Standard Guide for Use of Oil Spill Dispersant Application Equipment During Spill Response: Boom and Nozzle Systems[1]

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1. Scope

1.1 This guide covers the essential considerations for the maintenance, storage, and use of oil spill dispersant application systems.

1.2 This guide is applicable to spray systems employing booms and nozzles and not to other systems such as fire monitors, sonic distributors, or fan-spray guns.

1.3 This guide is applicable to systems employed on ships or boats and helicopters or airplanes.

1.4 This guide is one of four related to dispersant application systems. Guide F 1413 covers design, Practice F 1460 covers calibration, Test Method F 1738 covers deposition, and Guide F 1737 covers the use of the systems. Familiarity with all four standards is recommended.

1.5 The values stated in SI units are to be regarded as the standard. The inch-pound units given in parentheses are for information only.

1.6 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

F 1413 Guide for Oil Spill Dispersant Application Equipment: Boom and Nozzle Systems[2]

F 1460 Practice for Calibrating Oil Spill Dispersant Application Equipment Boom and Nozzle Systems[2]

F 1738 Practice for the Determination of Deposition of Aerially Applied Oil Spill Dispersants[2]

3. Significance and Use

3.1 This guide provides information, procedures, and requirements for management and operation of dispersant spray application equipment (boom and nozzle systems) in oil spill response.

3.2 This guide provides information on requirements for storage and maintenance of dispersant spray equipment and associated materials.

3.3 This guide will aid operators in ensuring that a dispersant spray operation is carried out in an effective manner.

4. Equipment Types For Vessels and Aircraft

4.1 A spraying system consists of one or more pumps, flowmeters, storage tanks, spray booms, and nozzles that are mounted in various configurations depending on the platform.

4.2 Dispersant application systems on ships or boats may be portable or permanently installed. Vessels may have built-in dispersant storage tanks and on-board pumps for use with the spraying system.

4.3 Dispersant application systems on helicopters are most commonly slung beneath the aircraft, with remote controls available to the pilot. Some specially configured helicopters have integral tanks and pumps. Helicopter spraying systems are available with dispersant capacity of about 500 to 2000 L (120 to 500 U.S. gal).

4.4 Dispersant application systems on single-engine airplanes have a built-in tank and pump, with the booms attached to the wings. Dispersant capacity varies with the airplane design but is about 400 to 4000 L (100 to 1000 U.S. gal).

4.5 Dispersant application systems can also be installed on large multiengine airplanes. These must be designed for each type of aircraft, and will include one or more pumps, flowmeters, dispersant storage tanks, and spray booms with nozzles. The airplane type and payload capability will determine the available dispersant capacity from about 4000 to 20 000 L (1000 to 5000 U.S. gal).

5. Equipment Configuration for Vessels and Aircraft

5.1 *Vessels*—Dispersant spray systems for boats have been designed for many types of craft. Most systems use water-compatible "concentrate" dispersants diluted with seawater during application. These dispersants are mixed with seawater by use of an educator or metering pump to allow for the dispersant to be used at the desired concentration (generally 5 to 10 %).

5.1.1 Mount the spray booms as far forward as possible so that the spray is applied in front of the bow wave, because, this wave can push oil out of reach of the spray at typical boat speeds. Nozzles and extensions should be downward-pointing

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[2] *Annual Book of ASTM Standards*, Vol 11.04.

and stable relative to the boom. Rig spray booms with multiple nozzles arranged to produce flat, fan-shaped spray patterns, striking the water (oil) surface in a line perpendicular to the direction of travel of the vessel. Nozzles producing a hollow-cone shaped spray pattern should not be used. Spray pressure should not be excessive so that the spray does not break the oil surface. Deliver the dispersant-water mixture to the oil surface, in the desired pattern, with a minimum amount of energy. The spray should strike the oil in small droplets of 300 to 500-μm volume median diameter (VMD). The droplets should be visually larger than a fog or mist and smaller than heavy rain drops. The fan-shaped sprays from adjacent nozzles should overlap just above the oil surface.

5.1.2 Relatively small spills, such as in harbors or rivers, may best be treated by vessels, but they are limited on large offshore spills by their spray swath and speed. For example, a boat operating at 10 km/h (5 knots or 6 mph), and spraying a 12-m (40-ft) swath, can only treat about 0.5 miles^2 (1.3 km^2) of oil spill surface in about 12 h.

