

Figure 5.3-2. Mechanism of Chemical Dispersion. Source: SL Ross (2000).

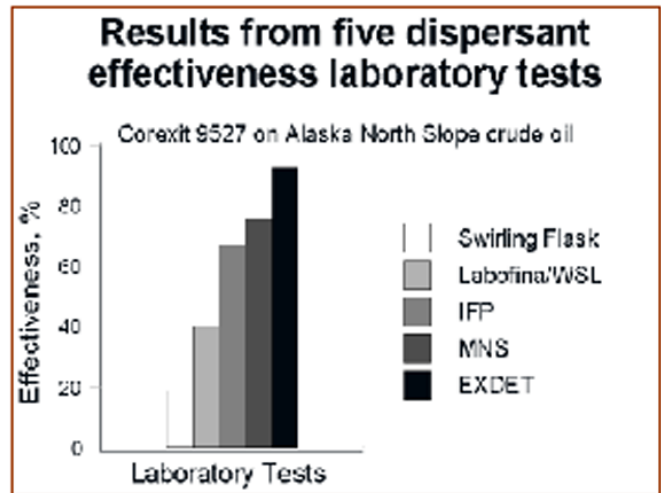


Figure 5.3-3. Laboratory dispersant effectiveness tests. Source: S. L. Ross (2000).

## ALTERNATIVE RESPONSE TECHNOLOGIES – OFFSHORE

### Dispersants

Dispersants are a class of spill-treating agents that, when applied to oil on water, form the oil into droplets which are driven into the top layer of water column (Fingas, 2001). Surface active agents (surfactants) are the key components of a chemical dispersant. These compounds contain both a water compatible and an oil compatible group. Because of this molecular structure, the surfactant locates at the oil-water interface, reduces the interfacial tension, enabling the oil slick to break up into small oil droplets. Once the droplets are dispersed into the water column, they are subjected to natural processes such as spreading by currents and biodegradation (NRC, 1989, SL Ross, 2000; appendix figure 5.3-2) A number of papers have been written explaining how dispersants work (Fingas 1988 and Fingas et al., 1997; 1995; 1993). In addition, many issues discussed below are summarized in American Petroleum Institute (1999; 1997).

The NRC (1989) study asked two questions:

- Do they do any good? (that is, are they effective?); and
- Do they do any harm (that is, are they toxic?).

These two issues are addressed below.

**Effectiveness.** “Dispersant effectiveness” is defined as a measure of how effective the application of dispersant might be on a targeted part of a slick. It is not to be confused with dispersant “operational efficiency” which relates to operational factors such as

having sufficient stockpiles of chemicals, application platforms, and fast response capabilities.

Also, “dispersant effectiveness” means the effectiveness of the dispersant under field conditions, rather than laboratory conditions. Unfortunately, there is little quantitative information on the effectiveness of dispersants when used in the field. Most quantitative information comes from a number of laboratory tests, which are poor simulators of dispersant-use in the field. The five most popular laboratory tests today (Swirling Flask, Labofina, IFP, MNS and Exdet; see Nordvik et al. 1993; appendix figure 5.3-3) have different designs and produce different results for identical dispersant/oil combinations. Although the results from any laboratory test can be useful in providing relative values of dispersant effectiveness between dispersant/oil combinations, they should not be trusted to predict absolute dispersant effectiveness values in the field.

Unfortunately, past field experiments do not provide good data either. This is because (1) there have been only a handful of open-ocean trials; and (2) there are no acceptable surface-sampling or remote sensing methods available for measuring the overall thickness or volume of a spill on the sea surface, and no acceptable methods for determining total volume of dispersed oil in the water column.

