Preliminary Information

# Scanning Mobility Particle Sizer™ Spectrometers

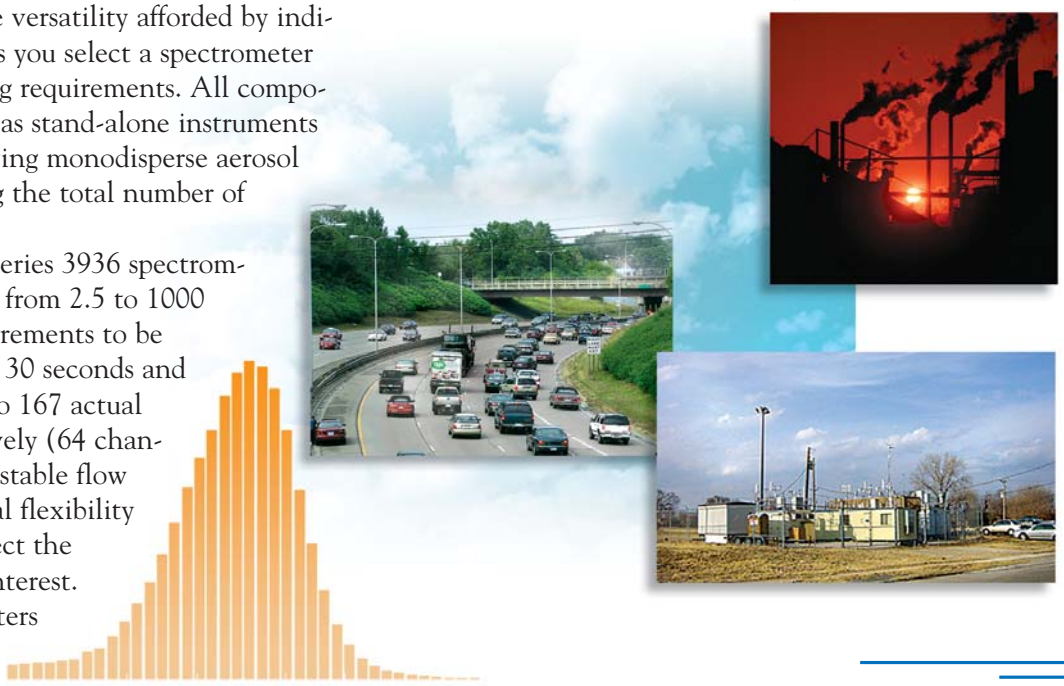
*Provide the highest resolution, most accurate particle size distribution measurements of submicrometer airborne particles!*

**TSI offers a complete family of Scanning Mobility Particle Sizer (SMPS™) spectrometers for submicrometer particle sizing. The Series 3936 component SMPS spectrometers offer great flexibility and the highest size resolution. The Model 3034 single-box SMPS spectrometer has an integrated design that greatly simplifies instrument set up, operation, and transport. All of these spectrometers use a continuous, fast-scanning measurement technique that eliminates gaps in particle-size-distribution data and provides highly accurate measurements.**

The **Series 3936 SMPS spectrometers** feature TSI Series 3080 Electrostatic Classifiers, with your choice of Differential Mobility Analyzer (DMA), and a large selection of Condensation Particle Counters (CPCs). The versatility afforded by individual components lets you select a spectrometer that best fits your sizing requirements. All components can be operated as stand-alone instruments for experiments involving monodisperse aerosol generation or counting the total number of particles.

Collectively, our Series 3936 spectrometers measure particles from 2.5 to 1000 nm. They allow measurements to be completed in as few as 30 seconds and display data using up to 167 actual size channels, collectively (64 channels per decade). Adjustable flow rates provide additional flexibility by allowing you to select the particle size range of interest. Series 3936 spectrometers provide an unmatched, proven solution for research involving combustion, atmospheric aerosols, indoor air quality, filter testing, and much more.

The **Model 3034 SMPS spectrometer** integrates a DMA and a CPC in a single cabinet. All flow controls and operating parameters are fixed. This greatly simplifies instrument transport, set up, and operation, and it eliminates the need for an aerosol specialist to run the instrument. The Model 3034 measures aerosol particles in the range from 10 to 487 nm with a total of 54 size channels (32 channels per decade). It is ideal for industrial research applications such as steady-state particle emissions testing, indoor-air-quality measurements, or inhalation research involving the health effects of ultrafine particles. The 3034 is also designed for continuous, long-term environmental monitoring without operator intervention.



