

# ULTRAFINE CONDENSATION PARTICLE COUNTER MODEL 3776

The Ultrafine Condensation Particle Counter (UCPC) Model 3776 is designed primarily for researchers interested in airborne particles smaller than 20 nm. With sensitivity to particles down to 2.5 nm, this UCPC is ideally suited for atmospheric and climate research, particle formation and growth studies, combustion and engine exhaust research, and nanotechnology research. It is compatible with TSI Scanning Mobility Particle Sizer™ (SMPS™) spectrometers.



## Applications

TSI offers the most comprehensive line of CPCs available. Building on a tradition of 30 years experience, TSI CPCs have become the standard to which all others are compared.

General applications include:

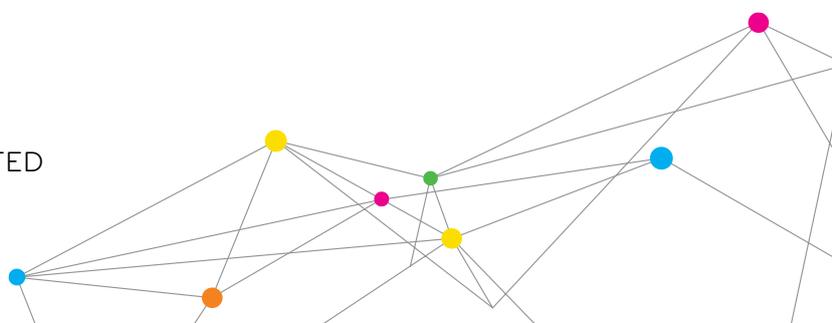
- + Basic aerosol research
- + Filter and air cleaner testing
- + Atmospheric and climate studies
- + Particle formation and growth studies
- + Combustion and engine exhaust studies
- + Inhalation or exposure chamber studies
- + Health effects studies

## Features and Benefits

- + Fast response to rapid changes in aerosol concentration
- + Extended single particle counting up to 300,000 particles/cm<sup>3</sup> with continuous, live-time coincidence correction
- + Butanol-friendly features, including anti-spill design, water-removal system, butanol odor absorber, and improved resistance to optics flooding
- + Removable saturator wick for easy transport and maintenance
- + Built-in data logging and storage capability with removable memory card
- + Built-in SMPS™ spectrometer compatibility
- + Auto recovery from power failure



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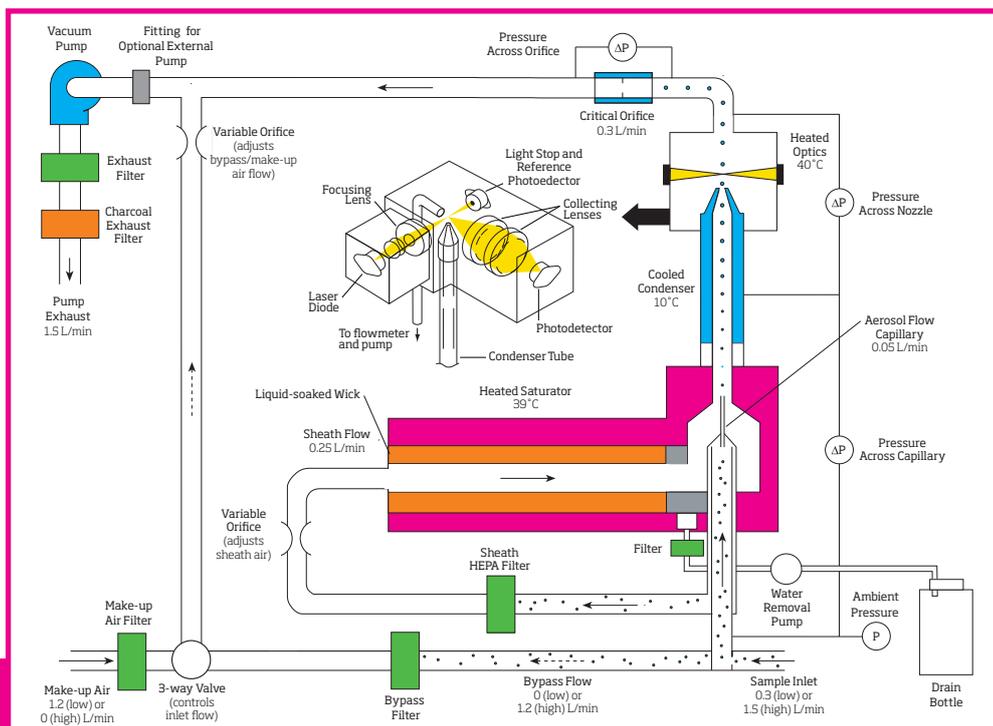
## Operation

