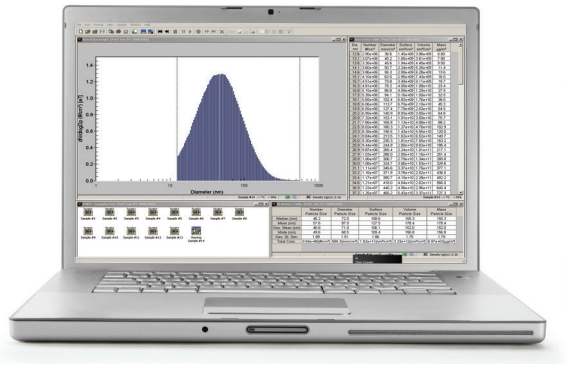
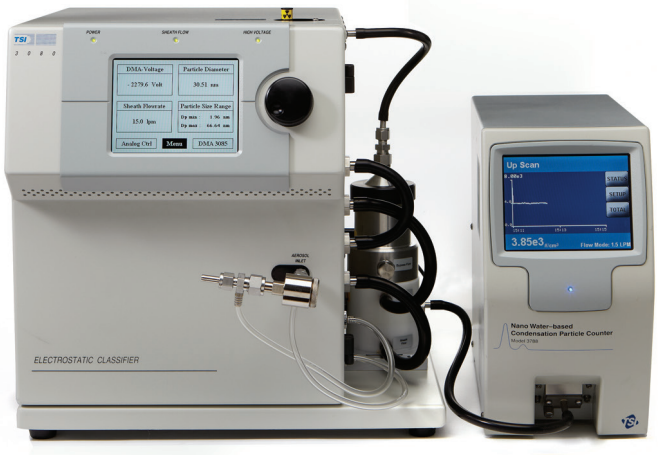
NANOSCAN SMPS SPECTROMETER COMPARED TO THE TSI® SMPS™ SPECTROMETER

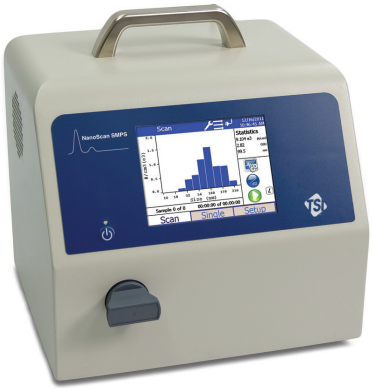
APPLICATION NOTE NANOSCAN-002

Scanning Mobility Particle Sizer™ (SMPS™) Spectrometer

TSI's SMPS Spectrometer is widely used as the standard for measuring aerosol particle size distributions. The SMPS Spectrometer has earned a well-deserved reputation for providing highly accurate and reliable size measurements for more than 30 years. In the last decade, advances in nanotechnology have created the need for a cost-effective, light-weight, battery-operated nanoparticle sizing instrument with performance comparable to the SMPS Spectrometer.







Derived from core TSI technologies, the NanoScan SMPS Model 3910 is an innovative solution for portable nanoparticle size measurements. The NanoScan SMPS uses scanning mobility particle sizing technology in an easy-to-use, light-weight, and battery-powered instrument. The portable design of the NanoScan SMPS is ideal for applications such as indoor/outdoor air quality investigations, combustion/emission research, mobile studies, health effects/inhalation toxicology, and industrial hygiene activities such as worker exposure, and point source identification.

Instrument Design

The NanoScan SMPS incorporates proven technology in a convenient design. The four key components of the NanoScan SMPS are derived from those of the SMPS Spectrometer:

1. Aerosol Conditioner	The NanoScan SMPS uses an inlet cyclone, analogous to the impactor of the SMPS spectrometer, to remove large particles. The cyclone cut-point is optimized for the size range of the NanoScan SMPS (Table 1), while the impactor of the SMPS Spectrometer can be selected for different cut-points.
2. Particle Charger	SMPS measurements are based on charged particles. The NanoScan SMPS uses a unipolar charger that charges more particles than the bipolar chargers used in the SMPS Spectrometer and eliminates the need for radioactive or x-ray radiation. A bipolar charger produces fewer multiply charged particles, making it useful for the larger particle sizes measured by the SMPS Spectrometer.
3. Size Selector	A narrow particle size is selected with a Differential Mobility Analyzer (DMA). The SMPS Spectrometer can be configured using two DMAs that cover a wide size range. The NanoScan SMPS uses a Radial DMA (RDMA) for size classification. A radial design is lighter and more compact than the traditional DMAs used with the SMPS Spectrometer, making it ideal for use in a portable instrument.
4. Particle Counter	The NanoScan SMPS uses an isopropanol-based Condensation Particle Counter (CPC) to provide accurate concentration measurements. Isopropanol, compared to butanol-based CPCs used in SMPS Spectrometer configurations, is an acceptable fluid in workplace and outdoor environments. CPCs used with the SMPS Spectrometer are available with butanol or water as the working fluid, covering different concentrations and lower cut-off sizes.

