What's New with the Model 3321 Aerodynamic Particle Sizer® (APS™) Spectrometer?

Answer: More accurate size and mass distributions than ever!

Application Note APS-002

Models 3300 and 3310

Introduced in 1982 and 1987, respectively, the original APS™ spectrometers from TSI provided rapid, high-resolution, number-weighted, aerodynamic, particle size distributions.[1] These instruments enjoyed a great success in many applications, but use of the instruments to calculate mass-weighted distributions was limited by a low level background of false counts created by what was then thought to be coincidence and phantom particle effects.[2] The presence of a few false counts in large-particle size channels would skew the entire mass distribution. The same false particles necessitated special operating techniques, e.g., adjustment of the PMT (Photomultiplier Tube) voltage, in applications such as filter testing and cyclone cut-off evaluation where a few false counts could be critical.

Model 3320

Introduced in 1997, the Model 3320 APS™ spectrometer featured patented, double-crest optics and improved signal processing that effectively eliminated the effect of false counts due to coincidence and phantom particles. Thus, it provided better distribution measurements of more concentrated aerosols.[3] Relative light scattering was added as a measurement parameter allowing a mode of data collection called "correlated mode", where data for aerodynamic size was correlated to light-scattering intensity for each particle. The instrument was instituted with volumetric flow control and engineered into a smaller, modern cabinet with front-panel display and control.

However, accuracy in calculating mass distribution was still limited by a very low-level background of false, large-particle counts revealed when the effect of the coincidence and phantom particles was eliminated. After investigation, it was determined that small particles were recirculating and reentering the measurement region at a much slower velocity, making them look aerodynamically large, but optically small (Figs. 1 and 2).[4-7] By examining the light scattered by "large particles", it is possible to identify these missized particles for which it is highly unlikely that the light-scattering and size data can correlate. Without altering the raw data, these missized particles can be eliminated by using a correlated "mask" to achieve accurate mass distributions (Fig. 3).

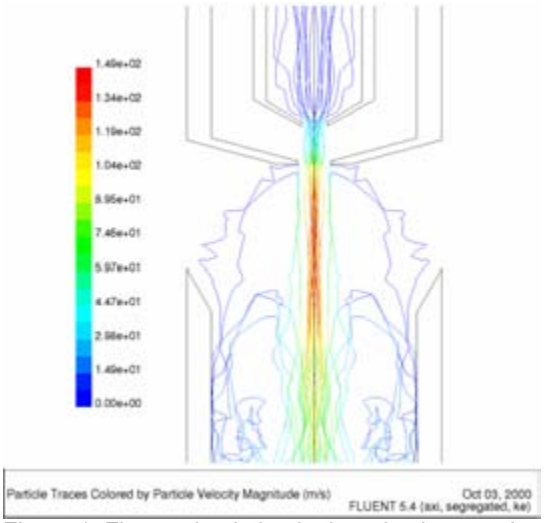

Figure 1: Flow recirculation in the eduction nozzle in Model 3320 APS™ spectrometer. Small particles in the recirculation flow may reenter the optics.[6]

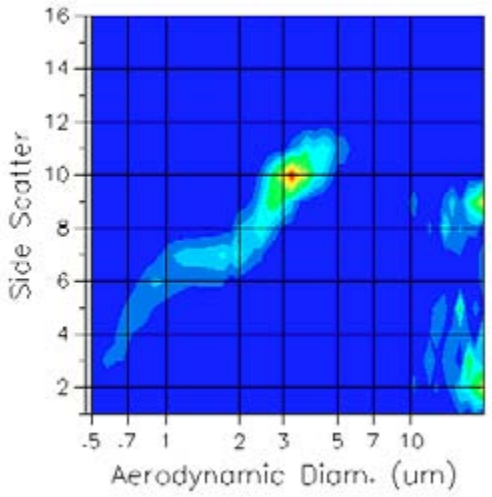

Figure 2: Typical data for Vanceril® with no correlated mask in Model 3320 APS™ spectrometer. The missized particles are aerodynamically large, but optically small.[5]

