R&D COMMITTEE

USE OF CHEMICAL DISPERSANTS ON OIL SPILLS

An Information Sheet on the Use of Chemical Dispersants as a Spill Response Strategy
June 1993

Summary—This fact sheet summarizes present information on chemical dispersants as a potential response tool for open-water application to oil spills. Chemical dispersants combine with oil and break a surface slick into small droplets, which wind, waves, and currents mix into the upper meters of the water column. Since the Torrey Canyon incident in 1967, dispersant formulations have dramatically changed. Compared to undispersed oil, most of today's common dispersants are of relatively low toxicity. Decisions regarding the use of dispersants must emphasize the potential effectiveness of the dispersant for a specific incident and evaluate the environmental trade–offs of the dispersant's toxicity to specific components of the open–water ecosystem against the adverse ecosystem effects of the oil itself. Dispersant effectiveness is affected primarily by the type of oil, environmental conditions, and the age of the spill (i.e., whether emulsification has occurred). Since use of dispersants assumes that not all oil can be collected by mechanical means before shoreline impact occurs, identification of those ecosystem compartment(s) where oil, or dispersed oil, will cause the least environmental impact govern environmental trade–offs. Dispersant use for open water oil spills should be considered as another tool available to responders if spill conditions meet specified criteria.

History and Past Use—Due to the lack of a validated method of evaluating dispersant effectiveness in the field and public perception of dispersant toxicity, considerable controversy exists concerning their use. The first large-scale use of dispersants was in response to the 1 million bbl spill of crude oil from the **Torrey Canyon** which grounded off the English coast in 1967. Over 10,000 bbl of various dispersants (mostly highly toxic degreasing agents) were sprayed on the water and shore, causing substantial biological impacts which received world–wide publicity. Since that time, adequate studies documenting their effectiveness in comparison to their publicized toxicity during the **Torrey Canyon** spill have not been conducted. Dispersants have been applied to several other large marine oil spills: the **Eleni V** (English coast, 1978), the **Hasbah 6** well blowout (Saudi Arabian coast, 1978), the **Ixtoc I** well blowout (southern Gulf of Mexico, 1979-1980), the **Betelguese** (Bantry Bay, Ireland, 1979), the **Puerto Rican** (California coast, 1984) and the **Braer** (Shetland Islands, 1993). However, lack of controls, ad hoc observations, poor documentation, and lack of objective criteria for effectiveness have made these situations less informative than might have been expected. Dispersant application during the **Exxon Valdez** spill similarly gave uncertain results: the initial test application did not show significant dispersion possibly due to inadequate wave action and poor visual conditions for verification, and subsequent adverse weather prevented further tests of effectiveness and subsequent use, due to weathering of the oil. Due to public perception and the fact that the decision process is not finalized for a spill before oil emulsifies, no other large-scale attempts have been made to use dispersants in the U.S. However, dispersants are routinely used in Europe both operationally and on intentional test spills. Effectiveness evaluation of these applications is limited to visual observations.

Information presented at recent dispersant workshops and the mood of the professional community indicate renewed interest in including dispersant use in contingency plans, probably due to the lower toxicity of newer products on the market, the fear of the devastating effects of an untreated catastrophic oil spill, and the specification in the Oil Pollution research questions remaining that are the subject of controversy today: the ability of available dispersant formulations to effectively disperse oil for specific conditions; the effects, both acute and longer term of the dispersants and dispersed oil on the various marine environments; and methods to monitor the effectiveness of dispersant application under spill conditions.

Mechanics of Dispersants—The key components of a chemical dispersant are one or more surface-active agents, or surfactants, which contain molecules with both water- compatible and oil-compatible portions. Most formulations also contain a solvent to reduce oil viscosity and facilitate dispersal. The surfactants reduce the oil-water interfacial tension, thus requiring only a small amount of mixing energy to increase the surface area and break the slick into droplets. Early dispersant formulations were derived from engine room degreasers, and some were highly toxic. More recent formulations use less toxic surfactants and solvents.

Several actions must occur for a surface oil slick to be chemically dispersed: (a) the surfactant must be applied to the oil in an appropriate ratio; (b) the surfactant must mix with the oil or move to the oil/water interface; (c) the molecules must orient properly to reduce interfacial tension; (d) energy (such as waves) must be applied to form oil droplets; and (e) the droplets must not immediately coalesce.

