to empty once full so that it can be used repeatedly. Suitable units include barges and portable tanks which can be set up on vessels of opportunity. When recovering very viscous oils, storage tanks must be heated to allow them to be emptied.

Once oil recovery is completed, booms and skimmers will need to be cleaned, overhauled and repaired and made ready for use in the next spill. It is also important to inspect and test equipment regularly so that it is in good working order, and to maintain personnel training standards by regular drills.

Overall, containment and recovery operations at sea require extensive logistical support. In rough seas, a large spill of low viscosity oil such as a light or medium crude oil can be scattered over many square kilometers within just a few hours. Oil recovery systems typically have a swath width of only a few meters and move at slow speeds (1 knot) while recovering oil. Thus, even if response personnel can be operational within a few hours, it will not be feasible for them to encounter more than a fraction of a widely dispersed slick. This is the main reason why containment and recovery at sea rarely results in the removal of more than a relatively small proportion of a large spill, at best only 10 - 15% of the spilled oil and often considerably less.

Sorbents are insoluble materials or mixtures of materials used to recover liquids through the mechanism of absorption, or adsorption, or both. Absorbents are materials that pick up and retain liquid distributed throughout its molecular structure causing the solid to swell in volume by 50 percent or more. Adsorbents are insoluble materials that become coated by oil on the surface, including associated pores and capillaries, without the solid swelling by more than 50 percent. To be useful in combating oil spills, sorbents need to be both oleophilic (oil-attracting) and hydrophobic (water-repellent). Although they may be used as the sole cleanup method in small spills, sorbents are most often used to remove final traces of oil, or in areas that cannot be reached by skimmers. Sorbent materials used to recover oil must be disposed of in accordance with approved local, state, and federal regulations. Any oil that is removed from sorbent materials must also be properly disposed of or recycled. Sorbents can be divided into three basic categories: natural organic, natural inorganic, and synthetic.

Natural organic sorbents include peat moss, straw, hay, sawdust, ground corncobs, feathers, and other readily available carbon-based products. Organic sorbents can adsorb between 3 and 15 times their weight in oil, but there are disadvantages to their use. Some organic sorbents tend to adsorb water as well as oil, causing the sorbents to sink. Many organic sorbents are loose particles such as sawdust, and are difficult to collect after they are spread on the water. These problems can be counterbalanced by adding flotation devices, such as empty drums attached to sorbent bales of hay to keep them afloat, and wrapping loose particles in mesh to aid in collection.

Natural inorganic sorbents consist of materials like clay, perlite, vermiculite, glass wool, sand, or volcanic ash. They can adsorb from 4 to 20 times their weight in oil. Inorganic sorbents, like organic sorbents, are inexpensive and readily available in large quantities. These types of sorbents are not used on the water's surface.

Synthetic sorbents include man-made materials that are similar to plastics, such as polyurethane, polyethylene, and polypropylene designed to adsorb liquids onto their surfaces like a sponge. Other synthetic sorbents include cross-linked polymers and rubber materials, which absorb liquids into their solid structure, causing the sorbent material to swell. Most synthetic sorbents can absorb up 70 times their own weight in oil.

Desired Outcomes

1. Improve the operational capability of existing spill response equipment to respond to oil spills in the marine environment.
2. Expand the capability of existing spill response equipment to enable oil recovery in cold water/broken ice conditions.
3. Develop capabilities to deflect or redirect oil in a broken ice field. Separate oil and ice on the waters surface to increase encounter rates for possible mechanical recovery or in situ burning in firebooms.
4. Improve the capabilities to process and transfer viscous oil and oil/water emulsions and integrate all processing phases (collection, pumping, storage and offloading).

Tactical Plan (2005-2010)

1. Continue technology assessments of prototype and commercially available offshore and fast-water booms and skimming devices, oil water separation and emulsion-breaking systems, and modular, easily transported temporary storage devices required to respond to open water oil spills.
2. Test and evaluate equipment and technologies required to respond to oil spills in cold water/broken ice conditions. Increase the encounter rates for mechanical response in broken ice.
3. Extend recent work on viscous oil pumping to understand the effects pieces of ice contained in the oil. The impact of slush ice and small ice pieces on the ability to pump recovered cold oil, oil-water emulsions and oily waste is a continuing problem.
4. Test and evaluate new and innovative technologies that will facilitate the separation of oil, ice and water when recovering spilled oil in cold water and broken ice conditions.
5. Test and evaluate oil spill containment systems capable of operating in high current environments.
6. Test and evaluate equipment and technologies required to handle and treat oily liquid and oily solid waste collected during response operations.

