COUNTING THE WAY TO CLEANER AIR

AIR QUALITY
MONITORING SOLUTIONS

UNDERSTANDING, ACCELERATED

AEROSOL SCIENCE MEETS AIR QUALITY MONITORING

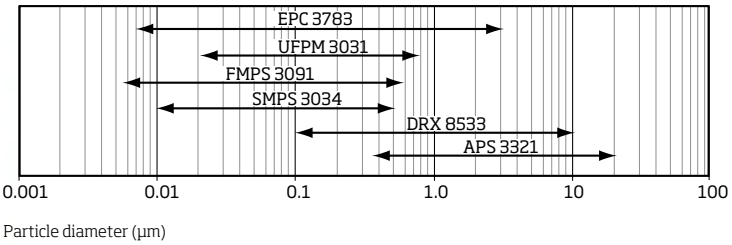
Practical Tools

+ Easy to install and operate
+ Flexible and convenient data acquisition
+ Long-term problem-free operation
+ Minimal maintenance
+ Low cost of ownership

Sophisticated Data

+ Real-time, simultaneous size segregated mass (PM1, PM2.5, PM10, Respirable, Total PM)
+ Real-time fine and ultrafine particle number (PN) concentration
+ Real-time fine and ultrafine particle (UFP) size distributions
+ Measurement techniques developed and preferred by researchers
+ International Organization of Standardization (ISO) approved measurement methods
+ Unparalleled accuracy and resolution
+ Proven results

Air Quality Monitoring Instrument Size Ranges

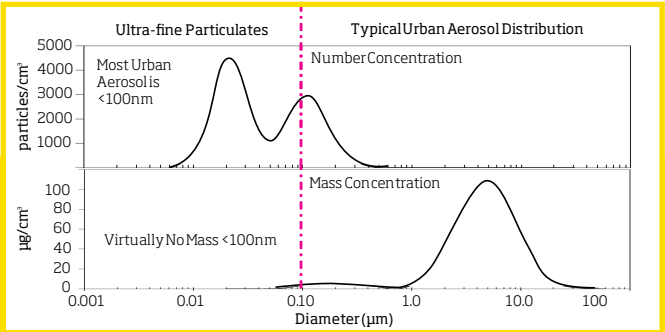


What are Ultrafine Particles (UFPs)?

+ The US Environmental Protection Agency (US EPA) definition: <100 nm
+ UFPs occur in massive numbers in urban air but essentially have no measurable mass.
+ The most variable fraction of urban environment is the ultra-fine particles. If temporal changes of ambient air particulate is of interest, the UFP component must be quantified.
+ The most common source of UFPs in urban environments is vehicle exhaust. The emissions of vehicles and other combustion sources is almost entirely in the ultra-fine size range.

Ultra-Fine Particles (UFPs) and Mass Measurement

+ The number of coarse (PM10) particles in urban air is at least 1,000 times less than the number of UFPs, yet they make up ~99% of mass. It takes a million UFPs (100 nm) to equal the mass of one 10 µm particle.
+ Traditional mass-based measurements like PM10 and PM2.5 do not represent UFPs. Filter based Federal Reference Methods (FRM), TEOMs and BAMs do not effectively measure ultrafine particles (UFP).
+ A count-based metric (number concentration) must be used to measure the amount of UFPs in ambient air.



Adapted from: Seinfeld, J. H.; Pandis, S. N. Atmospheric Chemistry and Physics; John Wiley and Sons, 1998.

Why Monitor Ultrafine Particles?

+ **Increased Exposure to Ultrafines:** Mounting evidence indicates that UFP exposure is higher than originally surmised. Recent studies show increased exposure near roadways[1], airports[2], tunnels[3], and schools[4].
+ **Air Quality/Visibility Effects:** Ultrafine particles from combustion sources are frequently hygroscopic. As such, at high relative humidity water condensation enlarges UFPs to a size that is efficient at scattering light, resulting in visibility degradation and significant contribution to haze and smog.
+ **Potential Health Effects:** There is currently no definitive answer as to whether or not UFPs are associated with negative health effects, but toxicological evidence points to UFPs as possible contributors to heart disease[5], lung disease[6], DNA damage[7], and translocation of UFPs to the brain[8].