Effectiveness—A number of factors influence the effectiveness of dispersants: the properties of the oil; slick thickness; oil-to-dispersant ratio; surfactant loss at water surface; surface tension; wind and wave energy; emulsion formation; and water temperature and salinity. Dispersant ratios must be adequate to reduce surface tension and be appropriate for the thickness of the slick. Dispersant droplet size must be smaller than oil film thickness. Present formulations are not available for fresh water, salinities greater than 40 ppt and arctic conditions, although research is ongoing to address these environments.

Various methods and tests have been devised to measure dispersant effectiveness. Most of these tests have been conducted in the laboratory, but not in the field. Discussions at an EPA-sponsored workshop indicated that present field tests on dispersant effectiveness are qualitative in nature and are very limited in quantitative terms. Past laboratory test results on effectiveness are contradictory, as there has been no validation of industry–submitted data, tests were conducted under "ideal" conditions, and tests were required for only one type of oil. In most cases, laboratory results can be used only as guidelines to estimate dispersant effectiveness during a field application.

At this time, the data available on different products are not directly comparable and cannot be relied upon for field decisions. However, discussions have been carried out within EPA to conduct effectiveness tests by the agency and to require products listed on the National Products List to exceed an effectiveness criterion.

Toxicity—Toxicity is the potential of a material to cause adverse effects in a living organism. Estimates of toxicity depend on experimental physiochemical and biological factors. Many early studies of the joint toxicity of oil and dispersants erroneously concluded that dispersed oils were more toxic than oil alone. In addition, many laboratory studies exposed biota to concentrations far above those expected in field situations. Recent studies conclude that the toxicity of chemically dispersed oil resides not in the dispersant but primarily in the oil droplets (for some species) and the low molecular weight and dissolved, aromatic, and aliphatic fractions of the oil (for most species).

Dispersant and oil concentrations decrease exponentially from the air-water interface to a depth of 10-12 meters. At these depths, values reach a level deemed no longer harmful to organisms in the area of a spill. In areas with restricted water circulation or shallow depths, the adverse effects of dispersed oil may be greater than the effects of the oil alone due to inadequate dilution. Absence of regional field data on dispersant effects on species of local significance often hampers site-specific decision making. Such species need to be identified during the planning phase to allow testing to be done.

Operational Constraints—Large spills cannot be treated in their entirety, but dispersants can be used tactically under favorable conditions to protect sensitive shoreline areas. Dispersant use may be very limited in cold water because the viscosity of the dispersants are affected to a greater degree than previously thought. The effect of limiting environmental conditions such as calm seas or strong winds must be taken into account when dispersant application is considered. Probability of a successfully operation depends upon the on-scene availability of adequate equipment, logistics, trained personnel, and dispersant to launch a timely operation, before the spill conditions preclude dispersant effectiveness.

The NCP Product Schedule lists over 50 available products for use as dispersants, based upon industry–submitted toxicity and effectiveness data. However, a current U.S. Coast Guard database review indicates that only Corexit 9527 is available in large enough quantities for a major spill response.

Recommendations—Caution and discretion should be used in applying dispersants to small marine spills. Further, dispersants should not be used in large, freshwater bodies of water (e.g., Lake Michigan) or marine waters that are restricted in flow, are shallow, and contain a large population of organisms (e.g., Chesapeake Bay). The decision concerning what mix of countermeasures to use on a given spill depends on the size and location of the spill, the type of oil, the weather and sea conditions, and the availability of the various countermeasures, including deployment. The use of dispersants should be considered when sensitive shoreline (e.g., wetlands) or surface ecological environments (e.g., those used by surface–feeding birds) are threatened or when important aesthetic (recreational beaches) or socioeconomic areas (e.g., marinas) could be adversely affected. The contingency planning phase must rank important environments for protection, both with mechanical means and by chemical measures, and define the criteria for use of such measures. The decision to use dispersants must evaluate whether it could reduce adverse environmental impact, whether it is the best response tool available to protect certain sensitive resources based upon the conditions of a spill, and whether a dispersant operation could be successfully launched.