

# PRODUCT

## INFORMATION

### Model 3022A Condensation Particle Counter

The Model 3022A is a general-purpose Condensation Particle Counter (CPC) that detects airborne particles greater than or equal to 7 nanometers in diameter. Its unique advantage is that it detects these small particles over a wide range of concentrations. Using both single-count and photometric detection modes, the Model 3022A provides highly accurate measurements, even in concentrations up to  $10^7$  particles per cubic centimeter. That's several orders of magnitude higher than other continuous-flow particle counters!

The Model 3022A offers many features that contribute to its overall versatility:

- A laser-diode light source and ruggedized optics ensure reliability, even in the field.
- An automatic fluid-filling system minimizes required maintenance, allowing you to monitor submicrometer particles continuously for weeks unattended.
- A selectable aerosol-inlet position provides great flexibility when determining experimental setups.
- A built-in microprocessor handles all data-processing tasks and monitors and controls temperatures, flow rates, and photodetector output for you.

**A continuous-flow, single-particle-counting CPC that works reliably in concentrations up to  $10^7$  particles/cm<sup>3</sup>**



- An RS-232 output port allows the CPC to interface directly with your computer.

The successor to TSI's widely used Model 3020,\* the Model 3022A benefits from over 20 years of development experience. Building upon this heritage, the Model 3022A provides added features that make it the standard against which all sensors of this type should be compared.

TSI is the world's leading manufacturer of high-performance CPCs. We offer additional models to accommodate specific needs. A comparison chart describing our complete line of CPCs appears on the back of this document. Contact your TSI representative for more information.

\*TSI Model 3020 is no longer available.



## APPLICATIONS

- Basic aerosol research
- Outdoor and indoor air-quality research
- Filter and air-cleaner testing
- Particle shedding and component tests
- Particle formation and growth studies
- Atmospheric and climate studies
- Particle counter calibration (when used as the reference standard)
- Combustion and engine-exhaust studies
- Inhalation or exposure-chamber studies

The Model 3022A is available in either a standard or a scanning configuration. The scanning version, Model 3022A-S, is required for use in TSI Scanning Mobility Particle Sizer (SMPS) systems. Collectively, SMPS systems configured with a 3022A-S provide size-distribution measurements from 0.007 to 1.0 micrometer. Specific size ranges vary depending on the Differential Mobility Analyzer used.

