Standard Terminology
Relating to Liquid Particles and Atomization[1]

This standard is issued under the fixed designation E1620; 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.

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.

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

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, *n*—a device to atomize liquid for the purpose of aeration.

Discussion—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, *n*—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**

[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.

Current edition approved Oct. 1, 2016. Published October 2016. Originally approved in 1994. Last previous edition approved in 2012 as E1620 – 97 (2012). DOI: 10.1520/E1620-97R16.

[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
$\mathbf{D}_{Nf}$, $\mathbf{D}_{Lf}$, $\mathbf{D}_{Af}$, $\mathbf{D}_{Vf}$
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 assist nozzle, *n*—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).

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

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

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

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

aspirating nozzle, *n*—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, *n*—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, *n*—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, *n*—see **by-pass nozzle**.

by-pass nozzle, *n*—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, *n*—a device wherein a rotating solid surface is the primary source of energy utilized to produce a spray.

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

centrifugal pressure nozzle, *n*—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, *n*—see **number density.**

cone atomizer, *n*—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, *n*—see **cone atomizer**.

convolution, *n*—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.

D_{Nf}, D_{Lf}, D_{Af}, D_{Vf}, *n*—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, *n*—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.[3,4]

deflector atomizer, *n*—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, *n*—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, *n*—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, *n*—see **dual orifice nozzle**.

duplex nozzle, *n*—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, *n*—an internal mixing pneumatic atomizer in which gas bubbles are dispersed in the liquid stream.

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

electrostatic atomizer, *n*—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, *n*—the diameter of a hypothetical sphere having the same volume as the actual particle.

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

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[3] Hammond, D.C., "A Deconvolution Technique for Line-Of-Sight Optical Scattering Measurements in Axisymmetric Sprays," *Applied Optics*, Vol 20, No. 3, February 1981, pp. 493–499.

[4] 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.

even spray atomizer, *n*—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, *n*—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, *n*—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, *n*—see **flat spray atomizer**.

flat spray atomizer, *n*—a fan spray atomizer that produces a planar spray pattern.

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

flood nozzle, *n*—see **deflector atomizer**.

flooding nozzle, *n*—see **deflector atomizer**.

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

flux, *n*—the number of particles flowing through a given area per unit time.

flux-sensitive, *n*—a sampling process where the magnitude measured responds to the flux of particles through the sampling region.

flux size distribution, *n*—the size distribution of particles passing through a sampling zone during a given interval of time, wherein individual particles are counted and sized.

DISCUSSION—Flux size distributions are typically obtained by collection techniques or by optical instruments capable of sensing individual particles in flight. Certain sampling methods may provide neither flux size distributions nor spatial size distributions.

fog, *n*—a quiescent cloud near the earth's surface.

fog nozzle, *n*—a high capacity pressure atomizer that produces a dispersion of fine drops.

full cone nozzle, *n*—see **solid cone atomizer**.

full cone pattern, *n*—a cone pattern wherein the liquid is distributed throughout the pattern.

gas atomizer, *n*—see **pneumatic atomizer**.

gas-liquid nozzle, *n*—see **pneumatic atomizer**.

global, *n*—indicates measurements or observations of a total dispersion of particles (such as, a sample representative of an entire liquid spray).

hollow cone atomizer, *n*—a cone atomizer wherein most of the liquid is directed toward the outside of the spray pattern.

hollow cone pattern, *n*—a cone pattern wherein most of the liquid is concentrated near the outside of the pattern.

hydraulic atomizer, *n*—see **pressure atomizer**.

impact atomizer, *n*—a pressure atomizer in which a spray pattern is achieved by the impaction of one or more liquid jets against a solid surface.

impingement atomizer, *n*—in rocketry, an impinging jet atomizer; in industrial processing, an impact atomizer.

DISCUSSION—Since this term is ambiguous, it is not recommended for describing either device.

impinging jet atomizer, *n*—a pressure atomizer in which atomization is achieved by the external collision of two or more liquid jets.

initial spray angle, *n*—the plane angle of the spray emerging from the nozzle discharge orifice.

internal mixing pneumatic atomizer, *n*—a pneumatic atomizer in which gas and liquid are introduced and mixed within the nozzle, and are then discharged as a two-phase dispersion through a common orifice.

laser diffraction, *n*—in particle measurement, the creation of a spatial pattern of light produced by the impingement of a laser beam on one or more dispersed particles, wherein the particle size distribution may be inferred from the nature of the pattern.