In a laminar-flow, alcohol-based CPC, an aerosol sample is drawn continuously through a heated saturator in which alcohol is vaporized and diffuses into the sample stream. Together, the aerosol sample and alcohol vapor pass into a cooled condenser where the alcohol vapor becomes supersaturated and ready to condense. Particles present in the sample stream serve as condensation nuclei. Once condensation begins, particles that are larger than a threshold diameter grow quickly into larger droplets and pass through an optical detector where they are counted easily.

Using a unique sheath-air-flow design that confines the aerosol flow path near the centerline of the condenser, the Model 3776 detects particles as small as 2.5 nanometers in diameter. This design exposes particles to the region of highest supersaturation and uniformity of alcohol vapor. As a result, even the smallest particles can be activated and grown to large droplets for easy optical detection. This unique design greatly enhances measurement response time, produces a sharply defined lower-size-detection limit (counting efficiency curve), and minimizes diffusion losses of ultrafine and nanoparticles.

An internal pump draws the aerosol sample into the Model 3776. The inlet flow can be configured for either high-flow mode operation (1.5 L/min) to improve response time and minimize particle transport loss, or low-flow mode operation (0.3 L/min) to provide flexibility when used as part of an SMPS spectrometer. In high-flow mode, 1.2 L/min of the inlet flow is diverted as a bypass flow. In both high and low-flow modes, 0.3 L/min of the inlet flow passes through the saturator, condenser, and optics regions of the instrument. Just prior to the aerosol flow capillary, the 0.3 L/min sensor flow splits into a 0.25 L/min sheath flow and a 0.05 L/min aerosol flow. The sheath flow is cleaned by a HEPA filter and drawn through a heated, liquid-soaked, porous tube where it becomes saturated with alcohol vapor. The aerosol sample joins the filtered vapor-saturated sheath flow right before the inlet of the condenser. A short, heated section at this juncture allows vapor to diffuse into the aerosol before entering the cooled condenser. The volumetric flow rate of the 0.3 L/min sensor flow is controlled accurately using a critical orifice, which also allows the use of an external vacuum source without change in flow control.

Real-time graphs of particle concentration versus time, concentration, totalizer function, and operating parameters are all viewable on the front-panel color display. Data are directly accessible via standard serial and USB interfaces at a maximum time resolution of 0.1 second. Instrument reading and status can be monitored through Ethernet in real-time.



### Software and Built-in SMPS Compatibility

Every Model 3776 is supplied with Aerosol Instrument Manager® software designed for use with Microsoft® Windows® operating systems. The software is used for instrument control and provides data collection, management, and export capabilities, as well as several choices for data display.

The Model 3776 comes standard with built-in compatibility for use in TSI Series Scanning Mobility Particle Sizer (SMPS) 3936 spectrometers. Collectively, SMPS spectrometers configured with a UCPC Model 3776 provide size-distribution measurements from 0.0025 to 1.0 micrometer. Specific size ranges vary depending on the Differential Mobility Analyzer (DMA) used and DMA/CPC flow rate settings. Ask your TSI representative for additional information on SMPS spectrometers.

