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Discussion of Oil Thickness/Concentration/Dosage Values

The figure "Slick/Dosage Parameters" in the DMP2 illustrates the relationship between oil thickness and equivalent volumes of oil per unit area, or "Concentration". The figure also provides corresponding amounts of dispersant that would be needed (i.e., "dosage") for a given oil thickness or concentration. Any line drawn vertically through the figure would give, for a selected average oil thickness, the corresponding volume of oil per unit area at that average thickness, and the amount of dispersant that would be needed ("Desired Dispersant Dosage") for that Average Oil Thickness or Concentration.

Along the top of the figure are Color Descriptions (Sheen, Rainbow, Metallic, etc.) corresponding to oil thickness values that are generally used within the oil spill response community. There is still some controversy over the precise thickness range that should be assigned to a given color category, as well as the number and description of those categories. However, these five categories and their corresponding thickness values are consistent with recent studies (BONNEX, 2002) and with recent efforts to establish common terminology among aerial observers (ASSIST, 2005).

Any attempt to estimate the volume of oil associated with a slick of a given appearance (or color category) is, of course, extremely difficult because of the uncertainties associated with slick dimensions, % coverage for a given color within those dimensions, and the broad range of thickness values associated with each color category (typically a full order of magnitude). Volume estimates should be bounded with minimum & maximum values reflecting the uncertainties associated with slick dimensions, %-coverage, and the full range of possible slick thicknesses. The stars shown within each color category are provided as suggested "nominal thicknesses", or near-mid-range-values, for each of the color categories. These are useful for the selection and possible use of "nominal" or "order-of-magnitude" values for oil thickness, concentration, and dosage associated with each color category.

As an example, if oil is observed within the Transitional Dark category, a nominal average thickness might be used as approximately 0.1 mm (a few thousandths of an inch). This order-of-magnitude estimate would correspond to a nominal concentration of 100 cubic meters of oil per square kilometer (~2 ½ bbl/acre), or ~ 100 gallons/acre. The Desired Dosage, at a dispersant-to-oil ratio (DOR) of 1:20, would therefore be 1/20 x 100 gallons/acre, or 5 gallons of dispersant per acre. The dosage selected for EDAC calculations (i.e., 5 gal./acre) is shown in the figure with corresponding thickness and concentrations very close to those used in this example.

At the bottom of the figure horizontal bars serve as reminders of the range of oil conditions that one could associate with oil slicks that have progressed through the rapid spread stages, influenced strongly by gravity and the viscosity of the oil. When spreading oil reaches a relatively stable condition where additional spreading is reduced considerably under calm conditions (sometimes referred to as “equilibrium” condition), average oil thicknesses may range from a few hundredths of a millimeter to a few tenths of a millimeter. Thin rainbow to silvery sheen films will normally exist around the perimeter of these slicks, taking on a greater percentage of the entire spill area as currents, wind and sea conditions continue to spread the oil.

Emulsions, viscous oils, and even light-to-medium-weight oils spilled onto very cold waters, will often achieve a thicker stable “equilibrium” condition that may be one to two orders of magnitude thicker (i.e., from nearly one to several millimeters in average thickness). These so-called “stable” thicknesses may not last long depending on the wind and sea conditions, and on the oil’s tendency to spread, emulsify, evaporate, and degrade. The important point is that crude oils, especially dark crude oils, will typically appear dark (or “true” in color) at these stable thicknesses and thicker. Unless bounded or herded by booms, winds, convergence zones, shorelines, etc., such dark layers will likely fall within the “Transitional” to continuous “Dark” categories, representing at least 1 to 100 bbl of oil per acre. It is no coincidence that the “achievable dosages” with most fixed-wing aircraft correspond nicely to this range of oil concentrations when spraying with DORs of 1:20 to 1:50 (note fixed-wing dosage bars in the figure). If necessary, fixed-wing platforms can normally achieve the required overall dosages for the heaviest slicks using multiple passes over the same slick.