Table 1 — Key Comparisons between the NanoScan SMPS and SMPS Spectrometer

	NanoScan SMPS	SMPS Spectrometer*
Size Range	10 to 420 nm	2.5 to 1000 nm
Size Resolution	8 channels/decade	64 channels/decade
Particle Concentration	100 to 10^6 particles/cm^3	1 to 10^7 particles/cm^3
Working Fluid	Isopropanol	Butanol or water
Charger/Neutralizer	Unipolar, corona charger (non-radioactive)	Bipolar, Kr-85 radioactive or soft x-ray neutralizer
Operation Mode	Portable, Stationary	Stationary
Data Logging	On-board memory, USB drive, Software via PC	Software via PC
Display	Color touchscreen	LCD screen
Power	AC or batteries	AC
Weight	8 kg (17.5 lbs)	25 – 33 kg (55 to 73 lbs)
Cost	$$	$$$$

*Size range and concentration depend on the DMA and CPC

Performance

The NanoScan SMPS and SMPS Spectrometer were compared based on concentration linearity, size accuracy, particle size distribution measurements, and reproducibility. TSI's SMPS Spectrometer is available in a variety of configurations, depending on the choice of DMA and CPC. The NanoScan SMPS was compared to the SMPS Spectrometer Model 3936L76, referred to as SMPS 3936L76 in the figures below. All data are the average of 3 to 5 measurements.

Concentration Linearity

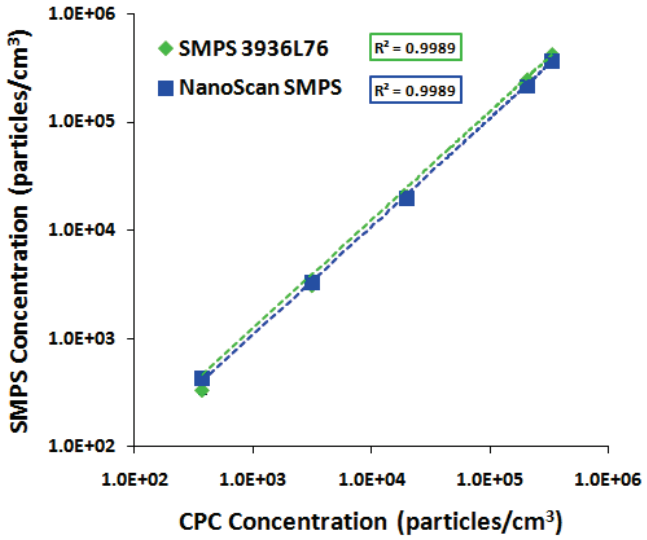


Fig. 1 — Concentration linearity of the NanoScan SMPS and SMPS 3936L76 measured against the Model 3776 CPC for NaCl aerosol. The NanoScan SMPS and SMPSL76 show a linear response (R^2 = 0.9989) and close agreement in the concentration range of 500 – 500,000 particles/cm^3 (four orders of magnitude).

Particle Size Accuracy

Table 2 — Particle Size Accuracy for NIST-traceable Polystyrene Latex Spheres (PSLs)

Nominal Size (nm)	Certified Size (nm)	SMPSL76 (nm)	NanoScan SMPS (nm)
20	21 ± 1.5	18.8	20.5
60	59 ± 2	59.4	64.9
80	81 ± 3	79.7	86.6
200	200 ± 6	194.6	205.4
300	300 ± 6	299.6	273.8
Discrepancy relative to certified size ranges		< 4%	< 8%

Polystyrene latex spheres (PSLs) were electrosprayed (TSI Model 3480) to generate PSL aerosol for SMPS measurements. Table 2 lists the certified particle sizes of NIST-traceable PSLs and the sizes measured by the NanoScan SMPS and SMPS 3936L76. The discrepancy of the mode diameters relative to the certified size ranges was < 4% for the SMPS 3936L76 and < 8% for the NanoScan SMPS.

Particle Size Distributions

Figure 2 shows results for 200-nm PSL, comparing particle size distributions measured using the SMPS Spectrometer and NanoScan SMPS, and the corresponding total concentration measured by each instrument. The 200-nm PSL data are representative of the similarities and differences in size distribution measurements between the NanoScan SMPS and SMPS Spectrometer for monodisperse samples. The particle diameters and total particle number concentrations agree well (within 5%). The NanoScan SMPS tends to show broader distributions of lower intensity, due to the lower resolution, i.e., wider size channels.

