# Frequently Asked Questions on Particle Size Distribution Results from Particle Counters

**Q: The particle size results I received include number-weighted and volume-weighted data. What is the difference?**

**A:** On particle counter type instruments, the particle size distribution (PSD) is constructed particle by particle as a frequency histogram, where a 1 µm particle has equal weighting to a 10 µm particle. However, since the volume of a particle increases proportionally to the diameter cubed ($D^3$), the 10 µm particle contains 1,000 times the volume and by extension 1,000 times the mass (assuming a uniform density) as the 1 µm particle. This exponential conversion is illustrated in the volume-weighted distribution, where the PSD is weighted based on the volume each particle contributes to the system. Subsequently, the volume data are inherently more sensitive to larger particles.

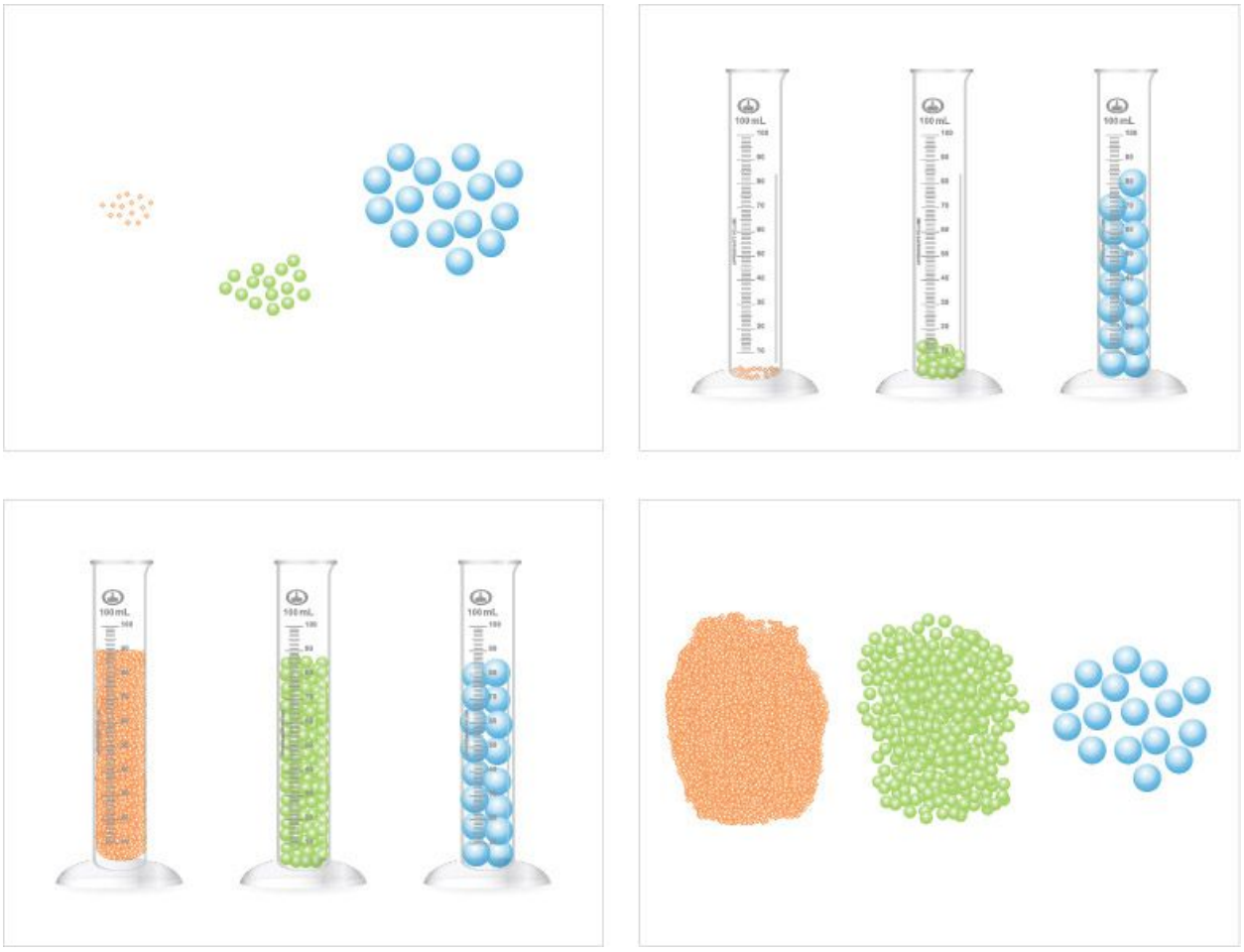

**Figure 1:** Top Left: Equal numbers of different sized spheres; Top right: Volume of equal numbers of different sized spheres; Bottom Left: Equal volumes of different sized spheres; Bottom Right: Number of equal volumes of different sized spheres

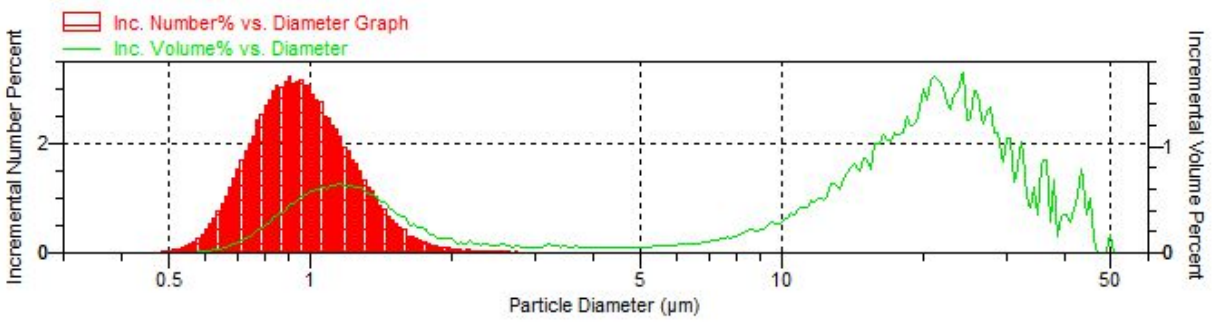


**Figure 2:** Number (Red) vs. Volume (Green) Distributions. Notice in this case the particulate less than 5 µm constitutes more than 99.9% of all particles counted, yet accounts for less than half of the particulate by volume or mass.

**Q: Okay. But which one is correct?**

**A:** Both are correct! The better question is which one is more useful for my application. If one is interested in knowing where the bulk or mass of the system lies, then volume data will likely be more useful. Another example is the API dosage weight of a tablet for a pharmaceutical. However, if one is interested in quantifying the number of particles (for instance if trying to limit particles present at certain sizes) then number data will be more useful. Number data may also be useful as a complement to volume data to help reveal subpopulations that may be obscured by the volume data.

