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

This standard is issued under the fixed designation F1413/F1413M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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, boats, helicopters, or airplanes.

1.4 This guide is one of several related to dispersant application systems using booms and nozzles. 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *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]

F1460 Practice for Calibrating Oil Spill Dispersant Application Equipment Boom and Nozzle Systems

F1738 Test Method for Determination of Deposition of Aerially Applied Oil Spill Dispersants

3. Significance and Use

3.1 This guide will enable design of oil spill dispersant application equipment using boom and nozzle systems and ensure a desired dosage and uniformity across the swath width.

3.2 This guide provides information for designing and specifying dispersant spray application equipment to obtain optimal application rates. These include specifications for minimum equipment performance, equations for estimating operational parameters, material considerations, and a list of information to be provided to the equipment purchaser.

4. Equipment Description

4.1 *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.

4.2 *Ship/Boat*—Nozzles should be selected with the assistance of the nozzle manufacturer. 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.

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

[1] This guide is under the jurisdiction of ASTM Committee F20 on Hazardous Substances and Oil Spill Responseand is the direct responsibility of Subcommittee F20.13 on Treatment.

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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.

4.4 *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. 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.

5. Minimum Equipment Performance Specifications

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

5.2 *Droplet Size Distribution*—The droplet size distribution of the dispersant reaching the target shall have a Volume Median Diameter (VMD) of 300 µm 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. Droplet size distribution may be measured using Test Method F1738.

5.3 *Maximum Delivery Variation Over Swath Width*—The equipment shall be capable of delivering dispersant with a maximum delivery volumetric 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.

6. Equipment Design

6.1 *Dispersant Injection Rate*—The dispersant injection rate (for undiluted or neat application, the dispersant injection rate is equal to the pump rate) must be sufficient to produce the required dosage.

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

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

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:

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

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).

6.2 *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 µm 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).

6.2.1 *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:

$$SR = 16.7 \cdot FN/d^{3} \tag{3}$$

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:

$$SR = 3.85 \cdot FN/d^{3} \tag{4}$$

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.).

6.2.2 *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.

6.2.2.1 Differential speed shall be verified using the following Eqs:

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

where:

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

Or equivalently in U.S. units:

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

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