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Beyond  
Measure.

# TSI® Particle Technology

Particle Instruments



## TSI Particle Technology

TSI Incorporated has been a leading developer of aerosol research instrumentation since 1966. TSI offers a line of particle instruments that is second to none. Our products for sizing, counting, generating, and dispersing aerosol particles are well known—and well respected—all over the world. We are dedicated to providing our customers with the most innovative particle technology available.

This catalog contains TSI's full line of proven particle instruments. Our particle technology is at the forefront of research, enabling our customers to investigate their cutting-edge research questions. Together with our customers, TSI moves aerosol science – and many associated fields – forward.

Browse through the following pages and let us know how we can help you achieve your research goals.

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# Applications

Collectively, our line of particle instruments spans the size range from 0.001 to 20 micrometers. This unique and comprehensive family of products is used all over the world in a variety of important and interesting applications.

- Environmental studies
- Filter testing
- Diesel and gasoline engine emissions measurements
- Climate change research
- Particle formation and growth studies
- Indoor air quality testing
- Health effects studies
- Instrument calibration and standards
- Basic aerosol research

Ask your TSI® representative for information about specific applications, instrument operation, specifications, or new instruments not included in this catalog. To request additional literature or to place an order, call:

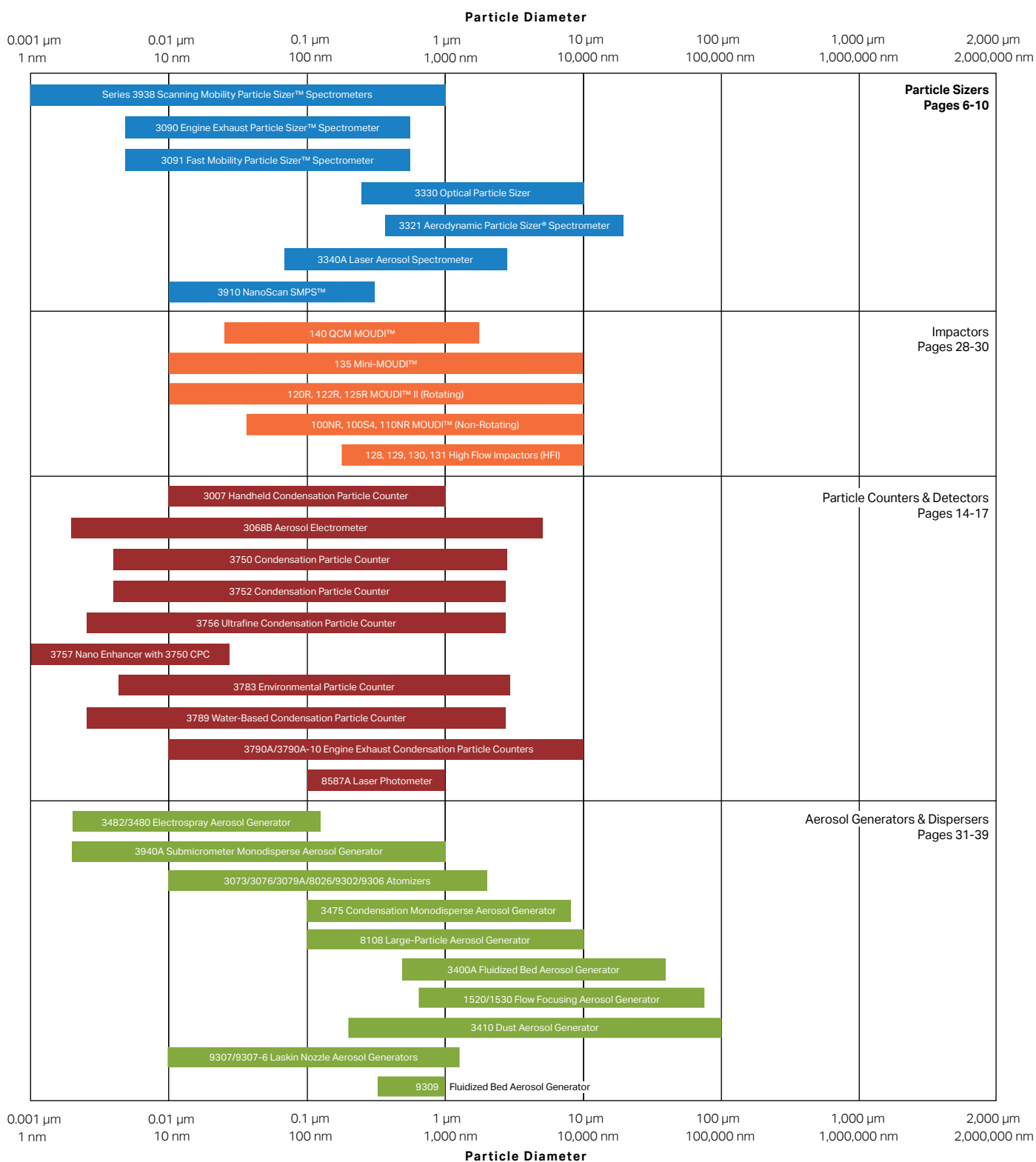
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# Operational Ranges for TSI® Particle Instruments



# Particle Sizers

## The most comprehensive selection of instruments for sizing submicrometer and supermicrometer particles

Please see the specification sheets for individual instruments for further details..

	Sizer	Particle Size Range (µm)	DMA	CPC	Working Liquid	Particle Concentration (Particles/cm³)	Measurement Time (sec)	Resolution (Total Channels Measured)	Channels per Decade	Key Feature
SMPS™	3938L50	0.01 to 1.0	3081A	3750	Butanol	1 to 10 <sup>7</sup>	10 to 600 (Selectable)	Varies by Model, 384 Channels from 0.001 to 1.0 µm Collectively	4, 8, 16, 32, 64, 128 (Selectable)	Highest Resolution; Individual Components Provide Greatest Flexibility
	3938L52	0.01 to 1.0	3081A	3752						
	3938N52	0.004 to 0.15	3085A							
	3938NL52	0.004 to 1.0	3081A & 3085A							
	3938L56	0.01 to 1.0	3081A	3756						
	3938N56	0.0025 to 0.15	3085A							
	3938NL56	0.0025 to 1.0	3081A & 3085A							
	3938L89	0.01 to 1.0	3081A	3789	Water					
	3938N89	0.0022 to 0.15	3085A							
	3938NL89	0.0022 to 1.0	3081A & 3085A							
	3938E89	0.0022 to 0.05	3086							
	3938EL89	0.0022 to 1.0	3081A & 3086	3757 & 3750	Diethylene Glycol & Butanol					
	3938E57	0.001 to 0.05	3086							
	3938EL57	0.001 to 1.0	3081A & 3086	3750	Butanol					
	3938W50*	0.01 to 0.8	3083							
3938W52	0.01 to 0.8	3083	3752			Butanol				
3938W89	0.01 to 0.8	3083	3789	Water						
NanoScan SMPS™	3910	0.01 to 0.42	Built In	Built In	Isopropyl Alcohol	100 to 10 <sup>6</sup>	60	13	8	Portable
Fast Sizers	3091 FMPS	0.0056 to 0.56	N/A	N/A	N/A	<10 <sup>7</sup>	1	32	16	Fast Distributions
	3090 EEPS™						0.1			
APS™	3321	0.52 to 20				0.001 to 1,000	1 Sec To 18 Hours (Variable)	52	32	Aerodynamic Size
OPS	3330	0.3 to 10				1 to 3,000	1 Sec to 24 Hours (Variable)	Up to 16	Variable	Portable
LAS	3340A	0.09 to 7.5				1 to 18,000	1 Sec to 60 Hours (Variable)	Up to 99		Optical to Smaller Sizes

N/A Not Applicable

\*The 3938W50 SMPS™ is available with various combinations of DMA polarity, CPC D50 cutpoint (7 vs. 10 nm), and calibration compliant with CEN/TS 17434. Please contact TSI for further details.

# Scanning Mobility Particle Sizer™ Spectrometers

## Model 3938

Our most versatile submicrometer particle sizers provide the highest resolution and accuracy available.

TSI® Scanning Mobility Particle Sizer™ (SMPS™) systems have advanced to the standard reference in sizing and counting of airborne nanoparticles. The US National Institute of Standards and Technology (NIST), and many other reference laboratories worldwide use the TSI® SMPS™. It is compliant with the ISO 15900:2009 standard.

It is routinely installed in environmental monitoring stations, filter testers, academic and industrial laboratories. The model 3938 features a selection of modules, which are automatically recognized during setup. It can achieve scan times of as low as 10 seconds while providing a very high size resolution.

Collectively, our series 3938 SMPS spectrometers measure particles from 1 to 1,000 nm. They display data up to 128 channels per decade, having up to 200 actual size channels in a single scan. A very wide concentration range is covered, from 1 to 10,000,000 particles/cm³, depending on CPC model.

Users may choose among four DMAs, five CPCs, and two different neutralization techniques. This versatility enables you to select a system that best fits your sizing requirements. The Electrostatic Classifier actively measures sheath flow temperature and pressure so that the sheath flow rate stays stable under a variety of conditions.

The components can be combined into a standalone electrostatic classifier for experiments involving monodisperse aerosol generation or measuring the size distribution and counting the total number of particles.

The end result is an unmatched, proven solution for research involving combustion, atmospheric aerosols, indoor air quality, filter testing, and much more.

When an SMPS is coupled with an OPS or APS, the continuous measurement range can be extended up to 10 µm or 20 µm, respectively. Paired with a QCM MOUDI™ real-time impactor, the density of a particular size fraction of particle can be determined.



1nm SMPS 3938E57

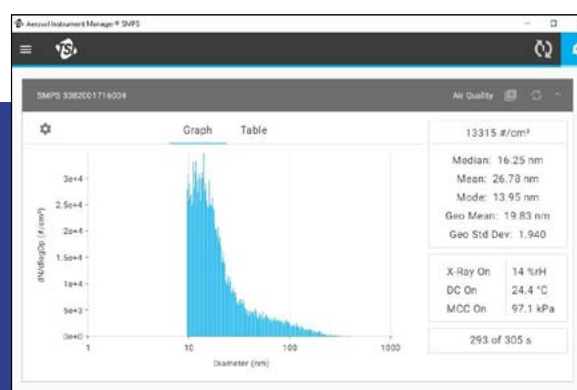


3086

3081A

3085A

3083



SMPS component systems give you the highest-resolution particle size data available with AIM 11 SMPS software.

## SMPS Accessories (available separately)

Specify	Description
3077/3077A	Aerosol Neutralizer
3088	Soft X-Ray Neutralizer



# NanoScan SMPS™ Nanoparticle Sizer

## Model 3910

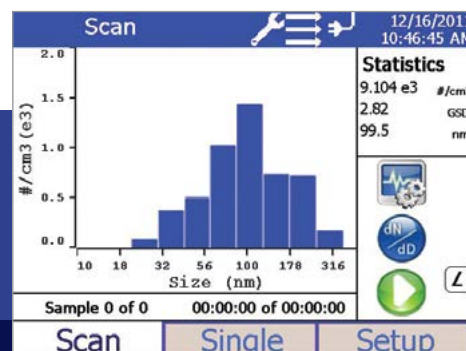
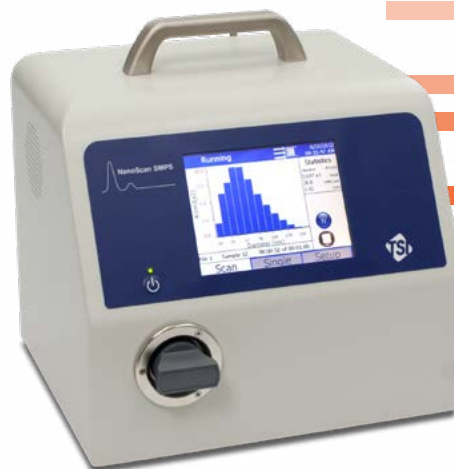
Affordable, portable nanoparticle sizer for particles down to 10 nm.