7. Test and evaluate the performance of sorbent materials.
8. Take advantage of planned full-scale field trials to validate and prove response technologies and strategies developed in laboratory and meso-scale experiments and to develop operational guidelines for particular response technologies.

For more information on Mechanical Containment and Recovery Projects, contact **Joseph Mullin** at 703-787-1556 or via email.

Mechanical Containment and Recovery Projects	
004	Cavitating Water Jet Cleaning Nozzle
032	Recapture of Oil from Blowing Wells
084	Surface Oil Spill Containment and Cleanup
085	Subsea Collection of Blowing Oil and Gas
109	Oil Spill Response Equipment Performance Verification
113	Open Ocean Boom Test
121	Water Jet Barrier Containment of Oil in the Presence of Broken Ice
152	Recovery Methods for High Viscosity Oils
153	Alaska Arctic Workshop
155	Identification of Substitute Test Facilities for OHMSETT
156	World Catalog of Oil Spill Response Products
158	Development and Evaluation of Shoreline Cleanup Techniques
159	Evaluation of Skimmers for Offshore and Ice-Infested Waters
163	Preparation a Test Protocol for Offshore Oil Skimmers and Containment Booms
180	Testing and Evaluation of Sorbents
244	Testing of Fire Resistant Booms in Waves and Flames
247	Numerical Modeling of Oil Boom Behavior and Rapid Current Boom Development
287	Fate and Behavior of Deepwater Subsea Oil Well Blowouts in the Gulf of Mexico
289	Re-Engineering of a Stainless Steel Fireproof Boom for Using in Conjunction with Conventional Firebooms
291	Technology Assessment and Concept Evaluation for Alternative Approaches to In Situ Burning of Oil in the Marine Environment
295	In situ Clean up of Oiled Shorelines; Svalvard Shoreline Project
297	Comprehensive Spill Response Tactics for the Alaska North Slope-Oil in Broken Ice Spill Response Scenarios
298	Testing at Ohmsett to Determine Optimum Times to Decant to Temporary Storage Devices
299	Estimation of Towing Forces on Oil Spill Containment Booms
309	Development of an OHMSETT Activity Summary Report
310	Mechanical Oil Recovery in Ice Infested Waters (MORICE) - Phase III
311	Oil Spill Containment, Remote Sensing, and Tracking from Deep Water Blowouts: Status of Existing and Emerging Technologies
324	Experimental and Analytical Study of Multi-phase Plumes in a Stratified Ocean with Application to Deep Ocean Spills
330	Oil Spill Response - Performance Review of Booms

333	Field Experiments at the Ohmsett Facility, Especially for a Newly Designed Boom System
348	Detection and Tracking of Oil Under Ice
353	The Use of Ice Booms for the Recovery of Oil Spills from Ice Infested Waters
354	International Oil and Ice Workshop
377	Project "Deep Spill"
391	Fire Boom Testing at Ohmsett
395	Extending Temporary Storage Capacity Offshore With Emulsion Breakers
428	Procedures for Reporting Tests of Oil Spill Containment Booms and Skimmers
457	Effect of Oil Spill Containment Boom Characteristics on Boom Performance
478	Development of a Standard Method for Measuring the Buoyancy-to-Weight Ratio for Oil Spill Containment Boom
511	Tailored Polymetric Materials for Oil Spill Recovery in Marine Environments
512	Transfer of Decanting Technology Research to Oil Spill Response Organizations and Regulators
515	Wave Field Characterization at the Ohmsett Wave Test Basin
516	Development of a Method to Produce Large Quantities of Realistic Water-In-Oil Emulsions for use in Evaluating Oil Spill Response Equipment and Methods
520	Summary Report of Activities at the Minerals Management Service Ohmsett Facility
528	Optimization of Oleophilic Skimmer Recovery
555	Partnering in a Workshop to Determine the Scope of an Experimental Oil Spill in Pack Ice in Canada
573	Oil Recovery with Novel Skimmer Surfaces under Cold Climate Conditions
586	Planning Support for an Experimental Oil Spill in Pack Ice
587	International Oil in Ice Workshop 2007
589	Investigation of the Ability to Effectively Recover Oil Following Dispersant Application
625	Oil Spill Training and Response (STAR) Calculator Program

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