# Series 3936 SMPS Spectrometers

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

Component SMPS spectrometers allow you to choose the DMA and CPC that best suit your application. Fourteen different configurations are available. This family of versatile spectrometers gives you:

**Fast results.** Complete particle size distributions can be produced in as few as 30 seconds.

**High-resolution data.** Up to 167 total size channels, collectively, and 64 channels per size decade.

*When configuring your Series 3936 SMPS spectrometer, you have a choice of six Condensation Particle Counters. Additionally, you may choose between two Differential Mobility Analyzers, or you may interchange DMAs to meet different measurement needs.*

**Broad size range.** These spectrometers cover a collective size range from 2.5 to 1000 nm.

**Wide concentration range.** Collectively, they span the range from 1 to $10^8$ particles/$cm^3$.

**Flexible set up.** Flow rates are fully adjustable to select the particle size range of interest; individual components can be operated separately to generate monodisperse particles or count the total number of particles.

**Simple control of operation.** Series 3080 Electrostatic Classifiers contain a built-in front panel display and a control knob, which allow you to scan through settings quickly and monitor or control instrument functions. Flow measurements are automatically corrected for ambient pressure and temperature, so there is no need for frequent calibration.

**Powerful software.** The Aerosol Instrument Manager® software works with Microsoft® Windows® operating systems. It features pull-down menus and dialog boxes to simplify set up, operation, data collection, and analysis.


Computer not included

**3936N86**

# Model 3034 SMPS Spectrometer

*An easy-to-use, submicrometer particle sizer designed for a wide range of industrial measurements or continuous environmental monitoring applications.*

This single-box spectrometer offers the ultimate in convenience and portability. Key features include:

**Integrated design.** The CPC and DMA are combined in a single cabinet. This translates into easy transport and quick set up—no parts to assemble or tubing to connect, and no flows to select or adjust!

**Simple operation.** Does not require an aerosol specialist to operate. Simply fill it with butanol, turn the power ON, let it warm up, and press "Start". The Model 3034 operates much like our easy-to-use Model 3321 Aerodynamic Particle Sizer® spectrometer, but for measurements in the submicrometer range.

**Long-term, unattended monitoring.** Designed for 30 days of continuous operation without maintenance. In the event of a power outage, measurements automatically resume upon power restoration.

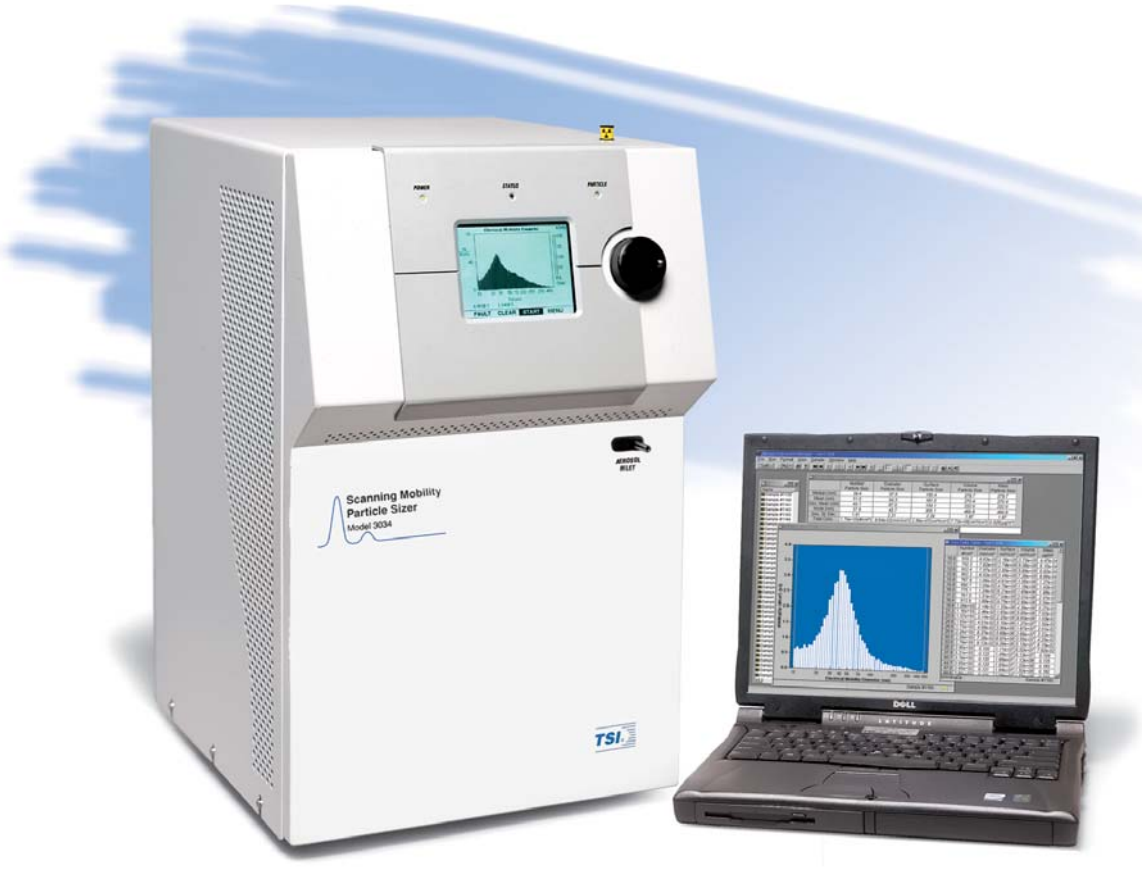
**Automatic correction for ambient conditions.** There is no need for data manipulation because measurements are corrected automatically for ambient pressure and temperature.

