Designation: E2408 − 04 (Reapproved 2015)

Standard Test Method for Relative Extensional Viscosity of Agricultural Spray Tank Mixes[1]

This standard is issued under the fixed designation E2408; 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 determination of the relative extensional viscosity or Screen Factor (SF) of dilute agricultural spray mixes.

1.2 The test can be used for tank mixes containing dissolved, emulsified or dispersed materials, or mixtures.

1.3 Results may be affected by the quality of the water used. Make-up water quality should therefore be specified in the presentation of results.

1.4 Proper safety and hygiene precautions must be taken when working with pesticide formulations to prevent skin or eye contact, vapor inhalation, and environmental contamination. Read and follow all handling instructions for the specific formulation and conduct the test in accordance with good laboratory practice.

NOTE 1—References to the development of extensional viscosity from dissolved polymers, extensional viscosity effects on the droplet size distribution of sprays, and measurements of screen factor on recirculated spray mixes containing polymers are available.[2,3]

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this 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:*[4]

D1193 Specification for Reagent Water

E609 Terminology Relating to Pesticides

E1116 Test Method for Emulsification Characteristics of Pesticide Emulsifiable Concentrates

2.2 *CIPAC Documents:*

CIPAC Monograph 1 (Instructions for the preparation of hard water)

CIPAC Method MT 18.1.1 to 18.1.7 (Instructions for the preparation of standard waters)

3. Terminology

3.1 *Definitions:*

3.1.1 *screen factor, (SF)*—the ratio of the flow time of a test fluid (t_p) to the flow time of water (t_w) through the screen viscometer apparatus.

3.1.2 *extensional viscosity, (E)*—a measure of the resistance of a fluid to distortion by a stretching force.

4. Significance and Use

4.1 Extensional viscosity is a measure of the resistance of a liquid to stretching forces, such as those occurring during the disruption of liquid films and the formation of sprays used in agriculture and other purposes including painting operations or metal working. This method for measurement of a Screen Factor, gives a relative value for extensional viscosity, which may be used:

4.1.1 To compare the potential for drift control of different polymers.

4.1.2 To compare the relative extensional viscosity component of different spray tank mixtures.

4.1.3 To determine the extent of breakdown of polymer solutions used as drift control additives during the recirculation of the solutions through pumps and screens.

4.1.4 To use as a parameter in the Spray Drift Task Force Models for droplet size prediction.

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[1] This test method is under the jurisdiction of ASTM Committee E35 on Pesticides, Antimicrobials, and Alternative Control Agentsand is the direct responsibility of Subcommittee E35.22 on Pesticide Formulations and Delivery Systems.

Current edition approved Oct. 1, 2015. Published February 2016. Originally approved in 2004. Last previous edition approved in 2009 as E2408 – 04(2009). DOI: 10.1520/E2408-04R15.

[2] Dexter, R. W., "Measurements of Extensional Viscosity of Polymer Solutions and its Effect on Atomization from a Spray Nozzle," *Atomization and Sprays*, Vol 6, 1996, pp. 167–191

[3] Zhu, H., Dexter, R. W., Fox, R. D., Reichard, D. L., Brazee, R. D., and Okzan, H. E.,"Droplet Size and Viscosity Effects in Recirculated Polymer Spray Solutions," *J. Agric. Engr. Res.*, Vol 67, 1997, pp. 35–45

[4] 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.

4.2 It should also be noted that many drift control polymers are irreversibly destroyed during the recirculation of spray mixes by pumping with high shear pumps such as gear or centrifugal pumps. It is advisable to subject the test mixture to similar pumping regimes to simulate practical conditions before carrying out the extensional viscosity test. Measurements of extensional viscosity are the only presently known method of determining the extent of this breakdown properties of dilute polymer solutions.

4.3 This method is intended to produce a relative value for extensional viscosity. The purpose of the method is to compare the extensional viscosity produced by different polymer types or concentrations of polymer in spray tank mixes.

5. Apparatus

5.1 *List of Materials for Construction of Screen Viscometer:*

5.1.1 *Item 1*—Fluorinated plastic ¼ in. (0.635 cm) straight union, reference SKU-II4, P#D1O77019. Norton Performance Plastics, 150 Dey Road, Wayne, New Jersey, 07470, USA.

5.1.2 *Item 2*—Cut five (5) ¼ in. diameter discs (see 5.2) from 100 mesh (150 µm aperture) USA Standard Testing Sieve, ASTM E11 specification, stainless steel plain weave screen, so as to fit tightly into the ¼ in. plastic union.

5.1.3 *Item 3*—Glass 25 mL pipette, {VWR catalog #7102 (1999)} or equivalent. External diameter of the tube below the bulb of the pipette = 0.82 cm. Cut off the lower part of the pipette at a point 2.5 cm below the bulb. Round off the sharp edges of the tube with a flame.

5.1.4 *Item 4*—Silicone rubber tubing, flexible, for use as a sleeve to join a glass tube (Item 5) to the lower end of the pipette (Item 3).

