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

1. Scope

1.1 This guide covers design criteria, requirements, material characteristics, and essential features for oil spill dispersant application systems. This guide is not intended to be restrictive to a specific configuration.

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

1.3 This guide covers systems for use on ships or boats and helicopters or airplanes.

1.4 This guide is one of four related to dispersant application systems. One is on design, one on calibration, one on deposition measurements, and one on the use of the systems. Familiarity with all four guides is recommended.

1.5 *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. Equipment Description

2.1 *General*—Oil spill dispersant spray systems include one or more booms with nozzles to form droplets, a pumping or pressure system to deliver dispersants to the boom, and associated piping and valving. All systems shall include a dispersant flow meter and a pressure gauge. All systems shall be equipped with provision for cleaning and drainage.

2.2 *Ship/Boat*—Each boom holding nozzles shall be designed to be mounted near the bow of the vessel so that the spray is uniformly deposited on the slick surface. Spray units can be portable or fixed. Flow correction or straightener devices, to ensure laminar flow, shall precede the nozzles. System components should be designed to give a uniform droplet spray as described in this guide. The spray pattern should be flat and strike the water in a line perpendicular to the vessel's line of travel. The nozzle spray angle should be such that spray from adjacent nozzles overlap just above the water.

2.3 *Airplanes*—Mounting of spray booms on aircraft is subject to federal regulation. Each installation or modification requires approval.

2.3.1 Nozzles may not be necessary on aircraft flying at speeds greater than 220 km/h (120 knots or 135 mph) because the wind shear alone can produce the required droplet sizes. Pressure-activated check valves must be used to eliminate drainage during nonspraying transits. In order to minimize the effects of wind shear, nozzles should be oriented aft (180° from the direction of flight).

2.4 *Helicopters*—Systems may consist of spray booms with nozzles and pump/tank assemblies directly attached to the helicopter or a bucket system slung below the helicopter.

2.4.1 The bucket system consists of a tank and pump assembly to which spray booms with nozzles are attached. The assembly is supported from the helicopter by a cable system and is remotely-controlled from the helicopter cabin. An indication of dispersant flow is required in the helicopter cockpit. The bucket must be stabilized against rotation, yaw, and sway.

3. Minimum Equipment Performance Specifications

3.1 *Target Dosage*—Oil spill dispersant spray equipment shall provide a dispersant dosage of between 20 to 100 L per hectare (2 to 10 U.S. gal per acre).

3.2 *Droplet Size Distribution*—The droplet size distribution of the dispersant reaching the target shall have a Volume Median Diameter (VMD) of 300 to 500 µm. The volume median diameter is a means of expressing droplet size in terms of the volume of liquid sprayed. The median volume diameter droplet size, when measured in terms of volume, is a value where 50 % of the total volume of liquid sprayed is made up of droplets with diameters larger than the median value and 50 % smaller than the median value. Droplets having diameters lesser than approximately 300 µm have a lower probability of hitting the target because of excessive wind drift. Particles with diameters greater than 500 µm have a high probability of penetrating through the oil slick to the water surface.

3.3 *Maximum Delivery Variation Over Swath Width*—The equipment shall be capable of delivering dispersant with a maximum delivery variance of 10 % over the swath width. The swath width is defined as the length between the points at which the delivery drops below 90 % of the design.

4. Equipment Design

4.1 *Dispersant Injection Rate*—The dispersant injection rate (for undiluted or neat application, the dispersant injection rate

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is equal to the pump rate) must be sufficient to produce the required dosage.

4.1.1 Dispersant injection rate (*DIR*) should be verified using the following Eqs:

$$DIR = 1.67 \times 10^{-3} \cdot S \cdot W \cdot D \quad (1)$$

where:

DIR = dispersant injection rate in L/min,
S = speed of the delivery vehicle in km/h,
W = swath width in m, and
D = dosage in L/ha.

Or equivalently in U.S. units:

$$DIR = 2.33 \times 10^{-3} \cdot S \cdot W \cdot D \quad (2)$$

where:

DIR = dispersant injection rate in U.S. gal/min (USGPM),
S = speed of the delivery vehicle in knots (if speed is in miles per hour multiply by 0.87),
W = swath width in ft, and
D = dosage in U.S. gal per acre (USGPA).