**Q: Is it valid to convert between number and volume data?**

**A:** It is a generally accepted practice in the industry to convert number results generated by particle counters into volume data. However, some caution must be employed as small relative errors in the number distribution can propagate into larger errors when converting to volume. Similarly, many more particles are typically required to be counted to achieve a suitable level of statistical precision in the volume-weighted results. Converting volume data generated by an ensemble technique such as laser diffraction into number data, while possible, is not recommended due to the increased potential for propagation of errors based on the assumptions typically made in the result generation algorithms.

**Q: Why does my volume-weighted particle size distribution look "choppy"?**

**A:** An excessively choppy volume distribution (see the blue and green line in Figure 3 below) may indicate an inadequate sample size was analyzed to "fill out" the distribution. Due to the relationship between number- and volume-weighted data, single particles captured at the top end of the distribution can contribute a significant amount of weight to the volume distribution relative to smaller particles, which can lead to greater variability in the volume data, especially at the higher percentiles. The influence of larger particles on the distribution will depend on the width of the distribution and sample size (i.e. the broader the distribution, the larger the sample size needed). This is a fundamental limitation of particle counting instruments as the particle concentration in the carrier media must be suitably dilute so individual particles can be detected, yet this is in opposition to the need to count large numbers of particles. In cases of very broad particle size distributions, it can be prohibitively impractical to count a

sufficient number of particles; hence, a technique such as laser diffraction may provide more precise volume-weighted particle size results, albeit with lower resolution.