5.1.5 *Item 5*—Glass tube, cut from a 2 mL pipette, Kimax #37000, or equivalent (American Scientific catalog #P4140-2). Dimensions of tube are: length = 3 cm; outside diameter = 0.62 cm. Round off the sharp ends of the tube in a flame.

NOTE 2—Appropriate safety precautions should be taken when using an open flame for rounding the ends of the glass tubes.

5.2 *Assembly of Screen Viscometer*—Refer to Fig. 1, which shows the arrangement of the separate items of equipment, and Fig. 2, which shows the placement of the screen pack in the plastic union.

5.2.1 Push the five stainless screen discs, one at a time, into the ¼ in. (0.635 cm) plastic union. Push each screen down to the central lug in the union, using a piece of ¼ in. glass tubing. Ensure that the last of the 5 screens fits tightly into the plastic tube to keep the pack of screens well compacted and fixed in place.

5.2.2 Push the silicone rubber sleeve (Item 4) on to the lower end of the pipette tube (Item 3). Leave approximately 0.8 cm of the silicone tube projecting beyond the glass.

5.2.3 Push the short glass tube (Item 5) into the plastic union firmly and press down on the pack of screens. Screw on the end cap of the union to retain the position of the screen pack. Ensure that the Teflon cone supplied with the union is fitted properly, to provide a leak tight seal. About 0.6 cm of the glass tube should protrude from the end cap of the union.

5.2.4 Push together the glass tube protruding from the end cap, into the silicone rubber sleeve attached to the pipette. Check the alignment of the pipette and screen pack for straightness.

5.3 *Other Accessories Required:*

5.3.1 Two 500 mL beakers.

5.3.2 A stand and clamp to hold the pipette firmly in a vertical position.

5.3.3 A stopwatch, reading to 0.01 s.

5.3.4 A 200 mesh USA Standard Testing (75 µm aperture) stainless steel sieve, 4 in. diameter.

5.3.5 A pipette bulb, or preferably, a low vacuum suction device (see 7.2.2).

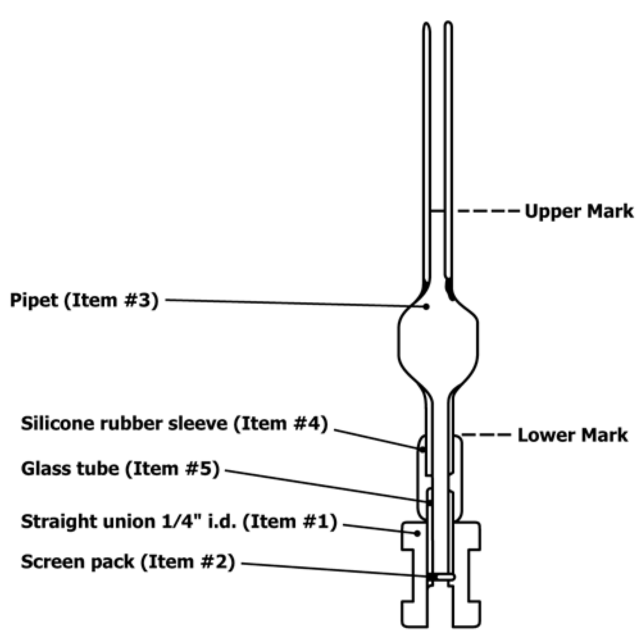

FIG. 1 Diagram of Apparatus

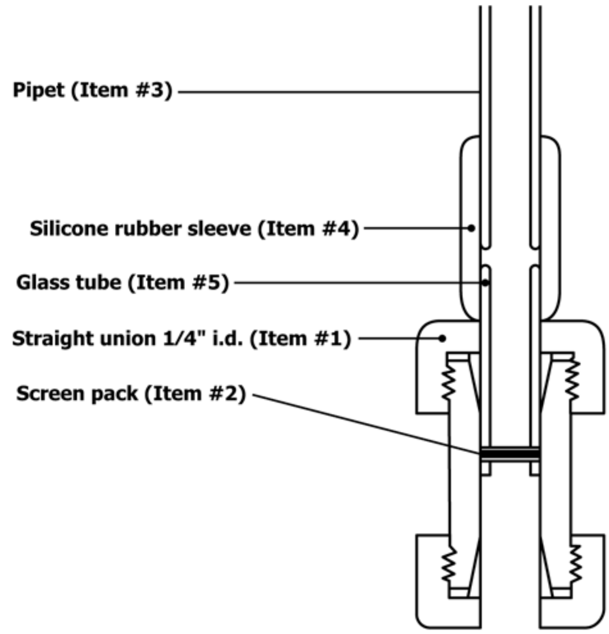

FIG. 2 Diagram of Apparatus

6. Test Materials

6.1 *Deionized Water,* filtered through a 200 mesh (75 µm aperture) stainless steel screen, for use in rinsing the apparatus and as a standard fluid for calibrating the screen pack.

