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X-572 Spray Nozzle Classification by Droplet Spectra

Developed by the Pest Control and Fertilizer Application Committee; approved by the Power and Machinery Division Standards Committee; adopted by ASAE xxxx.

1 Purpose and scope

1.1 This Standard defines droplet spectrum categories for the classification of spray nozzles, relative to specified reference fan nozzles discharging spray into static air or so that no stream of air enhances atomisation. The purpose of classification is to provide the nozzle user with droplet size information primarily to indicate off-site spray drift potential and secondarily for application efficacy.

1.2 This Standard defines a means for *relative nozzle comparisons only based on droplet size.* Other spray drift and application efficacy factors such as droplet discharge trajectory, height, and velocity, air bubble inclusion, droplet evaporation and impaction on target are examples of factors not addressed by the current Standard.

1.3 Liquid flow rate, liquid pressure, and physical changes to nozzle geometry and operation can affect the nozzle classification. A given nozzle can be classified into one or more droplet size categories, depending on the selection of flow rate, operating pressure, and other operational conditions.

1.4 Generally the Standard is based on spraying water through the reference nozzles and nozzles to be classified. However, spray liquid properties may affect droplet sizes and should be considered by the end user. Beside water, a surfactant-water mixture, with a dynamic surface tension of 40 ± 2 dynes/cm at 1 0-20 ms, such as 9 % (wt./wt.) isopropanol or 0. I % (v/v) Surfynol Tm TG-E surfactant [Air Products and Chemicals Inc., Allentown, PA, (tel. (610) 481-491 1)] in water should be sprayed through the nozzles to be classified (I) that are claimed to reduce spray drift, or (2) that utilize pre-orifices or internal turbulence chambers - *especially for cases near a threshold between classification categories*. If differing classifications [see 6 Nozzle classification procedures for statistical basis] are determined for water versus a mixture of water and surfactant, the finer of the two classifications should be reported.

2 Normative references

The following standards contain provisions that pertain to this Standard. All standards are subject to revision, and users of this Standard are encouraged to apply the most recent edition of the standards indicated below.

ASAE S327.2	*Terminology and Definitions for Agricultural Chemical Applications*
ASTM E1260	*Standard Test Method for Determining Liquid Drop Size Characteristics in a Spray Using Optical Non-imaging Light-Scattering Instruments*
ASTM E1296	*Standard Terminology Related to Liquid Particle Statistics*

3 Reference flat spray nozzles

3.1 The droplet spectra produced by single, elliptical orifice reference nozzles with specified, (I) liquid mixture [water], (2) liquid flow rates, (3) operating pressures, and (4) spray angles, all of which are specified by this Standard (see 3.5), establish the threshold of division between nozzle classification categories.

3. 1.1 Reference nozzle sets should be periodically checked, through laser droplet size testing, for consistency in droplet size production. A current list of users of this Standard should be maintained by ASAE PM-41 technical committee and be available to current and prospective users to provide contacts for exchanging and checking reference nozzles. Standard users are encouraged to inform, in writing with return address, ASAE PM-41 of Standard use.

3.2 Reference nozzles shall not be subjected to wear-inducing conditions that could alter orifice size, shape, smoothness, flow rate, and spray angle.

3.3 Classification categories, symbols and corresponding color codes are the following:

Classification Category	Symbol	Color Code
Very Fine	VF	Red
Fine	F	Orange
Medium	M	Yellow
Coarse	C	Blue
Very Coarse	VC	Green
Extremely Coarse	XC	White

3.4 Reference flow rate and operating pressure are specified for each reference nozzle, since droplet size spectra from pressure atomizers are affected by flow rate and operating pressure. The included angle of the fan spray, nominal rated flow rate, reference flow rate, and reference operating pressure are specified [see 3.5]. It should be noted that a nozzle body strainer, or screen, *is not used* for any nozzle tip in this Standard.

3.5 Classification category thresholds, nozzle spray angles, nominal rated flow ratings at 276 kPa (40 psi), reference flow ratings, and reference operating pressures are as follows:

Classification Category Threshold	Nozzle Spray Angle (0)	Nominal Rated Flow Rate [1] (L/min)	(gpm)	Reference Flow Rate [2] (L/min)	(gpm)	Reference Operating Pressure [3] (kPa)	(psi)
VF / F	110	0.38	0.10	0.48	0.1 3	450	65.3
F/M	110	1.1 4	0.30	1.1 8	0.31	300	43.5
M/C	110	2.27	0.60	1.93	0.51	200	29.0
C/VC	80	3.03	0.80	2.88	0.76	250	36.3
VC/XC	65	3.78	1.00	3.22	0.85	200	29.0

[1] Nominal rated flow rate is at 276 kPa (40 psi) and is for nozzle size selection only.

