PRODUCT INFORMATION

Model 1000XP—Wide Range Particle Spectrometer™ (WPS™)

- *With the lower size limit extended from 10nm to 5 nm, the WPS can now count and size aerosol particles automatically from 5nm to 10,000nm (0.005µm to 10µm) in up to 120 particle-size channels by laser light scattering, differential mobility analysis, and condensation particle counting*
- *An optional electrical ionizer is available for electrical mobility analysis without the use of a radioactive ionizer*

DESCRIPTION

The Wide-range Particle Spectrometer, or WPS™, is a new approach to aerosol measurement by combining laser light scattering, differential mobility analysis and condensation particle counting into a single, compact instrument to measure concentration and size distribution of aerosol particles from 5nm to 10,000nm (0.005µm to 10 µm) in diameter.

The WPS™ combines miniaturized instrument components, advanced electronics and sophisticated computer software to form one of the most advanced and user-friendly aerosol instruments ever developed. The WPS™ is easy to setup and use. Easily transported between the laboratory and the field, it is a versatile instrument suitable both for laboratory research and field applications.

Figure 1 is a simplified schematic diagram of the WPS™. For measurement in the 10 to 10,000 nm range, the instrument samples aerosol at the rate of 1.00 liter per minute, of which 0.7 L/min passes through a Laser Particle Spectrometer (LPS) for size analysis by laser light scattering. The remaining 0.30 L/min then passes through a differential mobility analyzer (DMA) and a condensation particle counter (CPC) to measure aerosol particle size to a lower limit of 10 nm. Measurement to a lower size limit of 5nm is accomplished by increasing the aerosol flow rate through the DMA and CPC to 0.45 L/min. The total aerosol flow through the WPS thereby also increases to 1.15 L/min.

The measurement range of the Laser Particle Spectrometer (LPS) is from 350nm to 10,000nm in particle diameter. The DMA-CPC combination can function as a Differential Mobility Spectrometer (DMS™) or a Scanning Mobility Spectrometer (SMS™) for size distribution analysis in two user selectable ranges: 10nm to 500nm or 5nm to 350nm. Both the DMA and the CPC (see Figure 2), as well as the LPS, are miniaturized in size so that the overall WPS is also small and compact.

DMA and CPC—The miniature, high-resolution DMA in the WPS™ operates at a sampling flow rate of 0.30 or 0.45L/min and a nominal sheath flow rate of 3.0 or 4.5 L/min. The overall length of the DMA is approximately 8" (200mm), which is about 1/3 of the overall length of the DMA in its traditional design. The shorter DMA design reduces particle loss by diffusion, leading to improved measurement accuracy for nano-sized particles.

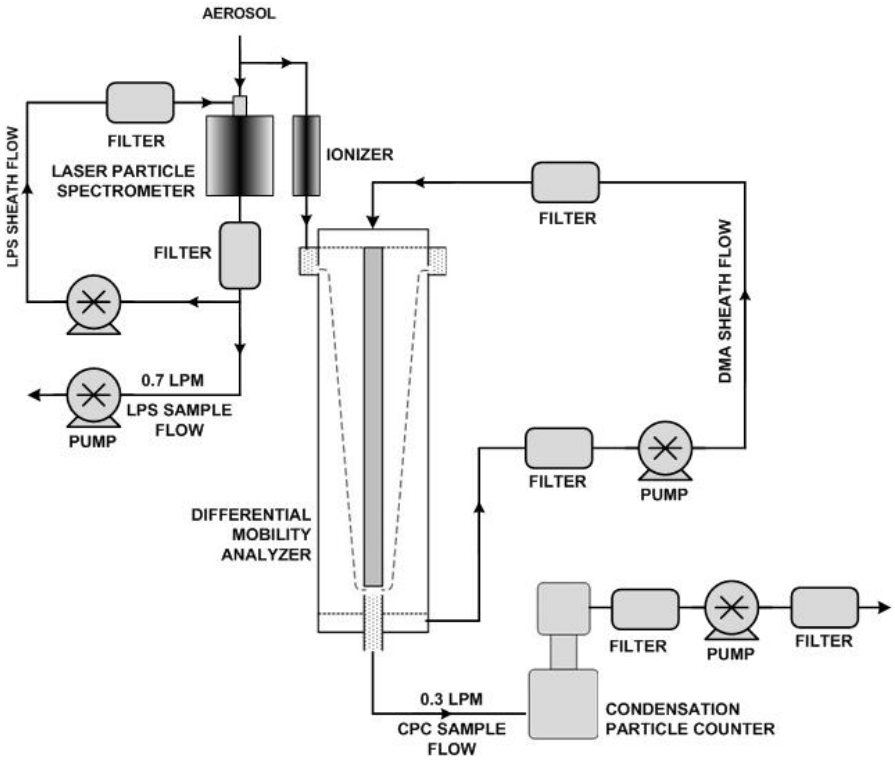

Figure 1. Simplified schematic diagram of the WPS

Figure 2. Miniature DMA and CPC

The new miniature CPC is based on a patented porous-metal saturator, dual reservoir technology of MSP. In this Dual-Reservoir CPC design, the aerosol is pre-heated before it is saturated by the working fluid (n-butyl alcohol) vapor to achieve a high degree of vapor saturation stability. The vapor saturated aerosol then flows through a condenser to activate particles as condensation nuclei for vapor condensation and droplet growth. The resulting droplets are then counted by a light scattering droplet counter.