TSI's NanoScan SMPS™ opens the door to routine nanoparticle sizing measurements for everyone. This revolutionary sizer fits a TSI® SMPSTM spectrometer into an affordable, portable package that is about the size of a basketball. Easy to use, lightweight, and battery-powered, the NanoScan SMPS™ enables investigators to assess airborne nanoparticle concentration and size in workplaces, schools, hospitals, without complicated setups. Size distributions are measured from down to 10 nm for concentrations up to 1,000,000 particles/cm<sup>3</sup>. Derived from TSI core technologies, the NanoScan SMPS is an innovative, cost-effective solution for real-time nanoparticle size measurements.

Data collection begins with a touch of the instrument display - no need for a dedicated computer to set up the instrument or save data. The user interface is intuitive and easy for new users to operate. The NanoScan SMPS displays real-time number, surface area, or mass size distributions, concentrations, and statistics. From the front panel, users can program start time, number of samples, and other parameters. A full suite of instrument diagnostic data gives the user security and ensures data quality.

In addition to nanoparticle size distributions, the NanoScan SMPS can collect second-by-second concentration data at a single mobility diameter. For example, if the nanoparticle source of concern generates 50 nm particles, it is possible to easily monitor 50 nm mobility diameter with 1 second time resolution to keep a real-time record of concentration levels.

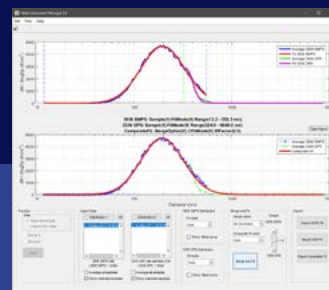
Combine the NanoScan SMPS and the Optical Particle Sizer 3330 to measure three orders of size magnitude from 10 nm to 10 µm using Multi-Instrument Manager (MIM) software.



Screen shot of NanoScan SMPS during nanoparticle size distribution measurement.

## NanoScan SMPSTM Accessories (available separately)

Specify	Description
3062	Diffusion Dryer
3062-NC	Diffusion Dryer (desiccant does not contain cobalt)



Screenshot of Multi-Instrument Manager (MIM) Software



# Optical Particle Sizer

## Model 3330

Portable and easy-to-use particle sizer for particles 0.3 - 10  $\mu\text{m}$  in size.

The Optical Particle Sizer 3330 (OPS) is a light, portable unit that uses single-particle counting technology to provide fast, accurate measurement of particle concentration from 0 to 3,000 particles/ $\text{cm}^3$  and particle size distribution for 0.3 to 10  $\mu\text{m}$  in up to 16 user-configurable channels. Backed by over 40 years of aerosol instrumentation design experience, the OPS uses state-of-the-art optics with 120° light collection and sophisticated electronics processing resulting in precision, high-quality data. The affordable, easy-to-use package features a color touch screen with an intuitive user interface. Rigorous factory calibration standards ensure measurement accuracy.

The model 3330 includes the ability to enter the index of refraction and shape factor of the aerosol into the software to provide more accurate size distributions. The size boundaries can be adjusted using both real and imaginary components of refractive index. A unique density for every size channel can also be entered into the software to further improve mass concentration measurements.

The model 3330 is manufactured at TSI's ISO 9001 certified facility. It is calibrated according to ISO 21501-1 using NIST traceable PSL spheres and TSI's Electrostatic Classifier and Condensation Particle Counters. PSL is the industry-wide calibration aerosol of choice because it is traceable to national standards throughout the world. Each OPS that leaves the factory is built for longevity, backed by TSI's commitment to quality, and supported by our worldwide network of committed TSI® professionals.

## Applications

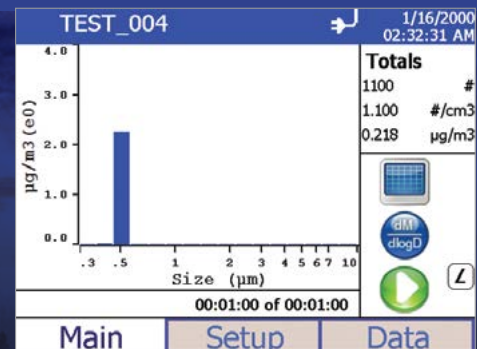
- Filter Testing
- Indoor Air Quality
- Workplace Monitoring
- Industrial Measurements
- Hotspots

### OPS Accessories (available separately)

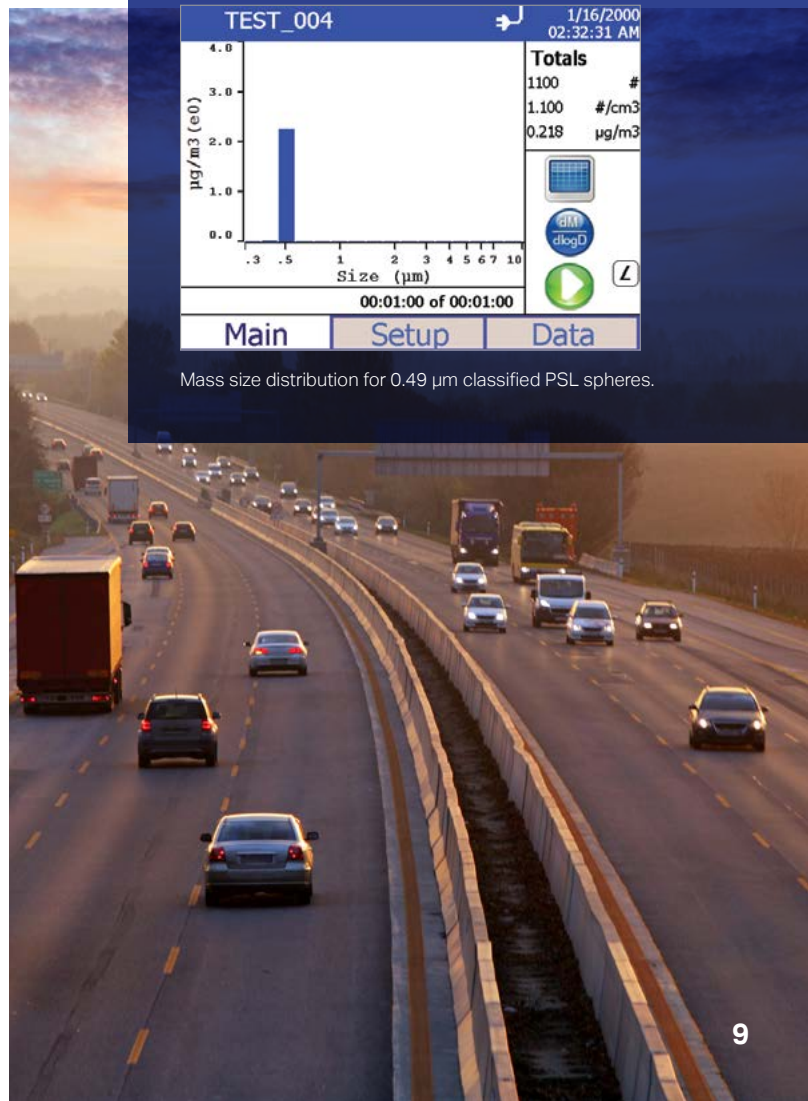
Specify	Description
3332-10	10:1 Diluter
3332-100	100:1 Diluter



OPS 3330 setup screen.



Mass size distribution for 0.49  $\mu\text{m}$  classified PSL spheres.



# Aerodynamic Particle Sizer® Spectrometer

## Model 3321

The way to determine a particle's true airborne behavior is to measure its aerodynamic diameter.

Aerodynamic measurements account for differences in particle size, shape, and density. This is crucial when determining if a particle will penetrate a filter, be removed by a collecting device, or be deposited in the lung. The Aerodynamic Particle Sizer® (APS™) spectrometer has been used successfully for over 30 years in laboratory and field applications to provide high-resolution, real-time aerodynamic measurements in the range from 0.5 to 20  $\mu\text{m}$ . It also measures side light-scattering intensity in the equivalent optical size range of 0.37 to 20  $\mu\text{m}$ . By providing paired data for each particle, the APS™ opens up exciting new possibilities for aerosol scientists interested in studying the shape and other characteristics of an aerosol.

The model 3321 APS™ spectrometer uses a patented, double-crest optical system for unmatched sizing accuracy. It also includes an optimized nozzle configuration and fast signal processing. The result is greater small-particle sizing efficiency, improved accuracy of mass-weighted distributions, and near elimination of false background counts. The Aerosol Instrument Manager® software provides advanced data-handling capabilities.



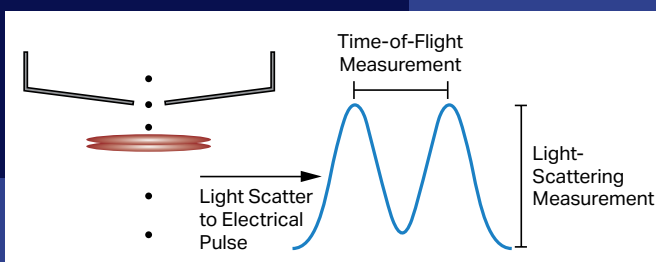
The 3321 has a large screen and indicator lights as well as an easy-to-use navigation wheel for simple user operation.

## Applications

- Atmospheric Monitoring for Supermicron Particles
- Air Cleaner Performance Testing
- Biological Aerosol Research
- Inhalation Toxicology

### APS Accessories (available separately)

Specify	Description
3302A	Aerosol Diluter
3306	Impactor Inlet



3321 APS time-of-flight measurement

# APS™ Accessories

## Aerosol Diluter

### Model 3302A

Dilutes high-concentration aerosols for use with the Aerodynamic Particle Sizer® (APS™) spectrometer.

This diluter reduces particle concentrations of high-concentration aerosols, providing a representative sample that meets the flow input requirements of the APS™ spectrometer. The 3302A achieves dilution ratios of 100:1 or 20:1 using easy-to-change capillary tubes. Two diluters in a tandem configuration provide dilution ratios as high as 10,000:1.

Engineered to provide very low particle loss in the 0.5 to 10  $\mu\text{m}$  size range, the Aerosol Diluter is totally self-contained and requires no outside power or compressed gas. Durable construction and simple maintenance procedures translate into years of trouble-free operation.



The model 3302A installs easily on top of the 3321 APS™ for a compact footprint.

## Impactor Inlet

### Model 3306

Collects a size-segregated sample for mass or chemical analysis while making APS™ measurements.

As an accessory for the APS, the 3306 combines a single-stage impactor with a filter. It takes a size-segregated sample and directs a diluted (80:1), representative portion of the initial test aerosol into the particle sizer for measurement. The inlet aerosol passes through a single-stage impactor (2.5 or 4.7  $\mu\text{m}$ , 50% cut size) and is collected with an after-filter for later mass or chemical analysis. The model 3306 includes two inlet throats: one for standard applications; the other a USP throat for pharmaceutical research.



The Impactor Inlet 3306 is designed to sit atop the Aerodynamic Particle Sizer 3321.

#### Accessory (available separately)

Specify	Description
3033	Vacuum Pump

# Laser Aerosol Spectrometer

## Model 3340A

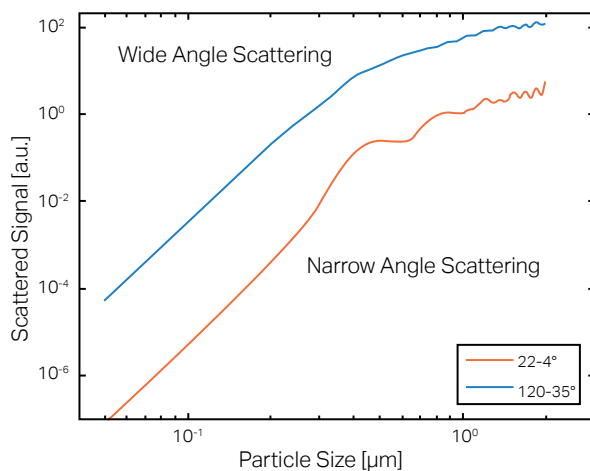
High-resolution optical particle sizing down to 90 nm.