**Nearly limitless data-storage capacity.** Each particle size distribution consumes only one kilobyte of disk space. An entire year's worth of continuous measurements requires less than 180 megabytes.

**Built-in diagnostics.** Status and diagnostic functions are easily accessible via the front-panel display.

**Real-time data display.** Shows a new particle size distribution on the front panel and in the software every three minutes.

**Views of results without interrupting data acquisition.** The software allows operators to analyze data files while data logging continues in the background.




3034

Computer not included

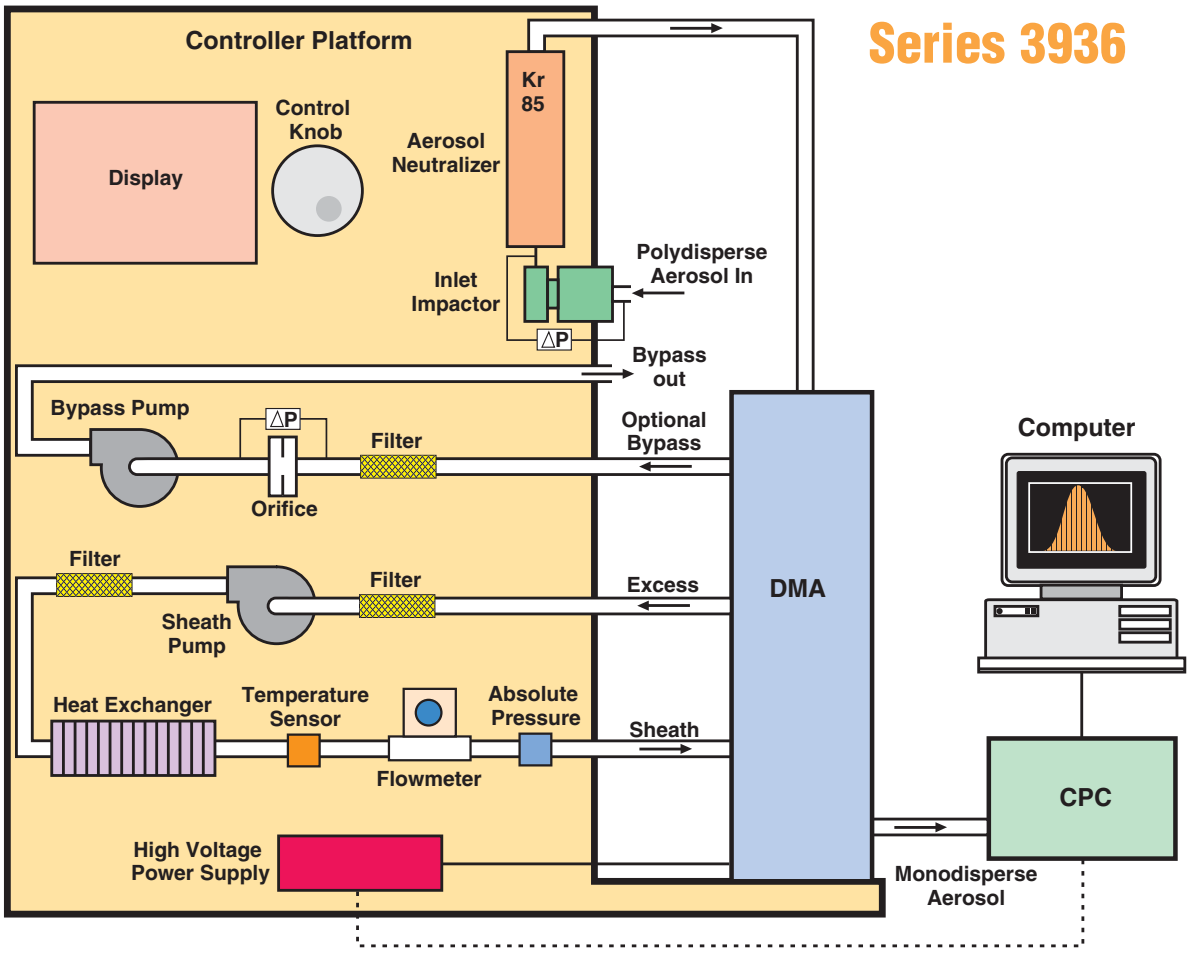
## SMPS Operation

All SMPS spectrometers use electrical-mobility particle size classification, combined with a Condensation Particle Counter (CPC). In Series 3936 instruments, the aerosol sample first passes through a single-stage, inertial impactor. This serves to remove large particles outside the measurement range that may contribute to data inversion errors caused by multiple charging. Next, the aerosol passes through a bipolar ion neutralizer. This creates a high level of positive and negative ions and brings the aerosol charge level to a Fuchs' equilibrium charge distribution.

The charged and neutral aerosol particles then enter a Differential Mobility Analyzer (DMA) in which particles are separated according to their electrical mobility. The DMA is constructed of two concentric cylinders: an inner electrode, and an outer electrode. The outer electrode is kept at ground potential, while a precise, negative voltage (0 to 10,000 VDC) is applied to the inner electrode to create an electric field. A HEPA-filtered, flow-controlled, laminar sheath-air flows along the annual space between the two electrodes. Aerosol particles are introduced into the DMA through a slit at the top of the outer electrode. Particles with negative charges are repelled towards and deposited on the outer wall. Neutral particles exit the DMA with the excess air. Particles with positive charges move rapidly across the clean sheath-air layer towards the negatively charged inner electrode.

Only particles within a narrow range of electrical mobility have the correct trajectory to pass through a narrow, open slit near the bottom of the inner electrode. After exiting the DMA, the classified particles are counted by a CPC, which accurately measures the particle concentration. By ramping the voltage of the inner electrode exponentially over a user-selected period of time, the entire particle size distribution and number concentration are measured to a high degree of accuracy.