A measure of effectiveness, based on the specific, or API, gravity of the oil has been developed by the ITOPF. The approach is based primarily on the fresh-oil density of the spilled oil (ITOPF 1987). This variable was used in the correlation because, when a marine spill happens, the properties of the spilled oil are usually not known except for the density of the oil or its API gravity. The ITOPF approach has been

**Table 5.3-2. Oil dispersibility as a function of API Gravity and Pour Point.**

Dispersibility Factor*	Oil Gravity and Pour Point	Oil Description
1	API Gravity over 45°	<ul style="list-style-type: none"> <li>•Very light oil</li> <li>•No need to disperse</li> <li>•Oil will dissipate rapidly</li> </ul>
2	API Gravity 35°- 45°	<ul style="list-style-type: none"> <li>•Light oil</li> <li>•Relatively non-persistent</li> <li>•Easily dispersed</li> </ul>
2W	API Gravity 35°- 45° Fresh Oil Pour Point >40°F	<ul style="list-style-type: none"> <li>•Light Oil</li> <li>•Very difficult to disperse if pour point of fresh oil is greater than water temperature</li> </ul>
3	API Gravity 17°- 34°	<ul style="list-style-type: none"> <li>•Medium density oil</li> <li>•Fairly persistent</li> <li>•Dispersible while fresh and unemulsified</li> </ul>
3W	API Gravity 17°- 34° Fresh Oil Pour Point >40°F	<ul style="list-style-type: none"> <li>•Medium Density Oil</li> <li>•Fairly persistent if pour point of fresh oil is less than water temperature</li> <li>•Not dispersible if pour point of fresh oil is greater than water temperature</li> </ul>
4	API Gravity less than 17° OR Fresh Oil Pour Point greater than 75 °F	<ul style="list-style-type: none"> <li>•Heavy or very high pour-point oil</li> <li>•Very difficult or impossible to disperse</li> </ul>

\*The lower the number the higher the dispersibility

used extensively by API and Regional Response Teams (RRTs) in the U.S.

Table 5.3-2 indicates that oils that have a fresh-oil API gravity of 18E or greater should be chemically dispersible<sup>4</sup>. Effectiveness is influenced by many factors including, in descending order of importance, the characteristics of the oil (for example, viscosity, slick thickness, oil composition – amounts of aromatic and aliphatic hydrocarbons, asphaltenes and waxes), the amount and type of dispersant applied, the available mixing energy (usually via wave action), the degree of weathering the spilled oil has undergone, and the salinity and temperature of the water (Fingas, 2001; NRC, 1989). In addition, in order to be effective, several things must occur (NRC, 1989):

- The dispersant must be sprayed onto the slick;
- The dispersant must mix with the oil or move to the oil-water interface;
- The dispersant must attain the proper concentration at the oil-water interface, reducing the interfacial tension (between the water and the oil) to a minimum;

- The oil must disperse into droplets, which is related to the amount of energy that is available in the environment.

Examples of oils that tend to disperse easily include diesel and oil, in general, that contain large amounts of saturates. Oils that are more difficult or impossible to chemically disperse include Bunker C and others that are composed primarily of resins, asphaltenes and higher molecular weight aromatics or waxes.

A critical factor in the strategy of dispersant application is that the viscosity of the oil increases rapidly with weathering. When a crude oil is spilled it begins to evaporate immediately and to emulsify with water (see discussion on weathering processes, above). This emulsification greatly increases the viscosity and greatly diminishes the dispersibility of the oil. The most important factor that causes poor dispersant effectiveness in the field is the viscosity of the spilled product at the time the chemical is applied; if the viscosity is extremely high, the dispersant will not mix properly with the oil. When an oil is highly viscous the applied chemical may simply “roll off” the oil or does not penetrate and mix with the mass of oil. Because more viscous oil is more difficult to disperse, response within a few hours is generally essential to maximize the effectiveness.

In general, more dispersant is needed when sea energy is low in order to yield the same amount of dispersed oil as when sea energies are high. This is

<sup>4</sup> API gravity =  $([141.5/\text{Specific Gravity}] - 131.5)$ . The higher the API gravity the lighter the oil. API gravity of 18E = Specific Gravity of 0.95.

especially the case when moderately dispersible oils are encountered. For example, assuming the same amount of dispersant is used in both low and high sea energy conditions, diesel and light crude oils will be dispersed at rates greater than 50 percent under any conditions. Medium crude oils, those that would disperse only under ideal conditions, need a greater amount of sea energy in order to show any significant dispersibility. Laboratory studies have shown that medium crude oils will disperse at rates of only around 10 percent under low sea energy conditions and as much as 70 percent under high sea energy conditions. Heavy oils, such as Intermediate Fuel Oil and Bunker C, do not disperse at a rate of greater than 10 percent under any circumstances (Fingas, 2001).