TSI's Laser Aerosol Spectrometer (LAS) 3340A is a high-sensitivity, high-resolution optical particle sizer. This "turn on and measure" instrument allows users to easily measure particle size distributions from 0.09 (90 nm) to 7.5  $\mu\text{m}$  in 100 user-configurable size channels in seconds. The patented intracavity laser and advanced optics overcome the limitations of conventional optical particle counters, and enhance the resolution and sensitivity of detection.

The 3340A is an essential tool to have for monitoring your filters or your processes, measuring in a lab, or sampling on field campaigns. The Laser Aerosol Spectrometer has become a de facto standard in air cleaner testing for Clean Air Delivery Rate (CADR).

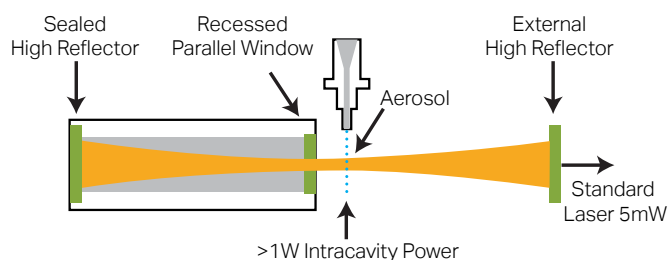


Monotonic Intensity Response



The 3340A uses a wide angle light collection to get a monotonic response over a wide range of particle sizes.

Patented IntraCavity Laser



The Laser Aerosol Spectrometer uses a He-Ne laser with a novel intracavity laser design to achieve higher light scattering sensitivity at a lower laser power.



# Fast Mobility Particle Sizer™ Spectrometer

## Model 3091

Measures size distribution and number concentration of rapidly changing, submicrometer aerosol particles in real time.

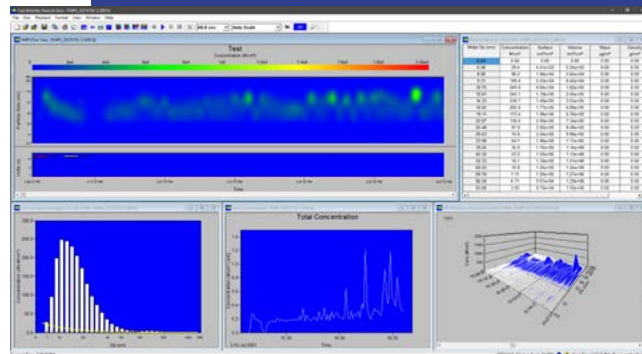
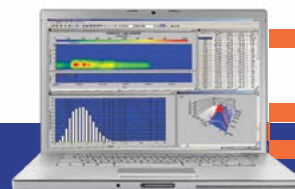
The Fast Mobility Particle Sizer™ (FMPS™) spectrometer measures particles in the range from 5.6 to 560 nm, offering a total of 32 channels of resolution (16 channels per decade of size). This submicrometer particle sizer uses an electrical mobility measurement technique similar to that used in the SMPS™ spectrometers. However, instead of a CPC, the model 3091 FMPS™ spectrometer uses multiple, low-noise electrometers for particle detection. This produces particle-size-distribution measurements with 1-second resolution, providing the ability to visualize particle events and changes in particle size distribution in real time.

The model 3091 operates at a high flow rate (10 L/min) to minimize diffusion losses of ultrafine and nanoparticles. It operates at ambient pressure to prevent evaporation of volatile and semivolatile particles. It requires no consumables. Plus, it uses an efficient pair of unipolar chargers to eliminate the need for a radioactive neutralizer.

The FMPS™ is easy to transport, set up, and operate. It can be configured to measure single or multiple runs continuously for up to 12 hours. Its large, color-LCD display and built-in control knob provide easy access to instrument functions, and data displays. The FMPS™ software highlights include a variety of graphing options, including 3-D playback of size distribution and concentration versus time, data export capabilities, and the ability to input individual effective densities per channel to calculate a continuous output of total particulate mass.

All of these features make the FMPS spectrometer appropriate for a variety of applications, especially particle formation and growth studies, indoor air quality measurements, environmental research, inhalation toxicology studies, urban canyon studies, and transient emission studies from stacks, boilers, and wood burners.

Developed by TSI Incorporated under license from Airel, Ltd. of Tartu, Estonia.



FMPS™ software offers advanced options for data display, such as Run View, concentration histogram, and 3D particle concentration graphs.

# Particle Counters and Detectors

In environmental research and monitoring, researchers face high concentrations in city centers, near freeways or harbors, or alternatively very low concentrations in remote locations which are used as reference sampling points.

In the laboratory, particle counters are often combined with other components in order to measure particle size distributions. Users in workplaces, hospitals, schools, homes and other sensitive environments may prefer water-based Condensation Particle Counters to ensure the occupants' safety and health. Combustion aerosols provide their own unique challenges, such as in sampling of the high temperature, humidity, and concentration aerosol without changing it, or complying with strict regulatory directives for engine exhaust emissions.

## Condensation Particle Counters

TSI® introduced its first Condensation Particle Counter (CPC) in 1978. Since then, we have continuously developed the technology further, working together with the research community along the way. Today we have the most modern, reliable and successful selection of CPCs, operating with water, butanol, isopropanol or diethylene glycol.

The applications for CPCs are very numerous. They are used around the world to count particles in air accurately – in laboratory setups, in sensitive environments (schools, workplaces), in vehicle emissions, or outdoors to monitor air quality. Our CPCs detect particles as small as 1 nm, count particles at up to 50 Hz and can handle concentrations up to  $10^7$  particles/cm<sup>3</sup>.

TSI® has a great depth of experience in designing and manufacturing CPCs and in supporting users in their CPC applications. With so many choices, let us help you to find the solution for your measurement challenge.



3756 shown

# CPC Comparison Chart

Please see the specification sheets for individual instruments for further details..



Specifications	3007	3750 & 3750-CEN*	3752	3756		3757-50	3790A/ 3790A-10	3783		3789			
D50 Min. Size (nm)	10	7	4	2.5		1***	23/10	7		2.2, 7, custom			
Max. Concentration (particles/cm³)	100,000	100,000	100,000; up to 10 <sup>7</sup> **		300,000		300,000	10,000/50,000		1,000,000		200,000	
Concentration Accuracy (%)	± 20	± 5	± 5; ± 20**		± 10		± 10; ± 15**	± 10		± 20		± 5	
Sample Flow (L/min)	0.1	1.0	0.3		0.05		1.0	1.0		0.12		0.3	
Total Inlet Flow Mode (L/min)	0.7	1.0	0.3	1.5	0.3	1.5	2.5	1.0		0.6	3.0	0.6	1.5
Response – T95 (s)	< ~3	~2	< 4	< 3	< 3	< 1	1.9	< 5		< 5	< 3	< 1	
Response – T10-T90 (s)	< 1.1	< 1	< 2	< 1.5	< 2	< 0.2	1.5	< 1.6		< 0.7		0.6	
Flow Source	Internal	External	Internal				External	External	External		Internal		
Working Fluid	Isopropyl	Butanol				Butanol and DEG		Butanol	Water				
Weight	1.7 kg (3.7 lbs.)	6.6 kg (~14.6 lbs.)	9.1 kg (~20 lbs.)				<20 kg (<44 lbs.)	5.5 kg (12 lbs.)	~10 kg (~22 lbs)		8.2 kg (18 lbs.)		
Display	Digital LCD	Embedded touch display					LCD	Embedded touch display					
Data Logging/ Storage	Internal memory	Internal memory					SD/MMC flash card	Flash Drive		Internal Memory			
TSI SMPS Compatibility	No	Yes (3082 classifier)					No	No		Yes (3082)			
Pulse Height Monitor	No	Yes					Yes	Yes					
Sample Speed (Hz)	1	50					10	1		50			
Additional Features	Battery-powered operation	Onboard flash data storage for standalone operation. Remote control via USB or Ethernet possible with AIM 11 CPC software or JSON command set, RS232 for serial command set					PMP/ ISO 27891 compliant for 23 nm/10 nm	Water use ~ 250 mL/wk.		(same as 3750x-series)			

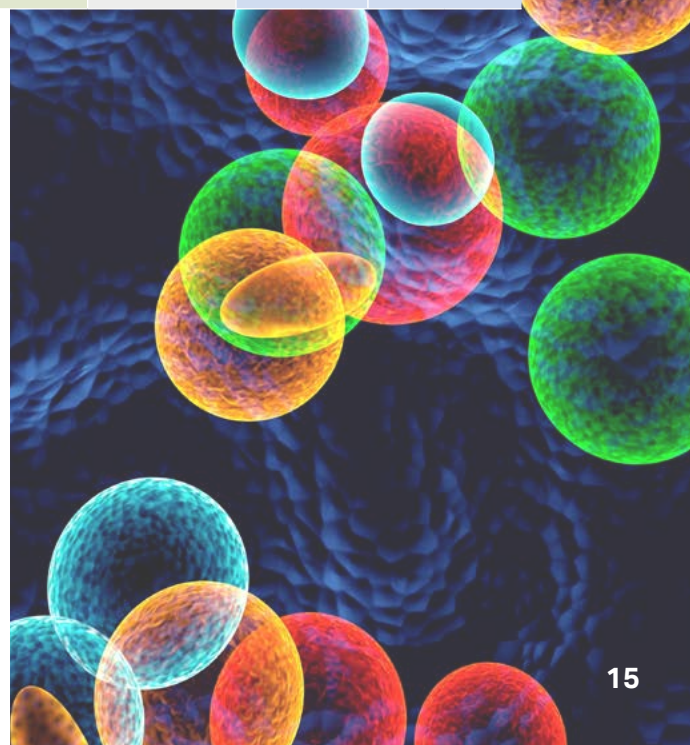
T95 indicates the time to get from 0 - 95% of the concentration; T0-T95.

\* 3750-CEN is available by applying a CEN calibration to an otherwise-standard 3750

\*\* 3752: Above 100,000 particles/cm<sup>3</sup> the 3752 uses photometric mode which has concentration accuracy of ±20%

3757-50: is concentration-dependent ± 10% below 1.65 x 10<sup>5</sup> particles/cm<sup>3</sup>; ± 15% at 3 x 10<sup>5</sup> particles/cm<sup>3</sup>

\*\*\* 1.4 nm electrical mobility diameter, 1.1 nm geometric diameter. Verified with NaCl particles



# Aerosol Electrometer

## Model 3068B

A reference standard for measuring the total amount of charge on aerosol particles.

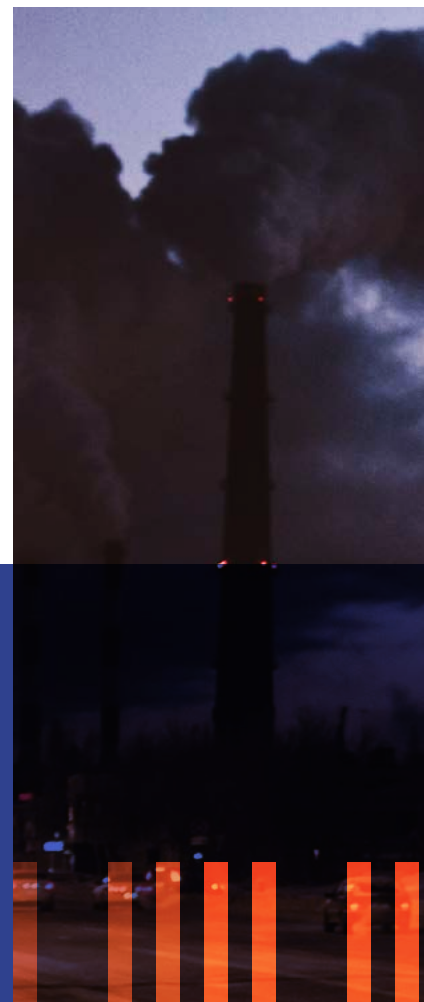
This reference instrument provides accurate measurements of total net charge on aerosol particles from 0.002 to 5  $\mu\text{m}$ . In combination with a monodisperse aerosol generator, it serves as a particle number concentration reference standard.