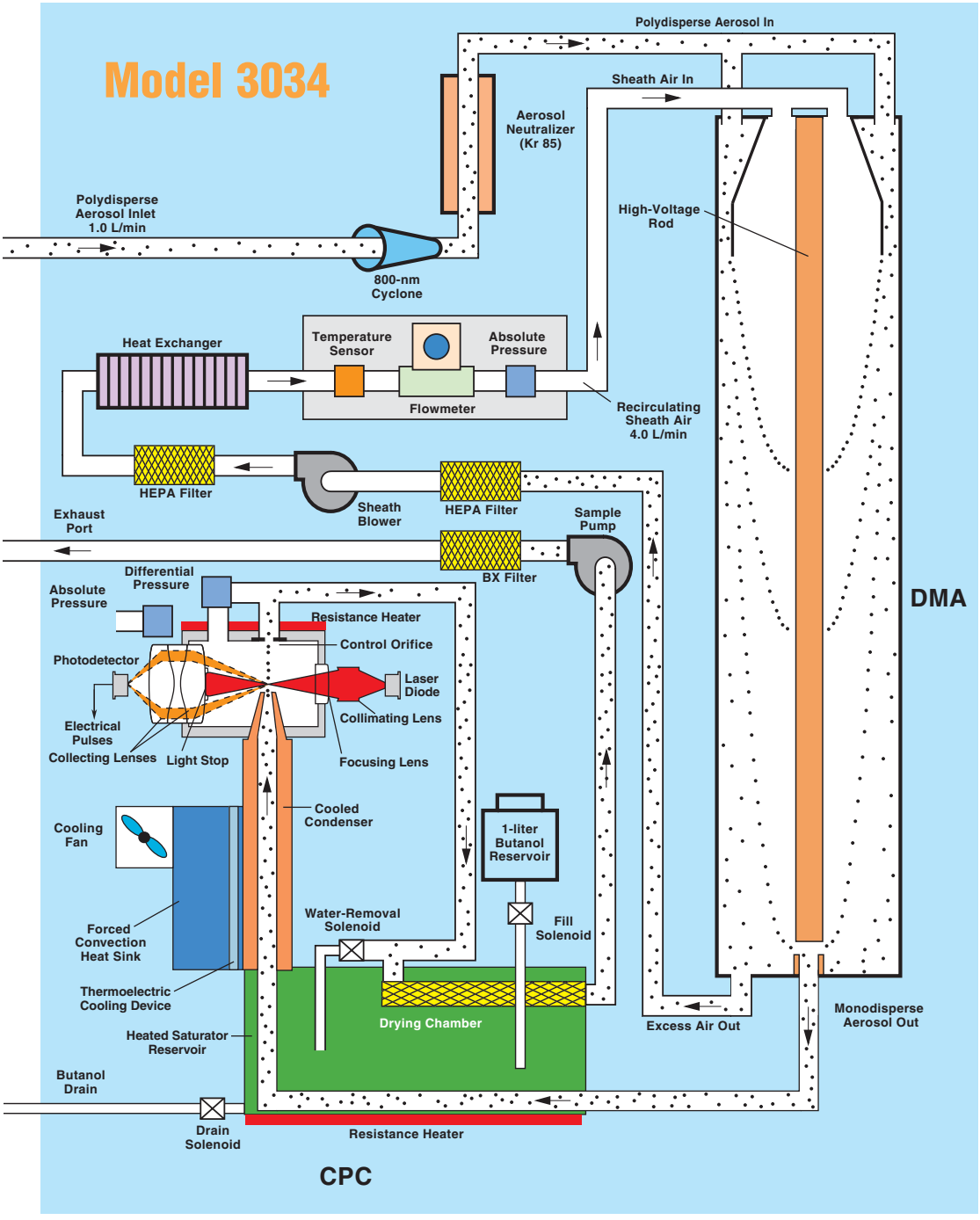
The flow rates in the Series 3080 Electrostatic Classifiers are temperature- and pressure-corrected. The Aerosol Instrument Manager software controls



the counting process, as well as data collection, calculation, and storage. It also corrects for multiple-charge effects and CPC detection efficiency.

Operation of the Model 3034 SMPS spectrometer is similar to the Series 3936, except that the DMA and CPC are integrated in a single cabinet. Instead of an inertial impactor, the 3034 uses a cyclone to remove large particles. The cyclone is less prone to clogging and is more suitable for long-term, unattended operation. All raw data calculations, including corrections for temperature, pressure, and multiple-charge effects, are made inside the Model 3034 before being shown on the integrated display or transmitted to a