If only low sea energies are present, much more dispersant is needed to disperse the same amount of oil. As much as five times more dispersant, at dispersant to oil ratios of up to 1:12.5, are needed under low sea energy conditions compared to conditions of high sea energy. For example, if 100 bbl of oil is spilled, and sea energies are moderately high (on a scale of 500, an energy level of 300), a dispersant-to-oil ratio of about 1:100 (42 gal of dispersant) is needed to achieve a 70 percent dispersion. On the other hand, if sea energies are near 50, the most dispersion that is possible is about 10 percent, even at dispersant-to-oil ratios of 1:12.5 (336 gal of dispersant) (Fingas, 2001). A dispersant-to-oil ratio of 1:20 are commonly cited in oil spill response plans. Understandably, it is preferable to apply only as much dispersant as needed for many reasons including those regarding environment and economics.

It is difficult to accurately measure dispersant effectiveness in either the laboratory or the field under either experimental or spill-of-opportunity conditions. While laboratory testing enables one to control for variables, it may not be representative of field conditions. Contrarily, field effectiveness judgements can be compromised by measurement inconsistencies, (for both oil remaining on the surface and oil in the water column) and by visual estimates due to the experience of the observer(s), the angle of the sun, and sea state, as well as by poor choices in the dispersant used and the weathered state of the oil. Thus, dispersant effectiveness results are usually given in terms of estimates or ranges rather than absolute values.

A study conducted by McAuliffe, et al. (1981) offshore southern California gives some “rules of thumb” regarding dispersant effectiveness. While some of these may appear to be obvious conclusions, they are nevertheless important considerations when deciding how to attack an oil spill:

- Chemical dispersion is more effective than natural dispersion in relatively calm seas;
- Dispersant treatment by air is superior, in most cases, to dispersant treatment by boat;
- Weathered oil is not dispersed as effectively as fresh oil; and
- A dispersant that performed poorly in the laboratory also performed poorly in the field.

In addition, oil slicks tend to spread with time, resulting in a larger area to treat, further emphasizing the need for speed early in a response. Finally, even if a dispersant application is judged to not be effective due to, for example, too much wind or not enough energy, the oil left on the surface, poorly dosed or not, reverts to a product that can either be treated again with dispersants (S. L. Ross 1985) or mechanically recovered, even with devices that rely on the principle of oleophilicity (oil sticking to surfaces).

Toxicity. The toxicity of dispersants is the other issue of concern. The wreck of the *Torrey Canyon*, offshore England in 1967, was the first occasion where dispersants, or dispersant-like substances were used to address oil spills. Unfortunately, the materials used in that event were extremely toxic and affected the shoreline organisms and habitats more severely than did the oil alone. That experience gave the concept of using dispersants a somewhat undeserved reputation since the substances used during the *Torrey Canyon* incident were of the first generation toxic-type (NRC, 1989). Over 3 million gallons of dispersants were sprayed onto about 105,000 bbl of oil. The dispersants used were surfactants mixed with aromatic hydrocarbon solvents, which were effective in removing the oil but highly toxic to any organisms when they were sprayed directly onto beaches (NRC, 1989). Oil contamination alone resulted in fewer adverse biological effects than on areas where those dispersants were used. Other early dispersants exhibited toxicities in the 5 to 50 mg/l LC<sub>50</sub> range. Since then, the formulation of dispersants has evolved into carefully controlled combinations of lower-toxicity solvents with surfactants with LC<sub>50</sub>s ranging from 200 to 500 mg/l (Fingas, 2001).

Oil/dispersant Fates and Trade-offs. Once an oil slick is dispersed, then what? In most places, oil slicks are subjected to surface currents, winds, and waves. If the oil is all or partially removed from the water surface, those factors that directly affect the movement and weathering of the oil, become detached from any changes in the characteristics of the oil. Sub-surface currents then predominate. If the dispersed droplets are small enough they will have little buoyancy and will be carried away and diluted by normal ocean current and movement. One of the inputs to a

decision regarding tradeoffs (discussed below) is where the oil might go if subsurface currents become the predominant influence on the plume of dispersed oil.