- High sensitivity of  $\pm 1$  fA
- Wide dynamic range with no range settings ( $\pm 12,500$  fA)
- Temperature stabilized to significantly reduce drift
- Automatic flow control (0.3 to 10 L/min) with accuracy down to  $\pm 3$  %
- Low internal particle losses
- Fundamental particle concentration measurement when used along with a TSI® Electrostatic Classifier. Cannot be used as a detector in a Scanning Mobility Particle Sizer™
- Wide particle size range (0.002 to 5.0  $\mu\text{m}$ )



### Accessory (available separately)

Specify	Description
3032	Vacuum Pump





## Laser Photometer

### Model 8587A

A compact, reliable photometer for a variety of applications, including customized filter testing.

This photometer features a reliable laser diode that produces constant laser power, so aerosol concentration measurements remain stable over a long period of time. An advanced sheath-air design keeps the optics clean for low background levels and minimal maintenance requirements. The modern electronics allow for exceptionally high dynamic range and low noise. The 8587A uses an internal switching valve to measure two aerosol streams, for example, both the upstream and downstream aerosol concentration in fit test chamber or filter testing applications. A special high-speed "purge" mode shortens the purge time when switching between upstream and downstream measurements. A simple serial command set can be incorporated into a custom computer program to give you complete flexibility in control and data management.



# Air Filter & Respirator Testers

8150



3160

8130A

Our automated air filter and respirator testers are known for easy, efficient, and reliable operation. Aside from automated testers, other components relevant to filter testing - for example, the Optical Particle Sizer 3330 - are also available individually.

Model	8130A <sup>a</sup>	8150	3160
Measurement Application	Loading and Quality Control Tests	Rapid Production Line Quality Control Tests	MPPS, Fractional-Efficiency Testing, Single-Size Quality Control Testing
Maximum Efficiency <sup>b</sup>	99.9999% (oil aerosol)		99.999999%
Aerosol Type <sup>c</sup>	DOP, PAO, DEHS, Paraffin, and other Oils or NaCl	DOP, PAO, DEHS, Paraffin, and other Oils	DOP, PAO, other Oils, or NaCl, PSL
Aerosol Generation	Atomizer		Atomizer with Classifier
Count Median Diameter <sup>d</sup>	0.185 µm (NIOSH Oil) or 0.075 µm (NIOSH NaCl)	0.185 µm (NIOSH Oil)	Selectable from 0.015 to 0.800 µm (NIOSH Oil)
Geometric Standard Deviation <sup>e</sup>	<1.6 (Oil) or < 1.86 (NaCl)	< 1.6 (Oil)	<1.3
Flow Rate	10 - 110 L/min	10 to 120 L/min	5 to 100 L/min
Resistance	0 to 250 mm H <sub>2</sub> O (0 to 2500 Pa)		0-150 mm H <sub>2</sub> O (0-1470 Pa)
Particle Detection	Light Scattering Photometers		Condensation Particle Counters
Typical Test Length	10 sec to > 2 hours	5-10 sec <sup>e</sup>	30 sec to hours <sup>d</sup>
Data Reporting	Touch Screen, Modbus TCP, and RS-232	RS-232, Modbus TCP	PC with Integrated Software
Operation	Stand-alone Reference Tester	Automated Production Lines	Stand-alone Tester
Applications	US 42 CFR part 84, EN 143, JMOL, ISO 23328-1	US 42 CFR part 84, EN 143	EN 1822 part 3, NFPA 1971, ASTM F2299, ISO 29463 part 3, ISO 21083-1

a) EN versions (for equivalent results to EN 143 standard) available (8130A-EN)

b) Efficiencies higher than 99.9999% require longer than typical testing times

c) Aerosol abbreviations: DOP (dioctyl phthalate), PAO (polyalpha olefin), DEHS (di-ethylhexyl sebacate)

d) EN version CMD and GSD are different. See spec sheet for more info.

e) Testing speed depends on the operational settings and integration into the production line

## Automated Filter Testers

### Models 8130A & 8130A-EN

Filter testers for commercial respirator and military mask testing.

The Automated Filter Tester 8130A continues to be the best solution for testing particulate respirator filters, disposable filtering facepieces, and a wide assortment of filter media. The tester provides measurements of filter penetration and filter pressure drop for the media (or finished filter) under initial or loading test conditions. It has a high degree of automation and self-diagnostics that greatly simplify operation, increase throughput, and improve overall measurement performance. The built-in capability to test with salt and oil means that just one unit is needed to test your product to: US 42 CFR 84, GB2626, JMOL, ISO 16900-3, EN 143, EN 13274-7, ISO 23328-1 and more.



### Model 8150

Taking high performance from the lab to the production line.

The Automated Filter Tester 8150 is designed for 100% quality assurance testing of P100, FFP3 and P3 and similar respiratory filters and cartridges directly in the production line. Applications include detecting defects from the manufacturing process such as cracks in filter media pleats, gaps in the adhesive or assembly defects, or media that does not meet performance specifications. While optimized for high-volume throughput and around-the-clock remote operation, the model 8150 also provides penetration measurement results matching those provided by the well-established 8130A used in the quality control lab. The 8150 is a highly compact automated filter tester that can easily be retrofitted into any existing production line.

The model 8150 complies with standards such as NIOSH 42 CFR 84 and EN143/EN149.



### Model 3160

Determines penetration vs. particle size of filters and filter media.

The Automated Filter Tester 3160 is the most advanced tester available for challenging filters and filter media with submicrometer aerosols. It can be used to test both low- and high-efficiency filters and filter media, up to 99.999999% efficient, or penetrations down to 0.000001%.

The 3160 uses a bank of atomizers - three for oil and three for salt - and the TSI® 3082 Electrostatic Classifier to challenge a filter or filter media with monodisperse particles. Two 3750 Condensation Particle Counters (CPCs) simultaneously count the number of particles upstream and downstream and computer software calculates the penetration value at each size. Filters can be sequentially challenged with up to 11 different monodisperse particle sizes from 10 nm to 1000 nm. At the end of a test, the 3160 generates a curve of penetration vs. particle size and produces a summary of test results, including the most penetrating particle size (MPPS). The quick test mode allows rapid testing of multiple samples at a single particle size, while minimizing operator exposure to aerosol. Test results can be automatically saved in a Microsoft® Access® data base and downloaded into Microsoft® Excel®.

The model 3160 complies with EN 1822-3, ISO 21083-1, and ISO 29463-5, and provides the most complete information on filter penetration available from any filter tester. You'll find it invaluable for product development and quality control.





## Large Particle Aerosol Generator

### Model 8108

Generates supermicron aerosols up to 10  $\mu\text{m}$  in diameter.

The Large Particle Aerosol Generator produces aerosol over a wide particle size range, from 0.3 to 10  $\mu\text{m}$ . Designed for easy cleaning, this generator produces potassium chloride (KCl) and other aerosols. A peristaltic pump pushes the KCl solution into a nozzle at the top of the generator, where a compressed air stream forces it out into a spray. As the droplets fall down the column, a counterflow of heated, ionized drying and dilution air moves upwards to neutralize the aerosol and remove excess water. The very broad size distribution exits the bottom of the generator, ready to be introduced into the test duct. The model 8108 meets the requirements of ASHRAE 52.2 and ISO 16890-2 for KCl test aerosol and can also be used for ISO/TS 11155-1:2001 filter efficiency testing.



# Engine Emissions & Non-Exhaust Emission Instruments

## Engine Exhaust Particle Sizer™ Spectrometer

### Model 3090

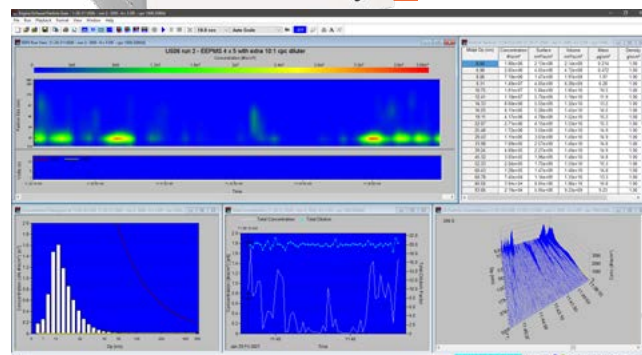
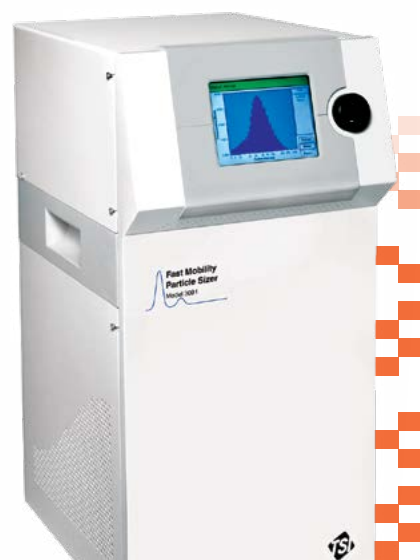
The best tool for measuring transient particle emissions and characterizing exhaust after-treatment devices in real time.

The Engine Exhaust Particle Sizer™ (EEPS™) spectrometer measures the size distribution of engine particle emissions in the range from 5.6 to 560 nm at 10 Hz. Users can visualize and study the dynamic behavior of emissions that occur during transient test cycles, such as changes in engine speed, or load. They may also measure emissions that occur during the first few seconds of a cold start or during regeneration of a particle trap or diesel particulate filter (DPF).

Measurements are displayed with high size resolution (32 total channels, 16 channels per decade of size). The EEPS™ spectrometer operates over a wide particle concentration range, which makes it well-suited for measuring upstream and downstream of a particle trap or DPF to determine soot loading and removal efficiency. The EEPS™ operates at ambient pressure to prevent evaporation of volatile and semivolatile particles, requires no consumables, and uses a pair of efficient, unipolar chargers to eliminate the need for a radioactive neutralizer. Users can select from multiple inversion matrices tailored to specific aerosols for more accurate measurements.

Like its sister instrument the Fast Mobility Particle Sizer (FMPS), the EEPS is a very easy-to-use device. All components, including the vacuum source, are housed in a single cabinet that weighs just 32 kg (~70 lbs). Just turn on the power and allow the instrument to warm up. An onboard Digital Signal Processor (DSP) inverts the raw data in real time to reduce data processing delays for faster results. The EEPS also features an external “start” input trigger for remote operation, two analog inputs to log and correlate other engine parameters, and four user-configurable analog outputs to integrate emission measurements with the test cell host computer.

The EEPS software allows users to display measurements in a variety of graphical and tabular formats, including 3-D viewing of size distribution and concentration versus time. These can be replayed for a unique “movie” view of the entire engine cycle, or you can zoom in on a period of interest. The software includes a data export capability and allows users to input individual effective densities per particle size channel to calculate a continuous output of total particulate mass.



### Applications

- Gasoline Direct Injection Engine Emissions
- Diesel Exhaust
- Brake and Tire Emissions
- Cold Start
- Engine and After Treatment Development

# Porous Tube Thermodiluter

## Model 3098

The 3098 Porous Tube Thermodiluter (PTT) is the next generation sample conditioning system specifically designed for the 3090 Engine Exhaust Particle Sizer™ (EEPS™) spectrometer to characterize advanced combustion designs and solid particle emissions from modern engines.

The PTT employs two porous tube diluters with a catalytic stripper (CS) to remove volatile species along with advanced mass flow controllers to provide real-time dilution ratio measurement and control.



