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Standard Terminology Relating to Liquid Particles and Atomization[1]

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INTRODUCTION

The transformation of bulk liquid into collections of discrete drops in sprays or mists is required for many processes including combustion, spray drying, evaporative cooling, humidification, and spray coating. Several techniques are commonly used to measure and characterize collections of drops as found in sprays, and a substantial body of terminology has evolved to describe liquid drops, drop populations, sprays, and spray devices, all of which are of interest to the users of liquid atomizers, spray instruments, and data. This terminology lists terms commonly encountered in the literature on liquid drops and sprays and provides definitions specific to the subject area.

1. Scope

1.1 In a broad sense, this terminology covers terminology associated with liquid particles dispersed in gas. The principal emphasis, however, is on particles produced by the process of atomization.

1.2 All terms, followed by their definitions, are arranged alphabetically. In addition, the terminology contains several tables wherein terms related to specific subjects are segregated and identified.

1.3 Within the broad scope, the following specific categories are included:

1.3.1 Terms pertaining to the structure and condition of individual particles or groups of particles as observed in nature.

1.3.2 Terms pertaining to the structure and condition of individual particles or groups of particles produced by an atomizing device.

1.3.3 Terms pertaining to atomizing devices according to the primary energy source responsible for spray development. (When more than one term is used for the same device or class of devices, the alternative term is followed by the preferred term.) Definitions of the devices may refer to their construction, operating principle, or distinctive spray characteristics. The atomizers, however, are not classified by their respective areas of application or end use. Moreover, the listed terms are generic and do not include brand names, trademarks, or proprietary designations.

1.3.4 Terms pertaining to statistical parameters involving particle measurement, particle size, and size distribution functions.

1.3.5 Terms pertaining to instruments and test procedures utilized in the characterization of liquid particles and sprays.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1356 Terminology Relating to Sampling and Analysis of Atmospheres

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

3. Terminology

aerating nozzle—a device to atomize liquid for the purpose of aeration.

NOTE 1—Although this term is occasionally used to designate certain types of airblast or internal mixing pneumatic atomizers, it is ambiguous and is not recommended for describing the latter devices.

aerodynamic diameter—the diameter of a hypothetical sphere having a specific gravity of unity and the same settling velocity as the actual particle.

aerosol, *n*—a dispersion of solid particles or liquid particles, or both, in gaseous media. **(D1356)**

air assist nozzle—a pneumatic atomizer in which pressurized air is utilized to enhance the atomization produced by pressurized liquid. The air may be required only for part of the operating range (for example, low liquid flow rates).

[1] This terminology 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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[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.

TABLE 1 Summary of Atomizer Terms

Pressure Atomizer (hydraulic atomizer, pressure atomizing nozzle, pressure nozzle, single-fluid atomizer)
  cone atomizer (cone spray nozzle)
    hollow cone atomizer
    solid cone atomizer (full cone nozzle)
  deflector atomizer (flood nozzle, flooding nozzle)
  dual orifice nozzle (duple nozzle)
  duplex nozzle

Fan Spray Atomizer:
  even spray atomizer (even flow atomizer)
  flat spray atomizer (flat jet atomizer)

Fog Nozzle

Impact Atomizer: (impingement atomizer):
  pintle atomizer
  splash cup atomizer
  splash plate atomizer

Impinging Jet Atomizer (impingement atomizer):
  doublet atomizer
  triplet atomizer

Plain Jet Atomizer (orifice atomizer, plain orifice atomizer, single jet atomizer, straight stream nozzle)
  simplex nozzle
Square Spray Nozzle

Swirl Atomizer
Swirl Chamber Atomizer (centrifugal pressure nozzle, swirl chamber atomizer)
  by-pass nozzle (bypass nozzle, flowback nozzle, recirculating nozzle, return flow nozzle, spill nozzle, spill return nozzle, spillback nozzle)
  dual orifice nozzle (duplex nozzle)
  duplex nozzle
  simplex nozzle
  variable-area nozzle
  Lubbock nozzle
  variable orifice poppet nozzle (variable orifice pintle nozzle)

Pneumatic Atomizer (air atomizing nozzle, blast nozzle, gas atomizer, gas-liquid nozzle, twin-fluid atomizer, two-fluid atomizer)
  air assist nozzle
  airblast nozzle (air blast nozzle, aerating nozzle)
    piloted airblast nozzle (simplex airblast nozzle)
    prefilming airblast nozzle