Laskin nozzle, *n*—a type of portable air-operated aerosol generator capable of producing droplets in the size range from 1 to 2 µm.

local, *n*—indicates measurements or observations of a small part of a larger region of interest.

log normal distribution, *n*—drop size distribution described by the following equation:

$$f_n(D) = \left(1/\sqrt{\pi}\right) \int_{-\infty}^{K \times Ln\,(D/D_{gm})} exp(-z^2)dz \quad (1)$$

where:

$f_n(D)$ = the number fraction of drops of diameter less than D,
D_{gm} = the geometric mean diameter,
K = $1/\left[\left(\sqrt{2}\right)\sigma_{gm}\right]$, and
σ_{gm} = the standard deviation of the geometric mean diameter.

DISCUSSION—This does not provide upper bound to *D*.

Lubbock nozzle, *n*—a variable-area nozzle in which a moveable plunger exposes additional inlet area as pressure increases.

mean diameters, *n*—the family of diameters, $\bar{D}_{pq}$, such that:

$$\bar{D}_{pq}{}^{(p-q)} = \left(\sum_i D_i{}^p\right)/\left(\sum_i D_i{}^q\right) \quad (2)$$

where:

p and q = dissimilar positive integers. (The value of q may also be "zero.")

DISCUSSION—This nomenclature was proposed by Mugele and Evans.[5] The bar over the D's indicates an averaging process as opposed to a fraction of a sum. See Practice E799 for computation of $\bar{D}_{pq}$ when data for discrete size classes are used.

Examples:
Area (surface) mean diameter is $\bar{D}_{20}$,
De Brouckere diameter is $\bar{D}_{43}$,
Evaporative diameter is $\bar{D}_{31}$,
Herdan diameter is $\bar{D}_{43}$,
Linear (arithmetic) mean diameter is $\bar{D}_{10}$,
Sauter mean diameter is $\bar{D}_{32}$, and
Volume mean diameter is $\bar{D}_{30}$.

mist, *n*—liquid, usually water, in the form of particles suspended in the atmosphere at or near the surface of the earth; small water droplets floating or falling, approaching the form of rain, and sometimes distinguished from fog as being more transparent or as having particles perceptively moving downward. **D1356**

monodisperse, *adj*—describing a population of drops of substantially equal diameter.

nebulize, *v*—to produce droplets.

normal distribution, *n*—drop size distribution described by the following equation:

$$f_n(D) = \left\{1/\left[\sigma\sqrt{(2\pi)}\right]\right\} \int_{-\infty}^{D} exp\left\{-\left[x - \left(\bar{D}_1\ o\right)^2\right] / \left(2\sigma^2\right)\right\} dx \quad (3)$$

where:

$f_n(D)$ = the (*D*) fraction of drops of diameter less than *D*.

DISCUSSION—This does not provide positive or negative bounds to the diameters.

Nukiyama-Tanasawa distribution, *n*—drop size distribution described by the following equation:

$$dN/dD = a \times D^m exp(-b \times D^n) \quad (4)$$

where:

N = the number of drops of diameter smaller than *D*, and *a, m, b,* and *n* are parameters (usually $m = 2$ and $n \neq 1$).

Nukiyama-Tanasawa nozzle, *n*—an internal mixing pneumatic atomizer consisting of two concentric tubes. Liquid emerging from the inner tube is atomized by air flowing through the annulus between the tubes.

number density, *n*—the number of particles contained in a specified volume of space at a given instant.

orifice atomizer, *n*—see **plain jet atomizer**.

particle, *n*—a small discrete mass of solid or liquid matter. **D1356**

patternate, *v*—to measure the pattern of a spray.

patternation, *n*—the measurement and characterization of spray patterns.

patternator, *n*—a device designed to patternate sprays.

PDPA, *n*—phase Doppler particle analyzer.

piezoelectric vibratory atomizer, *n*—a vibratory atomizer in which a piezoelectric transducer transmits high-frequency oscillations to a liquid, creating relatively uniform drops whose size is a function of the frequency of oscillation.

piloted airblast nozzle, *n*—an airblast nozzle combined with a lower capacity pressure nozzle.

pintle atomizer, *n*—an impact atomizer in which a liquid jet is directed against a fixed axisymmetric surface. (See also **variable-orifice poppet nozzle**.)

plain jet atomizer, *n*—a pressure atomizer comprising a simple orifice designed to produce an unstable liquid jet.

plain orifice atomizer, *n*—see **plain jet atomizer**.

pneumatic atomizer, *n*—a device wherein the movement of gas or vapor is the primary source of energy utilized to produce a spray.

prefilming airblast nozzle, *n*—an airblast nozzle in which solid surfaces are configured to produce a liquid film that subsequently is broken up by adjacent airstreams.

pressure atomizer, *n*—a device wherein pressurized liquid is the primary source of energy utilized to produce a spray.

pressure atomizing nozzle, *n*—see **pressure atomizer**.

pressure nozzle, *n*—see **pressure atomizer**.

primary atomization, *n*—the initial disintegration of a liquid jet, sheet, or film.

primary breakup, *n*—see **primary atomization**.

recirculating nozzle, *n*—see **by-pass nozzle**.

relative span, *n*—dimensionless parameter indicative of the uniformity of the distribution, and defined as follows:

$$\text{relative span} = \left(D_{V0.9} - D_{V0.1}\right)/D_{V0.5} \quad (5)$$

representative sample, *n*—a sample containing enough measured elements that the effect of random fluctuations is acceptably small.

return flow nozzle, *n*—see **by-pass nozzle**.