As with other Alternative Response Technologies (for example, *in-situ* burning) the decision to apply dispersants is a balancing of tradeoffs. Since dispersants are never 100 percent effective, any responder would have to ask if the process of apply dispersants is worth the costs (both environmental and economic) of attacking the spill by only mechanical means. For example, if even 50 percent of the oil is removed from the sea surface, is that 50 percent enough to remove a justifiable amount of impact to birds, mammals, shoreline habitats, cultural resources, marinas, harbors, water intakes, and other imperiled resources? A succinct summary of biological tradeoffs is from NRC (1989):

- In open waters, organisms on the surface will be less affected by dispersed oil than by an oil slick;
- Organisms in the water column, particularly the upper layers, could experience greater exposure to oil components if the oil was dispersed;
- In shallow water habitats with poor circulation, benthic organisms could be more immediately exposed to dispersed oil;
- Although some immediate biological effects of dispersed oil may be greater than for untreated oil, long-term effects on most habitats, such as mangroves, are less and the habitat recovers more quickly if the oil is dispersed before it reaches that area;
- Dispersed oil does not adhere as much as untreated oil to some organisms or habitats; and
- The application of dispersants after oil contacts some habitats, such as salt marshes, rocky shorelines and, sand and mud flats, is generally not effective and could do more harm than good.

Finally, NRC (1989) made the following recommendations regarding the protection of sensitive habitats:

- Sensitive inshore habitats, such as salt marshes, coral reefs, sea grasses and mangroves, are best protected by preventing oil from reaching them;
- Dispersion of oil at sea will generally reduce the overall, and particularly chronic, effect of oil on many habitats.

To further streamline this process, the RRT, the USCG, and the AC's are working toward establishing dispersant plans with pre-approved, approval with consultation, and quick approval process zones. Once the AC's develop these dispersant plans, they will be reviewed and approved by the RRT as prescribed by the NCP. Pre-approval zones are where dispersants can be applied relatively quickly under only the oversight of the Unified Command structure. Once approved, these dispersant plans will speed up the dispersant application to the oil and make the decision-making process more flexible.

A comprehensive discussion on the logistics of dispersant planning and application is beyond the scope of this appendix. However, some key factors that members of the UC must consider in their decision-making process are:

- availability of dispersant product;
- characteristics of delivery platforms (payload, pump rate, speed);
- spill conditions (e.g., type of spill, behavior of the oil, distance offshore);
- ability to identify thick oil areas and position spray equipment accordingly;
- availability of effectiveness monitoring; and
- weather and daylight hours.

### ***In-situ* burning**

While mechanical removal is often the preferred method, it is recognized that *in-situ* burning can be a viable option in conjunction with, or in lieu of, mechanical or other types of recovery. *In-situ* burning has been demonstrated to be a very useful response tool in open water conditions when used in conjunction with a fire resistant boom. Numerous burn tests have been done in the lab, in test tanks, and in the field (including one during the second day of the *Exxon Valdez* spill cleanup operation), which demonstrate the feasibility and effectiveness of this technique.

Currently, California does not permit the burning of oil within the State or on state waters. *In-situ* burning can be used in the State of California and its waters by Federal preemption of this Code, which is only possible under specific circumstances. *In-situ* burning may be considered in waters beyond three miles of the shore, which are under Federal jurisdiction. The FOSC would need to obtain approval from the EPA representative to the RRT. Concurrence from the State is necessary only when navigable waters under the jurisdiction of the State are threatened by the discharge of oil. In all cases, the State will be

notified of the use of *in-situ* burning. When appropriate and practicable, the EPA representative to the RRT shall consult with the Department of Commerce and Department of Interior Natural Resource Trustees, and Sanctuary Managers, if applicable.