References:

[1]Ntziachristos L, Ning Z, Michael D. Geller, and Sioutas C. 2007. Particle Concentration and Characteristics near a Major Freeway with Heavy-Duty Diesel Traffic. Environmental Science & Technolology 41(7):2223–2230.

[2]Hu S, Fruin S, Kozawa K, Mara S, Winer A, and Paulson S. 2009. Aircraft Emission Impacts in a Neighborhood Adjacent to a General Aviation Airport in Southern California. Environmental Science & Technology 43(21):8039–8045.

[3]Knibbsa L, de Deara R, Morawskab L, and Mengersenc K. 2009. On-road ultrafine particle concentration in the M5 East road tunnel, Sydney, Australia. Atmospheric Environment 43(22-23): 3510-3519.

[4]Morawska L, He C, Johnson G, Guo H, Uhde E, and Ayoko G. 2009. Ultrafine Particles in Indoor Air of a School: Possible Role of Secondary Organic Aerosols. Environmental Science & Technology 43(24):9052-9056.

[5]Jesus A. Araujo et al, 2008, "Ambient Particulate Pollutants in the Ultrafine Range Promote Early Atherosclerosis and Systemic Oxidative Stress", Circulation Research, 102:589-596.

[6]Stephania Cormier, PhD, June 2, 2009, presented at 11th International Congress on Combustion By-Products and Their Health Effects at the EPA Conference Center in Research Triangle Park, N.C.

[7]Elvira Vaclavik Bräuner et al, 2007, "Exposure to Ultrafine Particles from Ambient Air and Oxidative Stress–Induced DNA Damage," Environmental Health Perspectives, 115(8): 1177-1182.

[8]G. Oberdörster, et al, 2005, "Translocation of Inhaled Ultrafine Particles to the Brain," Inhalation Toxicology, 16:6-7,437-445.

ULTRAFINE PARTICLE (UFP) MONITORING

EPC™ Environmental Particle Counter™ Monitor Model 3783

Federal Reference Methods (PM2.5, PM10) and equivalent mass-based methods cannot quantify the amount of UFP in the air. The EPC™ monitor provides quantitative UFP concentration data in real time to supplement mass based FRM and equivalent methods. Targeted at unattended monitoring, the Model 3783 is easy to use, requires minimal maintenance, and has a variety of configuration choices.

The Result of Thoughtful Design, Rigorous Internal Testing, and Extensive Field Validation, the EPC™ Monitor is Engineered for Monitoring Performance.

Features and Benefits

+ Measures particles as small as 7 nm (0.007 µm)
+ Easy to operate and install
+ Low maintenance and consumables
+ Stand-alone operation
+ Simple and flexible data acquisition
+ Automated data analysis
+ Wide concentration range: 1 to 10^6 particles/cm^3; exclusively single particle counting
+ Advanced instrument diagnostics
+ Flexible sampling intervals down to 1 second
+ Rack mountable

Focus on Flexibility

Set-up options

+ Inlet flow: 3.0 or 0.6 L/min
+ Inlet location: front or back
+ Water connection: front or back
+ Optional rack mount hardware