4.2 *Droplet Size*—Shear is the controlling factor in determining droplet size. High shear rates result in small droplet sizes. For dispersant application, a small droplet size is not desirable, because the dispersant can drift away from the oil slicks. Large droplet sizes are also undesirable because large droplets can penetrate the oil slick. Experience has shown that a droplet size between 300 to 700 µm VMD is most effective. Shear has two components, nozzle shear rate and air shear. Air shear is only important for aircraft flying at speeds greater than 150 km/h (80 knots or 100 mph).

4.2.1 *Nozzle Shear Rate*—In order to achieve the desired droplet size, nozzle shear rate should not exceed 10 000 reciprocal seconds (s^{-1}) for aircraft systems and 2000 reciprocal seconds for ship or boat systems. Nozzle shear can be calculated using the following Eqs:

$$SR = 16.7 \cdot FN/d^{3} \quad (3)$$

where:

SR = shear rate in reciprocal seconds (s^{-1}),
FN = average flow rate per nozzle in L/min (calculated from total flow (dispersant and water) divided by the number of nozzles), and
d = the diameter of the nozzle orifice in cm.

Or equivalently in U.S. units:

$$SR = 3.85 \cdot FN/d^{3} \quad (4)$$

where:

SR = shear rate in reciprocal seconds (s^{-1}),
FN = average flow rate per nozzle in gal/min (USGPM) (calculated from total flow (dispersant and water) divided by the number of nozzles), and
d = the diameter of the nozzle orifice in inches (in.).

4.2.2 *Air Shear*—In addition to the nozzle shear rate calculations shown, aircraft dispersant application systems should be designed to optimize droplet size distribution by minimizing the differential between the speed of the aircraft and the dispersant exit speed. Differential speed should be less than 60 m/s (200 ft/s) in order to ensure close to 100 % deposition within the swath width.

4.2.2.1 Differential speed shall be verified using the following Eqs:

$$SD = SA - (0.212 \cdot FN/d^{2}) \quad (5)$$

where:

SD = the differential speed in m/s,
SA = the aircraft speed in m/s (for speed in km/h multiply by 0.28),
FN = the average flow rate per nozzle in L/min, and
d = the nozzle orifice diameter in cm.

Or equivalently in U.S. units:

$$SD = SA - (0.409 \cdot FN/d^{2}) \quad (6)$$

where:

SD = the differential speed in ft/s,
SA = the aircraft speed in ft/s (multiply knots by 1.69 to get ft/s),
FN = the average flow rate per nozzle in gal/min (USGPM), and
d = the nozzle orifice diameter in inches (in.).

5. Material Characteristics

5.1 *Corrosion Resistance*—Materials on ship or boat systems should be corrosion-resistant to salt water. All materials that come into contact with dispersants should be compatible with that dispersant. Special attention should be given to pump components. Consultation with the dispersant manufacturer is recommended.

5.2 *Extreme Temperature Properties*— Systems to be used or stored at extreme temperatures should be constructed of materials that are not adversely affected by those temperatures. Temperature range specifications should be clearly indicated on the spray equipment.

6. Information Provided to User

6.1 Performance data that shall be provided to the user by the manufacturer include:

6.1.1 Estimated or measured droplet size information (VMD in µm),

6.1.2 Volumetric output distribution over the swath width (%),

6.1.3 A table of pump rates and dispersant injection rates ranging from the recommended minimum to the recommended maximum,

6.1.4 Nozzle shear rate,

6.1.5 The nozzle design height for ship/boat systems,

6.1.6 Swath width,

6.1.7 Differential speeds for aircraft systems at various pump settings and aircraft speeds, and

6.1.8 Recommended operating pressures at the inlet to the boom.

6.2 *Dosage Chart*—The manufacturer shall supply the user with a chart of dosages achievable with different application vehicle speeds and different dispersant injection rates.

6.3 *Accuracy of Data*—The data shall be accurate to two significant figures.

6.4 *Materials of Construction*—The supplier shall provide the user with a list of materials of construction.

6.5 *Nozzles and Pumps*:

6.5.1 The supplier shall provide full data on the manufacturer, model numbers, and dimensions of nozzles supplied with the spray equipment.

6.5.2 The supplier shall provide full data on the manufacturer, model number, and basic maintenance and operational data on all major components of the spray equipment including pumps, eductors, flow meters, and engines.

6.6 *Operator's Manual*—The supplier shall provide a comprehensive operator's manual including diagrams of the equipment layout.

7. Keywords

7.1 aerial spray; boom and nozzles; dispersant application; dispersant spray equipment; dispersants; oil spill chemicals; oil spill dispersants; oil spill treating agents