Preliminary laboratory testing has been conducted on the crude oil currently being produced from the Santa Barbara Channel and Santa Maria Basin Areas. The results of these tests indicate that the crude oil has a low percentage of volatile components resulting in difficult ignition of the oil. Therefore, *in-situ* burning of discharged oil may not be an appropriate mitigation measure for the oils commonly produced offshore California.

*In-situ* Burning Equipment. Currently, there is no *in-situ* burning boom in California. In the event equipment was required, identification and mobilization of equipment would be coordinated through the FOSC. Manufacturers of fire-resistant booms are using various techniques to improve the longevity of booms, either through new materials or through new technology to allow for heat transfer between the inside of the boom and the water beneath the boom. Tests conducted by Oil Stop Inc. showed that fire temperatures reach 1093 °C (2,000 °F) and water temperatures reach 100 °C (212 °F). External boom temperatures reach 927 to 982 °C (1,700 to 1,800 °F) (Schulze, Keith, and Purcell, 1995).

Other research on fire-resistant booms indicates that there are still problems with boom durability for multiple burns. Also, the sea-keeping ability of fire-resistant booms in seas greater than 1 m (3 ft) remains a problem. Government development efforts should focus on developing protocols for design testing to document performance and to encourage further industry efforts to improve design.

*In-situ* Burning Procedures. Typically, *in-situ* burning involves burning a certain thickness of oil, preferably several centimeters, contained within a fireproof boom. Two vessels towing approximately 156 m (500 ft) of fireproof boom (plus sections of conventional boom and towing cables) at less than 50 cm/s (1 kt) collect oil until it fills one-half to one-third of the fireproof boom. The oil is generally ignited using a Heli-torch suspended from a helicopter. This device uses gelled gasoline to ignite the slick. Other methods of ignition include flare pistols, fused igniters, or floating plastic bags of gelled fuel (e.g., gasoline, diesel, jet fuel). Monitoring through the use of film or video footage taken from either a vessel or the air. Visual observations can also be made by a trained observer.

Generally, oil must be relatively fresh and at least three millimeters thick on the water surface to sustain burning. The temperature at which vaporization occurs and the combustion process begins varies according to the physical and chemical properties

of the crude oil being burned. Many crudes, however, contain volatile light ends that enable combustion to begin below 50 °C (122 °F). As the oil weathers, the more volatile light ends are lost, concentrating the more stable heavy ends and raising the ignition temperature. If the oil is spread thin or emulsified, it may be difficult or impossible to conduct effective *in-situ* burning operations.

For most fresh oils, once a slick is burning it will continue to burn until the slick becomes too thin to sustain burning. Some oil residue remains in the water from all burns, as the flame is quenched by heat losses to the water surface when the oil layer is thin. Burn efficiencies of greater than 90 percent have been easily obtained in test burns.

*In-situ* burning greatly reduces the need for recovery, storage, transportation, and disposal of a large percentage of the spilled oil. Successful *in-situ* burning depends on vaporizing oil and raising its temperature for oxygen to react in a combustion process. Ideally, this is a self-perpetuating reaction. Once initiated, the combustion reaction produces enough heat to continue vaporizing the oil. The water below the oil slick acts as a heat sink that constantly draws heat away from the oil slick. When the temperature of the oil drops to where it is no longer being vaporized, the combustion reaction ends.

Efficiency. Burning efficiency is calculated as the difference between the percentage of residue left and the initial amount of oil. Efficiency is largely a function of oil thickness within the fireproof boom. Oil thicker than 2 to 3 mm can be ignited and will burn down to 1 to 2 mm (0.04 to 0.08 in). Virtually any type of oil can be burned. However, the burning of emulsified oil is an uncertain process due to the water contained in the oil. Some oils will burn with 70 percent water content, but others with as little as 10 percent water content will not burn.

During the *Exxon Valdez* spill, a test burn using the 3M fire resistant boom was conducted 2 days following the spill. In this test, an estimated 357 to 714 bbl of North Slope crude oil were burned in approximately 75 minutes with an estimated efficiency of 98 percent. The volume elimination rate for this test, using a single 500-foot boom, was estimated to be between eight to 16 bbl per minute (Allen, 1990).