### Models

Specify	Description
3098S	PTT with 2.5m heated sample line
3098M	PTT with 4.0m heated sample line
3098L	PTT with 6.0m heated sample line
3095S	EEPMS (PTT and EEPS) w/2.5m HSL
3095M	EEPMS (PTT and EEPS) w/4.0m HSL
3095L	EEPMS (PTT and EEPS) w/6.0m HSL

### PTT Accessories (available separately)

Specify	Description
3098-KIT	Accessory Kit (HEPA filters)
3098-MFC	Spare Mass Flow Control Module
3098-PR	Pressure Reducing Device (for pre-GPF/PDF measurements)
3098-EX	Exhaust Venting Kit (to remove instrument exhaust from the room)

## Applications

- Diesel, Gasoline and Compressed Natural Gas Engine Exhaust Measurements
- Cold Start Engine Emissions
- Sub-23nm Solid Particle Emissions
- Non-Road Machinery Emissions
- Exhaust After-Treatment (DPF or GPF) Characterization
- Aircraft Engine Emissions
- Brake and Tire Wear Particle Emissions



# Engine Exhaust Condensation Particle Counters

## Models 3790A and 3790A-10

The particle number (PN) concentration benchmark for UNECE Regulations 83 and 49.

The Engine Exhaust Condensation Particle Counters (EECPCs) accurately measure PN concentration of exhaust emissions. In fact, the GRPE Particle Measurement Programme (PMP) concluded that PN measurements using a CPC plus evaporation tube are 20 times more sensitive and much less variable than the traditional mass (PM) method (i.e., gravimetric filter analysis\*). As a result, the measurement of solid PN emissions is part of Regulation 83 (Euro 6) for certification of new passenger vehicles, and Regulation 49 (EURO 6) for heavy-duty engines. Upcoming EURO 7/VII regulations are expected to reduce the cutpoint of the PN emissions down to 10 nm, for which the model 3790A-10 is now available.

The models 3790A and 3790A-10 EECPCs are fully compliant with PMP requirements incorporated in current and upcoming EURO regulations for light duty vehicles and heavy duty engine certification. The models 3790A/3790A-10 EECPCs incorporate a wide assortment of features such as an anti-spill design, condensate removal, removable saturator for ease of maintenance, built-in microprocessor with USB, RS-232 and Ethernet communication interfaces, touch-panel membrane keys and a display that enables instrument set-up, viewing particle concentration and count data, interrogating instrument status, and data storage capabilities. The EECPC includes our Aerosol Instrument Manager® software. An external vacuum pump is required to operate these CPCs.



3790A shown

### Models

Specify	Description
3790A	23nm EECPC (up to Euro 6/VI)
3790A-10	10nm EECPC (upcoming Euro 7/VII)

### EECPC Accessory (available separately)

Specify	Description
3032	Vacuum Pump



\*Particle Measurement Programme (PMP) Heavy-duty Inter-laboratory Correlation Exercise (ILCE\_HD) Final Report





# Nanoparticle Emission Testers

## Models 3795 & 3795-HC

### Solid Particle Measurements

Sampling from combustion sources is often challenging due to the presence of volatile material in the exhaust gas. Volatile components are extremely sensitive to sampling conditions and can grow existing particles and form new particles by nucleation. By oxidizing away volatile components and particles, the Nanoparticle Emissions Tester (NPET) 3795 measures only the remaining solid particles, using the same core technology as our research grade CPCs.

### Portable and Accurate

The NPET 3795 helps you bring laboratory-grade particle counting to your worksite. The NPET features a sampling probe compatible with tailpipes, built-in 10:1 dilution, and a catalytic stripper to remove volatile particles. The results are comparable to type-approval solid particle number instruments.

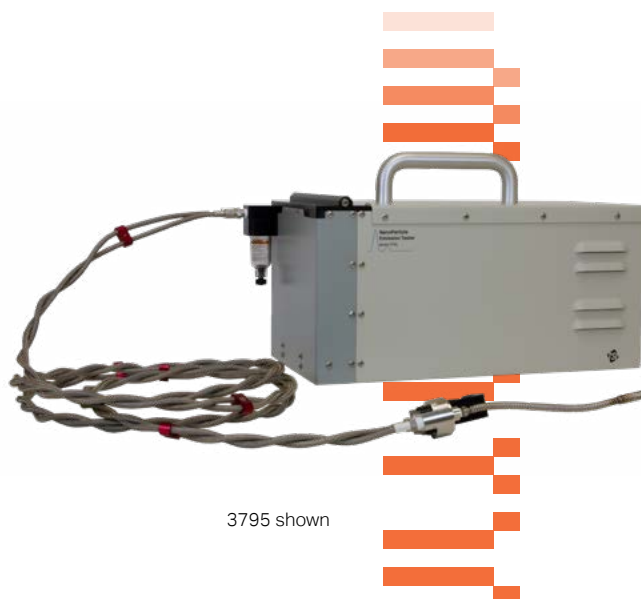
The NPET can be used to characterize various emission sources, such as tailpipes (diesel or gasoline combustion engines), wood stoves, or biomass or waste conversion power plants. The NPET serves also as reference unit in the on-going research of in-use testing of vehicles.

### Official Certification Testing

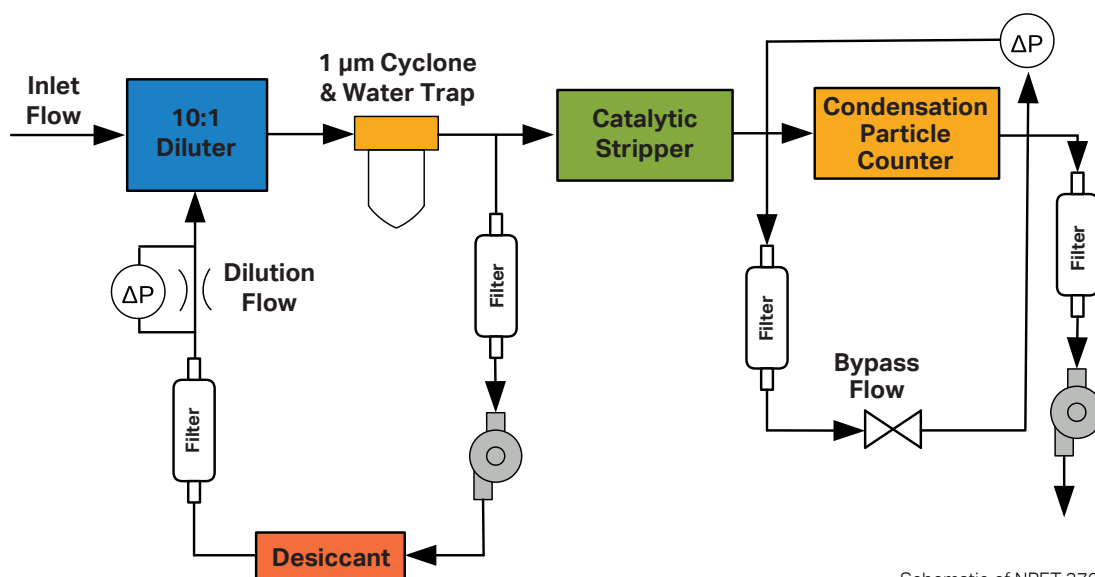
The NPET 3795 fully meets Swiss Regulation 941.242 for the periodic certification of diesel-powered machinery equipped with a DPF.

### General Emission Testing

The High-Concentration NPET 3795-HC was developed to assist DPF manufacturers, engine developers and fleet managers to assess nanoparticle emissions and the efficiency of after-treatment systems, without needing to meet the requirements of the Swiss regulation. The 3795-HC has an additional 20:1 dilution stage, making this instrument capable of measuring raw exhaust emissions up to 100,000,000 particles/cm<sup>3</sup>.



3795 shown



Schematic of NPET 3795

# Environmental Air Monitors

## Ultrafine Particle Monitors

### Model 3750-CEN

As a first step in harmonizing the measurement of ultrafine particles (UFPs) in the atmosphere, the European Committee for Standardization (CEN) drafted the Technical Specification CEN/TS 16976 which defines a set of requirements for the Condensation Particle Counter (CPC) and the sampling system.

The model 3750-CEN CPC is fully compliant with CEN/TS 16976. Your order includes the verification and calibration by the World Calibration Centre for Aerosol Physics, Leibniz Institute for Tropospheric Research (TROPOS).

The Sampling System for Atmospheric Particles 3750200 conditions the aerosol according to the technical specifications of CEN/TS 16976 such as requiring less than 30% particle loss for 7 nm particles and an aerosol dryer. It can be combined with the 3750-CEN CPC but also with other nanoparticle counters from TSI such as the SMPS™.



## BlueSky™ Air Quality Monitor\*

### Model 8143

As an Internet of Things (IoT) solution, these hyperlocal, cloud-based air quality monitors offer data interfacing using WiFi, and comes standard with an SD memory card for duplicate data storage. While specifically designed for outdoor environmental monitoring, BlueSky™ Air Quality Monitors can also be utilized inside buildings, homes and manufacturing facilities to measure indoor air quality.

\*This product is only available in North America and Europe.



## DustTrak™ Environmental Monitor

Whether working at a construction site, engineering firm or managing the aftermath of wildfires, the DustTrak™ Environmental Monitor is a robust, reliable solution for environmental monitoring. This instrument is compatible with a variety of sensors to detect volatile organic compounds (VOCs), gases, wind speed and more. TSI® also offers a cloud-based management system, allowing you to access data anytime and anywhere.



## DustTrak™ DRX Aerosol Monitor

### Models 8533, 8533EP & 8534

DRX monitors are light years ahead of any other. The DustTrak™ DRX monitor, for instance, simultaneously measures both mass and size fraction. Measure PM1, PM2.5, Respirable, PM10 and TPM simultaneously with no need for size-selective inlet conditioners.



## Sidepak Personal Aerosol Monitor

### Model AM520

The SidePak™ Personal Aerosol Monitor AM520 is a small, portable, battery-operated, data-logging, light-scattering laser photometer that provides real-time aerosol mass concentration readings of dusts, fumes, mists, smoke and fog within a worker breathing zone. Newly designed inlet conditioners increase the mass concentration capability and provide size fraction cut points for PM10, PM 4 (Respirable), PM 5 (China Respirable), PM 2.5, PM 1 and 0.8 µm Diesel Particulate Matter (DPM). This monitor is the perfect solution for real-time, personal aerosol sampling in a variety of workplace environments, including but not limited to general industry, foundries, construction sites, chemical plants, refineries, petrochemical, power and utilities, transportation, aerospace, maritime, confined spaces and mining.



# Cascade Impactors

Airborne particulate matter affects each of us in numerous ways. Characterizing that particulate matter, in terms of its mass and/or chemical content, gives us insight into ambient air quality, atmospheric composition, vehicle emissions, industrial particle emissions, and many more applications.

For over 30 years, Microorifice Uniform Deposit Impactors (MOUDI™) manufactured by MSP® have been widely used for collecting airborne particles in a size-segregated fashion, allowing researchers to learn more about the morphology and chemical composition of the sampled particles. Each MOUDI™ stage has thousands of precision drilled holes to reduce pressure drop and increase uniformity of particle deposition.

TSI's suite of cascade impactors can collect particles with aerodynamic diameters (cutpoints) from 10 nm to 10 µm, in 3 to 13 different size fractions, and at flow rates of 2, 10, 30 or 100 L/min.

To learn more about TSI's cascade impactors, take a look at our individual offerings or contact a member of TSI's team today!

## Real-Time Quartz Crystal Microbalance (QCM) MOUDI™

### Model 140 QCM MOUDI™

The QCM MOUDI has a 2.5-µm inlet and six stages with sharp collection efficiency curves and calibrated cutpoints of 960, 510, 305, 156, 74 and 45 nm at 10 L/min inlet flow rate. The QCM MOUDI provides excellent mass measurement accuracy thanks to the integrated humidity conditioning system that ensures reliable coupling of aerosol particles to the quartz crystal sensors, and eliminates undesirable solid particle bounce. With the QCM MOUDI, setup and measurement time has gone from hours to minutes allowing the user to collect size fractionated aerosol masses, in real time (1 Hz data collection), from tens of nanograms up to a few hundred micrograms.

