Comparison of the Grimm Optical Particle Counter to the TSI Aerodynamic Particle Sizer

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Abstract

This study compared the response of the Grimm Particle Dust Monitor (PDM) 1108 and a PDM 1109 to that of the APS 3321 as a function of particle size (0.3 µm to 10 µm) and particle type (Arizona road dust, carbon black, polystyrene latex, PSL). Monodisperse PSL spheres were generated with a Collison nebulizer. Polydisperse aerosols were generated with a Wright dust feeder. Clean, compressed air was used to dilute the aerosol to the intended mass concentration. The test aerosol was injected into a chamber and sampled concurrently by a PDM 1108, a PDM 1109, and an APS 3321.

Objective

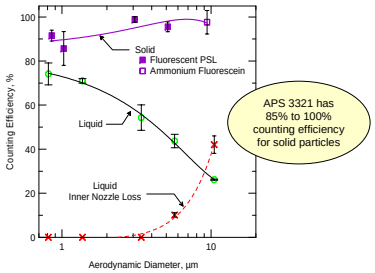
- To compare the performance of the Grimm PDM 1108 and the Grimm PDM 1109 to the TSI APS 3321

Introduction

The Grimm PDM 1108 optical particle counter measures particle number concentration in 15 channels from 0.3 µm to 20 µm. A newer version, the PDM 1109, uses a laser with a smaller wavelength than in the PDM 1108 to measure particle number concentration in 32 channels. These instruments are well suited for industrial hygiene applications because they are compact, battery powered, direct reading, and capable of operating in dusty environments (up to 100 mg m^{-3}). Little has been published to document the performance of either the PDM 1108 or the PDM 1109.

The TSI aerodynamic particle sizer (APS) model 3321 provides similar information over the same size range, but it is substantially more expensive than either PDM, powered by AC current, and limited to particle concentrations below 1000 particles cm^{-3}. Considerable work has aimed to document the performance of the APS 3321 and earlier APS models.

Shown below, the APS has 85% to 100% counting efficiency for solid particles. Thus, we use it in this work as the reference standard.



Counting efficiency of the APS 3321 (Volckens and Peters, in press, Journal of Aerosol Science).

Methods

Experimental details

Shown at right, clean air was mixed with aerosol and injected into a 1-m^3 chamber. This aerosol was then simultaneously sampled by an APS 3321, a PDM 1108, and a PDM 1109. Each instrument was set to report a size distribution every 6 seconds

The following aerosols were generated:

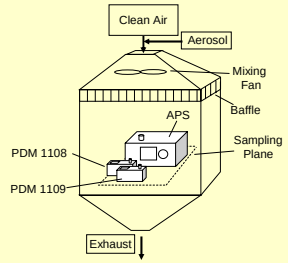
- Monodispserse polystyrene latex spheres (PSL)
  - 0.83 µm, 1.0 µm, 3.0 µm green PSL
  - 1.0 µm white PSL
- Polydisperse dust
  - Arizona road dust
  - Carbon black

Analysis

- Monodisperse PSL
  - Number concentration summed over channels with PSL peak
  - Channel midpoint diameter of peak determined
- Polydisperse dust
  - Number concentration converted to mass distribution
  - Respirable mass concentration calculated by integrating mass distribution with respirable curve.

Instruments

	Grimm PDM 1108	Grimm PDM 1109	TSI APS 3321
Measurement Principal	Optical	Optical	Optical and Time-of-flight
Size Range, µm	0.3 - 20	0.25 - 32	0.5 – 20
Number of Channels	15	31	52
Max Number Conc., p cm-3	2,000	2,000	1,000
Max Mass Conc., mg m-3	100	100	Not reported



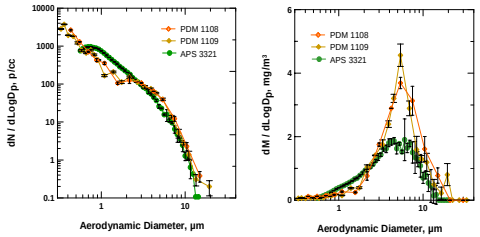
Experimental set up

Results: Mondisperse PSL

	Grimm PDM 1108	Grimm PDM 1109	TSI APS 3321
Number Concentration Peak Midpoint Diameter, µm			
0.83 µm PSL spheres	0.90	0.68	0.78
1.0 µm PSL spheres	0.90	0.90	0.90
3.0 µm PSL spheres	2.5	2.5	2.8
Mean Number Concentration ± St. Dev., particles cm^{-3}			
0.83 µm PSL spheres	3.2 ± 0.3	3.8 ± 0.4	3.1 ± 0.24
1.0 µm PSL spheres	0.67 ± 0.04	0.69 ± 0.02	0.54 ± 0.09
3.0 µm PSL spheres	0.028 ± 0.016	0.035 ± 0.018	0.022 ± 0.007

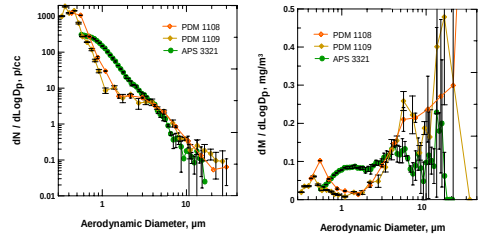
- Results for white PSL (not shown) were similar to those of green PSL
  - Suggests that difference in refractive index not important here
- In most cases, PDMs sized particles slightly smaller than APS
- Number concentration measured by PDMs was greater than APS
  - APS counting efficiency not truly 100% (see graph far right)
  - Thus, PDM concentration may be closer to the true concentration

Results: Polydisperse



Arizona Road Dust

- *Number Concentration*
  - PDM 1108 less than PDM 1109 smaller than 2 µm
  - PDMs less than APS between 1 µm and 2 µm (difference is evident even on the log plot)
  - PDMs greater than APS larger than 3 µm
- *Mass Concentration*
  - Estimate by all instruments quite comparable
  - Data affected by assumed shape factor and density



Carbon Black

- *Number Concentration*
  - PDM 1108 less than PDM 1109 smaller than 2 µm
  - PDMs less than APS between 1 µm and 2 µm
  - PDMs greater than APS above 4 µm
- *Mass Concentration*
  - Estimate by PDM less comparable with APS than in the case of Arizona road dust
  - Data in large channels of PDMs more variable than that of APS

Conclusions

- The PDM 1108 responded similarly to the PDM 1109;
- Both PDMs were able to detect particles smaller than that of the APS;
- Although number concentration reported by the PDM 1108 and PDM 1109 were both greater than the APS in monodisperse tests, they were lower than the APS in polydisperse tests; and
- Particle refractive index may affect polydisperse size distribution measured with the PDM 1108 and PDM 1109.