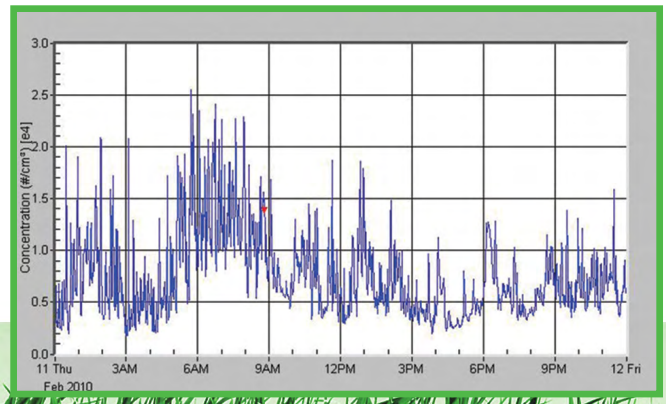
Instrument interface options

+ Color touch screen with graphical interface
+ Upgraded Aerosol Instrument Manager® software
+ Terminal command set with ASCII data stream

Data acquisition options

+ USB stick
+ Ethernet
+ USB port
+ RS232 port

EPC™ monitor display of particle concentration vs. time



Ultrafine Particle (UFP) Monitor Model 3031

The Model 3031 provides continuous ambient particle concentration and size distribution data for long term, air quality monitoring. Ultrafine particle (UFP) monitors are installed in a variety of air monitoring networks across the globe, allowing worldwide UFP concentration comparisons for the first time ever.

Features and Benefits

+ Size range: 20 to 800 nm
+ Long-term, unattended operation
+ Low start-up and operating costs
+ No working fluids; no radioactive source
+ Convenient data management with remote internet access
+ Standardized measurement method
+ Extensive field validation

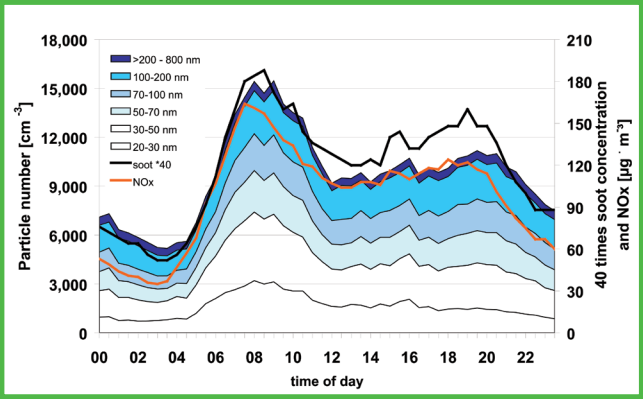
The Making of the UFP Monitor

+ In 2005, the European Union (EU) established the first regulation to restrict the number, not mass, of ultrafine particles in light duty diesel vehicle emissions.
+ Accordingly, the Clean Air for Europe (CAFE) program brought about the Thematic Strategy on Air Pollution which implemented a means to improve data quality for advanced environmental monitoring, including UFP number concentration and size distribution.
+ UFIPOLNET project was initiated to develop an affordable, low maintenance monitor for UFP number concentration and size distribution, thus the TSI Model 3031.

Model 3031 Design Criteria

+ Affordable price
+ Low cost of ownership
+ Seamless integration into monitoring systems
+ Easy to use
+ Manageable data sets
+ Reliable data
+ Sensitive and accurate

UFIPOLNET
ultrafine particle size distributions in air pollution monitoring networks



Half-hour average particle number concentrations from UFP Monitor compared to NOx, soot; weekly average 24/1-19/3/07.

Reference: Saxon State Agency for Environment and Geology (LfUG), Data from measurements in EU-LIFE project UFIPOLNET, which was cofunded by the European Community under LIFE04 ENV/D/000054 Source: Holger Gerwig, LfUG

HIGH RESOLUTION PARTICLE SIZING

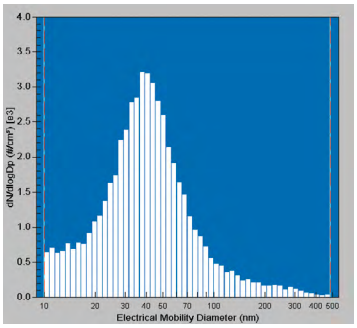
Single-Box Scanning Mobility Particle Sizer™ SMPS™ Spectrometer Model 3034

The SMPS™ spectrometer Model 3034 is an easy-to-use, accurate, high resolution particle sizer with superior resolution designed for continuous environmental monitoring applications. This single box SMPS™ spectrometer offers the ultimate in convenience and portability, making it the instrument of choice for users in need of precise data for long term installations.

