Designation: F 1738 – 96 (Reapproved 1999)

Standard Test Method for Determination of Deposition of Aerially Applied Oil Spill Dispersants[1]

This standard is issued under the fixed designation F 1738; 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 test method covers the measurement of the deposition of an aerially applied dispersant on the surface of the ground or water. The test method of obtaining these measurements is described, and the analysis of the results, in terms of dispersant use, is considered. There are a number of techniques that have been developed, and this test method outlines their application. These measurements can be used to confirm or verify the specifications of a given equipment set, its proper functioning, and use.

1.2 This test method is applicable to systems used with helicopters or airplanes.

1.3 This test method 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.

1.4 There are some exposure and occupational health concerns regarding the methods described. These are not discussed in this test method since they are a function of dispersant formulation. Anyone undertaking such experiments should consult the occupational health experts of the dispersant manufacturer regarding the precautions to be used.

1.5 The values stated in SI units are to be regarded as the standard.

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 1737 Guide for Use of Oil-Spill Dispersant Application Equipment During Spill Response: Boom and Nozzle Systems[2]

3. Significance and Use

3.1 The deposition of an aerially applied dispersant is defined as the amount of an aerially applied dispersant that contacts the surface; whereas, application dosage (frequently referred to as application rate) is the amount of material that is released per unit area by the delivery system. The units of deposition are litres per hectare or U.S. gallons per acre. The deposition may differ from the application dosage (volume of material per unit area) for many reasons, such as, the effects of wind on the spray and the evaporation of the dispersant after it has been released from the aircraft.

3.2 This test method describes the measurement of the ability of a spray system to deposit a dispersant on oil. It is not intended that this test method be used at the time of a spill. These techniques are intended to determine the equipment performance during the development of new systems and after the repair or significant modification of a system.

3.3 The data obtained from the use of this test method can be directly related to the deposition of dispersant on an oil slick, and thus can serve to determine both the dispersant deposition and the droplet size.

3.4 Dispersant deposition and droplet size data can be used as a technical basis for the optimization of dispersant application equipment and its use.

4. Apparatus and Materials

4.1 The basic concept is to provide a collection surface on which the aerially applied material is deposited. The amount of material and the deposition pattern and its droplet size can be measured using this surface. Several systems and methods have been developed, and each has its own advantages and disadvantages.

4.2 These measurements require a large, flat open area (such as a field or an airport) which is suitable for low-level flying and maneuvering. The location should be away from human habitations or environmentally sensitive areas in order to minimize problems due to noise and drifting spray.

4.3 These field programs should be conducted under low-wind conditions in order to minimize drift. Near-surface turbulence due to thermal gradients or atmospheric instability

[1] This test method is under the jurisdiction of ASTM Committee F-20 on Hazardous Substances and Oil Spill Response and is the direct responsibility of Subcommittee F20.13 on Treatment.

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

can contribute to a variation in the results. These measurements cannot be carried out in the presence of precipitation or in heavy concentrations of dust.

4.4 All tests are to be conducted with the flight path in an upwind direction. The upwind direction is chosen to simplify the interpretation of the data and to conform with typical field practice. It may be necessary to alter the flight path slightly for changes in wind direction during the course of an experimental program.

4.5 It is common practice to use a dye, soluble in the dispersant, which will assist in the detection of the dispersant by the analysis system. Oil Red B and Rhodamine WP have been used at concentrations of 0.1 to 2.0 %. The sensitivity of current detection systems allows the use of concentrations at the 0.1 % level or less.

4.6 The area used will become covered with dispersant spray, and it is suggested that the area not be used for agricultural purposes at least until any evidence of the dispersant or dye is no longer observable. The length of time depends on the weather conditions, especially precipitation that occurs after the spray program has been completed.

5. Deposition Measurement Methods

5.1 These techniques involve the use of a collecting surface of known area and the measurement of the amount and character of the dispersant deposited on this area. A variety of systems may be used, such as the following:

5.1.1 *Glass Petri Dishes or Similar Containers*—Flat dishes of known area are placed in a line perpendicular to the flight path, and extending over a distance 25 % greater than the expected swath width. Dishes of a diameter of 120 to 140 mm are typically used. There should be about twenty dishes placed across the flight path in order to have an adequate number of sampling points. In a typical experimental setup, the distance between sampling dishes should be greater than one metre and less than three metres. This criteria may require more or less than twenty dishes depending on the spray system being tested. Each sampling dish should be identified by a unique label, indicating its place on the sampling line and the number of the spray pass. The marking should be made in such a fashion that it will not be removed by the dispersant, the material used to dissolve the dispersant, water, or rough handling. The sampling dishes are kept covered until just before the spray run to reduce the possibility of contamination. The placement, uncovering, and retrieval of these dishes is labor intensive. After the spray run, the dishes are collected and washed with a suitable solvent, such as methanol or hexane, to collect the deposited material. The amount of dye present can be determined by using a colorimeter sensitive to the dye used. The system must be calibrated using a sample of the dyed dispersant and solvent mixture for that experimental pass. For these measurements, care must be taken to ensure that the same dilution factors are used for both the calibration and material from the sampling dishes, since the measurement instruments are only linear over about an order of magnitude of concentration. From these sets of data, the amount of material deposited on the surface in any units required, such as litres/hectare (U.S. gal/acre), can be calculated.