*In-situ* burning is applicable for removing oil contained by fire booms on open water or for small spills on land. While it can eliminate a substantial amount of oil in a very short time, it is not a complete disposal technique. A tar-like residue, which would need to be removed manually is generally left after combustion. The residue and any remaining debris must be disposed of properly. For spills reaching the shore, in some cases and with approval, the residue may be left to degrade naturally or nutrients may be added to speed up the natural degradation process.

Environmental Effects of *In-situ* Burning. The primary objective of oil spill abatement and cleanup is to reduce the effect of spilled oil on the environment. The use of *in-situ* burning may be considered when the preferred techniques are judged to be inadequate and the environmental benefit of *in-situ* burning outweighs its adverse effects.

Some critics of *in-situ* burning have raised questions about the effects of air pollution resulting from the process. Between October 26 and November 10, 1992, MMS, Environment Canada, and the American Petroleum Institute, conducted six meso-scale burn tests and two evaporation tests to better quantify air quality data related to *in-situ* burn processes. The data from the meso-scale experiments indicated that burn products reach safe levels within several kilometers of the burn site and that the eventual concentrations of particulates and associated pollutants are several orders of magnitude below acutely toxic levels. *In-situ* burning can present health hazards to response personnel carrying out burning and other response operations downwind. Additional research is needed to fully document these hazards and to develop methods to minimize these hazards.

In August 12, 1993, MMS, USCG, Canadian Coast Guard, and Environment Canada also co-sponsored a large-scale *in-situ* test burn off the coast of Newfoundland, Canada. Two separate burns, each involving the spilling of 309 bbl of Alberta Sweet Mixed Blend crude oil, were examined. Efficiency of removal rates of 99 percent were reported for both burns. Environment Canada published a preliminary report that included the following findings:

- Burning at sea is feasible and practical.
- The fireproof boom stood up throughout the tests, but more work is necessary for it to last longer. Sea motion combined with heat appears to have reduced the life of the boom (48 hours in test tanks). The total burn during the tests lasted 4 hours.
- Some observations from the burns did not correspond to previous test tank data. First, several effects, such as the rapid sea burns noted in test tanks, did not occur at sea. Second, burn rate calculations must more accurately account for the effects of wind. Even a small amount of wind (8-11 km/hr (5 to 7 mph) during the second burn) drove the oil far into the apex of the boom and thereby reduced the burning rate to about two-thirds of previous calculations.
- Burning outside of the fire-resistant boom occurred on about three occasions as a result of too much oil in the boom, but did not result in

sheening. Either some form of containment occurred naturally, or the overflow was very viscous.

## ALTERNATIVE RESPONSE TECHNOLOGIES - ONSHORE

### Shoreline Cleaning Agents

These materials, also known as surface-washing agents, have not been widely used, in part, because of the same toxicity concerns that have been directed at dispersants (Fingas, 2001). While toxicity of dispersants have been a problem in the past, the better beach cleaners have very little aquatic toxicity. Beach cleaners would be used where oil had contacted the shoreline and involve a two-step process: first, applying the cleaner at low tide where it is left to soak for as long as possible, and second, washing the loosened oil with low pressure water into the water where it can be skimmed or sorbed. The National Oceanic and Atmospheric Administration occasionally conducts tests of various materials that are considered for use to clean shorelines. For example, during the *Morris J. Berman* spill in Puerto Rico, NOAA tested two types of chemical cleaners compared to hot water, high pressure washes (NOAA, 1994). One of the products tested did not require soaking while the other was of lower toxicity. This situation of considering tradeoffs is typical of many oil spill responses. Some laboratory and field-scale tests have shown that as much as 90 to 95 percent of the oil can be removed in this manner. MMS and Environment Canada have developed a laboratory effectiveness test on weathered Bunker C oil, a very thick and viscous material, which might be considered a worst-case scenario. The best results for removing Bunker C was 55 percent in salt water and the associated toxicity was greater than 10,000 ppm (for a 96-hour LC<sub>50</sub> test on rainbow trout). Only a few beach cleaners have met both the effectiveness and toxicity criteria and been approved in the United States and Canada.