Features and Benefits

+ Size range: 10 to 487 nm
+ Integrated design: CPC[1] and DMA[2] in a single cabinet
+ 54-channel resolution
+ NIST[3] measurement method to size standard reference materials (SRM)
+ Simple instrument set up and operation
+ Powerful software for data collection and analysis

[1]CPC- Condensation Particle Counter;
[2]DMA- Differential Mobility Analyzer;
[3]NIST- National Institute of Standards and Technology



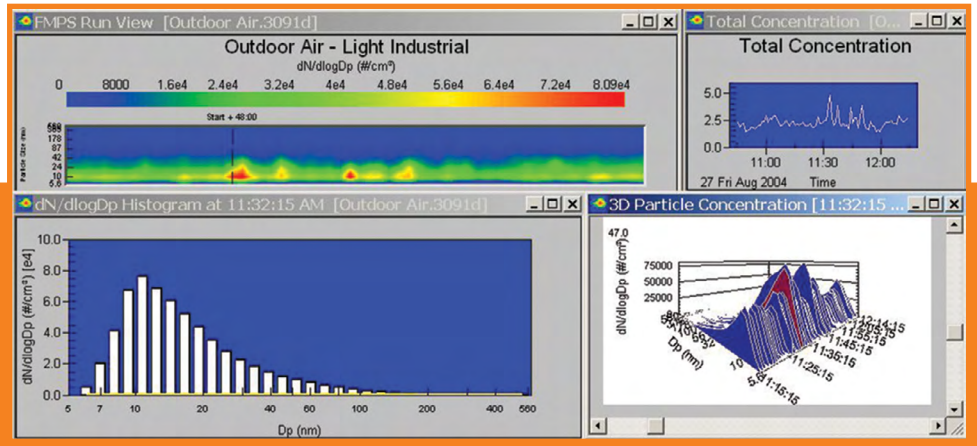
Model 3034 Ambient Air Size Distribution

Fast Mobility Particle Sizer™
FMPS™ Spectrometer
Model 3091

The FMPS™ spectrometer has unsurpassable temporal resolution. Measuring complete number size distributions of ambient air particles in one second, the Model 3091 is fast enough to see combustion emission events in real time. FMPS™ spectrometer users can watch and record data as the UFP number concentrations jump orders of magnitude during an event and then decay over time, eventually returning to background levels.

Features and Benefits

+ 5.6 to 560 nm
+ Size distributions in one second
+ No working fluids or radioactive source
+ High sample flowrate (10 L/min) significantly reduces sample losses
+ Easy to use, turn on and run
+ Wide, dynamic concentration range
+ 32-channel resolution
+ Flexible data management with full-featured software program



FMPS Data of outdoor air taken in a light industrial area.

REAL-TIME LARGE PARTICLE SIZING AND PARTICLE MASS (PM) MEASUREMENTS

Aerodynamic Particle Sizer® (APS™) Spectrometer Model 3321

The Aerodynamic Particle Sizer® (APS™) spectrometer Model 3321 sizes particles from 0.37-20 µm in as little as one second. Used extensively for outdoor monitoring, the Model 3321 measures particle concentrations and size distributions in real time with a high degree of precision and resolution.

The power of the (APS™) spectrometer lies in the fact that the measurement is independent of the refractive index of the sample particles. Consequently, for real world and test aerosols alike, the actual resolution of the instrument over the entire operating range is truly extraordinary and unique.

Embraced by government agencies across the globe for its ease of use and high quality data, the APS™ spectrometer is a great first choice to monitor fine and coarse mode outdoor air concentrations. Biological aerosol tracking, dust storm monitoring, and effective density measurements are just a few of the applications in which this popular instrument has been used.