External Mixing Pneumatic Atomizer
  Laskin nozzle

Internal Mixing Pneumatic Atomizer
  (aerating nozzle,
  Nukiyama-Tanasawa nozzle,
  effervescent atomizer)

Centrifugal Atomizer (rotary atomizer, slinger)
  rotary cup atomizer (spinning cup atomizer)
  rotary disk atomizer (spinning disk atomizer)
  rotary wheel atomizer

Vibratory Atomizer (vibrative atomizer)
  electromagnetic vibratory atomizer
  piezoelectric vibratory atomizer
Berglund-Liu atomizer
  sonic nozzle
  ultrasonic nozzle
  vibrating needle atomizer
  vibrating reed atomizer

Electrostatic Atomizer

Shear Coaxial Injector
  swirl coaxial injector

Siphon Nozzle (aspirating nozzle)

Sonic Nozzle (sonic-whistle atomizer, ultrasonic nozzle)

TABLE 2 Characteristic Particle Diameters and Distribution Functions

Aerodynamic Diameter
Area (surface) Mean Diameter
D_{Nf}, D_{Lf}, D_{Af}, D_{Vf}
De Brouckere Diameter
Equivalent Volume Sphere Diameter
Evaporative Diameter
Herdan Diameter
Linear (arithmetic) Mean Diameter
Log Normal Distribution
Mean Diameters
Normal Distribution
Nukiyama-Tanasawa Distribution
Relative Span
Rosin-Rammler Distribution
Sauter Mean Diameter
Square Root Normal Distribution
Stokes' Diameter
Upper Limit Log Normal Distribution
Volume Mean Diameter

air atomizing nozzle—see **pneumatic atomizer**.

air blast nozzle—see **airblast nozzle**.

airblast nozzle—a pneumatic atomizer that utilizes a relatively large volume of low-pressure air.

NOTE 2—The term is occasionally used to designate the entire class of pneumatic atomizers.

aspirating nozzle—see **siphon nozzle**.

atomization, *n*—the process of atomizing.

atomize, *v*—to transform bulk liquid or slurry into particles.

atomizer, *n*—a device for atomizing.

Berglund-Liu atomizer—a vibratory atomizer in which a piezoelectric transducer transmits high-frequency oscillations to a liquid stream discharged through an orifice, creating relatively uniform drops whose size is a function of the frequency of oscillation and the flow rate of the liquid through the orifice.

blast nozzle—see **pneumatic atomizer**.

breakup, *n*—liquid disintegration that occurs during atomization.

breakup length, *n*—the distance between the liquid discharge point of an atomizing device and the point where liquid breakup commences.

bypass nozzle—see **by-pass nozzle**.

by-pass nozzle—a swirl chamber atomizer containing by-pass orifice(s) or port(s) through which part of the inlet liquid may be withdrawn from the swirl chamber and returned to

the supply tank or pressure pump suction. The discharge flow is modulated by controlling the pressure in the bypass line, using a valve in the line.

cavitation, *n*—the formation of vapor-filled cavities in the interior or on the solid boundaries of liquids in motion where the pressure is reduced to a critical value without a change in ambient temperature.

centrifugal atomizer—a device wherein a rotating solid surface is the primary source of energy utilized to produce a spray.

NOTE 3—Alternatively, an atomizer that rotates to distribute the liquid.

centrifugal pressure nozzle—see **swirl chamber atomizer**.

circumferential patternation, *n*—measurements taken in a circumferential direction, showing the variation in liquid flux about the nozzle axis.

cloud, *n*—any collection of particulate matter in the atmosphere dense enough to be perceptible to the eye, especially a collection of water drops. **(D1356)**

coalescence, *n*—the merging of two or more liquid particles to form a single liquid particle.

concentration—see **number density.**

cone atomizer—an atomizer that produces a conical spray pattern.

cone pattern, *n*—a diverging spray pattern that is nominally symmetric about the nozzle axis and whose apex is located at or near the nozzle discharge orifice.

cone spray nozzle—see **cone atomizer**.

convolution—the combination of local measurements of drop size distribution and number density into equivalent line-of-sight values of drop size distribution and optical extinction.