Rosin-Rammler distribution, *n*—drop size distribution described by the following equation:

$$f_v(D) = 1 - exp\left[-\left(D/D_{RR}\right)\right]^n \quad (6)$$

where:

$f_v(D)$ = the volume fraction of liquid in drops of diameter less than D_{max},
D_{RR} = the "Rosin-Rammler" diameter ($D_{V0.632}$ from "Rosin-Rammler" distribution, f_v), and
n = parameter indicating the size span of the distribution.

DISCUSSION—This does not provide upper bound to *D*; and, for values of *n* less than or equal to 3, there is an infinite number of drops in the neighborhood of zero diameter.

rotary atomizer, *n*—see **centrifugal atomizer**.

rotary cup atomizer, *n*—a centrifugal atomizer in which liquid is fed to the interior surface of a spinning cup, from which it is flung out to form a spray.

[5] Mugele, R.A., and Evans, H.D., "Droplet Size Distribution in Sprays," *Industrial and Engineering Chemistry*, Vol 43, No. 6, June 1951, pp. 1317–1324.

rotary disk atomizer, *n*—a centrifugal atomizer in which liquid is introduced near the center of one or more spinning disks, spreads out toward the rim, and is flung out to form a spray.

rotary wheel atomizer, *n*—a centrifugal atomizer that consists of a rotating, hollow cylinder in which liquid is introduced to the interior and flows through passages to openings, where it is broken up into drops.

satellite drops, *n*—drops formed during atomization that are associated with a much larger drop.

secondary atomization, *n*—the disintegration of unstable drops or liquid fragments resulting from primary atomization to produce stable drops.

shear coaxial injector, *n*—a pneumatic atomizer consisting of a central liquid stream surrounded by a high-velocity co-annular gas stream.

sheet disintegration, *n*—the breakup of an unstable liquid film into particles.

simplex airblast nozzle, *n*—see **piloted airblast nozzle**.

simplex nozzle, *n*—a swirl chamber atomizer comprising a single set of tangential liquid inlets (or slots) combined with a single circular discharge orifice.

single-fluid atomizer, *n*—see **pressure atomizer**.

single jet atomizer, *n*—see **plain jet atomizer**.

siphon nozzle, *n*—a pneumatic atomizer in which an air stream aspirates and atomizes liquid from a reservoir located beneath the nozzle.

slinger, *n*—see **centrifugal atomizer**.

slurry, *n*—a suspension of solids in liquid.

solid cone atomizer, *n*—a cone atomizer in which a significant quantity of liquid is directed into the center region of the spray pattern.

solid cone pattern, *n*—*Syn.* for **full cone pattern**.

sonic nozzle—a pneumatic or vibratory atomizer in which energy is imparted, at frequencies below 20 kHz, to the liquid.

Discussion—For frequencies greater than 20 kHz, see **ultrasonic nozzle**.

Discussion—Alternatively, a pneumatic atomizer in which gas velocities reach or exceed the local speed of sound.

sonic-whistle atomizer, *n*—a pneumatic type of sonic or ultrasonic nozzle.

spatial averaging, *n*—the combination of particle size distributions for regions or locations within a liquid dispersion into a distribution representative of a larger sampling region.

spatial resolution, *n*—because of ambiguities due to alternative definitions, it is recommended that "spatial resolution" not be used unless a specific definition is provided by the user.

spatial size distribution, *n*—the size distribution of particles in a given volume of space, wherein there is no significant variation in the distribution during the sampling interval.

Discussion—Spatial size distributions are typically obtained by high-speed imaging or sensing of diffracted light from a particle ensemble. Spatial size distributions may be transformed into flux size distributions by multiplying the number (or fraction) of particles of a given velocity by that velocity.

spill nozzle, *n*—see **by-pass nozzle**.

spill return nozzle, *n*—see **by-pass nozzle**.

spillback nozzle, *n*—see **by-pass nozzle**.

spinning cup atomizer, *n*—see **rotary cup atomizer**.

spinning disk atomizer, *n*—see **rotary disk atomizer**.

splash cup atomizer, *n*—an impact atomizer in which one or more liquid jets are directed against the internal surface of a cup.

splash plate atomizer, *n*—an impact atomizer in which one or more liquid jets are directed against a flat plate.

spray, *n*—a dynamic collection of particles, usually generated by the process of atomization.

spray, *v*—to disperse or apply as a spray.

spray angle, *n*—the plane angle formed by the profile of a spray pattern.