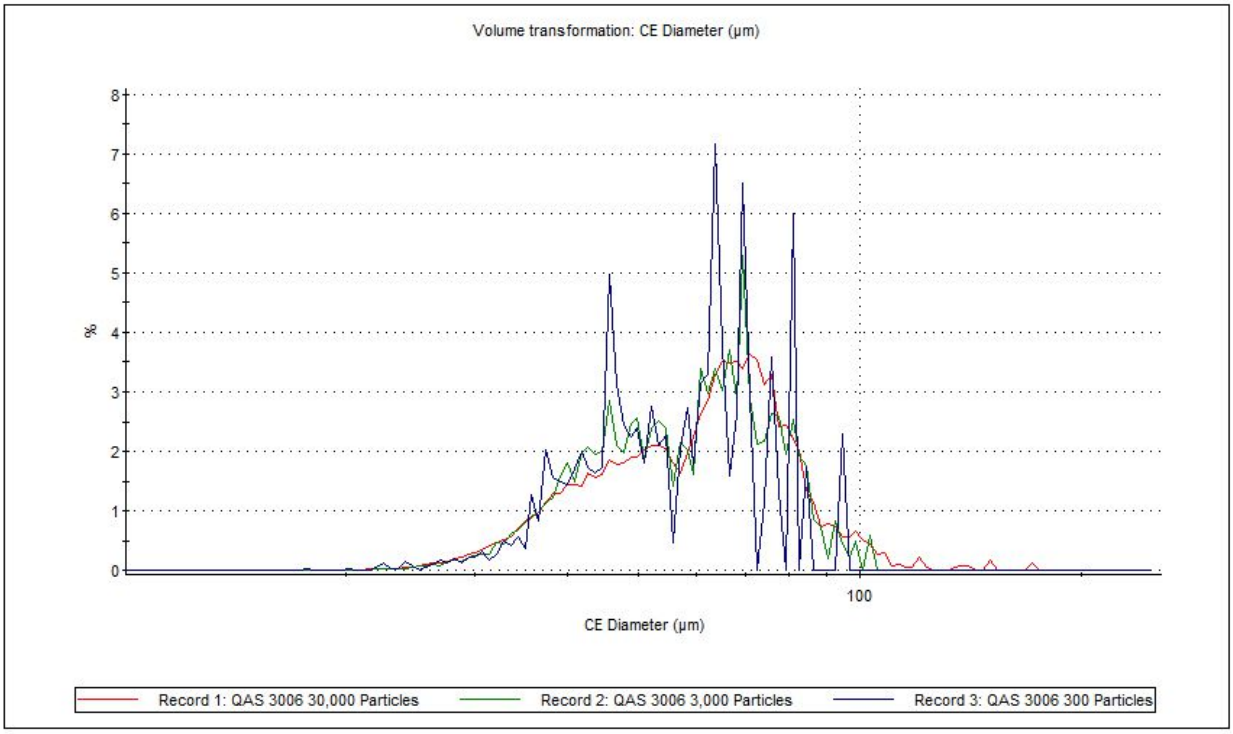


**Figure 3**: Impact of sample size on distribution continuity. Red line = 30,000 particles counted, Green line = 3,000 and Blue = 300.

**Q: Why don't my particle size results agree with results generated by a different technique?**

**A:** Confirm the type of weighting used. Laser diffraction, for instance, produces volume-weighted data so only comparisons between volume-weighted data generated by other techniques should be made with this technique. Additionally, the influence of particle shape, porosity, and optical properties can lead to different results on particle sizing techniques that employ different detection principles.

**Q: How reproducible are my results? What difference between samples or aliquots should be considered significant?**

**A:** PTL has standard operating procedures for representative sampling, sample preparation, and analysis for our various analytical techniques to ensure results generated are as reproducible as possible. Our instruments are also performance verified for accuracy on a routine schedule. However, all materials are different and the only way to truly verify the results are consistent between samples or aliquots is through replicate testing. Furthermore, "significantly different" will depend on the measurement uncertainty. PTL offers method development and validation services to ensure the test is accurate, robust, and precise for your particular material and to allow for meaningful specifications to be established for your product.