Features and Benefits

+ Size range: 0.37- 20 µm
+ Measurement independent of the particle's refractive index
+ Unmanned operation with real-time front panel display
+ Easy to use and reliable
+ 52 channels of size resolution

DustTrak™ DRX Aerosol Monitor
Models 8533 and 8534

Using the DustTrak™ DRX aerosol monitor, one instrument can do the work of five by providing simultaneous mass measurements in one second: PM1, PM2.5, PM4, PM10, and total PM. There is no need for size selective inlets because in each one second sample, the complete suite of PM size fractions is measured in real time. This powerful instrument comes in a lightweight and portable package.

Features and Benefits

+ Color touch-screen with graphical interface
+ Battery operated
+ On-board data logging and built-in Ethernet
+ Optional environmental enclosure with omni-directional sampling inlet
+ Optional wireless modem and solar power system
+ No consumables and low cost of ownership

Used in Air Quality Networks

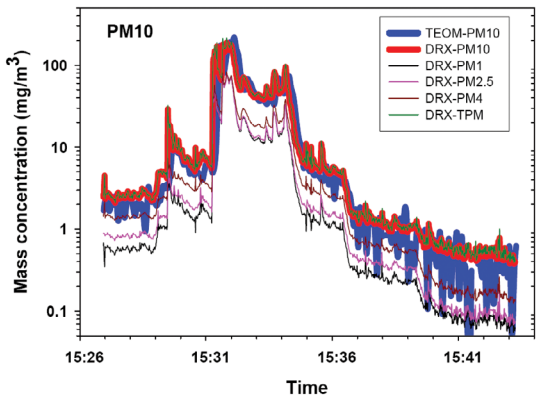
Government air quality groups worldwide are successfully using the DustTrak™ aerosol monitor for long term, continuous PM measurements. Ideal for temporal measurements and unattended operation, the DustTrak™ aerosol monitor is the instrument of choice due to its comprehensive data, fast time response, low maintenance, and ease of use.

Proven Results

Extensive testing has demonstrated that the DustTrak™ aerosol monitor is highly correlated with the TEOM (an EPA standard reference equivalent method). The data shows excellent agreement for all of the individual size channels over a wide range of aerosol mass concentrations

DustTrak™ DRX Aerosol Monitor Advantages Over TEOM

+ Simultaneous size segregated mass fractions
+ Data in one second- six times faster than TEOM
+ No inlet impactors
+ No consumables
+ Low maintenance
+ Low cost of ownership



A1 dust concentration measured by TEOM and DRX. The TEOM had a PM10 impactor on its inlet, while the DRX did not have any impactor on its inlet. Excellent correlation is documented for PM2.5, PM4 (respirable), and TPM (total PM). While the DustTrak™ aerosol monitor can measure all the size fraction simultaneously, separate TEOM runs were necessary for each different TEOM size fraction.

LIGHT SCATTER AND OPTICAL PARTICLE SIZING

Integrating Nephelometer
Model 3563

Skillful design, hand-crafted construction, and precision electronics make the Model 3563 the world's most accurate and sensitive integrating nephelometer.

Featuring extremely low noise levels and repeatable measurements over time, the Model 3563 provides: 1) meaningful light scatter measurements in the cleanest environments and 2) the ability to accurately detect small measurement changes in both urban and remote environments. This extremely well characterized instrument has been relied on for decades by climate change, visibility and air quality investigators to provide reliable and consistent measurements for temporal and spatial comparisons worldwide.

Features and Benefits

+ Simultaneous three-color detection for clues to particle composition
+ Measures forward light scatter and backward scatter independently
+ Integration angle of 7° to 170°
+ Well characterized, close-to-ideal light source
+ Flowrates of 20-200 L/min; low diffusion losses and fast response times
+ Real-time background subtraction of Rayleigh scattering
+ Continual measurement of light intensity and dark counts
+ Proven performance at long term monitoring sites (NOAA, Global Atmospheric Watch (GAW) stations)

Optical Particle Sizer
Model 3330

The OPS Model 3330 is a full-featured optical particle counter at an affordable price.