#### Accessories (available separately)

Specify	Description
140-HFSS	High Flow Sampling System
0140-01-1010	Impactor Stack, QCM MOUDI, 6 stages
0140-98-1308	Replacement QCM Crystal/Plate
3334-10	Diluter, 10:1 @10 L/min
3334-100	Diluter, 100:1 @ 10 L/min





## Non-Rotating MOUDI™

### Models 100NR, 100S4, 110NR MOUDI™

Non-rotating MOUDI™ are classic, research cascade impactors with sharp cut-sizes and low internal losses. These impactors are used for collecting size-fractionated particle samples in the 0.056 to 10 µm aerodynamic diameter range with a 30 L/min sampling flow rate.

Particle deposits are collected on standard 47 mm substrates which can be analyzed for mass, chemical composition or by microscopy.



Model	Stages	Nominal Cut Points (µm)	Flow Rate (L/min)	Pressure Drop (kPa)
100S4	3	10, 2.5 and 1.0	30	1
100NR	8	10, 5.6, 3.2, 1.8, 1.0, 0.56, 0.32, and 0.18	30	10

110NR	10	10, 5.6, 3.2, 1.8, 1.0, 0.56, 0.32, 0.18, 0.10, and 0.056	30	40
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### Accessories (Available Separately)

Specify	Description
0100-01-1050	Vacuum Pump, 100/110, 110V
0100-01-1051	Vacuum Pump, 100/110, 220V, EU
0100-01-1052	Vacuum Pump, 100/110, 220V, UK
0100-01-0079	Vacuum Pump, 100S4, 110V
0100-47-AF	Al Foil Substrates, 47 mm, Pkg. 300
0001-01-9953	Glass Fiber Filters, 47 mm, Pkg. 100
0001-01-5024	Quartz Fiber Filters, 47 mm, Pkg. 100
0100-01-0100	Silicone Impactor Surface Spray
0100-96-0558	Silicone Lubricating Grease, 5.3 oz
0110-73-0496	Transformer, 240 to 120VAC

### Model 135 Mini-MOUDI™

Mini-MOUDI™ 135 impactors are high-accuracy impactors with a low sampling flow rate and a small physical size. They are available with 6, 8, and 10 impactation stages to provide size-fractionated particle samples.

The Mini-MOUDI™ 135 are used for personal exposure sampling and for unique applications such as characterizing e-cigarette smoke. Particle deposits are collected on 37 mm semicircular substrates.



135-6 with cowl inlet shown

Model	Stages	Nominal Cut Points (µm)	Flow Rate (L/min)	Pressure Drop (kPa)
135-6	6	10, 5.6, 3.2, 1.8, 1.0, and 0.56	2	1
135-8	8	10, 5.6, 3.2, 1.8, 1.0, 0.56, 0.32, and 0.18	2	10

135-10	10	10, 5.6, 3.2, 1.8, 1.0, 0.56, 0.32, 0.18, 0.10, and 0.056	2	40
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### Accessories (available separately)

Specify	Description
0135-01-0100	Vacuum Pump, 135-10, 110V
0135-01-0101	Vacuum Pump, 135-10, 220V, EU
0135-01-0102	Vacuum Pump, 135-10, 220V, UK
0135-01-0014-AF	Al Foil Substrates, Pkg 300
0135-01-5203	Glass Fiber Filters, 37-mm, Pkg 100
0135-75-5007	Vacuum Pump, 135-6, 135-8, 110V charger
0135-75-5008	Vacuum Pump, 135-6, 135-8, 220V charger
0135-78-0060	Semicircular Substrate Punch

## Rotating MOUDI™

### Models 120R, 122R, 125R

MOUDI™-II and NanoMOUDI™-II are second generation impactors. These impactors are noted for their superior aerodynamic design, sharp cut-size, and low particle loss characteristics. Up to 6,000 precision micro-orifice nozzles are used to reduce pressure drop, jet velocity, particle bounce, and re-entrainment.

MOUDI™-II allow users to sample uniformly for days thanks to the reliable internal impaction plate rotation. Sampling flow rates are 30 L/min for the models 120 and 122, and 10 L/min for the model 125. The nominal cut-size aerodynamic diameter range is 10 nm to 10 µm. MOUDI-II can be operated remotely through an Ethernet connection to the onboard PLC.

Model	Stages	Nominal Cut Points (µm)	Flow Rate (L/min)	Pressure Drop (kPa)
120R	10	10, 5.6, 3.2, 1.8, 1.0, 0.56, 0.32, 0.18, 0.10, and 0.056	30	40
122R	13	10, 5.6, 3.2, 1.8, 1.0, 0.56, 0.32, 0.18, 0.10, 0.056, 0.032, 0.018 and 0.010	30	90
125R	13	10, 5.6, 3.2, 1.8, 1.0, 0.56, 0.32, 0.18, 0.10, 0.056, 0.032, 0.018 and 0.010	10	90



120R MOUDI™ shown

#### Accessories (available separately)

Specify	Description
0120-98-1051	Vacuum Pump, 120R, 110V
0120-98-1050	Vacuum Pump, 120R, 220V
0122-01-2016	Vacuum Pump, 122R, 230V, EU
0122-01-2011	Vacuum Pump, 122R, 230V, US
0125-98-0100	Vacuum Pump, 125R, 110V
0125-98-0101	Vacuum Pump, 125R, 220V
0130-75-AF	Al Foil Substrates, 47mm, Pkg. 300
0122-90-AF	Al Foil Substrates, 90mm, Pkg. 100
0001-01-9953	Glass Fiber Filters, 47mm, Pkg. 100
0001-01-5024	Quartz Fiber Filters, 47mm, Pkg. 100
0130-01-5010	Glass Fiber Filters, 90mm, Pkg. 100
0100-01-0100	Silicone Impactor Surface Spray
0100-96-0558	Silicone Lubricating Grease, 5.3 oz.

## High Flow Impactors

### Models 128, 129, 130, 131

High Flow Impactors (HFI) are ideal for sampling particles at low concentrations, for obtaining samples in short sampling intervals, or for collecting more mass per stage as compared to more conventional medium flow rate impactors. HFIs are available with 3, 4, 5 or 6 stages in the 0.25 to 10 µm aerodynamic size range. HFIs sample at a high flow rate with a low flow resistance. Particle deposits are collected on 75-mm substrates which can be analyzed for mass, or via chemical analysis or microscopy.

Model	Stages	Nominal Cut Points (µm)	Flow Rate (L/min)	Pressure Drop (kPa)
128	3	10, 2.5 and 1.0	100	0.6
129	4	10, 2.5, 1.0, and 0.25	100	5
130A	5	2.5, 1.4, 0.77, 0.44 and 0.25	100	6
130B	5	2.5, 1.4, 1.0, 0.44 and 0.25	100	6
131A	6	10, 2.5, 1.4, 0.77, 0.44 and 0.25	100	6
131B	6	10, 2.5, 1.4, 1.0, 0.44 and 0.25	100	6



MOUDI™ 130A shown

#### Accessories (available separately)

Specify	Description
0130-01-1051	Vacuum Pump, 128–131, 110V
0130-01-1050	Vacuum Pump, 128–131, 220V, EU
0130-01-1050	Vacuum Pump, 128–131, 220V, UK
0130-75-AF	Al Foil Substrates, 75 mm, Pkg. 300
0130-01-5010	Glass Fiber Filters, 90 mm, Pkg. 100
0100-01-0100	Silicone Impactor Surface Spray
0100-96-0558	Silicone Lubricating Grease, 5.3 oz

# Aerosol Generators and Dispersers

**Collectively, our generators and dispersers produce particles in the range of 0.001 to 200  $\mu\text{m}$  from liquids, suspensions or powders.**

Visit <http://www.tsi.com/aerosol-generators-and-dispersers/> for the full overview.

## Monodisperse Generators

This type of generators is useful anywhere a precise, monodisperse aerosol is needed. Specific applications include calibrating particle counters, testing various filters, and studying size-dependent particle properties.

Model	3480	3482	3940A and 3082	3475	1520/1530
Particle Size Range ( $\mu\text{m}$ )	<0.002 to >0.15		0.001 to 1.0	0.1 to 8.0	0.8 to 12 (dry particles) / 15 to 90 (droplets)
Particle Concentration (particles/ $\text{cm}^3$ )	$\sim 10^7$	Up to $10^7$	$< 10^5$	$> 10^6$	$\sim 10^3$ (at 1 $\mu\text{m}$ ) to $\sim 10^4$ (at 10 $\mu\text{m}$ )
Nominal Flow Rate (L/min)	0.2 to 2.5		0.2 to 3.5	3.5 to 4	5 to 25

## Electrospray Aerosol Generator

### Models 3480, 3482

Produces monodisperse particles as small as 2 nm.

The Electrospray Aerosol Generator (EAG) uses a patented technique to produce high concentrations of monodisperse, submicrometer particles in the range from 2 to  $>150$  nm in diameter. The EAG produces such small, uniform particles by pushing a charged liquid solution or suspension through a capillary tube and exerting an electrical field on the liquid at the capillary tip. The electrical field pulls the liquid from the capillary, forming individual droplets. Air and  $\text{CO}_2$  mixed with the droplets evaporate the liquid, and the remaining particles are neutralized by an ionizer. The result is a neutralized, monodisperse aerosol. Applications for the EAG include instrument calibration, analysis of nanomaterial suspensions, macromolecular analysis, and nano-aerosol studies.

The classic model 3480 uses a pressure capsule fluid delivery system and radioactive Po-210 neutralizer.

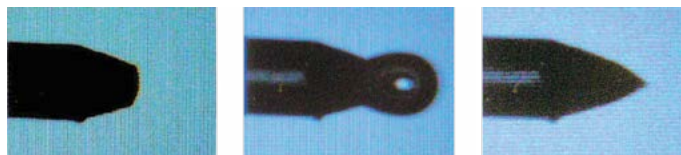
The next generation model 3482 features a built-in touch screen, soft x-ray neutralizer, and syringe pump liquid delivery system.



3480 and 3482

### Accessories (available separately)

Specify	Description
3482-SPUMP	Syringe Pump
3482-SPUMP-ACC	1 mL Syringe with Connectors
3482-SPUMP-ACC KIT	Syringe Pump and Accessory Kit
3482050	Model 3482 Accessory Kit
348002	Replacement Po-210 Aerosol Neutralizer for Model 3480
1031535	3480 Maintenance Kit
1036008	3480 Accessory Kit



The 3482 produces particles down to 2 nm. The camera (3482) or viewing window (3480) allows you to easily see the capillary tip during operation: (1) no liquid flow; (2) with liquid flow but no electric field; (3) with liquid flow and electric field (showing the formation of the Taylor cone).

# Submicrometer Monodisperse Aerosol Generation System

## Model 3940A

A complete system for generating monodisperse, submicrometer particles.

The Submicrometer Monodisperse Aerosol Generation System gives you the ability to produce monodisperse particles from 0.01 to 1.0  $\mu\text{m}$  in diameter. The system includes:

- Electrostatic Classifier 3082
- Long DMA 3081A
- Aerosol Neutralizer 3077A
- Aerosol Neutralizer 3012
- Filtered Air Supply 3074B
- Constant Output Atomizer 3076
- Diffusion Dryer 3062
- Dilution Bridge 1035575



# Electrostatic Classifiers

## Model 3082

Primary-standard instruments that produce highly monodisperse, submicrometer aerosols.

The 3082 Electrostatic Classifiers are primary standard aerosol instruments that give you highly monodisperse, submicrometer aerosol from a polydisperse source. Our classifiers are first-principles instruments (i.e., they are not calibrated against other particle instruments), and have been used in a variety of aerosol generation and particle sizing applications with highly repeatable results.

The Electrostatic Classifier uses a Differential Mobility Analyzer (DMA) to classify and select out a narrow, predictable size band. TSI® provides a choice of four DMA columns. You can purchase any column and interchange them on the same platform, giving you unprecedented versatility. The platform is available separately for use with your own DMA, just connect the tubing and enter the DMA dimensions on the touch screen.