personal computer running TSI's Aerosol Instrument Manager software. Data correction allows the 3034 to provide accurate size distribution measurements at elevations other than sea level.

Series 3770 butanol-based CPCs used in Series 3936 SMPS spectrometers, as well as the CPC inside the Model 3034 SMPS, include TSI's patented water-removal technology. This ensures that data integrity is not compromised by butanol that becomes contaminated with water in humid environments. Of course, our Series 3780 Water-based CPCs completely eliminate any concern of water uptake and feature the advantage of using a readily available, odorless working fluid.



## SMPS Applications

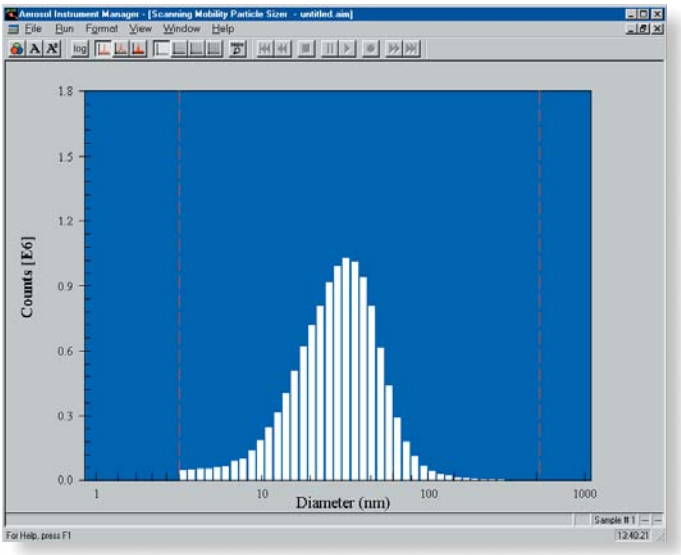
All SMPS spectrometers provide accurate particle size distribution and number concentration measurements of submicrometer aerosols. Applications include:

