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Standard Guide for Determining Cross-Section Averaged Characteristics of a Spray Using Laser-Diffraction Instruments in a Wind Tunnel Apparatus[1]

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INTRODUCTION

In this guide, test methodologies are described specifically relating to the use of laser diffraction (LD) instrumentation to estimate the droplet-size distribution for liquid sprays released into moving air streams. This guide presented is primarily applicable to aerial agricultural spraying, aerial forest sprays, or air-blast spraying. Cases in which the spray is ejected into a quiescent gas environment that lacks the unifying effect of a well-defined gas co-flow may require different techniques or instrumentation or both. In this guide, an average droplet size distribution for the entire spray is determined. It requires that the spray be statistically steady in time, but it may be polydisperse and spatially non-uniform.

The droplet-size distribution used for characterization of a moving spray source must be determined from a "flux-sensitive sample" or equivalent. This is because a flux-sensitive sample provides the fraction of the total liquid flow rate contributed by each size class of droplets and, therefore, is directly related to the spray coverage. In contrast, the LD instrument derives its droplet-size distribution from a "spatial sample," and therefore, its use for spray characterization is limited to test conditions under which equivalence between flux-sensitive samples and spatial samples can be established. Such equivalence exists when the velocity of all droplets of the spray is equal and creating these conditions is the basis of this guide.

All tests relating to this guide require a wind tunnel with a test section of sufficient size that it contains the entire spray plume up to the plane of measurement without droplets impacting the test section walls under the prescribed operating conditions. The unobstructed wind tunnel air stream shall be uniform and free of turbulence. The test air speed shall be chosen to match the relative speed of the sprayer to the ambient conditions.

1. Scope

1.1 The purpose of this guide is to define a test procedure for applying the laser diffraction (LD) method to estimate an average droplet size distribution that characterizes the flux of liquid droplets produced by a specified spray generation device under specified gas co-flow conditions using a specified liquid. The intended scope is limited to artificially generated sprays with high speed co-flow. The droplets are assumed to be in the size range of 1 μm to 2000 μm in diameter and occur in sprays that are contained within a volume as small as a few cubic centimetres or as large as a cubic metre. The droplet sizes are assumed to be distributed non-uniformly within the spray volume.

1.2 This guide is intended primarily to guide measurement of performance of nozzles and atomizers using LD instruments.

1.3 Non-uniform sprays require measurements across the entire spray cross section or through several chords providing a representative sample of the overall spray cross section. The aim of multiple-chord measurements is to obtain a single droplet size distribution that characterizes the whole spray rather than values from a single chordal measurement.

1.4 Use of this guide requires that the instrument does not interfere with spray production and does not significantly impinge upon or disturb the co-flow of gas and the spray. This technique is, therefore, considered non-intrusive.

[1] This guide is under the jurisdiction of ASTM Committee E29 on Particle and Spray Characterization and is the direct responsibility of Subcommittee E29.02 on Non-Sieving Methods.

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1.5 The computation of droplet size distributions from the light-scattering distributions is done using Mie scattering theory or Fraunhofer diffraction approximation. The use of Mie theory accounts for light refracted through the droplet and there is a specific requirement for knowledge of both real (refractive) and imaginary (absorptive) components of the complex index of refraction. Mie theory also relies on an assumption of droplet homogeneity. The Fraunhofer diffraction approximation does not account for light refracted through the droplet and does not require knowledge of the index of refraction.

1.6 The instruments shall include data-processing capabilities to convert the LD scattering intensities into droplet size distribution parameters in accordance with Practice E799 and Test Method E1260.

1.7 The spray is visible and accessible to the collimated beam produced by the transmitter optics of the LD instrument. The shape and size of the spray shall be contained within the working distance of the LD system optics as specified by the instrument manufacturer.

1.8 The size range of the LD optic should be appropriate to the spray generation device under study. For example, the upper bound of the smallest droplet size class reported by the instrument shall be not more than ¼ the size of $D_{V0.1}$.

1.9 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.10 *This standard may involve hazardous materials, operations, and equipment. 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.*

1.11 *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]

E799 Practice for Determining Data Criteria and Processing for Liquid Drop Size Analysis

E1260 Test Method for Determining Liquid Drop Size Characteristics in a Spray Using Optical Nonimaging Light-Scattering Instruments

E1620 Terminology Relating to Liquid Particles and Atomization

2.2 *ISO Standards:*[3]

ISO 13320:2009 Particle Size Analysis — Laser Diffraction Methods, General Principles

3. Terminology

3.1 *Definitions*—For definitions of terms used in this standard, refer to Terminology E1620 and ISO 13320:2009.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *aerial spraying, n*—practice of delivering spray via an airborne vehicle such as a fixed-wing aircraft or helicopter.

3.2.2 *atomizer, n*—spray generation apparatus.

3.2.2.1 *Discussion*—Various definitions for “atomizer” are defined in Terminology E1620 by construction and atomization method.

3.2.3 *co-flow, n*—coherent, moving gas phase surrounding a plume of spray droplets that significantly influences the direction of movement of droplets in a spray plume.

3.2.4 *co-flow generation device, n*—wind tunnel or other device that creates a steady, uniform air stream in the plane of measurement.

3.2.5 *concentration sensitive, adj*—statistical quantity derived from a spatial sample.

3.2.6 *droplet size distribution, DSD, n*—mathematical or graphical representation of droplet sizes of a given spray frequently shown as a volume fraction, number fraction, or cumulative fraction distributions.

3.2.7 *laser diffraction, LD, n*—used in this guide to refer to a class of laser droplet-sizing instruments known collectively as laser diffraction instruments, also used to qualify data gathered using an instrument of this type.

3.2.8 *monodisperse, adj*—refers to a spray in which all droplets have identical size.

3.2.9 *nozzle, n*—spray generation apparatus.

3.2.9.1 *Discussion*—Various definitions for “nozzle” are defined in Terminology E1620 by construction and atomization method.

3.2.10 *number concentration, n*—number of particles in a unit volume of space.

3.2.11 *obscuration, n*—percentage or fraction of incident light that is attenuated as a result of extinction (scattering or absorption or both) by droplets.

3.2.12 *obstructed, adj*—refers to co-flow generation device when the spray generation device is mounted such that it interferes with the gas-phase co-flow.

3.2.13 *plume, n*—ensemble of droplets that constitutes a spray.

3.2.14 *polydisperse, adj*—refers to a spray in which droplets have different sizes.

3.2.15 *sample distance, n*—separation between the sample volume of the LD system and the spray nozzle.

[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.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.