Bioremediation: Bioremediation is an artificially-enhanced biodegradation process where biological tools, usually bacteria and fungi, are used to degrade oil *in-situ*. Hundreds of species of naturally-occurring bacteria and fungi have been found that degrade certain components of oil, particularly the saturate portion, which contain 12 to 20 carbon atoms configured in straight chains (Fingas, 2001). Some species will also degrade the aromatic portion (one or more benzene rings) that also have a lower molecular weight. Generally, the fewer the saturates (for example, in asphalts), the less biodegradation will occur.

Degradation agents are most useful along shorelines that are hard to clean otherwise. These might include cobble and armor beaches<sup>5</sup>, where the oil can seep into the large interstices between the rocks and be difficult to remove using other tools (such as bulldozers). Since digging up and cleaning large quantities of oily rocks is both damaging to the environment and very costly, the application, and possibly multiple reapplications, of bacterial degraders possibly enhanced by a fertilizer, would remove all but the heaviest oil from within the interstices. This, in the long-term, prevents “reiling” from the essentially nonweathered oil that would otherwise remain beneath the armored areas. In contrast, other types of non-rocky shorelines such as sandy beaches, can be readily cleaned by removing the sand, which can be treated in various ways (for example, incineration) and replaced at the original site.

Degradation agents that include a fertilizer as a carrying agent along with other trace elements are known as bioenhancement agents. They help to encourage the growth of naturally-occurring *in-situ* oil-degrading (eating) bacteria. Since oil-eating organisms are found nearly everywhere, it has not been found to always be necessary to include a bacteria in the degradation agent. However, some agents, known as bioaugmentation agents, have been developed that do contain their own custom-made bacteria. This has caused concerns regarding the introduction of “foreign” bacteria into the environment where the oil has been spilled. Also, these types of agents have not been as effective as the bioenhancement agents which stimulate local bacteria.

While bioremediation agents do remove saturates and some aromatic fractions of the oil, the process may take weeks or months to remove the degradable fraction of the oil and still leave the undegradable portions, such as the asphaltenes and heavy aromatics. The advantage to this is the lighter, degradable portion is often less toxic than the heavier, nondegradable portion. In this respect, bioremediation can be a useful tool.

No action. Occasionally, no clean up operations are undertaken at certain onshore sites and the oil is left to degrade naturally. This technique is most commonly used when oil contamination is found on high-energy beaches (primarily boulder, cobble and rock) where wave action will remove most oil contamination in a relatively short period of time. This also minimizes exposure of oil clean up responders to dangerous surf conditions.

<sup>5</sup> Armor beaches are those that consist of mostly flat stones that form an interlocking network, armoring the beach. Oil seeps between the upper layer of stones into the smaller cobble and gravel layers beneath.

## DISPOSAL OF OILY MATERIAL

One of the major issues associated with an oil spill response is the handling of collected products and contaminated cleanup materials, soil, and debris (Padre, Assoc., 2001). Each category of material/waste has its own type of response and management problems. For example, the first option for recovered liquids is to store them in separate tankage until a final disposition of the fluids is agreed upon by the RP and the appropriate regulating agency. Crude oil that is spilled into marine waters, recovered, and transported to a refinery may be considered a product that may not be subject to hazardous waste management regulations. The collected crude oil may be shipped to the refinery of original destination or another refinery that can accept the spilled crude oil.

Recycling is another option by which recovered petroleum may be managed as a material (Padre, Assoc., 2001). This option includes using the petroleum as: (1) in incineration as a fuel, (2) as a substitute for raw material feedstock, or (3) as an ingredient used in the production of a product (for example, asphalt). State law requires the consideration of recycling. Recovered petroleum that is not accepted by a refinery or cannot be recycled must be managed as a waste. In order to determine the appropriate method of management, the waste must be characterized by a state-certified laboratory to determine whether the waste is hazardous or nonhazardous. It is the responsibility of the RP to have the waste accurately characterized for proper disposition.