- Basic aerosol research
- Nanotechnology research
- Atmospheric and climate studies
- Indoor-air-quality measurements
- Pollution studies
- Smog chamber evaluations
- Aerosol dynamics
- Combustion and engine exhaust studies
- Materials synthesis
- Filter efficiency testing
- Nucleation/condensation studies
- Inhalation toxicology studies
- Characterization of sprays, powders, and other generated aerosols
- Mobilie aerosol studies
- Long-term, unattended environmental monitoring

Major components in Series 3936 SMPS spectrometers work as stand-alone instruments in a variety of applications. For example, the Series 3080 Electrostatic Classifiers function as a monodisperse aerosol generator; the CPC is a particle concentration detector.

## Software

SMPS spectrometers include the Aerosol Instrument Manager software, a program designed for use with Windows operating systems. It controls instrument operation, collects high-resolution data, and provides impressive file-management capabilities. Data can be weighted by any moment of number concentration, including diameter, surface area, volume, or mass.




*The SMPS spectrometer gives you high-resolution particle-size distribution measurements in as few as 30 seconds.*

Comprehensive statistical analysis is computed automatically for the entire distribution or specific size ranges you define. An export function allows easy transport of files to spreadsheet or other applications for customized data handling. Additional software capabilities include multiple-scan averaging, a buffer for comparing data sets, programmable start/stop times, and automatic file storage and printout options. For the Series 3936 SMPS spectrometers, the Aerosol Instrument Manager software can also offer multiple-charge correction for up to 10 charges, and corrects the data for the impactor and CPC lower-detection counting efficiencies. For the Model 3034 SMPS, all data corrections are implemented within the instrument's firmware. Upon a power failure, the software for the 3034 automatically restarts and resumes data acquisition and storage after power is restored.

**SMPS SPECTROMETERS**

| Model | Particle size range (µm) | Particle concentration (#/cm$^3$) | Measurement time (sec) | Resolution (total channels measured) | Channels per decade | Key feature | DMA | CPC | Condensing liquid |
|---|---|---|---|---|---|---|---|---|---|
| **3936L72** | 0.01 to 1.0 | 1 to $10^7$ | 30 to 600 (selectable) | Varies by model, 167 channels from 0.0025 to 1.0 µm, collectively | 4, 8, 16, 32, 64 (selectable) | Highest-resolution; individual components provide greatest flexibility | 3081 | 3772 | n-butyl alcohol |
| **3936L75** | | 2 to $10^8$ | | | | | | 3775 | |
| **3936N75** | 0.004 to 0.15 | | | | | | 3085 | | |
| **3936NL75** | 0.004 to 1.0 | | | | | | 3081 & 3085 | | |
| **3936L76** | 0.01 to 1.0 | 10 to $10^7$ | | | | | 3081 | 3776 | |
| **3936N76** | 0.0025 to 0.15 | | | | | | 3085 | | |
| **3936NL76** | 0.0025 to 1.0 | | | | | | 3081 & 3085 | | |
| **3936L82** | 0.01 to 1.0 | 1 to $10^7$ | | | | | 3081 | 3782 | water |
| **3936L85** | | 1 to $10^8$ | | | | | | 3785 | |
| **3936N85** | 0.005 to 0.15 | | | | | | 3085 | | |
| **3936NL85** | 0.005 to 1.0 | | | | | | 3081 & 3085 | | |
| **3936L86** | 0.01 to 1.0 | 2 to $10^7$ | | | | | 3081 | 3786 | |
| **3936N86** | 0.0025 to 0.15 | | | | | | 3085 | | |
| **3936NL86** | 0.0025 to 1.0 | | | | | | 3081 & 3085 | | |
| **3034** | 0.01 to 0.487 | 1 to 2.4×$10^6$ | 180 | 54 | 32 | Simple operation | Built in | Built in | n-butyl alcohol |