5.2 *Helicopters*— Spraying systems on helicopters are either integral (attached to the airframe) or external units that have a combined tank, pump, and spray boom assembly suspended below the aircraft from a cargo hook, as specified by the manufacturer of the bucket. Sufficient room must be allowed between the helicopter and the spray unit to allow for safe connection and disconnection. Spraying is controlled from the cockpit with an electrical remote control unit, attached by cable to the spray system. Nozzles should be oriented parallel to the direction of travel and pointed aft on the spray boom. Only concentrate dispersants applied without dilution are suitable for aerial spraying. The spray-boom altitude, when spraying, should not be over 9 m (30 ft).

5.2.1 Helicopters are limited in the volume of dispersant they can carry, typically under 2000 L (500 U.S. gal). They have greater speed than vessels, however, and if working near the source of dispersant supply, helicopters provide very efficient dispersant application on small areas.

5.3 *Small Airplanes*— Small single-engine airplanes typically will have a wind-driven pump that draws dispersant from a tank to feed the spray booms, that are usually fitted close to the trailing edge of the wing. The dispersant is discharged through nozzles (spaced at intervals along the boom) that are designed to generate droplets within the required size range. The dispersant pump should be capable of spraying at a rate that is required for a surface coverage of 20 to 100 L/hectare (2 to 10 U.S. gal/acre). The pump rate should be variable in flight, and regulated and monitored with a pre-calibrated flowmeter or pressure gage. Air shear, that affects droplet size, may be a problem for lower viscosity dispersants of less than 60 mpa (cSt), at aircraft velocities exceeding about 200 km/h (100 knots or 120 mph). The spray-boom altitude during application should not be over 9 m (30 ft).

5.3.1 Small airplanes generally have limited load capacity, about 400 to 3000 L (100 to 800 U.S. gal). This size of aircraft may provide rapid response to small spills, and has longer range and greater speeds than a helicopter system.

5.4 *Large Airplanes*— Large multiengine, propeller-driven, airplanes offer increased payload, range, and speed for the treatment of large spills. Most of these aircraft require the installation of wing-mounted booms and other integral parts. Some large cargo airplanes have a rear cargo or personnel door that can be opened in flight, can accommodate portable tank systems, and have extendable booms that can be deployed in flight. Such a system can be permanently fitted to a dedicated airplane, or installed as needed in an airplane of opportunity. These systems may require specific certification by aviation authorities for use on a particular type of aircraft.

5.4.1 These larger aircraft will generally fly at altitudes of 15 to 30 m (50 to 100 ft) when applying dispersant to the oil.

5.4.2 The largest dispersant liquid capacity for such aircraft is 20 000 L (5000 U.S. gal). Aircraft range and payload characteristics can limit the dispersant volume. Application rates from 20 to 100 L/hectare (2 to 10 U.S. gal/acre) can be achieved. Typical coverage for these systems is 30 hectares/min (75 acres/min) at 130 to 150 knots.

6. Control of Spraying Operations

6.1 Whichever method is employed to apply dispersants, an objective assessment is required to ensure that a vessel or aircraft spraying operation is conducted properly and effectively. Direction of the operation and observation of its effectiveness can best be conducted from another controller (spotter) aircraft overhead. This can be a light airplane or helicopter, but it must have a high endurance and good radio communications with the spray aircraft or vessel. An airborne observer can not function adequately in the spraying aircraft. To ensure safety in such a case, all the aircraft must have planned for, and maintained, continuous communications.

6.2 Personnel in the controller (spotter) aircraft can identify the heavier concentrations of oil (or those slicks posing the greatest threat), direct spray aircraft or boats to the target, request spraying to be started and stopped, and judge the accuracy of the application. These aerial functions are important for spraying operations since oil visibility from a vessel or a spray plane is limited. Air support is essential when large multiengine aircraft are used for spraying. Even when using helicopters and small airplanes for spraying, it is not reasonable to rely on pilot observation, since all of the sprayed area is behind the aircraft. Consequently, the area of coverage and the effect of the dispersant is better seen by an observer in a control plane at a higher altitude, who also can better direct the spray plane on the next pass, in the same or a different treatment area.

7. Storage and Handling of Dispersant and Dispersant Application Systems

7.1 Dispersants are to be handled and stored in accordance with information provided by the manufacturer's Material Safety Data Sheets (MSDS), labels, and user-specified policies. (See 10.1.)

7.2 Dispersant application systems will normally be loaded, by means of pumps, with dispersants from drums, storage tanks, or tank trailers. Pumps of adequate capacity must be available to load dispersant rapidly in order to reduce aircraft downtime between sorties.