In a traditional CPC, the condensed working fluid and the condensed moisture are both returned to the working fluid reservoir. Under moderate to high humidity conditions, the condensed water would fill working fluid reservoir, thereby displacing the working fluid from the saturator pores, leading to erroneous measurement results.

In MSP's Dual-Reservoir CPC technology, the condensate is collected in a separate condensate reservoir, thereby avoiding possible erroneous concentration reading that may result from incorrect operation of the instrument under moderate to high humidity conditions.

Laser Particle Spectrometer (LPS)—The LPS is a proprietary MSP design with wide angle collecting optics, a laser diode light source, and a solid state photomultiplier detector. The light scattering response of the LPS is predicted by Mie theory calculations and verified by experiments. The response function of the LPS is shown in Figure 3.

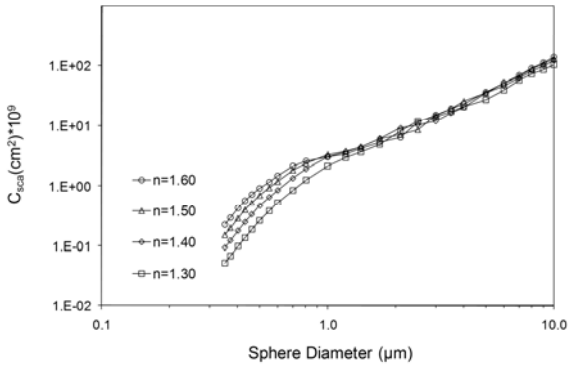

Figure 3. Light scattering response of the LPS

For refractive index between 1.30 and 1.60, the known response function of the LPS can be used to correct for sizing errors due to particle refractive index. The user can select the particle refractive index value—if it is known—for automatic refractive index correction. Alternatively, if the refractive index is unknown, the user can use the overlapping size range between the DMS and the LPS, from 350nm to 500nm (when using the DMA in the 10-500nm range), to find an empirical value for the refractive index that would minimize the count differences between the measurement techniques, thereby obtaining an estimate of the unknown particle refractive index.

Calibration and Standardization—The DMA is calibrated at the factory using a NIST-traceable calibration procedure and using SRM (Standard Reference Material) 1691 from NIST, which is comprised of polystyrene latex (PSL) spheres with a NIST certified 269-nm diameter. Calibration of the LPS is similarly established using NIST spheres as well as commercial sources of PSL with NIST traceable diameters. The factory calibration of the LPS, therefore, is for a refractive index of 1.585 for the PSL.

The lower particle size limit and the counting efficiency of the CPC have been established through careful comparison with other CPCs made at MSP and those available from another manufacturer.

System Control—Operational control of the WPS™ is managed by a powerful single-board computer running on Windows XP OS embedded in the computer, a digital system board (DSB), an analog system board (ASB), and other custom circuit boards handling signal processing functions.

Through the WPS Commander™ software, customized measurement recipes can be created and stored by the user and retrieved for measurement. The different operational modes of the instrument (see section below), the resolution and number of size channels, as well as system start and stop times, the number of measurement cycles, etc. can be easily selected. These features, along with user-friendly data analysis software provided, would easily make the WPS™ one of the most advanced and easy-to-use instruments ever developed in the aerosol measurement field.

OPERATIONAL MODES

The WPS™ is comprised of a LPS (Laser Particle Spectrometer) and a DMS™ (Differential Mobility Spectrometer). The DMS™ can also operate in the rapid "scanning" mode, or the Scanning Mobility Spectrometer, i.e.

the SMS™ mode. These individual aerosol spectrometers can operate singly, or in combination, to provide the following five operational modes:

- LPS = Laser Particle Spectrometer
- DMS™ = Differential Mobility Spectrometer
- SMS™ = Scanning Mobility Spectrometer
- WPS™ = DMS + LPS
- SWPS™ = SMS + LPS

FEATURES

- Miniature high-performance aerosol sensors and instrument components:
  - High resolution Differential Mobility Analyzer (DMA)
  - Dual-Reservoir Condensation Particle Counter (CPC)
  - Wide-Angle Laser Particle Spectrometer (LPS)
- Number of Size Channels:
  - LPS: 24 channels
  - DMS: 1 – 96 channels
  - SMS: 12, 24, 48, and 96 channels
  - SWPS: 36, 48, 72, and 120 channels
- NIST traceable particle size calibration
- Pulse-width modulated control for accurate temperature and flow rate settings
- Recipe control of instrument operations
- Remote control and operation (wireless or Ethernet)
- Five (5) user selectable modes of instrument operation
- Powerful, built-in computer
- Easy-to-use software for data analysis
- Self-contained flow system (no external pump needed)

