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Standard Guide for Ecological Considerations for the Use of Chemical Dispersants in Oil Spill Response: Tropical Environments[1]

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1. Scope

1.1 This guide covers recommendations for use of chemical dispersants to assist in the control of oil spills and is written with the goal of minimizing the environmental impacts of oil spills. Aesthetic and socioeconomic factors are not considered; although, these and other factors are often important in spill response.

1.2 Each on-scene commander has available several means of control or cleanup of spilled oil. Chemical dispersants should be given equal consideration with other spill countermeasures.

1.3 This guide presents general guidelines only. The dispersibility of the oil with the chosen dispersant should be evaluated in compliance with relevant government regulations. Oil, as used in this guide, includes crude oils and fuel oils. Differences between individual dispersants and to a certain degree, differences between different oils are not considered.

1.4 This guide is one of several related to dispersant considerations in different environments. The other standards are listed in Section 2.

1.5 This guide applies to marine and estuarine environments but not to freshwater environments.

1.6 In making dispersant use decisions, appropriate government authorities should be consulted as required by law.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F2532 Guide for Determining Net Environmental Benefit of Dispersant Use

3. Significance and Use

3.1 This guide is meant to aid local and regional spill response teams who may apply it during response planning and spill events.

3.2 This guide presents data on the effects of surface oil, dissolved oil and dispersed oil on components of tropical environments. These data can aid in decision-making related to the use of dispersants to minimize environmental damage from oil spills.

4. General Considerations for Making Dispersant-Use Decisions

4.1 The decision of whether to use or not to use dispersants in a given spill situation involves trade-offs. Dispersing a slick at one site temporarily introduces more oil into the water column at that site than would be there if a surface slick floated over it. Therefore, adverse effects on water column organisms may be increased at that site so that adverse effects can be decreased at other sites.

4.2 Dispersant use is primarily a spill mitigation method, not a cleanup method. Such use can give spill response personnel some control over where the impacts of a spill will occur whatever types of impacts they may be. Since some environments are known to be more vulnerable to the longer-lasting impacts of spilled oil, an acceptable trade-off may be to protect those environments by dispersing an oil slick in a less sensitive or less productive environment. In general, the net environmental benefit of dispersant use versus non-use should be evaluated (see Guide F2532). The net environmental benefit

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

of a particular countermeasure involves evaluating benefits and disadvantages of the particular technology being evaluated, versus other cleanup methods or no action, on the habitat or ecosystems involved in the area. Environmental benefit analysis is best conducted before the spill.

4.3 In this guide, environments that are most vulnerable to the longer-term impacts of oil contamination are identified. Protection of these environments is recommended as a high priority, by means of dispersants or other methods.

5. The Tropical Environment

5.1 Tropical environments encompass many different habitats. This guide will cover those habitats that are important in terms of decisions to use dispersants. The applications of dispersant to open waters and waters of depth greater than about 10 metres will not be covered here and is covered by other guides listed in Section 2. Shallow waters and habitats associated with mangroves, seagrasses and coral reefs are important considerations. Habitats other than those such as sand beaches, mudflats, cobble beaches and rocky shores may be common in certain localities but are generally less-sensitive.

5.2 Mangrove ecosystems are intertidal forests dominated by various species of woody halophytes that are commonly called mangroves. There are many families and species of mangroves (**1-4**)[3]. Mangrove ecosystems occur in tropical low-energy depositional areas. Mangroves tend to further promote the deposition and recycling of organic and mineral matter. Their extensive root systems are very important in stabilizing intertidal sediments (**4**). Adult mangroves form the structural basis for the mangrove community in that they provide attachment sites for many species of animals and shelter for many others.

5.2.1 Mangrove ecosystems contribute to the productivity of tropical marine ecosystems where they play the same but more important roles as do salt marshes in temperate climates. Mangroves are important as nursery areas as well as for the detritus that they supply to the surrounding communities (**3**). Much of the world's fish populations depend on detritus and remineralized nutrients exported from mangrove areas (**5**).