7.3 Conduct routine maintenance on dispersant application systems and subcomponents in accordance with the manufacturer's recommendations, to ensure system readiness and availability for immediate use.

7.3.1 Nozzles on dispersant application systems must be cleaned and inspected after each day's operation and before storage of the system. Pumps and systems using seawater (as from vessels) must be rinsed well with fresh water.

7.3.2 The system calibration should be checked at least once a year (see Practice F 1460). Spray systems should be cleaned, and the calibration checked, after each exercise or spill incident in which the equipment was used, and after making any changes in the system configuration. Also, systems must be completely drained and freeze-protected, as necessary, after each use.

7.3.3 Any remote control devices used in operation of a dispersant system should be checked immediately prior to any use of the system.

7.3.4 Operating crews should be given comprehensive training in dispersant application systems installation and methods of use. Practical exercises should be held frequently.

8. General Considerations for Dispersant Application

8.1 *Primary Considerations*:

8.1.1 Use of dispersants, particularly in a specific area, may be subject to regulatory approval. Dispersant response is for use in the early stages of a spill; so, it is strongly recommended that a rapid approval mechanism, or pre-approval, be part of response planning.

8.1.2 *Nature of Oil Slick(s) to Be Treated*:

8.1.2.1 The effectiveness of dispersants is dependent (assuming proper application) on two factors; the oil composition and the sea surface energy. The primary factor is the oil composition. Heavier oils, those that contain large amounts of components such as asphaltenes, disperse poorly, and those which have only a small amount of these disperse more easily. As oil weathers on the sea surface, its composition changes and it generally becomes less dispersable. Some oils can also form highly viscous water-in-oil emulsions, known as "chocolate mousse," particularly in areas of high energy waves. Once mousse has formed, dispersants may not be effective.

8.1.2.2 Viscosity is an indicator of the oil composition, but affects dispersion by its influence on the amount of dispersant penetrating into and mixing with the oil. Dispersant can run off the surface of highly viscous oils or will mix only slowly with them. Traditionally, oils of a viscosity between 2000 and 10 000 mPa were thought to be undispersable. However, viscosity may not be as much a limitation as is composition as noted above, especially for dispersants which are not quickly lost to the water column. Viscosity may have its largest effect on the time required for mixing with the oil.

8.1.2.3 Natural weathering (evaporation) affects the composition and viscosity of the oil. Much of the oil evaporated will usually consist of the most dispersable fraction. Also, loss of the lighter fractions by evaporation increases the viscosity. This combined effect may rapidly reduce the dispersability of some spilled oils. Some oils are not effectively dispersed after only 24 h on the surface.

8.1.2.4 Surface sea energy can be an important factor in dispersant effectiveness. Higher sea energy is needed to disperse oil of less favorable composition. Very low sea energies often result in poor dispersant performance. Very high seas can be detrimental since they can promote water-in-oil emulsion formation and can cause oil slicks to become discontinuous or submerged. Spraying such slicks can result in significant dispersant loss.

8.1.3 *Environmental Conditions, Including Wind, Sea State, Visibility, and Temperature of Air and Water*— It is essential to minimize dispersant loss in aerial application due to wind drift and air turbulence. Large droplets assist in this, but, in addition, the aircraft should be flown as low as safety considerations allow. It is also best to fly into the wind while spraying, so as to limit wind drift.

8.1.4 *Availability of Application Logistic Support*:

8.1.4.1 Dispersant spraying from vessels has limitations due to the low area coverage rate and the inherent difficulties of locating oil slicks from a vessel. Vessels of all sizes need the assistance of an aircraft overhead to direct them in spraying dispersants.

8.1.4.2 Small airplanes with high endurance, low fuel consumption, rapid turn-around times, and an ability to operate from short and even improvised landing strips may be suitable for spraying close to shore. The ability of helicopters to spray in confined situations and operate from a base very near the spill site is often valuable, but only provided that an adequate supply of dispersant can be maintained in such areas. The advantages of larger multi-engine airplanes in range, payload, and speed has to be weighed against the need for longer runways, greater operational support, and the location or delivery site of dispersant supply.

8.1.4.3 Good organization is needed to maintain spraying operations for the maximum available time during daylight hours. This may require maintenance of equipment and replenishing of supplies during the night. Supplies of fuel and dispersant for aircraft and vessels are critical and must be maintained. Dispersants will usually be supplied in drums and often delivered in quantity to a large airport. Delivery in bulk by trucks or road tankers, with high-capacity pumps, could supply areas (and possibly smaller aircraft) nearer to the spill location; although, loads of dispersant in drums may be adequate to support a small-scale operation.