When oil slicks are dark in color and are not free to spread (e.g., when contained or herded), it is impossible to estimate oil thickness by appearance alone. However, at sea, under most conditions, an experienced observer can usually determine if an uncontained slick contains sufficient “dark” or “true-colored” oil to justify the use of chemical dispersants. Based on his/her own experience with the spilled (or similar) oil and the conditions that influence spreading & emulsification, an experienced observer can generally anticipate the “desired” dosage, thus providing meaningful input for an effective “achievable” dosage. If a system’s swath, speed and pump rate can not be adjusted to achieve the required dosage in a single pass, then multiple passes may be required. Unlike fixed-wing platforms, the use of vessels and helicopters allows one to operate over a broad range of application speeds, thereby enabling a broader range of achievable dosages, and avoiding the need for multiple passes.

Everyone (field personnel, supervisors, Incident Command, regulators, environmental groups, advisors, the media, etc.) must recognize that the physical and chemical properties of spilled oil, and the rates at which these properties change, create conditions that challenge the very best of equipment, techniques and intentions we can ever use to track, contain, recover and eliminate spilled oil. Studies, laboratory experiments, field exercises and actual spill events have given, and will continue to provide, meaningful tools and guidelines for efficient spill response. However, because of the uncertainties associated with spreading and transport, with different oils, in different environments, the best of our spill response “science” is often reduced to “best estimates”, “best available resources”, and “best intentions”. Nevertheless, these efforts have lead to continuous improvement in the development of efficient response strategies and demonstrated effectiveness under many circumstances.

With dispersants, for example, the natural variability of oil slick size, shape and thickness make it nearly impossible to actually achieve a "desired" dosage based on estimated dispersant effectiveness for a given dispersant-to-oil ratio (DOR). Within a single spray system's swath there is likely a variation of several orders of magnitude in oil slick thickness. The best of research into controlled pump rates, nozzle design, droplet size and modification due to wind shear, evaporation, etc. still can't correct for the constantly changing and non-uniform oil distribution on the surface. We will always have some portions of the slick over-dosed and under-dosed; some dispersant will miss oil completely; and wind or platform-generated air currents will complicate the ultimate deposition of the dispersant upon the intended target slick. In addition, there is the challenge of timing "on" and "off" commands associated with high-speed platforms flying at 50- to 100-ft altitudes; the need to turn and realign without gaps and excessive overlap between successive passes; and, the difficulty of judging whether application parameters (e.g., pump rate or speed) should be adjusted to account for perceived effectiveness when effective dispersion may not be visible for minutes, hours, or at all. In spite of these inherent inaccuracies, dispersant operations have been successfully carried out in the United States, Europe, Africa, and Asia Pacific with significant success and minimal unexpected environmental consequences.

These uncertainties should not discourage or frustrate responders, regulators, etc. into avoiding the use of chemical dispersants. Instead, we should simply recognize the inherent limitations of the dispersant option, strive to minimize any negative effects or inefficiencies because of these uncertainties, continue to test and refine our tools and techniques, and develop realistic expectations involving meaningful Effective Daily Application Capacities (EDACs). Just as these and other environmental factors serve to confound the effectiveness of other response options, there will be times and places where dispersant application may not be effective, or may be of limited value. Net benefit analyses and ecological risk assessments should be conducted as appropriate for different environmental conditions and potential exposures.

Other response options such as mechanical containment/recovery and controlled burning also have significant constraints and uncertainties associated with their effective use on open water. The rapid spread of oil over large areas, complicated by the same irregularities in size, shape and thickness discussed above, means that any response option governed by areal coverage rate (i.e., swath and speed) will have a potential Oil Encounter Rate that is dictated by the amount of oil available (i.e., "concentration"). It is important that planners, regulators, responders, etc. examine these options with the same awareness of oil and environmental constraints, and with the same appreciation of system performance limitations that is needed for the effective use of dispersants.