### Disposal at sea of water separated from recovered oil

Oil recovered at sea typically contains significant amounts of seawater (Padre, Assoc. 2001). In order to maintain the efficiency of the skimming process for recovery, this water must be separated/decanted from the oil and discharged back into the ocean during recovery operations. Separated seawater typically contains elevated levels of hydrocarbons; thus, the discharge of this material may constitute the discharge of a pollutant. This issue is presently being discussed with regulatory agencies to determine whether a National Pollutant Discharge Elimination System (NPDES) permit, or a waiver from the permit, is required before separated/decanted water may be discharged back into State waters. The “discharge” of separated/decanted water may be recognized by the FOSC as an integral part of offshore skimming operations and as an excellent waste minimization tool. Both oil and oily water recovered from skimming operations should be off-loaded to facilities where it can be effectively recycled or managed within established process and treatment streams. Such facilities may

include terminals, refineries, commercial reclaimers and recyclers, and RP facilities.

### **Contaminated debris**

Contaminated debris (including organic material), contaminated cleanup equipment (booms, pompoms, sorbents, etc.), and other contaminated materials that cannot be recycled must be managed as a waste. The materials must also be characterized before the appropriate waste management option is determined. It typically is not possible to completely avoid the generation of oily debris resulting from the contact of floating oil with waterborne solids. However, it is possible to minimize the generation of oily debris in the coastal intertidal zone if the anticipated area of oil impact can be cleaned prior to stranding of the spilled oil. This has been successfully accomplished in a small number of past spills.

### **Treatment of oily wastes**

Petroleum and petroleum-contaminated cleanup materials can potentially be treated at a temporary storage site. One of the treatment processes that may be used is a transportable treatment unit (TTU). The most likely treatment process undertaken with a TTU will be separation of seawater from collected petroleum. Any water generated through the separation of petroleum and seawater may potentially be discharged to a sanitary sewer system or back to marine waters. A portable incinerator may be another type of TTU available during a spill response for use with contaminated material. The use of an incinerator will require a permit from the local air quality agency.

### **Sorbent use/reuse**

Synthetic sorbents (pads, sweeps, booms) have become standard response materials in the mechanical recovery of spilled oil (Padre, Assoc. 2001). Their oleophilic, hydrophobic character makes them efficient at separating oil and water, and they are routinely used to recover oil from solid surfaces as well. Since oiled sorbent material often constitutes a substantial percentage of the oily solid waste generated during spill response and cleanup, opportunities for minimizing this waste volume should be considered. Some sorbents are designed to be reusable or can be recycled onsite with inexpensive gear.

### **Petroleum-contaminated soil recycling and reuse**

While the volume of petroleum-contaminated soil associated with coastal spills is generally lower

than inland spills, opportunities for recycling/reuse should be considered. For soils satisfying the waste profiling requirements of state and commercial facilities, reuse as daily landfill cover after appropriate treatment is a potential option in California.

### **Temporary storage**

To expedite the removal of spilled oil, refined products, and contaminated material from marine waters during an emergency response, temporary storage sites may be erected at appropriate shore locations determined in coordination with the appropriate local and state agencies. The transportation of oil and contaminated material to temporary storage sites during the emergency response may be exempt from certain handling and permitting requirements. Temporary storage sites should be available at an onshore location that is convenient to the recovery operations for the temporary storage of recovered petroleum products and contaminated materials and debris.

### **Characterization of Recovered Material**

Recovered petroleum and contaminated debris that cannot be recycled must be characterized to determine its waste classification before the waste can be shipped to an appropriate waste management facility for final disposal. The actual testing may be conducted on representative samples of each type of waste by a state-certified laboratory. Testing criteria can apply to any oily water, sorbents, booms, and debris generated as a result of an oil spill cleanup. Once the waste is characterized, disposition options can be selected.

### **Transportation**

Any recovered petroleum product deemed not acceptable for handling as a product and contaminated material must be transported to an approved waste management facility. The type of waste management facility selected is based on the nature of the waste and results of the waste characterization performed.

**Hazardous Waste.** Waste classified as hazardous under either federal or state regulations must be transported to a permitted or interim status hazardous waste facility. Hauling of the waste must be done by a state-licensed hazardous waste hauler. All hazardous materials shipped offsite must be transported in compliance with applicable regulations. Waste determined to be a nonhazardous but designated waste can be transported to a Class II waste management facility.



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