Particles classified with our Electrostatic Classifiers range in size from 0.001 to 1.0  $\mu\text{m}$ . For monodisperse aerosol generation, simply set the touch screen for the desired particle size.



Electrostatic Classifiers are included in our SMPS™ systems. Models 3082 and 3081A are part of the 3940A Submicrometer Monodisperse Aerosol Generation System. DMA columns are interchangeable. For restrictions, consult local authorities on the use of Aerosol Neutralizers. The Nano DMA was developed in cooperation with the University of Minnesota Particle Technology Laboratory and Gerhard Mercator University. Refer to United States Patent Number 6,230,572.

### Electrostatic Classifiers and DMAs

Specify	Description
3082	Electrostatic Classifier
3081A	Long DMA (10 nm to 1 $\mu\text{m}$ )
3085A	Nano DMA (2 to 150 nm)
3083	Wide-Range Vienna DMA (10 to 800 nm in a single scan)
3086	1 nm DMA (1 to 50 nm)

### Accessories (available separately):

Specify	Description
3077	Aerosol Neutralizer
3077A	Aerosol Neutralizer (for High Concentrations/Charges)
3088	Advanced Aerosol Neutralizer (Soft X-Ray)
6005931	Lead Shielding Column



# Condensation Monodisperse Aerosol Generator

## Model 3475

Generates high-concentration, monodisperse aerosols quickly and accurately.

The Condensation Monodisperse Aerosol Generator (CMAG) is a Sinclair-LaMer-type instrument that produces high-concentration, monodisperse aerosol particles. It is well-suited for challenging HEPA and ULPA filters, seeding wind tunnels, conducting inhalation studies, or other applications requiring monodisperse particles in high concentrations.

The CMAG generates liquid or solid particles from a variety of oils, waxes, and other materials. It generally produces concentrations greater than  $10^6$  particles/cm<sup>3</sup>, and operates at a flow rate of 3.5 - 4 L/min. Particles can be fluorescently or radioactively labeled. Monodisperse particles can be generated by condensing volatilized oil or wax onto solid seed particles; in this case, the final monodisperse size is within the range of 0.1 - 8  $\mu$ m, and is user-adjustable. The CMAG can also generate particles via homogenous nucleation, resulting in a polydisperse aerosol. The CMAG can operate for long periods without interruption. Aerosol may be monitored for concentration using the optional Process Aerosol Monitor 3375.

Please specify voltage requirements at time of order.



### CMAG Accessories (available separately):

Specify	Description
3375	Process Aerosol Monitor



# Flow Focusing Monodisperse Aerosol Generator

## Model 1520

Produces monodisperse droplets and solid particles.

The Flow Focusing Monodisperse Aerosol Generator (FMAG) 1520 uses the aerodynamic flow-focusing effect to accurately control the diameter of a liquid jet for generating monodisperse droplets from 15 to 90 µm in diameter, which can then be dried to produce particles from 0.8 to 12 µm in diameter. In normal operation, a built-in syringe pump pushes liquid out of a 100-µm-diameter nozzle and is stretched to a much thinner stream by the focusing gas flow. The resulting thin liquid jet then breaks up into uniform-sized droplets after passing through a vibrating ceramic aerosol generation head. A coaxial flow of clean air is introduced to dry the droplets into solid particles. The aerosol then exits the top of the FMAG after passing by a built-in electrical corona ionizer and inspection light for easy viewing. The large 100-µm-diameter nozzle in the FMAG enables aerosol generation over extended periods of time without experiencing nozzle clogging problems, and at a very low liquid pressure. This low shear stress generally enables biological cells to remain viable, even after dispersion as uniform particles. The closely-related model 1530 omits the drying air, ionizer, and light, and has provisions for remotely mounting the aerosol generation head upside down for generating large droplets.



# Polydisperse Generators

This type of generator is typically capable of spraying aqueous solutions (e.g. salt), suspensions PSL, gold or glass nanoparticles), or oil or similar substances. They serve a variety of applications from laboratory research, field tests of detectors, and filter testing.

Model	3073	3079A	3076	9302/9306	8026	8108	9307/9307-6
Particle Size Range (µm)	0.01 to 2.0 (nominal 0.3 count mean diameter)				0.1 to 10		0.01 to 2.0 (PSL spheres)
Particle Concentration (particles/cm³) in Output	10² to 10⁷	>10⁸	>10⁷	>10⁷	10⁶	<10³ at 1 µm	>10⁷
Nominal Flow Rate (L/min)	0.3 to 4.5	1.0 to 4.2	3.0	6.5 to 39	1.25	140	30 to 10³
Note	Portable, battery option available	Portable	Laboratory grade	Collision atomizers	Portable	Designed for ISO 16890-2 and ASHRAE 52.2 filter testing	Laskin nozzle atomizers

# Portable Test Aerosol Generator

## Model 3073

A portable test aerosol generator for low and high concentration polydisperse aerosols. It generates submicron aerosols from oils, and from salt or PSL gold or glass solutions. The innovative new flow control reduces power consumption and achieves highly stable particle production rates, ideal for calibration of particle sizing instruments. Its compact and lightweight design coupled with battery operation (sold separately) make it a perfect fit for use in field test applications.





## Portable Atomizer

### Model 3079A

This rugged, compact atomizer generates particles in concentrations over  $10^8$  particles/cm<sup>3</sup> and offers an adjustable flow rate from 1.0 to 4.2 L/min. A built-in, low-noise compressor provides compressed air, and the atomizer head is made entirely of stainless steel. Operating components are protected by a hood, making this atomizer highly portable and suitable for acceptance tests.

## Single-Jet Atomizer

### Model 9302

Our simplest atomizer is highly compact and includes a built-in pressure regulator for controlling air from an external source. It produces particles in concentrations over  $10^7$  particles/cm<sup>3</sup> at a nominal flow rate of 6.5 L/min.

## Constant Output Atomizer

### Model 3076

Generated aerosols of stable concentrations over  $10^7$  particles/cm<sup>3</sup> (nominal). Its nominal aerosol flow rate is 3.0 to 3.5 L/min. Stainless steel components make this Collison-type atomizer suitable for biological and medical research, material synthesis, filter testing, instrument calibration, and basic research.

## Six-Jet Atomizer

### Model 9306

Features a high flow rate and a built-in dilution system. Users may individually select up to six jets, each producing particle concentrations greater than  $10^7$  particles/cm<sup>3</sup> at 6.5 L/min (nominal at 25 psig pressure). Built-in dilution air controlled by a rotameter allows you to vary the output particle concentration.

All six atomizers produce a mean droplet diameter of 0.3  $\mu$ m with a geometric standard deviation of less than 2.0 when generating salt solution. They are suitable for work with a wide range of solutions and suspensions, including polystyrene latex (PSL) spheres, dioctyl phthalate (DOP), silicon oil, salt or sugar solutions, and methylene blue.

# Large Particle Aerosol Generator

## Model 8108

Generates aerosols up to 10 µm in diameter.

The Large Particle Aerosol Generator produces aerosol over a wide particle size range, from 0.1 to 10 µm. Designed for easy cleaning, this generator produces potassium chloride (KCl) and other aerosols. A peristaltic pump pushes the KCl solution into a nozzle at the top of the generator, where a compressed air stream forces it out into a spray. As the droplets fall down the column, a counterflow of heated, ionized drying and dilution air moves upwards to neutralize the aerosol and remove excess water. The very broad size distribution exits the bottom of the generator, ready to be introduced into the test duct. The model 8108 meets the requirements of ASHRAE 52.2 and can also be used for ISO 16890-2 filter efficiency testing. It's an ideal aerosol generator for fractional efficiency testing of general ventilation filters and automotive cabin-air filters.

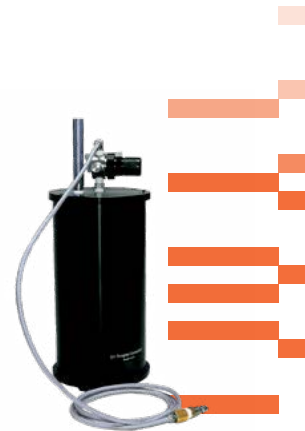


# Oil Droplet Generator

## Model 9307

Laskin nozzle Oil Droplet Generator 9307 (single-jet) is designed to generate large numbers of particles for many applications, such as seeding of Particle Image Velocimetry (PIV) or Laser Doppler Velocimetry (LDV) flows or filter testing.

This generator is typically used with oil, but can also be used with other fluids such as DEHS or salt solutions (for aerosolizing solid salt particles after drying).





## Seed Particle Generator

### Model 9307-6

TSI's model 9307-6 is a general purpose atomizer that uses Laskin nozzles to produce large quantities of oil or salt particles. An internal baffle removes the largest particles, while a valve and pressure gauge arrangement provides an easy way to control inlet air and pressure, allowing for larger particle output volume if necessary.



# Powder and Dust Dispersers

This type of generators disperse dry dust and powders for applications that need continuous and basic stable dosing with high accuracy. These aerosols are commonly used in basic aerosol science, filter testing, industrial processes, and quality assurance tasks.

Model	3410U	3410L	3400A	9309
Particle Size Range (µm)	0.2 to >100	0.2 to >100	0.5 to 40	N/A
Particle Mass Concentration	50 to 20,000 mg/m³	0.5 to 160 g/m³	10 to 100 mg/m³	N/A
Nominal Flow Rate (L/min)	8 to 35	25 to 67	5 to 15	Adjustable pressure up to 16 bar
Note	Refillable during operation. Cover included to keep dust dry. Modular.		Fluidized bed. Not compliant with RoHS	Fluidized bed

## Fluidized Bed Aerosol Generator

### Model 3400A

Disperses powders with stable concentrations for dust experiments or particle seeding.

The Fluidized Bed Aerosol Generator (FBAG) is a general-purpose powder disperser. It prepares any dry, free-flowing powder for dispersion in a gas. It disperses powders that range from 0.5 to 40 µm, with concentrations from 10 to 100 mg/m³. Unsurpassed constant output and concentration make the FBAG useful for inhalation toxicology studies, laser-velocimeter seeding, and filter testing.



Not compliant with RoHS.  
Not sold in Europe.

#### Accessories (available separately):

Specify	Description
3012A	Aerosol Neutralizer
3074B	Filtered Air Supply
1502574	Replacement bronze beads (not RoHS compliant)

## Dust Aerosol Generator

### Model 3410

The Dust Aerosol Generator 3410 comes in two versions that differ in the way the powder is fed to the disperser.

The Dust Aerosol Generator 3410 disperses dry dust and powders for applications that need continuous and stable dosing with high accuracy. The interchangeable dispersing units make it possible to disperse different materials (e.g. soot, TiO<sub>2</sub>, cellulose, or ISO 12103 test dust) at different output concentrations. A purged cover keeps the material dry even in locations with higher ambient humidity.

Both versions disperse the powder via an ejector nozzle with ceramic inlay to make it more resistant against abrasive material. Shear forces in the ejector nozzle disperse and de-agglomerate particles. In both models the reservoir can be refilled while in operation to accommodate any required operation interval.

The model 3410U is for poorly flowing powders at low dosing rates (50 mg/m³ to 20 g/m³). Here the powder is continually poured onto a metal ring where excess material falls off the side and back into the reservoir.

The model 3410L meters powder using a moving toothed belt. The well-defined spaces between the teeth ensure a constant and reproducible supply of powder and achieves mass concentrations of 0.5 to 160 g/m³.