8.1.4.4 Further, provision must be made for relief crews for both flight and ground operations as the operation requires.

8.1.5 *Dispersant Stockpile*:

8.1.5.1 An adequate supply of suitable dispersant should be available to support at least two days of spray operations. For large spray operations, up to about 200 000 L (50 000 U.S. gal) may be required near the spill location. Both the supply of dispersant and the availability of freighter aircraft on short notice should be addressed in response planning.

8.1.5.2 Resupply of dispersant can be a limiting factor in continuing a dispersant spraying operation. Dispersant applications can continue during daylight hours, and five or more sorties by each airplane are possible per day, depending on the distance of the flight base from the spill and the facilities at the base.

8.2 *Calculation for Dispersant Application*:

8.2.1 The application rate required is determined by the type of oil, its thickness, and the prevailing conditions. Control of the application rate can be achieved in two ways, either by varying the pump discharge rate or the vessel or aircraft speed. The general relationship between the variables is shown as follows:

$$\frac{pump\ discharge\ rate}{(L/min)} = 0.003 \times \frac{application\ rate}{(L/h_a)} \times \frac{speed}{(knots)} \times \frac{swath\ width}{(m)}$$

8.2.2 As an example, a slick estimated to be about 0.2 mm thick, would represent an oil volume of 2 m^3/hectare, and a dispersant application rate of 50 to 100 L/hectare (5 to 10 gal/acre) would be required if a concentrate dispersant was used at a dispersant to oil ratio of 1:20. A vessel traveling at 10 knots, spraying a swath width of 30 m, would need to discharge dispersant at a rate of 100 L/min (25 U.S. gal/min) to achieve this application rate. If an aircraft flying at 90 knots (105 mph) with an effective swath of 15 m was used instead to treat the same slick, a discharge rate of 400 L/min (100 U.S. gal/min) would be required.

8.3 *Correlation of Slick Thickness With Volume per Unit Area and Practical Dispersant Application*.

8.3.1 The purpose of all oil spill response, including use of dispersants, is, so far as possible, to prevent spilled oil from reaching and impacting shorelines, or from entering areas of particular environmental sensitivity. Within this parameter, it is usually most important to concentrate on the treatment of the thickest regions of the slick. It is ineffective and inappropriate to apply dispersants on sheens. Typically, these two types of slicks can be easily identified from the air.

8.3.2 Dispersant application rates of the order of 30 to 100 L/hectare (3 to 10 U.S. gal/acre) have been found to be appropriate in most situations. Thicker patches may call for an increase in the application rate. It is best to start treatment of the oil at a rate of about 50 to 70 L/hectare (5 to 7 U.S. gal/acre) and reduce this as indicated by the observed results. Some spills have been treated successfully with 20 to 30 L/hectare (2 to 3 U.S. gal/acre). Discharge rates can be varied providing the nozzles selected produce a stable spray and the discharge is monitored by a flowmeter or other calibrated system.

9. Vessel and Aircraft Safety

9.1 Great care should be used while working around vessels or aircraft. The many hazards normally associated with operation of equipment is compounded with the rolling of vessels and the presence of rotating propellers of aircraft. The captain of the vessel, or the pilot of an aircraft has the final approval or disapproval of all activities conducted by or upon their craft. Operators of vessels and aircraft should make auxiliary personnel aware of the particular safety concerns associated with their operations. The crews of these vessels and aircraft have training and experience that go beyond the scope of this guide. Their instructions concerning the operation of, and safety precautions related to, their craft should be heeded without question.

9.2 Dispersants can create a slippery, and therefore unsafe, work area, especially on the deck of a vessel, and spills should be minimized by promotion of good housekeeping. Dispersants also exhibit a strong degreasing action and regular checks are recommended to ensure that they do not contaminate lubricants on machinery. Vessels and aircraft should therefore be hosed down regularly with fresh water to remove salt water spray as well as dispersant.

10. Dispersant Deployment and Monitoring Activities

10.1 It is important that all workers are well trained in handling dispersants and wear appropriate personal protective equipment (PPE) when transferring a chemical to boats or airplanes. Excessive exposure to the chemical vapors should be avoided, as recommended or required by the particular MSDS. Any personnel aboard vessels near the area where dispersants are being used should remain off open decks until the spraying operation is concluded. If dispersant mist consistently blows onto crew areas of vessels engaged in spraying, the spray system needs to be evaluated for the need to change the nozzle design or the pump operation and pressure, so that the dispersant is deposited at the desired dosage on the oil only.