AccuSizer® Data Interpretation

AccuSizer systems

OVERVIEW

The Entegris AccuSizer® is both a liquid particle counter and a high resolution particle size analyzer. This technical note shows typical results from the AccuSizer, and explains how to interpret the data generated.

INTRODUCTION: SINGLE PARTICLE OPTICAL SIZING

The AccuSizer is based on the technique of single particle optical sizing (SPOS). As shown in Figure 1, a particle passes through a constricted sensing zone where it interacts with light via both extinction (obscuration) and scattering. The extinction and scattering pulses generated are combined and fed into a pulse height analyzer, also called the counter. A calibration curve then transforms each pulse into the related particle size.

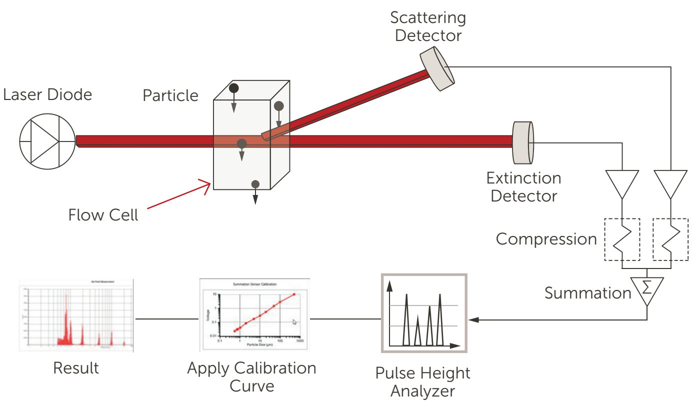

Figure 1. The SPOS technique

The result is both a particle size distribution and the concentration in particles/mL. The AccuSizer can therefore be used as both a particle counter, and particle size analyzer. The primary result generated is the number distribution since particles are analyzed one at a time so the primary result is the particle number distribution, as opposed to ensemble techniques that inspect a large number of particles and use an algorithm to derive particle size distribution. Since the particles are individually analyzed, the SPOS technique is inherently a higher resolution technique as compared to ensemble techniques, such as laser diffraction.

The size reported is an equivalent spherical diameter (ESD). A sphere of the reported size would create the same pulse as the one analyzed. Figure 2 shows three examples for different shape particles with the dashed red line showing the ESD.

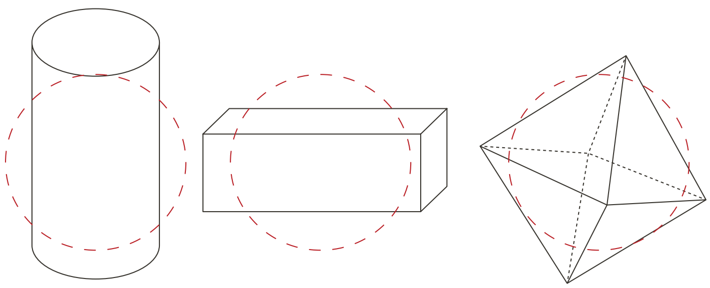

Figure 2. Equivalent spherical diameter

TYPES OF DISTRIBUTIONS: NUMBER VS. VOLUME

As mentioned earlier, the primary result is a number distribution. This can be converted to an area, which is seldom used, or volume distribution. The volume distribution is sometimes used to compare AccuSizer results to other techniques, like laser diffraction, that generate the primary result in this format.

Consider a distribution containing three particles of sizes 10, 20, and 30 µm as shown in Figure 3.

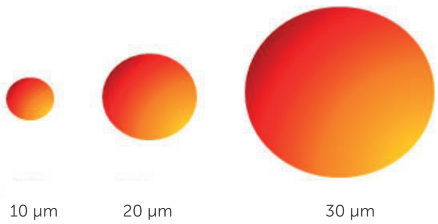

Figure 3. Three particles in a distribution 10, 20, and 30 µm

The number distribution is plotted in Figure 4, where it shows that there is an equal number, 1, at each particle size.

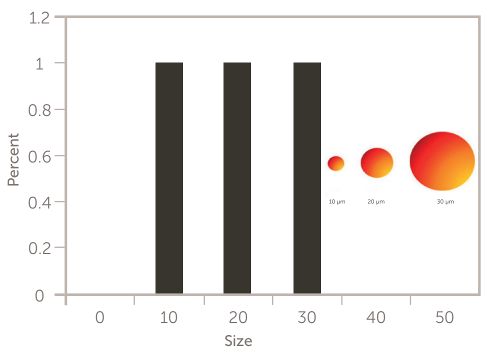

Figure 4. Number distribution result

Now, if the total volume of all particles is calculated and then we create the volume distribution shown in Figure 5, we see that most of the total volume (>70%) comes from the 30 µm particle and very little comes from the 10 µm particle.