[2] Reference flow rate is the actual rate used and has a tolerance of ± 0.04 L/min (± 0.0 1 gpm). Reference flow rate was determined for this Standard from Q = k.P. The orifice coefficient (k) for each single, elliptical orifice reference nozzle is calculated from the nominal rated condition. The reference operating pressure (P) is listed in the above table. Tolerances for the reference operating pressure are described in the following footnote.

[3] Reference operating pressure is the hydraulic pressure used to obtain the reference flow rate and should be within a tolerance range of ± 3.4 kPa (± 0.5 p.s.i.) of the value tabled above. If the tolerance reference flow rate at the tolerance reference operating pressure can not simultaneously be achieved, a different nozzle should be selected.

All pressures are measured with a test gage with a minimum accuracy of 2 kPa (0.25 p.s.i.) (accuracy grade = 3A). Test pressure is obtained via a capillary tube connected to a tee that accommodates the nozzle body to minimize flow restrictions and potential pressure drop between the capillary and nozzle tip. No nozzle strainer is present in the nozzle body.

4 Droplet sizing

4.1 The droplet spectra from the reference nozzles., and from nozzles to be classified, should be measured with a laser-based instrument. Commercial droplet sizing instruments typically use either (I) laser diffraction, (2) laser imaging, or (3) laser-based phase-Doppler techniques. Instrument use should minimize the measurement of interactions that could occur between the instrument and droplets in-flight in the spray. Instrument technologies other than laser-based may be use d provided that accuracy and repeatability are comparable with that of laser instruments.

4.1.1 Verification or calibration to known standards of any measurement method is essential. Instrument particulars, such as size range configuration, obscuration, multiple scattering,, verification, droplet path angle, calibration, and repeatability, shall be addressed such that accurate, and repeatable day-to-day measurements are obtained.

4.2 Nozzles are oriented to discharge the spray to allow for scanning the entire spray plume by the laser instrument. The height of the laser below the nozzle, or the distance between the nozzle discharge and measurement point, should range from 200 mm (8 in.) to 500 mm (20 in.). However, exceptions to this distance range may be necessary to reduce the fouling of instrument lens.

4.3 Droplet size measurement must ensure that a representative, cross-sectional sample of the spray plume is obtained. Acceptable methods include traversing the nozzle through the laser during data sampling, or by calculating droplet sizes by merging data of multiple readings from representative samples of the spray plume. The method chosen should be consistent between reference nozzles and nozzles being classified. ASTM Standards addressing instrument use and spray sampling should always be consulted for best measurement procedures.

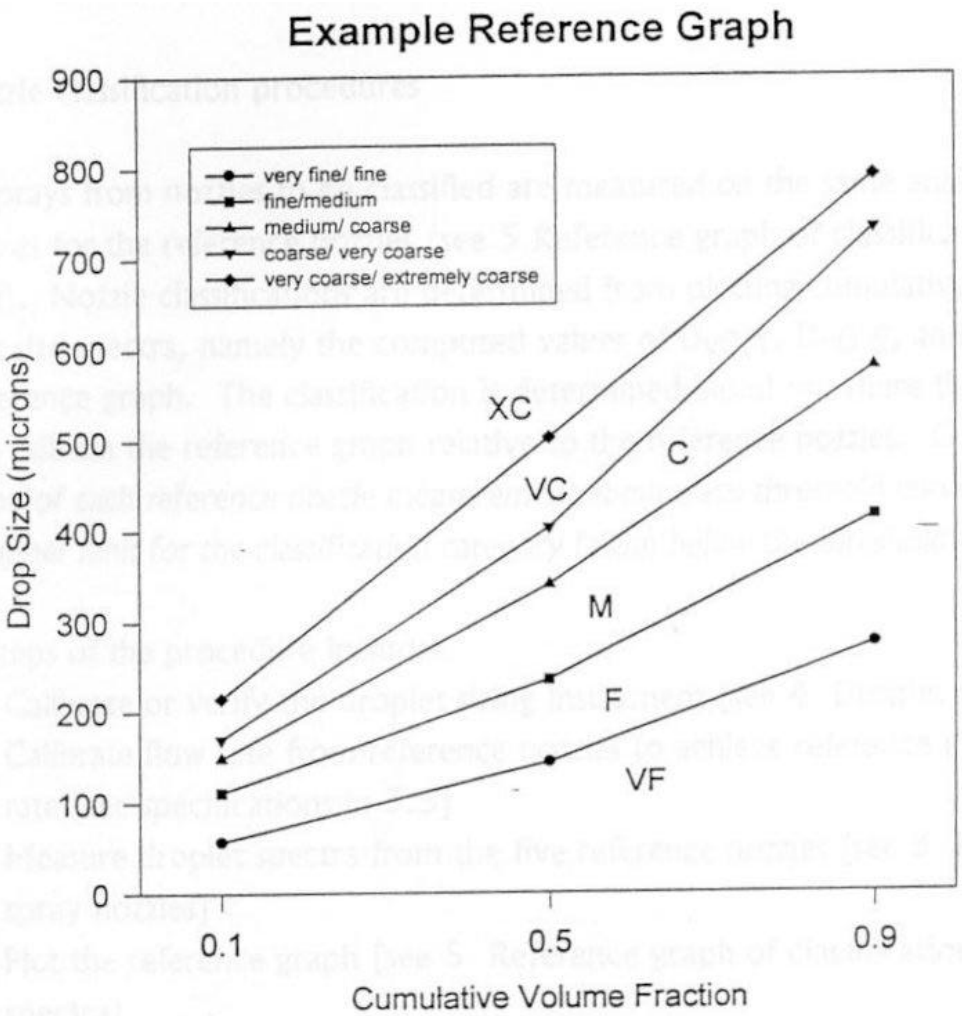
4.4 A minimum of three separate, replicate measurements shall be averaged to establish the cumulative volume versus droplet size spectra relationship, including values of Dvo1. 1, Dvo.5, and Dvo.9. The exact number of replicate measurements shall be determined based on the desired standard deviation and resulting resolution in classification (see 6).