Optical particle counters (OPCs) are frequently used for ambient monitoring to provide an estimate of the supermicron particle size fraction. The Optical Particle Sizer (OPS) Model 3330 from TSI is a cut above the field of standard OPCs, providing a higher quality measurement paired with a state-of-the-art user interface. This light, portable unit delivers impressive resolution, a wide concentration range and a host of user-friendly features.

Features and Benefits

+ Size range: 0.3 to 10 µm
+ 16 size channels with user adjustable size binning
+ Variety of real-time data display options including, particle number concentration and calculated mass distributions
+ Built-in data logging capability for up to 30,000 samples
+ Portable, battery-powered
+ Modern GUI with intuitive user interface
+ Filter-based sample collection for later gravimetric or chemical analysis

Environmental Sampling System
Model 3031200

This must-have accessory for outdoor monitoring can be used with all TSI submicron particle sizers and counters for representative sampling and conditioning for accurate measurements. The US EPA-approved inlet protects your particle monitoring equipment and also conditions the air stream to reduce humidity effects.

Features and Benefits

+ Standard PM10 inlet
+ Sharp cut PM1 cyclone
+ Low-maintenance drying system using a Nafion dryer
+ Flexible setup options
+ Minimal particle losses

TSI Particle Instrument Software

Each TSI particle sizer and counter is paired with specialized software which can be used for instrument control and diagnostics as well as data acquisition, management, and analysis. The software package is tailored to the type of data the instrument collects and the instrument application. Data can be weighted by any moment of number concentration, including diameter, surface area, volume, and mass. Export functions allow easy transport of files to spreadsheets or other applications for customized data handling.

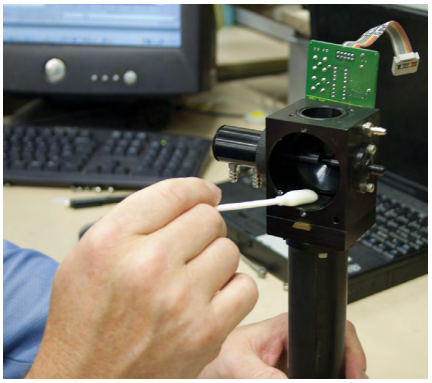
A Few Highlights

+ Variety of 2D and 3D graphing options
+ Automated statistical data analysis
+ Flexible export functions
+ Real-time data display
+ Sample and file management capability
+ Advanced post-processing options

Automatic Statistical Analysis for Each Sample

	Number Particle Size	Diameter Particle Size	Surface Particle Size	Volume Particle Size	Mass Particle Size
Median (nm)	50.1	83.8	152.0	270.0	270.0
Mean (nm)	65.9	113.6	192.8	288.9	288.9
Geo. Mean (nm)	51.4	85.9	150.0	242.2	242.2
Mode (nm)	47.8	91.4	289.0	399.5	399.5
Geo. St. Dev.	1.98	2.10	2.09	1.89	1.89
Total Conc.	6.84e + 04 (#/cm^3)	4.51 (mm/cm^3)	1.61e + 09 (nm^2/cm^3)	5.17e + 10 (nm^3/cm^3)	62.0 (µg/m^3)

TSI SERVICE, SERVICE AGREEMENT, AND EXTENDED WARRANTIES



Protect Your Investment...Protect your Data Accuracy.

TSI's Particle Instruments are the most reliable and accurate measurement instruments in the industry. Ensure your instruments are properly calibrated and at peak performance with routine annual service or a TSI QualityGuard™ Service Agreement.

For More Information Or To Discuss Your Application
Give TSI a call or send an e-mail to the contact information found below!

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