$\mathbf{D}_{Nf}$, $\mathbf{D}_{Lf}$, $\mathbf{D}_{Af}$, $\mathbf{D}_{Vf}$—diameters such that the cumulative number of particles, (*N*), length of diameter, (*L*), surface area, (*A*), or volume, (*V*), from zero diameter to these respective diameters is the fraction, (*f*), of the corresponding sum for the total distribution.

Example:

$D_{V0.5}$ is the volume median diameter; that is, 50 % of the total volume of liquid is in drops of smaller diameter and 50 % is in drops of larger diameter.

deconvolution—a procedure by which line-of-sight measurements of drop size distribution and optical extinction are converted into local representations of the distribution and number density.

DISCUSSION—For sprays whose drop size distributions are axisymmetric in space, an Abel inversion procedure has been used to perform the deconvolution.[3]

deflector atomizer—an atomizer in which a liquid jet spreads out over a solid surface, forming a spray whose shape depends upon the solid surface.

dispersion, *n*—a system of particles distributed in a solid, liquid, or gas.

dispersion, *n*—the spread of values of a frequency distribution about an average (in statistics). (Quantitative measures of dispersion include range, variance, standard deviation, mean deviation, and relative span.)

doublet injector—an impinging jet atomizer in which there are two colliding liquid jets.

drop, *n*—a single liquid particle having a generally spheroidal shape.

droplet, *n*—see **drop**; also a small drop.

dual orifice nozzle—a swirl chamber atomizer containing a primary injector and a concentric annular secondary injector, each injector comprising a separate orifice and set of tangential slots. The nozzle is normally operated only with the primary injector at low flow rates, with secondary liquid introduced at a specified pressure. (This definition applies to devices used in the gas turbine industry.)

duple nozzle—see **dual orifice nozzle**.

duplex nozzle—a swirl chamber atomizer comprising a single discharge orifice and two sets of tangential slots, each with a separately controlled liquid supply. The smaller (primary) slots supply liquid at low flow rates, and both sets (primary and secondary) are utilized as flow increases.

effervescent atomizer—an internal mixing pneumatic atomizer in which gas bubbles are dispersed in the liquid stream.

electromagnetic vibratory atomizer—a vibratory atomizer in which an electromagnetic transducer transmits high-frequency oscillations to the liquid.

electrostatic atomizer—a device wherein an electric charge is the primary source of energy utilized to produce a spray.

emitting spray angle, *n*—see **initial spray angle**.

equivalent volume sphere diameter—the diameter of a hypothetical sphere having the same volume as the actual particle.

even flow atomizer—see **even spray atomizer**.

even spray atomizer—a fan spray atomizer that produces a relatively uniform band of liquid, usually by means of injection, through an elliptical orifice. (This definition applies to devices utilized in the agricultural industry.)

external mixing pneumatic atomizer—a pneumatic atomizer in which pressurized gas is directed on a liquid film or jet outside the nozzle, so as to form a spray.

fan pattern, *n*—a spray pattern in which the liquid flux is concentrated in a narrow oval or ellipse in a plane perpendicular to the spray axis.

fan spray atomizer—a pressure atomizer that produces a flat sheet of liquid that collapses into particles. The angle or width of the sheet is controlled by the shape of a slot or oval discharge orifice, by an external deflector, or by impinging jets.

flat jet atomizer—see **flat spray atomizer**.

flat spray atomizer—a fan spray atomizer that produces a planar spray pattern.

NOTE 4—In agricultural applications, the spray patterns have tapered edges.

flood nozzle—see **deflector atomizer**.

flooding nozzle—see **deflector atomizer**.

flowback nozzle—see **by-pass nozzle**.

[3] Hammond, D. C., "A Deconvolution Technique for Line-Of-Sight Optical Scattering Measurements in Axisymmetric Sprays," *Applied Optics*, Vol 20, Number 3, February 1981, pp 493–499; Yule, A. J., Ah Seng, C., Felton, P. G., Ungut, A., and Chigier, N. A., "A Laser Tomographic Investigation of Liquid Fuel Sprays," *Eighteenth Symposium-International-on Combustion*, Pittsburgh: The Combustion Institute, 1981, pp 1501–1510.