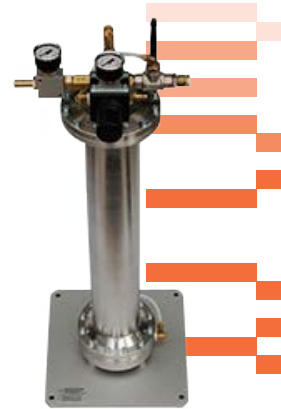
#### Accessories (available separately):

Specify	Description
3074B	Filtered Air Supply
3410-DISL	Model L Dispersion Unit for 3410U
3410-DISU	Model U Dispersion Unit for 3410L
3411	Remote Control (for 3410U, 3410L, 3413U, and 3413L)
3413L	Full Enclosure (includes 3410L generator)
3413U	Full Enclosure (includes 3410U generator)

## Solid Particle Generator

### Model 9309

The Solid Particle Generator 9309 is ideal for dispersing solid particles in order to seed flow fields in high pressure or high temperature environments, like combustion in open flames. This fluidized bed generator uses  $\text{SiO}_2$ ,  $\text{TiO}_2$ , and  $\text{Al}_2\text{O}_3$  dry powders, for example. The generator is designed to be operated at high pressures and the powder must be kept dry in order for the powders to disperse properly.



# Instruments & Accessories

## Flow Calibrators

### Models 4148 & 4048

TSI Flow Calibrators are small, simple and portable flow measuring devices. A low pressure drop minimizes the impact on your experiments.

These easy-to-read, handheld units can be powered through the included battery pack or via the included universal power supply allowing for portable benchtop use. The standard or volumetric (selectable by software) flow rate is continuously displayed allowing for fast and easy confirmation of the inlet flow displayed on the unit. The flow calibrators are temperature-compensated and pressure-corrected allowing calculated volumetric flow readings to have an accuracy of  $\pm 2\%$  of reading. An in-line HEPA filter is included to protect the flowmeter from particles in the aerosol sample and help maintain calibration.

The model 4148 operates from 0 to 20 L/min and has barb fittings for 1/4" tubing.

The model 4048 operates from 0 to 200 L/min and has barb fittings for 3/8" tubing.

Both models are calibrated for air.



## Aerosol Humidity and Temperature Sensor

### Model RHT3000

Humidity and temperature affect aerosol processes and properties. This sensor was designed to measure both parameters in an aerosol flow and to record them along with your aerosol measurements.





## Diffusion Dryers

### Models 3062 & 3062-NC

Removes moisture from sample aerosols.

Our Diffusion Dryers include removable extractor for collecting large water droplets. Desiccant surrounding the aerosol flow path removes excess moisture by diffusional capture. Because aerosol never comes in contact with the desiccant, there is minimal particle loss. Regenerate the desiccant simply by removing it from the Diffusion Dryer and baking it at 120°C. Maximum flow rate is 4 L/min. The -NC version has identical specifications, but no cobalt in the orange desiccant.



## Radioactive Aerosol Neutralizers\*

### Models 3012, 3054, 3077

Minimize particle losses and coagulation by electrostatic charges, or charge particles properly for size analysis or air-filter measurements.

Aerosol particles dispersed by nebulization, combustion, or powder dispersion are usually electrostatically charged and are subject to high losses during transport. To reduce transport losses and ensure that instruments operating on the electrostatic principle work properly, particles must be neutralized. These Aerosol Neutralizers use a radioactive source (<sup>85</sup>Kr) to perform this function. The radioactive source ionizes the surrounding gas creating positive and negative ions. Particles carrying a high charge can discharge by interacting with ions of opposite polarity. After a short time, the particles reach charge equilibrium. TSI® recommends models 3012A, 3054A, or 3077A for aerosols with higher charge levels or when operating at higher flow rates or high concentration.

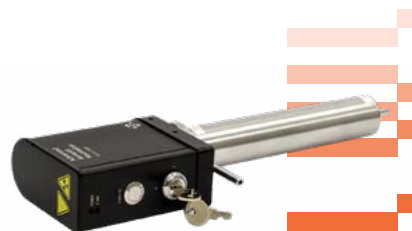
### Radioactive Aerosol Neutralizers

Specify	Description
3012	For general-purpose applications with high flow rates (up to 50 L/min). 2 mCi, 74 MBq
3012A	Same as above, but with five times the activity (10 mCi, 370 MBq)
3054	Suitable for high flow rate applications (up to 150 L/min). 10 mCi, 370 MBq
3054A	Same as above, but with twice the activity (20 mCi, 740 MBq)
3077	For general-purpose applications with low flow rates (up to 5 L/min); standard with 3938 Scanning Mobility Particle Sizer™ spectrometers. 2 mCi, 74 MBq
3077A	Same as above, but with five times the activity (10 mCi, 370 MBq)

## Non-Radioactive Aerosol Neutralizers

### Model 3088

The TSI® Advanced Aerosol Neutralizer 3088 offers an alternative to traditional radioactive neutralizers frequently required for aerosol measurement applications. Due to increasingly stringent local, state and national regulations, obtaining licensing to acquire and use radioactive sources is often difficult and in some cases prohibited. Fully compliant with US FDA, CDRH\* standards, the patented model 3088 provides an attractive alternative, with sizing performance virtually identical to TSI's Aerosol Neutralizer 3077A.



The 3088 is compatible with TSI's SMPS spectrometers models 3938, 3936 and 3034, and Electrostatic Classifiers 3082 and 3080. Like a radioactive neutralizer, it uses bipolar ions to neutralize particles up to 10<sup>7</sup> particles/cm<sup>3</sup>, and does not generate particles. Its maximum design flow rate is 5 L/min.

\*Provide end-user name and address when ordering Aerosol Neutralizers. TSI has been issued license number 1154-200-62 by the Minnesota Department of Health to sell and distribute these Aerosol Neutralizers. Users in the United States need not apply for additional U.S. Government licenses to handle these products. However, some state and local governments may require special licenses, and some organizations may have special handling procedures. Check all local requirements.

## Electrical Neutralizer

### Model 1090

The Electrical Neutralizer 1090 produces a Boltzmann equilibrium charge equivalent to that produced by a radioactive ionizer, but without the use of radioactivity. The model 1090 uses both positive and negative ions produced from an electrical AC corona discharge to condition the particles, and does not generate contaminant particles. The model 1090 can operate at flow rates from 0.5 to 2.5 L/min.



## Filtered Air Supply

### Model 3074B

Cleans, dries, and regulates compressed air for aerosol generation and other applications.

The Filtered Air Supply removes oil or other liquid droplets from the incoming air using two prefilters. It also removes any remaining moisture in the air stream by passing the air through an advanced regenerating membrane dryer. Plus, it removes fine particles and vapors using a high-efficiency filter at the outlet. This full-featured compressed-air conditioner allows you to make pressure adjustments using an included gas-regulator valve. It handles a maximum flow rate of 60 L/min at a dewpoint as low as 2°C. Maximum inlet pressure is 1,000 kPa (150 psig).



## Flow Splitter

### Model 3708

Routes sample from one source to several instruments.

The Flow Splitter directs an aerosol sample to as many as four destinations at once. This accessory is especially useful when performing instrument comparison or calibration experiments. Smooth flow transitions provide equal flow distribution. Stainless-steel construction and an electropolished interior prevent the aerosol from being contaminated or lost to the walls. The Flow Splitter has a  $\frac{3}{8}$ -inch straight-tube inlet and four  $\frac{1}{4}$ -inch outlets (outside diameters). Maximum total flow rate is 30 L/min.



# Particle Size Selector

## Model 376060

Allows selection of different cutoff sizes for CPCs.

The Particle Size Selector (PSS) allows you to control the lower size cutoff of a TSI® Condensation Particle Counter (CPC). The PSS is a separating device that selectively removes small particles from an aerosol by diffusion. Simply add or remove diffusion screens to change the lower cutoff size. The cutoff shifts toward larger sizes as more screens are added.

The PSS includes 11 screens and, therefore, can be configured for 11 cutoff sizes. An extra set of 12 screens may be ordered to expand the cutoff range further. Specific cutoff sizes vary based on CPC operating flow rate.

The technique of using a Condensation Particle Counter with diffusion screens to select specific particle size ranges is covered in United States Patent Number 5,072,626.



### PSS Accessory (available separately):

Specify	Description
376061	Set of 12 additional diffusion screens

# Vacuum Pumps

## Models 3032 & 3033

Use these top-quality Gast pumps when you need a portable vacuum source.

The model 3032 is a quiet diaphragm-type pump that produces flow rates up to 5 L/min. Oversized, permanently lubricated bearings promote longer life and maintenance-free operation. The pump operates in any position. We offer this small, reliable pump for use with our 3790A /-10, 3783, and 3750 Condensation Particle Counters, or 3938 Scanning Mobility Particle Sizer™ spectrometers containing a 3750 CPC.

The model 3033 produces flows up to 60 L/min. This high-quality, rotary-vane pump contains self-sealing, compound-carbon vanes that self-adjust as they wear. Therefore, it always operates at top efficiency. Permanently lubricated ball bearings make the 3033 virtually maintenance-free. This is the pump we recommend for use with our 3068B Aerosol Electrometer or when using multiple CPCs that require an external vacuum source. This pump is also suitable for TSI 3306 Impactor Inlet when used with our APS.

### Vacuum Pumps

Specify	Description
3032	Diaphragm pump, for flow rates up to 5 L/min, 115 V
3032-1	Diaphragm pump, for flow rates up to 5 L/min, 230 V
3033	Rotary-vane pump, for flow rates up to 60 L/min, 115 V (Available in voltages of 100-240VAC and 50-60 Hz)

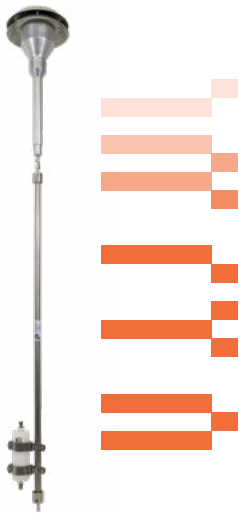
TSI® recommends these pumps only for use with specific TSI® particle instruments. Please specify voltage requirements at time of order.

# High Flow Sampling System

## Model 140-HFSS

The High Flow Sampling System (HFSS) 140-HFSS is an accessory designed to be used with the 140 QCM MOUDI™ when sampling ambient air at varying temperature and humidity conditions.

A Nafion® dryer can reduce the relative humidity of the sample air from as varying as ~100 % at 40 °C to below 80 % at normal room temperature (i.e. 25°C), avoiding water condensation in the sampling line upstream of the QCM MOUDI™.



TSI® Incorporated serves a global market by investigating, identifying, and solving measurement problems. As an industry leader in the design and production of precision instruments, TSI® partners with research institutions and customers around the world to set the standard for measurements relating to aerosol science, air flow, health and safety, indoor air quality, fluid dynamics, and biohazard detection. With headquarters based in the U.S. and field offices throughout Europe and Asia, TSI has established a worldwide presence in the markets we serve. Every day, our dedicated employees turn research into reality.

### Ordering

To order, contact your nearest representative or sales office. If you don't know which office handles your territory, then contact our corporate headquarters. Our staff will answer any questions you may have or they will put you in contact with the appropriate sales office. Contact information can also be found on the TSI® website. When ordering, specify the model number, instrument name, accessory models and names, and voltage requirements and final country of delivery.

### Customer Service

TSI Customer Service Specialists are available to answer your questions about installation or operation:

US & Canada: +1 800 874 2811  
UK: +44 1494 459200  
Germany: +49 241 52303 0  
or visit: [www.tsi.com](http://www.tsi.com)

### General Information

TSI Incorporated manufactures innovative instruments for use in industry and research. The particle instruments described in this catalog represent only one of our product families. TSI offers a broad array of sensors and instrumentation systems used in a variety of measurement applications around the globe.

Headquartered in Shoreview, Minnesota, TSI has sales and representative offices all over the world. For more information on TSI particle instruments, use the contact information shown below or visit [tsi.com/contact-us](http://tsi.com/contact-us). For information on TSI instruments not discussed in this catalog, go to the main TSI web page at [www.tsi.com](http://www.tsi.com).

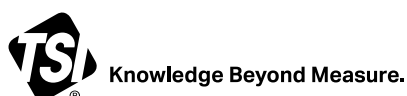
A sincere effort was made to ensure that all information in this catalog was current at the time of publication. However, specifications, features, and availability are subject to change. Please check with your TSI representative for the latest information. Prototype or early instruments are depicted in some photographs. Final products may vary from those pictured.

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