5.1.2 *Metal Troughs*— A variation of the sampling dish is a V-shaped metal trough, divided into sections and placed perpendicular to the flight path. Each section is about two metres long with a cross section of about 6 cm. A number of troughs, connected end-to-end, are used to cover a length of about 25 % greater than the total spray width. After a spray run, the troughs are washed with a solvent, such as methanol or hexane, and the eluent from each section is collected for analysis. The concept is similar to that of the glass dishes, but this system has the advantage of sampling the total spray width, and providing an average dose over the discrete section. One major advantage of the troughs is that they remain in place during a number of experimental runs, thus reducing the time between runs. This allows for more runs per day.

5.1.3 *String Measurement*—Another method uses a cord or string that is either stretched across the width of the spray or is supported on a series of stands. Except for very narrow-width application systems, the string is supported about every two metres by a stand. The dispersant is collected by the string, and thus the needed data are obtained. Since the cross section of the string is much smaller than that of the Petri dish or trough, more dye may be needed in the sprayed dispersant. The string is then allowed to dry. The amount of material that the string collected is determined by a fluorometric or colormetric technique. This method measures the relative deposition only, and not the absolute deposition.

5.1.4 *Data Determination*—The data collected from these types of measurements is the same in character. The amount of dispersant that reaches the ground is measured as a function of the position along the swath of the spray. From this, spray patterns can be determined and plotted. Data gathered using dishes and the metal troughs can be used to compute the actual deposition.

6. Drop-Size Determination

6.1 While the techniques of Section 5 provide an accurate measurement of the deposition, they do not give any indication of the drop size or drop-size distribution. Since this is an important parameter in the proper use of dispersants, drop-size measurements are also required in order to characterize a dispersant application system. The basic principle of most drop-size measurements is to capture the falling drops on a surface and then measure the area of the drop. The surface must be calibrated so that the conversion factor from drop volume to surface drop diameter is known.

6.1.1 The analysis of such drop sizes is expressed as a volume median diameter (VMD). The VMD is the effective diameter of a distribution of various drop sizes. It represents a single parameter description of a spray-pattern droplet size distribution and is statistically based. Therefore, VMD cannot be used to compute the terminal velocity of a drop or its momentum. It is the momentum that is critical for the dispersant, since this determines the probability of the droplet penetrating the slick.

6.2 Most techniques developed for pesticide drop-size measurements fail since the deposition for dispersants is several orders of magnitude greater than those used for pesticides. When these techniques are used for dispersants, the flux of droplets are so dense that they overlap, and thus, individual particles cannot be measured.

6.3 There are a number of methods that have been used in the measurement of drop size. Most use paper as the absorbing material. One common system uses specially coated cards such as those manufactured by Ciba-Geigy. There are two products that are typically used: a water-sensitive paper, that is yellow in color and stains blue when exposed to water and the other is white which stains blue when exposed to organic materials. These materials can be used to measure spray distributions and swath widths as well as droplet size. Special paper that is used by the printing industry for color reproduction can be used for the same purpose. Another system collects the drops on rolls of paper tape. All such methods require the calibration of the detection medium in terms of the relationship between droplet size and the drop area on the material. This is done in the laboratory.

6.4 Drop size can be determined by measuring the size of the projected image of the drop. Counting the drops and determining the drop size can be done either manually or using electronic image analysis systems. A large number of drops must be examined in order to achieve good statistics. Manual counting is a time-consuming and tedious process. Modern electronic image analysis systems are expensive and take considerable time and skill in order to produce high-quality results.

6.5 The use of recently developed laser-scattering systems have yet to be demonstrated to be successful in field measurements. The sampling volume of most of these systems is quite small, and the density of drops that traverse this volume is small. Thus, there are problems in obtaining good statistics with such a system.

7. Data Analysis

7.1 There are two types of information that need to be derived from these tests. The first is the distribution of material across the swath width and the second is the determination of the range of the drop sizes.

7.2 The determination of the distribution of material across the swath width can be done by extracting the information from the volume of material deposited on the Petri dishes, in the V-troughs, or on the string. The final output is a graph such as is shown in Fig. 1. These data are easy to interpret. There was a wing tank on the starboard side of the aircraft which produced some turbulence and thus reduced the amount of spray deposited as shown in the left of the graph. The graph slopes slightly upward indicating a slight crosswind moving from the left to the right. The random peaks on the right are caused by the slight crosswind. The pattern is good, and with the exception of the wing tank, there are no problems. The effects of the wing tank are not large enough to exclude the use of the plane for dispersant application with the existing spray system. Larger nozzles in the area of the wing tank could produce an even flatter pattern. The errors in this sort of measurement are about 10 %. This is not a significant error.