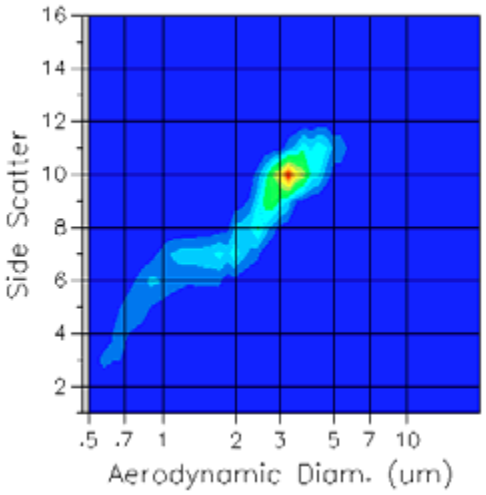

Figure 3: Typical data for Vanceril® with a user-defined mask in Model 3320 APS™ spectrometer to remove missized particles.[5]

Figure 4: Flow recirculation is restricted in Model 3320 APS™ spectrometer with a redesigned eduction nozzle[6] that is identical to the nozzle in Model 3321.

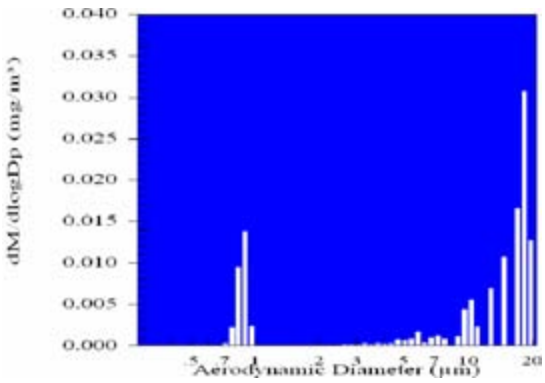

Figure 5: Mass distribution of PSL given by Model 3320 APS™ spectrometer with no correlated mask and the original eduction nozzle shown in Figure 1.[6] A few, false, large-particle counts skewed the whole mass distribution.

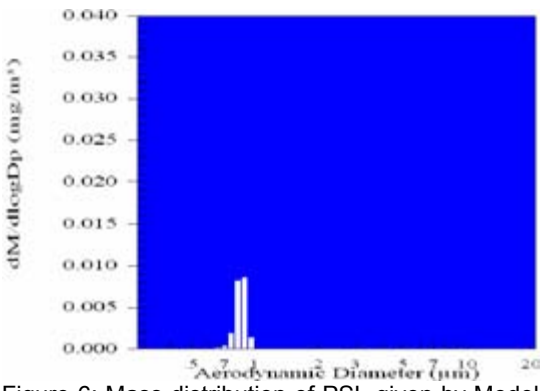

Figure 6: Mass distribution of PSL given by Model 3320 APS™ spectrometer with no correlated mask and the redesigned eduction nozzle (identical to the nozzle in Model 3321) shown in Figure 4.[6] The missized particles were eliminated without the need of data manipulation.

In order to implement the correlated mode where light-scattering and size data are correlated, a reduction in timing resolution was needed. The number of raw channels for aerodynamic size data was reduced from 1024 to 256 in correlated mode in order to provide 256 raw channels for light scattering data. This caused a "choppy" look at the smallest size channels of the size distribution.

Model 3321

Introduced in 2001, this model features several enhancements made to the 3320 platform. The eduction nozzle was redesigned based on the results of flow modeling to minimize the chance of particle recirculation in the optics region that could lead to false large-particle counts (Fig. 4).[6] Elimination of particle recirculation results in more-accurate mass distributions without the need of a "mask" or any other data manipulation (Figs. 5 and 6). Electronic changes to the Programmable Logic chip eliminate a minor timing issue in the 3320; thereby, optimizing the time spent processing a particle event. In addition, aerodynamic sizing resolution was restored in correlated mode at the expense of light-scattering resolution by assigning 1024 raw channels for aerodynamic-size data and 64 raw channels for light-scattering data. With these enhancements, the 3321 can now attain very accurate size and mass distributions.

Model 3321 upgrade of a Model 3320

Model 3320 APS™ spectrometer can be upgraded to Model 3321. The benefits of upgrading are more accurate measurements of mass distribution and higher aerodynamic sizing resolution in correlated data mode. The upgrade consists of replacing the eduction nozzle and related parts, a new digital printed circuit board, a new front panel, and full update on firmware and software along with a full standard service and calibration. Contact your TSI representative for pricing.

References

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