4.5 Tap water is the test liquid for reference nozzle droplet sizing determinations. Exceptions to using water alone for nozzles to be classified are specified in 1.4. Ambient temperature and measurement technique should result in negligible droplet evaporation.

5 Reference graph of classification droplet spectra

5.0 A reference graph for nozzle classification shall be established from droplet size spectra measurements obtained for all of the reference nozzles. Droplet diameter (microns) is plotted versus the cumulative spray volume (fraction or percent) (ordinate) for the five reference nozzles as a reference graph. These curves define the classification thresholds between categories.

5.1 Cumulative volume for the reference graph shall range from I 0 to 90 percent. The graph can be simplified by using computed values of Dvo.1, Dvo.5, and Dvo.9. An example reference graph developed from measurements averaged from three types of laser instruments is as follows:



5.2 Droplet spectra measurements for (A) reference nozzles and (B) nozzles to be classified shall be performed with the same (I) instrument, (2) measurement method, (3) sampling technique, (4) scanning technique, (5) operator, and (6) similar environmental condition. Any deviation in these six factors may void the accuracy of the classification. The reference graph shall be verified before and after measurements are taken to classify nozzles. The frequency of graph verification should insure that repeatable classification results are obtained throughout testing.

6 Nozzle classification procedures

6.1 Sprays from nozzles to be classified are measured on the same analyzer at the same settings as for the reference nozzles (see 5 Reference graph of classification droplet spectra). Nozzle classifications are determined from plotting cumulative volume versus droplet size spectra, namely the computed values of Dvo.1, Dvo.5, and Dvo.9, onto the reference graph. The classification is determined based on where the droplet size spectra falls on the reference graph relative to the reference nozzles. *One standard deviation of each reference nozzle measurement above each threshold curve determines the actual upper limit for the classification category falling below the threshold curve.*

6.2 Steps -of the procedure include:

1. Calibrate or verify the droplet sizing instrument [see 4 Droplet sizing]
2. Calibrate flow rate from reference nozzles to achieve reference discharge flow rate [see specifications in 3.5]
3. Measure droplet spectra from the five reference nozzles [see 3 Reference flat spray nozzles]
4. Plot the reference graph [see 5 Reference graph of classification droplet spectra]
5. Measure the droplet spectrum for the nozzle, pressure, flow rate, geometry and operational combination to be classified
6. Plot the measured droplet spectrum on the reference graph
7. Determine the classification based on the category where the measured spectrum falls - *taking into account one standard deviation of the reference nozzle measurement above the threshold curve as the statistical basis for decisions involving classifications close to the reference curves. One standard deviation above the reference curve is the upper limit for the corresponding lower category.*

6.3 The measured droplet spectrum for a given nozzle/pressure combination should fall in a single classification category, without intercepting or crossing a reference threshold curve. In the event a reference threshold division is intercepted or crossed, the finer of the classification categories shall be reported to indicate the smallest droplet size of the categories involved. *Again, the standard deviation in measurement accuracy of the threshold curve should be taken into account, even when curves cross threshold curves (see 6 and 6.2).*