Discussion—The angle may be perceived visually or measured by an instrument. The exact numerical value of the angle depends on the curvature of the pattern profile, the definition of its boundaries, the specific measurement technique, and the bias of any observer whose judgment may be required when assessing the angle.

spray characterization, *n*—the process of describing a spray, based on theory or measurement, in terms of parameters such as liquid flow or flux, patternation, particle size, and velocity.

spray pattern, *n*—the flux distribution of liquid discharge by an atomizer.

square root normal distribution, *n*—drop size distribution described by the following equation in derivative form:

$$df_n/dD = \left\{1/\left[2\sqrt{(2\times\pi\times\sigma_s\times D)}\right]\right\} \times exp\left\{-\left[\left(\sqrt{D}\right)-\left(\sqrt{D}\right)_{med}\right]^2/\left[2\times\sigma^2\right]\right\} \quad (7)$$

where:

f_n = the number fraction of drops of diameter less than D, and

σ_s = the "standard deviation" from $\left(\sqrt{D}\right)_{med}$.

Discussion—This also has no upper bound to diameters. There are also problems with the calculations at the lower bound (no square root of negative diameter and hence the normal curve requires special treatment to obtain meaningful count at the smaller diameter end).

square spray nozzle, *n*—a pressure atomizer with a special orifice outlet configuration designed to create a spray whose cross section approaches a square.

straight stream nozzle, *n*—see **plain jet atomizer**.

Stokes' diameter, *n*—the diameter of a hypothetical sphere having the same density as the actual particle, as computed from the following Stokes' drag force formula:

$$\text{Drag force} = 3\pi\mu v_p\,(\text{Stokes' diameter}) \quad (8)$$

where:

μ = viscosity of fluid medium creating drag on the particle, and
v_p = velocity of the particle relative to the medium.

swirl atomizer, *n*—a pressure atomizer in which the liquid is swirled, typically by means of tangential inlets, slotted distributors, vanes, or cores.

swirl chamber atomizer, *n*—a swirl atomizer in which a chamber is located between the swirl generating devices and a discharge orifice.

swirl coaxial injector, *n*—a pneumatic atomizer consisting of a central liquid stream surrounded by a high-velocity co-annular gas stream, wherein swirl is unparted to at least one of the streams.

temporal averaging, *n*—the combination of particle size distributions obtained at different points in time into a distribution representative of a longer time interval.

temporal resolution, *n*—because of ambiguities due to alternative definitions, it is recommended that "temporal resolution" not be used unless a specific definition is provided by the user.

temporal size distribution, *n*—see **flux size distribution.** In context with particle size distributions, the use of *temporal* is not recommended because of possible confusion with other meanings for this term.

triplet injector, *n*—an impinging jet atomizer in which there are three colliding liquid jets.

twin-fluid atomizer, *n*—see **pneumatic atomizer**.

two-fluid atomizer, *n*—see **pneumatic atomizer**.

ultrasonic nozzle, *n*—a pneumatic or vibratory atomizer in which energy is imparted, at high frequency, to the liquid.

Discussion—Common usage refers to frequencies within or above the human auditory range, but recommended practice should be restricted to frequencies above 20 kHz.

Discussion—For frequencies below 20 kHz, see **sonic atomizer**.

upper limit log normal distribution, (ULLN), *n*—drop size distribution described by the following equation:

$$f_v(D) = \left\{1/\sqrt{\pi}\right\} \int_{-\infty}^{del \times log[A \times D/(D_{max} - D)]} exp(-t^2)\, dt \quad (9)$$

where:

$f_v(D)$ = the volume fraction of liquid in drops of diameter less than D,
D_{max} = the upper bound of drop diameters, and
del and A = ULLN parameters determining dispersion and skewness.

variable-area nozzle, *n*—a pressure atomizer in which the open area of one or more liquid flow passages may be varied so as to control the discharge characteristics.

variable-orifice pintle nozzle, *n*—see **variable-orifice poppet nozzle**.

variable-orifice poppet nozzle, *n*—a variable-area nozzle in which a moveable poppet determines the annular orifice area.

vibrating needle atomizer, *n*—a vibratory atomizer in which liquid under pressure is supplied through a hollow vibrating needle.

vibrating reed atomizer, *n*—a vibratory atomizer in which individual drops are produced from a liquid reservoir by an oscillating reed.

vibrative atomizer, *n*—see **vibratory atomizer**.

vibratory atomizer, *n*—a device wherein an oscillating solid surface is the primary source of energy.