6.2 *Test Fluid(s),* as required to be tested.

7. Procedure

7.1 *Preparation of Test Fluids for use in Screen Viscometer:*

7.1.1 Dilute the formulation in the appropriate standard water to the desired spray concentration. Pass approximately 500 mL of the liquid so prepared through a 200 mesh USA Standard stainless steel sieve, to remove poorly dispersed aggregates or gels. The test can be run with as little as 200 mL of the test fluid. The temperature of the fluid should be kept at standard temperature, preferably in a constant temperature room.

NOTE 3—Dilute solutions of high molecular weight polymers often require prolonged dissolution to allow for complete swelling and dissolution, especially if provided as solids. Note also that excessive stirring or shearing by pumping can cause degradation of the polymer molecules resulting in a decrease in molecular weight and viscosity. If the solution is drawn up into the screen viscometer too rapidly, it may be degraded. It has been found useful to use a vacuum device that provides a low and consistent suction to the pipette.

7.2 *Calibration of Screen Viscometer:*

NOTE 4—Water is used as the calibration fluid.

7.2.1 Place 400 mL of deionized water in a 500 mL beaker and adjust to the required temperature. (A temperature of 23 to 25°C has been used, but any temperature at which the screen factor is required may be used. The calibrating fluid (water) and the test fluid must be run at the same temperature).

7.2.2 Lower the screen viscometer assembly into the water, clamp the pipette in a vertical position, and draw up water into the pipette through the screen pack, by applying vacuum to the top of the pipette. Draw the water up to a point about 2 in. above the upper timing mark.

7.2.3 Raise the pipette tip above the surface of the liquid about 2 cm, and fix in position using the clamp, so that the liquid will fall freely from the pipette in air during draining. Then allow the water to run out of the pipette freely under gravity. Start the stopwatch as the meniscus passes the upper timing mark, and stop the watch when the meniscus passes the top edge of the silicone rubber sleeve. The efflux time is short and practice may be needed to obtain consistent results. Record the efflux time.

7.2.4 Repeat the measurement a total of 5 times, and average the efflux times. This is the efflux time for water (t_w). Record the temperature of the room and fluid.

7.3 *Testing Spray Fluids:*

7.3.1 Completely drain the screen viscometer after calibration with deionized water.

7.3.2 Draw up the test fluid (as in 7.2.2) and record the efflux time for the fluid. Repeat the measurements a total of 5 times.

7.3.3 Record the average time as the efflux time of the fluid (t_p).

7.3.4 If a second test fluid is to be run, then the screen viscometer should be thoroughly rinsed with filtered deionized water and drained between tests.

NOTE 5—If inconsistent results are obtained it is probably due to trapped air. Air bubbles can be released by tapping the pipette bulb and screen pack.

8. Report

8.1 Report the following information:

8.1.1 Average efflux time for water, t_w.

8.1.2 Average efflux time for the test fluid, t_p.

8.1.3 Calculate the average value of Screen Factor:

$$\text{Screen Factor (SF)} = \frac{\text{average efflux time of the test fluid}}{\text{average efflux time for water at specified temperature}} = \frac{t_p}{t_w} \quad (1)$$

8.1.4 In all cases the water quality should be specified, in particular the concentration and chemistry of the dissolved solids content of the liquid. Any unusual treatment of the spray liquid, for example pretreatment by pumping, should be reported.

9. Precision and Bias

9.1 *Precision*—The reproducibility of this test method as determined by statistical analysis of results obtained from several laboratories in a round robin was as follows, averaged over single operators:

For water flow times (t_w),

Standard deviation of t_w = 0.7 to 4 % for a single operator

For polymer solution flow times (t_p),

Standard deviation of t_p = 0.8 to 3 % for a single operator

For Screen Factor values (*SF*),

Standard deviation of *SF* = 1.5 to 6 % for a single operator

9.1.1 *Repeatability* is expressed in terms of the standard deviation from the mean in several tests. The existing data from the round robin indicate that the standard deviation of Screen Factor for measurements of several different fluids conducted by all operators in aggregate is approximately 15 %.

NOTE 6—In the round robin procedure adopted, each operator was required to construct his own apparatus, so that some differences in results from different operators would be expected, increasing the standard deviation between operators.

9.2 *Bias*—There exist other methods for the determination of extensional viscosity. Extensional viscosity is dependent upon the strain rate for most polymer solutions, an different methods of measurement may give different extensional viscosity values, because of variations in the strain rate applied in the equipment. This method may provide values for Screen Factor that do not agree with the results of extensional viscosity from other methods. This method operates at relatively low extensional strain rates and may therefore be biased towards low extensional strains, so that the values of extensional viscosity may be relatively low, compared with, for example, the Rheometrics RFX instrument. However, the method gives good comparisons between fluids and is more sensitive than other methods, especially at low polymer concentrations. Reports of the use of this method and its relevance to spray droplet size control are available (see Section 2, Referenced Documents).