# Specifications

## Scanning Mobility Particle Sizer Spectrometers

*Refer to separate product sheets for descriptions and specifications of individual components for Series 3936 SMPS spectrometers.*

| | Series 3936 | Model 3034 |
|---|---|---|
| **Particle Size Range** | Varies by configuration; spans range from 2.5 to 1000 nm, collectively | 10 to 487 nm, fixed size range |
| **Max. Particle Size Resolution** | 64 channels/decade, very high resolution | 32 channels/decade, high resolution |
| **Total Channel Numbers** | 167 (varies by configuration; spans 167 channels from 2.5 to 1000 nm, collectively) | 54, fixed |
| **Aerosol Concentration** | 1 to $10^8$ particles/$cm^3$ (varies by configuration) | 1 to $2.4\times10^6$ particles/$cm^3$, fixed |
| **Scan Time** | 30 to 600 sec, user-selectable, fast continuous scanning | 180 sec, fixed, fast continuous scanning |
| **Measurement Time per Scan** | 20 to 300 sec, user-selectable | 165 sec, fixed |
| **Data Averaging (Scans per Sample)** | 1 to 999, user-selectable | 1 to 20, user-selectable |
| **Aerosol Flow Rate** | 0.2 to 2 L/min, user-adjustable | 1.0 L/min, fixed, no adjustment required |
| **Sheath Flow Rate** | 2 to 20 L/min, user-adjustable | 4.0 L/min, fixed, no adjustment required |
| **Working Fluid** | n-butyl alcohol (butanol) or water (depends on CPC) | n-butyl alcohol (butanol) |
| **Working Fluid Capacity** | 0.5 L | 1 L (>30 days continuous run time) |
| **Operating Temperature** | 10 to 35°C | 5 to 35°C |
| **Storage Temperature** | 0 to 40°C | 0 to 40°C |
| **Aerosol-inlet** | | |
| **Temperature** | 10 to 35°C | 5 to 35°C |
| **Humidity** | 0 to 90%, noncondensing | 0 to 95%, noncondensing |
| **Pressure** | 75 to 105 kPa (with Series 3770 CPCs); 70 to 110 kPa (with Series 3780 WCPCs) | 75 to 105 kPa (sea level to 2,132 m) |
| **Data Logging** | Via attached PC running Microsoft Windows, unattended run time, limited only by PC hard disk size | Same as Series 3936 |
| **File Size per Sample** | 5.7 kilobyte (using 120 sec upscan, 15 sec downscan time) | 1 kilobyte |
| **Radioactive Charger/Neutralizer** | 74 MBq (2 mCi), bipolar, Kr-85, long half-life of 10.8-year (Model 3077)* | 370 MBq (10 mCi), bipolar, Kr-85, long half-life of 10.8-year (Model 3077A)* |
| **Inlet accessory** | Single-stage, inertial impactors (Three impactors to choose, each with a different cut size) | Cyclone, 0.8 µm (50% cut size) |
| **Display** | 320×240 pixel monochrome LCD for Electrostatic Classifier | 320×240 pixel monochrome LCD |
| **Warm-up Time** | Approx. 10 min. at 20°C for CPC | Approx. 12 min. at 20°C |
| **Communications** | RS-232 and USB for data; RS-232, USB, and Ethernet for status | RS-232 for data and status |
| **Power Requirements** | *Series 3770 CPCs:* 100 to 240 VAC, 50/60 Hz<br>*Series 3780 WCPCs:* 100 to 230 VAC, 50/60 Hz<br>*3080L/N Electrostatic Classifier:* 200 W<br>*3772 CPC:* 210 W<br>*3032 Vacuum Pump for 3772 CPC:* 280 W<br>*3775/6 CPC:* 335 W<br>*Series 3780 WCPCs:* 125 W | 90 to 260 VAC, 50/60 Hz, 250 W |
| **Dimensions (HWD)** | *3080L:* 64×41×46 cm (25×16×18 in.)<br>*3080N:* 41×41×46 cm (16×16×18 in.)<br>*3772:* 26×18×25 cm (10×7×10 in.)<br>*3775/6:* 25×32×37 cm (10×13×15 in.)<br>*Series 3780:* 31×16×28 cm (12×6×11 in.) | 59×36×45 cm (23×14×18 in.) |
| **Weight** | *3080L:* 23.2 kg (51.2 lbs)<br>*3080N:* 20.1 kg (44.3 lbs)<br>*3772:* 5.5 kg (12.2 lbs)<br>*3775/6:* 9.9 kg (22 lbs)<br>*Series 3780:* 5.5 kg (12 lbs) | 28 kg (61lbs) |

## To Order

When selecting a Scanning Mobility Particle Sizer (SMPS) spectrometer, your main considerations should be particle size range, particle concentration, instrument scan time, and instrument type (component or single-box design).