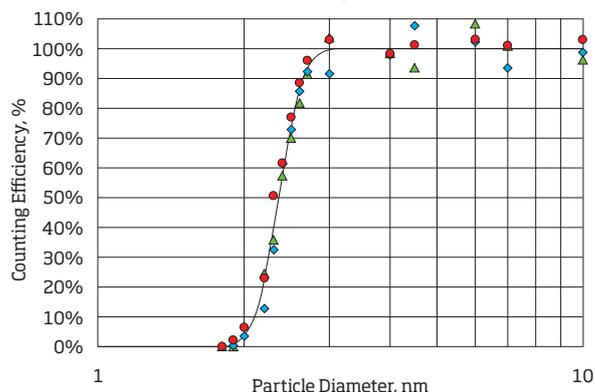
### Selectable Size Limits

The optional Particle Size Selector (PSS) Model 376060 lets you choose any of eleven cutoff sizes between 0.032 and 0.267 micrometer. The PSS uses a series of fine-mesh screens to remove small particles by diffusional capture. An additional set of diffusion screens (available separately) lets you select cutoff diameters up to 0.6 micrometer.

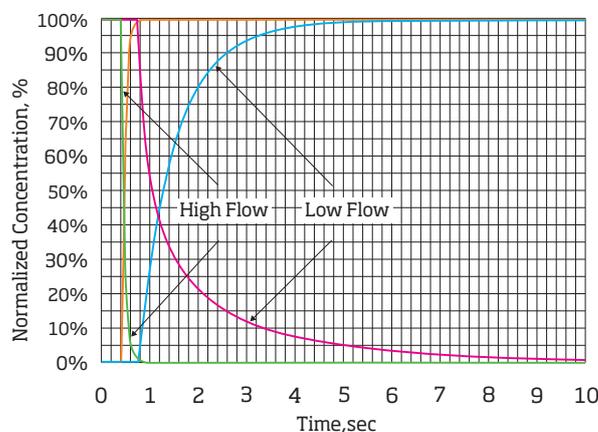
Diffusion Screens	Particle size cut, $\mu\text{m}$ (50%)*	
	Flow 0.3 L/min	Flow 1.5 L/min
0	0.003	0.003
1	0.032	0.014
2	0.056	0.024
3	0.079	0.033
5	0.123	0.050
6	0.147	0.058
7	0.170	0.066
8	0.192	0.074
9	0.216	0.081
10	0.240	0.089
11	0.267	0.096

\*Calculated using efficiencies for 3776 UCPC and diffusion screen

TSI Model 3776 Efficiency, Sucrose Particles



TSI Model 3776 Response Time



### TO ORDER

#### Condensation Particle Counter

Specify	Description
3776	Ultrafine Condensation Particle Counter with TSI Aerosol Instrument Manager software

### ACCESSORIES

Specify	Description
376060	Particle Size Selector with 11 screens
376061	Additional screens for Particle Sizer Selector, set of 12
1031558	Inlet Cyclone (calculated cut-points: 5.90 $\mu\text{m}$ @ 0.3 L/min; 1.53 $\mu\text{m}$ @ 1.5 L/min)
1031498	Maintenance Kit for 3776 UCPC (includes 1 reservoir cover, 3 O-rings, screws, ten 0.50" diameter plugs, ten 0.75" diameter plugs, 3 aerosol flow control orifices, 5 small charcoal filters, 2 micropump filters, 2 makeup air/butanol fill filters, 2 exhaust/bypass air filters, and 2 sheath air HEPA filters, and 2 saturator wicks)
1031495	Replacement Saturator Wick Kit for 3776 CPC (includes 2 saturator wicks)

Accessories must be ordered separately

# SPECIFICATIONS

## ULTRAFINE CONDENSATION PARTICLE COUNTER MODEL 3776

### Particle Size Range

Min. Detectable Particle ( $D_{50}$ ) 2.5 nm, verified with DMA-classified sucrose particles  
Max. Detectable Particle >3  $\mu\text{m}$