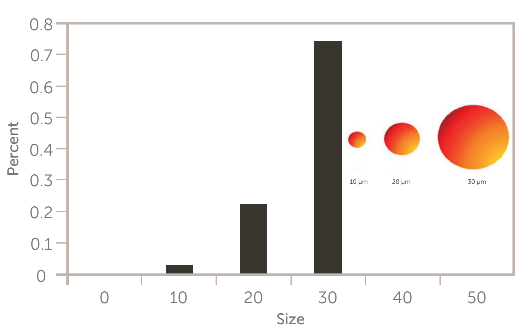

Figure 5. Volume distribution result

A typical number based AccuSizer result is shown in Figure 6. The conversion to a volume distribution is shown in Figure 7. Note how much smaller the number distribution appears. These are the same results, just presented with a different calculation basis number vs. volume.

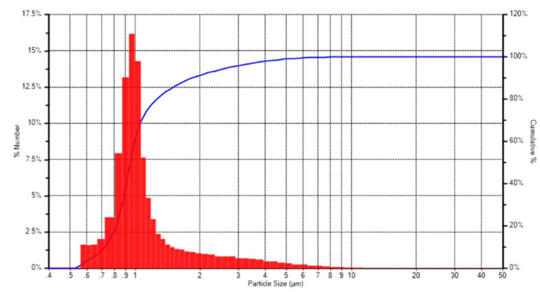

Figure 6. Number distribution result

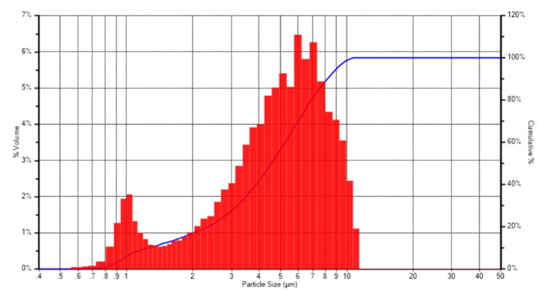

Figure 7. Volume distribution result

The calculated differences between the number and the volume distributions are shown in Table 1.

	Mean	Std dev.	Mode	Median
Number	1.16	1.07	0.6	0.83
Volume	5.2	3.06	6.15	3.38

Table 1. Number vs. volume distribution

CALCULATED RESULTS

The calculated numerical results are the values used for specifications, and all other important interpretation considerations. In the first result, most people focus on the central point of the distribution that can be described by values, like the mean, median and mode.

The mean is a calculated value for the central point - similar to but not exactly the same as the "average." There are several possible approaches for calculating the mean. The accepted techniques for calculating the mean diameters, and graphing the results of a particle size distribution, are explained by several national and international standards.[1, 2, 3] The most common values reported are the number, area, and volume weighted mean. The typical equation used to define these values are given in Table 2.

Symbol	Definition	Equation
D 1,0	Number mean	$\sum n_i D_i / N$
D 3,2	Surface area mean	$\frac{\sum n_i D_i^3}{\sum n_i D_i^2}$
D 4,3	Volume mean	$\frac{\sum n_i D_i^4}{\sum n_i D_i^3}$

Table 2. Calculated mean diameters

For our example, distribution of 10, 20, and 30 μm, the number mean would be 20 μm, while the volume mean would be 27.2 μm.

Other calculated results displayed by the AccuSizer are summarized below:

RESULT	DEFINITION
Concentration	Number of particles/mL
Sensor file	The calibration file used
Sensor model	Typically LE400, FX or FX Nano
SUM vs. EXT	Summation or extinction cal curve
Sensor S/N	Sensor serial number
Sample time	Measurement duration in seconds
Fluid volume	Total sample volume
Threshold	Smallest particle size analyzed
Total # sized	Number of particles analyzed

RESULT TABLES

The AccuSizer can display results in 16, 32, 64, 128, 256 or 512 size channels. The number of size channels must be selected before the measurement in the dialog box is accessed by clicking control menu, system menu.

Alternatively, up to six user defined channels can be chosen by the operator to define specific size values of interest. A tabular result showing user defined channels is shown in Table 3.

Cumulative summary table

Diameter	Number Particles Sized	Cumulative Number ≥Diameter	Number Particles/mL ≥Diameter	Number %	Volume %	Cumulative Number >Diameter	Cumulative Volume ≥Diameter
0.50 microns	235590	263335	87354968	89.464	8.660	100.000	100.000
2.01 microns	23830	27745	9203728	9.049	23.441	10.536	91.340
5.02 microns	3426	3915	1298706	1.301	39.985	1.487	67.899
9.99 microns	453	489	162214	0.172	26.311	0.186	27.914
14.98 microns	35	36	11942	0.013	1.604	0.014	1.604
25.01 microns	1	1	332	0.000	0.000	0.000	0.000

Table 3. Tabular result of user defined channels

RESULT GRAPHS

A graphical representation of the particle size distribution is presented in a range of formats. The graphical result is most often displayed as a histogram distribution. The particle size is plotted on the x-axis and the percent of the total distribution within a size band is plotted on the y-axis. The result shown in Figures 7 and 8 are examples of histogram graphs. If the histogram bars are replaced by a curve that passes through the central point of each size band the frequency result is generated as shown in Figure 8.