APPLICATIONS

- Atmospheric aerosol measurement
- Indoor air quality research
- Characterization of emission source particles
- Aerosol characterization for inhalers, atomizers, nebulizers for drug delivery and medical research

CONFIGURATIONS

Configuration A (standard)—Configuration A provides the full range of measurement capabilities of the instrument including:

- Concentration and distribution measurement from 5nm – 10,000nm (no LPS-DMA overlap) or 10nm - 10,000nm (with 350-500nm LPS-DMA overlap)
- Five (5) user selectable, operational modes: SWPS™ (scanning wide range particle spectrometer), WPS™, SMS™, DMS™, and LPS modes

Configuration B (optional)—Configuration B provides a more limited range of measurement capabilities including:

- Concentration and size distribution measurement in two user selectable ranges: 5nm – 350nm or 10nm -500 nm
- Two (2) operational modes as: DMS™ and SMS™

Configuration B can be upgraded to Configuration A at the factory by adding the LPS hardware and making associated software changes.

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SPECIFICATIONS

Subject to change without notice

Wide-Range Particle Spectrometer (WPS™)

1	Sample Flow Rate	1.00 L/min (or 1.15 L/min)
2	Particle Size Range	5nm to 10,000nm
3	Size Resolution	User-selectable, up to 120 channels from 5nm to 10,000nm
4	Differential Mobility Analyzer (DMA)	Miniature high-resolution DMA
5	Condensation Particle Counter (CPC)	Continuous flow Dual-Reservoir CPC
6	Laser Particle Spectrometer (LPS)	High-resolution, wide-angle LPS, 350nm to 10,000nm
7	Sample Interval Time	60 sec to 24 hrs, user selectable
8	Sample Averaging	2-999 scans
9	Instrument Modes	Five (5) modes of operation
	Scanning Wide-Range Particle Spectrometer (SWPS™)	SWPS™ = SMS™ + LPS
	Wide-Range Particle Spectrometer (WPS™)	WPS™=DMS + LPS
	Scanning Mobility Spectrometer (SMS™)	SMS
	Differential Mobility Spectromer (DMS™)	DMS
	Laser Particle Spectrometer (LPS)	LPS
10	Ambient Pressure Range	800 to 1050 mbar absolute pressure
11	Ambient Temperature Range	10 to 35 ºC
12	Ambient Humidity Range	0-90% RH, non-condensing
13	Power	90-264 VAC, 47-67 Hz, single phase, 135 W steady state, 160 W start up
14	Dimensions	17.0” (W) x 20.5” (D) x 12.5” (H)
		432 mm (W) x 521 mm (D) x 318 mm (H)
15	Weight	55 lbs (25 kg)

Differential Mobility Spectrometer (DMS) and Scanning Mobility Spectrometer (SMS™)

1	Sample Flow Rate	0.30 or 0.45 L/min
2	DMA Sheath Flow Rate (Recirculating)	3.0 or 4.5 L/min
3	Particle Size Range	DMA, 5-350 or 10-500 nm; CPC 5 nm to 1000nm
4	DMA Sizing Accuracy	Mean Mobility Diameter: ±3% referenced to 269nm NIST SRM 1691
5	CPC Count Accuracy	± 10% (compared to standard MSP CPC); <10% coincidence error; Single particle counting mode
6	CPC Concentration Range	0 to 10^4 particles/cm^3 (single particle counting mode)
7	CPC Coincidence	10% @ 10,000 cm^{-3}
8	CPC Working Fluid	n-butyl alcohol (butanol)
9	CPC Response Time (95% response)	< 5 sec
10	DMA-CPC Aerosol Concentration Range	20 to 10^7 particles/cm^3 (total aerosol concentration)
11	Measurement Cycle Time	60 to 300 seconds, user selectable
12	Size Resolution	12, 24, 48, or 96 channels, log scale in the SMS Mode; 1-96 channels, log or linear scale in the DMS Mode
13	Sample Interval Time	60 sec to 24 hrs, user selectable
14	Sample Averaging	2-999 scans

Laser Particle Spectrometer (LPS)

1	Sample Flow Rate	0.7 L/min
2	Sheath Flow Rate	3.0 L/min
3	Particle Size Range	350nm to 10,000nm
4	Particle Concentration Range	0 to 500 particles per cm^3

5	Size Resolution	16 channels per decade; 24 channels total
6	Light Source	Laser diode, 785nm, 50 mW (polarized perpendicular to scattering plane),
7	Light Collection	20 to 100 degrees
8	Detector	Infrared enhanced photomultiplier tube
9	Count Accuracy	± 10% (compared to standard MSP LPS); <10% coincidence error
10	Sample Interval Time	1 sec to 24 hours, user selectable
11	Sample Averaging	2-999 scans