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Statistical Analysis Methods

The quantities reported in the Data Report are calculated in accordance with ASTM Standard E799-92, "*Standard Practice for Determining Data Criteria and Processing for Liquid Drop Size Analysis*".

Explanation Of Terms Used On Droplet Size Reports

Graphs

Diameter Distribution : a histogram of counts in the size classes; also called *number distribution*.

Volume Distribution*:* a histogram of the volume (in μm^3) represented by the counts in each size class.

Area Distribution: a histogram of the area (in μm^2) represented by the counts in each size class.

Cumulative Volume: a histogram of the total volume (in μm^3) represented by the counts in all size classes below a given size class.

Sample Analysis Summary (*diameters in µm*)

Means: [Diameter means are calculated based on the discrete particle diameters and counts]

Arithmetic mean*:* the average diameter on a simple numerical basis (**D10**):

$$D_{10} = \left[\frac{1}{N} \sum_{i=1}^{N} D_i \right]$$

Surface mean*:* the diameter of a drop whose surface area, if multiplied by the total number of droplets, will equal the total surface area of the sample (**D20**)*:*

$$D_{20} = \left\{ \frac{1}{N} \sum_{i=1}^{N} D_i^2 \right\}^{1/2}$$

Volume mean*:* the diameter of a drop whose volume, if multiplied by the total number of droplets, will equal the total volume of the sample.(**D30**)*:*

$$D_{30} = \left\{ \frac{1}{N} \sum_{i=1}^{N} D_i^3 \right\}^{1/3}$$

Sauter mean: the diameter of a drop whose area to volume ratio is the same as that of the entire sample (**D32**):

$$D_{32} = \left[\frac{\sum_{i=1}^{N} D_i^3}{\sum_{i=1}^{N} D_i^2} \right]$$

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Generalized mean diameter:

$$D_{np} = \left\{ \frac{\sum_{i=1}^{N} D_i^n}{\sum_{i=1}^{N} D_i^p} \right\}^{1/(n-p)}$$

Volume percentiles: [*Volume percentiles are based on the data after processing into the Class Table. The representative diameter for each class is the mid-point of the bin range.*]

DV01 : the diameter such that the collection of drops whose diameter is below this value represents 10% of the sample volume

DV05 : the diameter such that the collection of drops whose diameter is below this value represents 50% of the sample volume

DV09 : the diameter such that the collection of drops whose diameter is below this value represents 90% of the sample volume

Relative span :

$$Span = \left[\left\{ \frac{\left(D_{V0.9} - D_{V0.1}\right)}{D_{V0.5}} \right\} 100\% \right]$$

System Performance Summary

Validation

Attempted: The number of samples attempted during data acquisition

Validated: The number of samples fulfilling the validation requirements during data acquisition

Validation Rate: The ratio of *Validated* to *Attempted* samples

Data Rate : average rate of attempted and validated samples

Elapsed Time: Total elapsed time measured from when data acquisition is started and terminated at each individual location, adjusted for deadtime settings.

Velocity

[*Velocity statistics are based on the discrete particle velocity data*]

Mean: The mean particle axial velocity weighted for residence time:

$$\bar{U}_{weighted} = \left[\frac{\sum_{i}^{N} \mathbf{U}_i \Delta t_i}{\sum_{i}^{N} \Delta t_i} \right]$$

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Variance: The variance of the velocity weighted for residence time:

$$\sigma^2_{weighted} = \overline{u^2} = \left[\frac{\sum_i^N (U_i - \overline{U})^2 \Delta t_i}{\sum_i^N \Delta t_i} \right]$$

RMS: The RMS value calculated using the weighted variance:

$$\sigma = \sqrt{\overline{u^2}}$$

Skewness:

$$S_{weighted} = \overline{u^3} = \left[\frac{\sum_i^N (U_i - \overline{U})^3 \Delta t_i}{\sigma^3 \sum_i^N \Delta t_i} \right]$$

Flatness factor:

$$K_{weighted} = \overline{u^4} = \left[\frac{\sum_i^N (U_i - \overline{U})^4 \Delta t_i}{\sigma^4 \sum_i^N \Delta t_i} \right]$$

Sample [*Sample statistics are based on the discrete particle data*]

Variance of diameter:

$$\sigma^2 = \int_{D_0}^{D_m} n(D)(D - D_{10})^2 dD$$

expanding this yields:

$$\sigma_n^2 = D_{20}^2 - D_{10}^2$$

Skewness of diameter:

$$S_n = \int_{D_0}^{D_m} n(D)(D - D_{10})^3 dD / \sigma_n^3$$

expanding this yields:

$$S_n = \left(D_{30}^3 - D_{10}\left(D_{10}^2 + 3\sigma_n^2\right)\right) / \sigma_n^3$$

Concentration: After correcting for cross-sectional bias, the size histogram is integrated with respect to diameter to produce the concentration [particles/cc].

Volume Flux: The volume of dispersed phase crossing the measurement volume per unit time per unit area [cc/sec/cm2].

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Void fraction:

$$vf = \left[\frac{\sum_{i=1}^{N} \Delta t_i}{T} \right]$$

where:
T is the duration of block during which *N* samples occur.

Volume fraction: The percent volume of dispersed phase to carrier phase.

$$Vf = \left[\left(\frac{p}{6} \right) \left(\frac{(D_{10})^3}{V} \right) \right]$$

where:
V is the measurement volume size.

Turbulence energy:

$$T = \left[\left(\frac{s}{\overline{U}} \right) 100 \right]$$

Statistical Definitions of Quantities Reported in Drop Size Distribution Table

Count: Straight count of the number of drops in the sample falling into that bin.

Percentage occurrence: The ratio of the number of drops in the i^{th} bin to the total number of drops in the sample:

$$\left[\frac{n_i}{N} \right]$$

Percent surface area: The ratio of the sum of the squares of the diameters for all drops in the i^{th} bin to the same sum for all drops in the sample:

$$\left[\frac{\sum_{n=i} D_i^2}{\sum_{n=0}^{N} D_n^2} \right]$$

Area: The total surface area [µm^2] associated with the droplets contained within the i^{th} bin.

$$A_i = \left[p \sum D_i^2 \right]$$

Cumulative area: The total surface area [µm^2] associated with the droplets contained within all bins up to the i^{th} bin.

$$A_{cum_i} = \left[p \sum_{n==0}^{i} D_n^2 \right]$$

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Volume: The total volume [μm^3] associated with the droplets contained within the i^{th} bin.

$$V_i = \left[\frac{p}{6}\sum D_i^3\right]$$

Cumulative volume: The total volume [μm^3] associated with the droplets contained within all bins up to the i^{th} bin.

$$V_{cum_i} = \left[\frac{p}{6}\sum_{n=0}^{i} D_n^3\right]$$

Percent volume: The ratio of the sum of the cubes of the diameters for all drops in the i^{th} bin to the same sum for all drops in the sample:

$$\%V_i = \left[\frac{\sum D_i^3}{\sum_{n=0}^{N} D_n^3}\right]$$

Cumulative volume percent: A running total of the percent volume for all bins up to the i^{th} bin.

$$\%V_{cum_i} = \left[\frac{\sum_{n=0}^{i} D_n^3}{\sum_{n=0}^{N} D_n^3}\right]$$

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