7.3 The second is the droplet size distribution. The graph in Fig. 2 shows a typical droplet-size distribution. While this graph can be used directly to determine the droplet size distribution, the most common representation of these data are summarized in a single parameter, the VMD. This can be calculated very simply, directly from the data used to prepare the graph. In Fig. 2, there are 100 size ranges, each 10 µm in width. The number and width of ranges is a characteristic of the measurement equipment. In order to calculate the VMD, assume the diameter of each drop is the average value of the range, that is the 20 to 30-µm range has a diameter of 25 µm. Calculate the volume, *V*, of such a drop using the following formula:

$$V = \frac{\Pi}{6} D^3$$

where:
D = mean diameter of the range.

This must be done for all 100 ranges. From this volume data, the VMD can be calculated from the following equation:

$$VMD = \sqrt[3]{\frac{6}{\Pi} \frac{\Sigma(V)}{\Sigma(N)}} = \sqrt[3]{1.91 \frac{\Sigma(V)}{\Sigma(N)}}$$

where:
$\Sigma (V)$ = sum of the volumes (all 100 ranges), and
$\Sigma (N)$ = total number of particles (all 100 ranges).

For example, from the data in Fig. 2, the linear-symmetric curve has a VMD of 464 µm and the nonlinear asymmetric

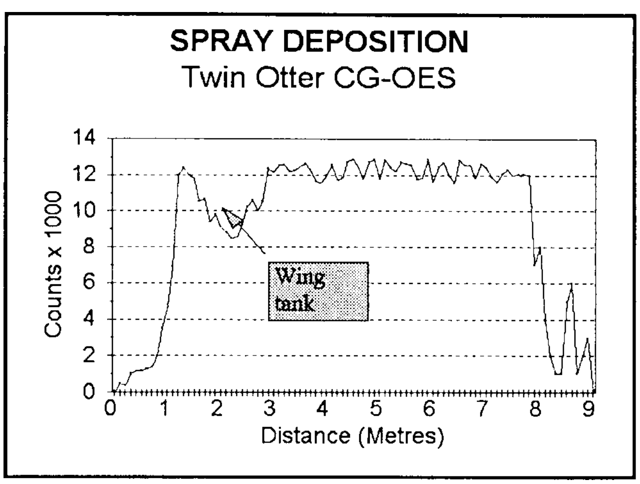

FIG. 1 Typical Deposition Pattern

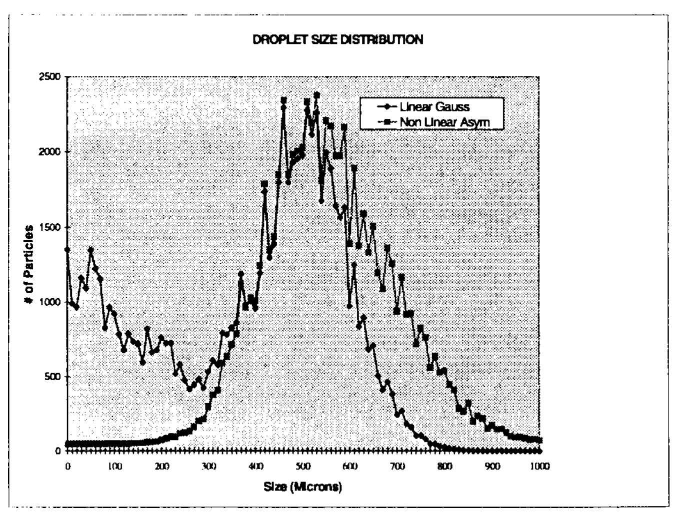

FIG. 2 Droplet Size Distribution

curve has a VMD of 593 µm.

7.3.1 It should be noted that the VMD for both distributions are similar and reflect that limited influence of the small particles and those particle sizes which are present outside the main curve. With high-quality data, such as shown here, the visual estimation of 500 µm is adequate and would reduce the amount of calculations needed to determine drop size.

8. Ancillary Concerns

8.1 With a knowledge of the deposition rate and the droplet size distribution, it is possible to evaluate the effectiveness of a dispersant application system to deliver the dispersant to the ocean surface at a known volume and droplet-size distribution. The delivery ratio is defined as the ratio of the amount of material that arrives at the surface to the amount of the dispersant pumped from the aircraft. If this ratio is less than about 70 %, then a study should be conducted to determine the sources of the loss, so that corrective action can be taken. Possible losses are due to wind drift and evaporation of the material during its transit through the air. Both these effects become more prominent as the height of the aircraft above the surface increases. Wind sheer at the nozzle and high turbulence in the atmosphere can result in the production of small droplets that do not reach the ground and hence can cause a low delivery ratio.