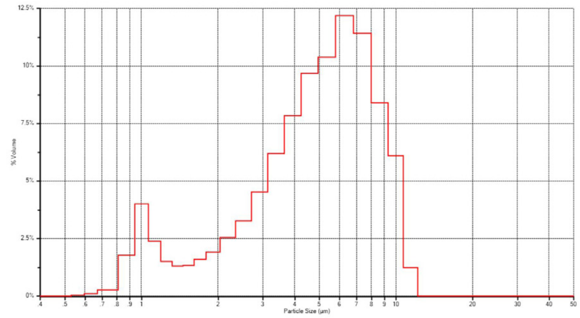

Figure 8. Volume distribution, line chart

Plotting the result as shown in Figure 8 is preferred rather than a bar graph when overlaying more than one result on the same plot.

If a line is drawn through the central point of each size band, but plotted as size on the x-axis and percent under a given size on the y-axis, then the cumulative distribution is displayed as seen in Figure 9.

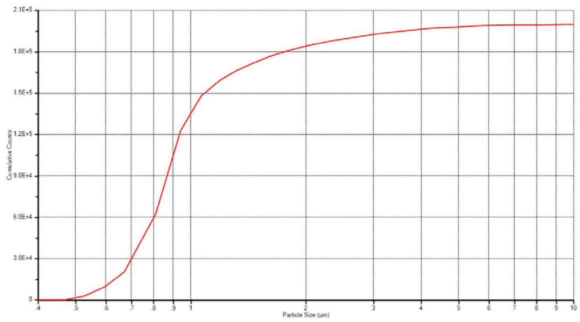

Figure 9. The cumulative volume result

OTHER RESULTS: D10, D50, D90

Another approach to describe the particle size distribution is to define three points on the distribution associated with the diameters below which 10, 50, and 90 percent lies. These are the D10, D50, and D90 as shown in Figure 10.

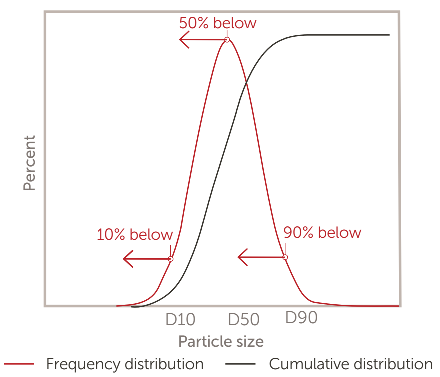

Figure 10. D10, D50, D90

To display the D10, D50 (also the median), D90, and other percentiles within the distribution, select Display, Show Cumulative Result, and the data shown in Figure 11 will be displayed.

Summary of Volume Weighted Cumulative Distribution
5% of total particle volume <1.51 microns
10% of total particle volume <2.21 microns
15% of total particle volume <2.87 microns
20% of total particle volume <3.40 microns
25% of total particle volume <4.21 microns
30% of total particle volume <4.73 microns
35% of total particle volume <5.52 microns
40% of total particle volume <6.15 microns
45% of total particle volume <6.85 microns
50% of total particle volume <7.23 microns
55% of total particle volume <8.05 microns
60% of total particle volume <8.50 microns
65% of total particle volume <9.09 microns
70% of total particle volume <9.99 microns
75% of total particle volume <10.55 microns
80% of total particle volume <11.35 microns
85% of total particle volume <12.40 microns
90% of total particle volume <13.22 microns
95% of total particle volume <14.58 microns
99% of total particle volume <16.24 microns

Figure 11. Show cumulative result

References

[1] ASTM E2578; *Standard Practice for Calculation of Mean Sizes/Diameters and Standard Deviations of Particle Size Distributions*

[2] ISO 9276-2; *Representation of results of particle size analysis—Part 2: Calculation of average particle sizes/diameters and moments from particle size distributions*

[3] ISO 9276-1; *Representation of results of particle size analysis—Part 1: Graphical Representation*

FOR MORE INFORMATION

Please call your Regional Customer Service Center today to learn what Entegris can do for you.
Visit entegris.com and select the Contact Us link to find the customer service center nearest you.

TERMS AND CONDITIONS OF SALE

All purchases are subject to Entegris' Terms and Conditions of Sale. To view and print this information, visit entegris.com and select the Terms & Conditions link in the footer.

Corporate Headquarters
129 Concord Road
Billerica, MA 01821
USA

Customer Service
Tel +1 952 556 4181
Fax +1 952 556 8022
Toll Free 800 394 4083