### Ordering a Series 3936 SMPS Spectrometer

Series 3936 spectrometers include these main components:

3080N or 3080L
: Electrostatic Classifier (includes 3080 Controller Platform, 3081 or 3085 Differential Mobility Analyzer†, 3077 Aerosol Neutralizer‡, and 1035900 Inlet Impactor)

3772, 3775, 3776, 3782, 3785, or 3786
: Condensation Particle Counter

3032 (110 VAC), 3032-1 (220 VAC), or
3032-EC (230V, Europe only)
: Vacuum Pump (for spectrometers with 3772 CPC only)

390087 Interconnecting hardware and SMPS software (AIM3936)

The table on the previous page shows the various combinations of DMA and CPC, along with some general specifications. We offer 14 standard Series 3936 configurations, each identified on the matrix by a model number. For detailed specifications on major SMPS components, refer to separate product sheets on the components identified above.

### Ordering a Model 3034 SMPS Spectrometer

| *Specify* | *Description* |
|---|---|
| 3034 | SMPS spectrometer, single-box configuration (includes 3077A Aerosol Neutralizer‡ and 1031097 cyclone) with Aerosol Instrument Manager software (AIM3034) |

Computers must be purchased separately.

## Bibliography


Wang, S.C. and R.C. Flagan, Scanning Electrical Mobility Spectrometer, *Aerosol Sci. and Tech.* **13**:230-40 (1990). *TSI paper A80*

Wiedensohler, A., An Approximation of the Bipolar Charge Distribution for Particles in the Submicron Range, technical note, *J. Aerosol Sci.* **19**(3):387-9 (1988).


### Upgrade your older SMPS spectrometer!

Customers with Series 3934 SMPS spectrometers can upgrade to a Series 3936 spectrometer. Keep the CPC, pre-impactor, and Aerosol Neutralizer, then let us modify your old DMA for use on a Model 3080 platform! Purchase of the Series 3936 software upgrade is required. Call your TSI representative for additional requirements. It is not possible to upgrade to a Model 3034 SMPS spectrometer.

### Optional Accessories

| *Specify* | *Description* |
|---|---|
| 379020 | Rotating Disk Thermodiluter—Compliments TSI particle sizers and counters, especially when diluting or conditioning exhaust emissions from stacks or diesel and spark-ignition engines is required. |
| 390069 | Data Merge Software—Enables the merging and fitting of SMPS and APS™ data files to create and display a wide particle size range from 0.0025 to 20 µm. The software greatly simplifies the tedious task of merging data files, and allows users to fit a set of data to unimodal, bimodal, or trimodal distribution functions, based on user inputs. You may also select lognormal, Rosin-Rammler, or automatic fit-functions. Graphical and tabular data can be printed, copied to the clipboard, and saved. Merged data can also be exported in a variety of formats. |
| 3089 | Nanometer Aerosol Sampler—Allows sampling of charged particles, like those from a DMA, onto sample substrates for further analysis. |



Technology used in the Model 3034 SMPS spectrometer is protected by United States Patent Numbers 4,790,650 and 5,118,959. The design of the Model 3085 Nano DMA used in the Series 3936 SMPS spectrometers is covered under United States Patent Number 6,230,572. Series 3936 SMPS spectrometers were developed in cooperation with the California Institute of Technology and AEA Technology.

The Rotating Disk Thermodiluter and its accessories are produced in Switzerland by Matter Engineering AG. The Data Merge Software module was developed in cooperation with Chimera Technologies, Inc.

*TSI is authorized by the United States Nuclear Regulatory Commission to distribute these and other Aerosol Neutralizers. If your location is within the United States, no other federal license is required. Check local regulations for your own protection. End-user name and address are required. †DMAs are interchangeable. The Model 3080 classifier platform accommodates only one DMA at a time. ‡Model 3077 and 3077A Aerosol Neutralizers are shipped separately from other system components. To order an SMPS spectrometer without a neutralizer, contact your TSI representative.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