5.2.2 Mangrove forests dominate much of the world's tropical shoreline; many are adjacent to tanker routes, oil fields and refineries. The low energy characteristic of mangrove forests leads to the entry and retention of oil in these environments(**4**).

5.3 *Coral Reefs*—Coral reefs are structures created and maintained by the establishment and growth of hard corals and coralline algae (**6**). They may be comprised of emergent or submergent reefal zones, or a combination of both. Geomorphology, barrier and fringing reefs protect the insular and continental coastlines which they border from erosion. Typically, the coral reef provides habitat for a large variety of attached plants and epifauna, infauna, mobile invertebrates, and fishes. The large number of economically important species they support make reefs locally important in commercial and sport fisheries. The resultant high diversity and abundance of reef associates and the functional and spatial dominance of corals and coralline algae are the essential characteristics of coral reefs.

5.3.1 Coral reefs are circumglobal in the tropics and subtropics between the northern and southern hemispheric 18.5 °C climatic isotherms (**6**). A majority of coral species and the most diverse reefs occur in Indo-West Pacific seas. Tropical West Atlantic and Eastern Pacific reefs are generally less diverse in terms of corals and reef associates.

5.4 *Seagrasses*—Seagrasses can be found in shallow marine environments from the tropics to Polar regions. This guide focuses on those located in tropical waters. Seagrass beds form a discrete ecosystem that traps detritus derived from terrestrial and marine sources, and then exports large quantities of plant and animal materials, including leaf and root fragments, dissolved organic matter, and detritus, to the open sea (**5**). The presence of an extensive network of roots and rhizomes facilitates the sediment-binding ability of the grass beds; the seagrass leaves effectively retard currents, thus promoting sedimentations of organic and inorganic materials around the plants.

5.4.1 Seagrass communities are among the most productive of natural ecosystems (**5**). Seagrass leaf blades support large numbers of epiphytes which can equal the biomass of the grass itself. Major food chains are based upon a variety of epiphytes and associated organisms. Active sulfur, nitrogen, phosphorus, and carbon cycles are maintained through the sediment-plant-water interfaces, and the dense interlacing mat of vegetation provides ideal cover for foraging marine fauna as well as shelter and protection for larval and juvenile forms.

5.5 Seagrass and coral environments may also occur in sub-tropical ecosystems.

6. Effects of Oil and Dispersed Oil on Tropical Biota

6.1 *Mangroves*—Mangroves are primarily impacted by oil by three different routes; through the oiling of the pneumatophores, or breathing pores typically located on special aerial roots or stems, through oil absorption from the water column and through oil absorption through the roots from contaminated soil/sediment and ground water (**7-12**). Mangroves with oil on pneumatophores may die within about 5 to 7 days, depending on oxygenation conditions at the site (**13-15**). Mangroves may die from high concentrations of oil in the water column (**16-18**). The third route of oil impact on mangroves, through oil absorption from the soil, is also well documented (**19-22**). Oil in mangrove-dominated sediments can cause long-lasting effects and degrades only very slowly (**23-27**). Sublethal effects including leaf loss, deformations, and low growth can persist for five years after the spill event (**8**, **9**, **28**). Replanting mangroves, a primary restoration method is successful in soils with reduced hydrocarbon content (**29-33**). Natural regrowth occurs, but occurs slowly (**34-36**). Countermeasures which reduce the amount of oil arriving into the mangrove area are suggested (**37-40**).

6.1.1 Low levels of oil from either dissolved/dispersed oil in the water column or in the sediments cause a variety of sub-lethal effects on mangroves, including leaf loss, reduced

[3] The boldface numbers in parentheses refer to a list of references at the end of this guide.

growth of adventitious roots, abnormal pneumatophores and mineral imbalance, and slow growth rates (**41-44**). Studies show that these effects will persist from 1 year up to 7 depending on amount of oil and environmental conditions.

6.2 *Biota Associated with Mangrove Forests*—Mangrove forests provide shelter and support for an extensive system of biota including algae, crustaceans, and molluscs. Dissolved and dispersed oil can cause lethality to mangrove biota at levels as low as 20 ppm and naphthalene as low as 0.4 ppm on prolonged contact (**43-52**). Studies have shown that the abundances of species inversely correlated with the apparent oil damage (**53**). Other studies have shown that the specific numbers of a given species did not necessarily correlate with oil content (**54**, **55**).