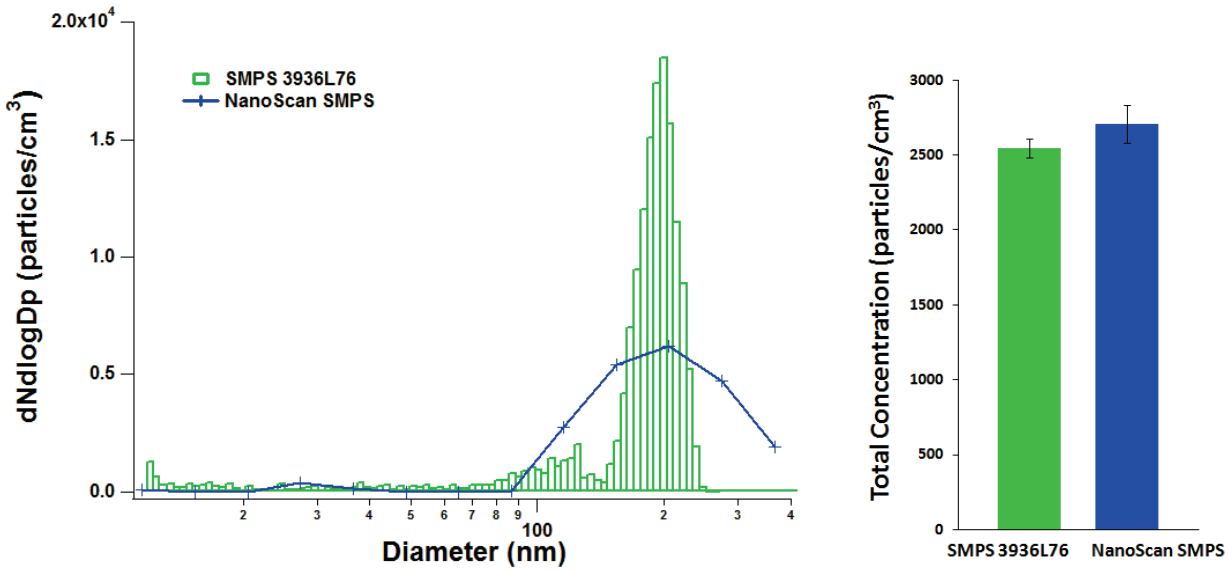


Fig. 2 — Particle size distributions for 200-nm PSL (left) and corresponding total concentrations (right).

Reproducibility

The reproducibility of the NanoScan SMPS and SMPS Spectrometer is highlighted by replicate measurements of polydisperse NaCl aerosol (Fig. 3) generated using a Constant Output Atomizer (TSI Model 3076).

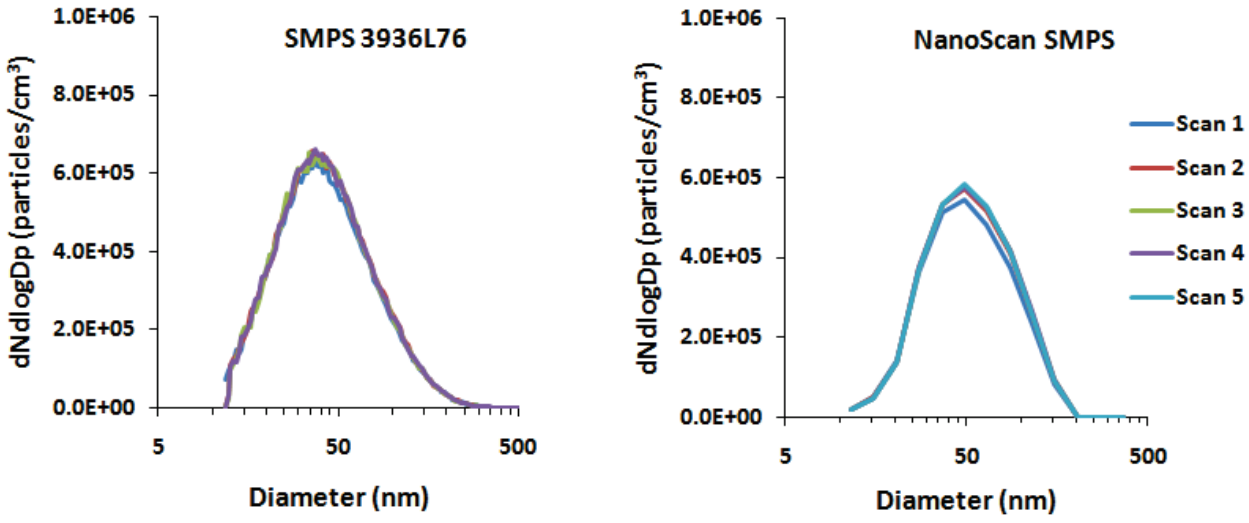


Fig. 3 — Particle size distribution measurements of polydisperse NaCl.

Both instruments give highly reproducible data. For the SMPS Spectrometer, the relative standard deviations in median particle diameter and total concentration were < 3.0% and 1.2%; for the NanoScan SMPS, these values were 1.1% and 2.7%, respectively. These values indicate the stability of the aerosol generated by the atomizer as well as the reproducibility of the SMPS instruments. The shapes of the particle size distributions measured by the two instruments are more similar for polydisperse samples compared to monodisperse samples.

Summary

The NanoScan SMPS demonstrates performance comparable to the TSI SMPS Spectrometer in terms of concentration linearity, size accuracy, particle size distribution measurements, and reproducibility. The portability, onboard data logging capability, and lower cost of the NanoScan SMPS offer greater flexibility for mobile applications and multi-site measurements. The SMPS Spectrometer remains the reference, high-resolution and multi-purpose instrument with configurable components for stationary measurements. The NanoScan SMPS brings sophisticated technology into the field, while providing measurements that are consistent with high-resolution laboratory SMPS data.