### Particle Concentration Range

Single Particle Counting 0 to  $3 \times 10^5$  particles/cm<sup>3</sup>, single particle counting with continuous, live-time coincidence correction; display concentrations up to  $10^6$  particles/cm<sup>3</sup>

### Particle Concentration Accuracy

$\pm 10\%$  at  $< 3 \times 10^5$  particles/cm<sup>3</sup>

### Response Time

High-flow Mode <0.8 sec to 95% in response to concentration step change  
Low-flow Mode <5 sec to 95% in response to concentration step change

### Flow

Aerosol Flow Rate 0.05  $\pm$  0.005 L/min  
Sensor Flow Rate 0.3  $\pm$  0.015 L/min (sheath + aerosol)  
High-flow Inlet 1.5  $\pm$  0.05 L/min  
Low-flow Inlet 0.3  $\pm$  0.015 L/min  
Flow Source Internal high-vacuum diaphragm pump with brushless DC motor (15,000-hr rated lifetime); vacuum source, but internal plumbing by monitored across capillary  
Flow Control Volumetric flow control of sensor flow critical orifice, aerosol flow is through differential pressure

### Operating Temperatures

Saturator 39  $\pm$  0.2°C  
Condenser 10  $\pm$  0.2°C  
Optics 40  $\pm$  0.2°C

### False Background Counts

<0.01 particle/cm<sup>3</sup>, based on 12-hr average

### Aerosol Medium

Recommended for use with air; safe for use with inert gases such as nitrogen, argon, and helium (performance specifications are for air)

### Environmental Operating Conditions

Ambient Temperature 10 to 35°C (50 to 95°F)  
Ambient Humidity 0 to 90% RH, noncondensing  
Ambient Pressure 75 to 105 kPa (0.75 to 1.05 atm)

### Condensing Liquid

Working Fluid Reagent-grade n-butyl alcohol (not included)  
Filling System Electronic liquid-level sensor initiates automatic filling as needed, requires connection to fill bottle (included with instrument)

### Water Removal

All condensate is collected and removed automatically by a constant-flow-rate micropump, may be switched on for use in humid environments

### Communications

Protocol Command set based on ASCII characters  
Interfaces RS-232 9-pin, D-sub connector  
USB Type B connector, USB 2.0 compatible at 12 Mb  
Ethernet 8-wire RJ-45 jack, 10/100 BASE-T, TCP/IP

### Data Logging and Storage

SD/MMC flash memory card

### Averaging Interval

1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, or 60 seconds (set from front panel), software provides more averaging options

### Analog Inputs

Two BNC connectors, 0 to 10 V (data recording for external sensors)

### Outputs

Digital Display Graph of concentration vs. time, concentration, time and total counts, status (temperatures, pressures, laser power, aerosol flow, etc.)  
Analog BNC connector, 0 to 10 V, user-selectable function output (linear/log concentration or DMA voltage control)  
Pulse BNC connector, TTL level pulse, nominally 400 nanosec wide

### Software

Supplied with TSI Aerosol Instrument Manager® software

### Calibration

Recommended annually

### Power Requirements

100 to 240 VAC, 50/60 Hz, 335 W maximum

### Physical Features

Front Panel LCD TFT QVGA (320×240 pixel) 5.7-in. color display, sample inlet, LED particle indicator light, rotate/select control knob, flash memory card slot  
Rear Panel Power connector, USB, Ethernet, two 9-pin D-sub serial connectors, two BNC inputs, BNC outputs, fan, butanol-fill butanol drain connector, pump-exhaust port, fill bottle  
two connector, makeup-air port, and bracket  
Side Panel Butanol-level viewing window

### Dimensions (H x W x D)

25 × 32 × 37 cm (10 × 13 × 15 in.), not including fill bottle and bracket

### Weight

9.9 kg (22 lbs)

Specifications are subject to change without notice.

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

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