6.3 *Coral Reefs*—Corals can be exposed to oil by two modes, direct oiling and through the uptake of dissolved or dispersed oil. Direct oiling occurs rarely but can result in extensive mortality. The uptake of dissolved and dispersed oil can result in severe mortality at levels as low as 12 μL/L for prolonged exposures (**56**). Corals are not usually subject to harmful concentrations of water-borne hydrocarbons by the passage of a slick overhead and are typically unaffected (**57-60**). Similarly, corals have been shown to reject particles of oil larger (>60 μm) than dispersed droplets (**61**). Corals are, however, particularly susceptible to high concentrations of dissolved and dispersed oil and this may lead to long lasting effects or mortality (**43**, **44**, **48**, **62-65**). Because dispersants move oil into the water column, they may increase the effect of the oils on corals (**5**, **66**, **67**). Exposure of corals to about 20 to 50 ppm of dissolved or dispersed oil showed that behavioral reflexes were induced in corals, however depuration was noted within a week and recovery within a few weeks (**68-70**). Some long-lasting effects of low-level exposure were observed, including reduced growth and deformation.

6.4 *Biota Associated with Coral Reefs*—Coral reefs provide shelter and support for an extensive system of biota. Prolonged exposure to dissolved and dispersed oil can cause lethality to reef biota at levels as low as 20 ppm (**12**, **43-48**, **51**, **52**, **71-73**). Studies have shown that the abundances of species inversely correlated with apparent oil damage (**74**). Increasing amounts of oil availability, such as through the use of dispersants, increases the exposure of organisms to oil (**75 and 76**).

6.5 *Seagrasses*—Seagrasses can be exposed to oil by two methods, direct oiling and through the uptake of dissolved or dispersed oil. Direct oiling occurs rarely but can result in extensive mortality (**17**). The uptake of dissolved and dispersed oil can result in severe mortality at levels as low as 100 μg/L (**77**). Seagrasses are not usually subject to harmful concentrations of water-borne hydrocarbons by the passage of a slick overhead and are typically unaffected (**78-80**). Seagrasses are, however, particularly susceptible to high concentrations of dissolved and dispersed oil and this may lead to long lasting effects or mortality. The lethal toxicity to seagrasses varies very much with species, and is between 75 to 125 ppm in 100 h (**81**, **82**). Use of dispersants may increase the exposure of seagrasses to oil (**83**, **84**).

6.6 *Biota Associated with Seagrasses*—Seagrasses provide shelter and nutrients for an extensive system of biota (**85**, **86**). Dissolved and dispersed oil can cause lethality to these biota at levels as low as 20 ppm (**12**, **43-48**, **51**, **52**, **71-73**). Increasing amounts of oil availability, such as through the use of dispersants, increases the exposure to organisms (**75**).

7. Recommendations

7.1 Dispersant use decisions must be based on the net environmental benefit analysis of use versus non-use of dispersants.

7.2 Dispersant use decisions should include consideration of the proximity of the dispersant application to sensitive marine environments including mangrove forests, seagrasses and corals.

7.3 An important consideration is the flushing rate of water in the mangrove, seagrass and coral areas. If the flushing rate is rapid, dissolved and dispersed oil will have minimal effects.

7.4 In many jurisdictions there are regulatory limitations in water depth (3 to 30 m) that dispersants can be applied. These limitations shall be followed.

7.5 Dispersants are best applied in deep waters and not in direct proximity to mangroves, seagrasses and corals.

7.6 Chemical dispersion should be considered a viable option even if dispersed oil might enter the mangrove forest. Dispersants should not be used to remove oil adhered to mangroves or shorelines. Shoreline cleaners or surface washing agents can be considered for removing adhered oil.

7.7 Application of dispersants to prevent oil from entering the sensitive habitats of tropical environments should be considered to minimize environmental impact.

7.8 The potential environmental impact of the dispersed oil plume trajectory should be considered.

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