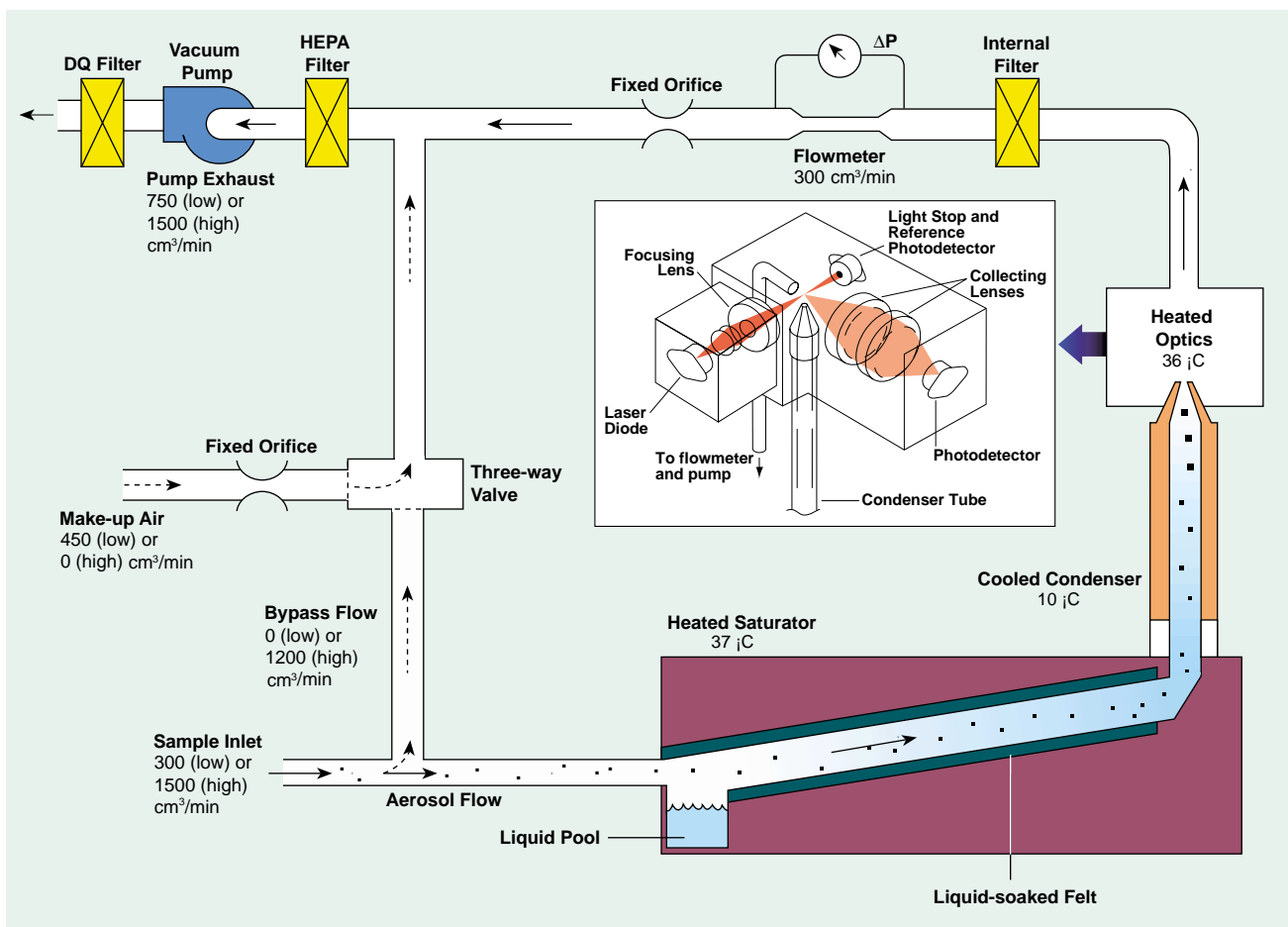
## OPERATION

CPCs take advantage of the principle that supersaturated vapor condenses on small particles.

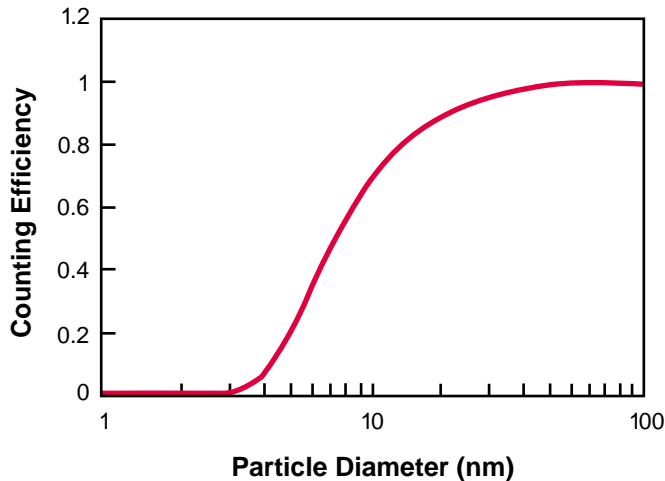
An internal pump draws the aerosol sample into the Model 3022A. The inlet can be configured for high-flow operation (1.5 liters per minute) to speed response time and minimize transport loss, or low-flow operation (0.3 liters per minute) to provide flexibility when used as part of an SMPS system. A linear-element flowmeter controls the flow volumetrically.

Upon entering the instrument, the sample passes through a heated saturator, where butanol evaporates into the air stream and saturates the flow. The aerosol sample then passes into a cooled condenser tube, where vapor supersaturates and condenses onto the airborne particles. This produces larger, easily detectable aerosol droplets. These droplets pass through an optical detector immediately after leaving the condenser.

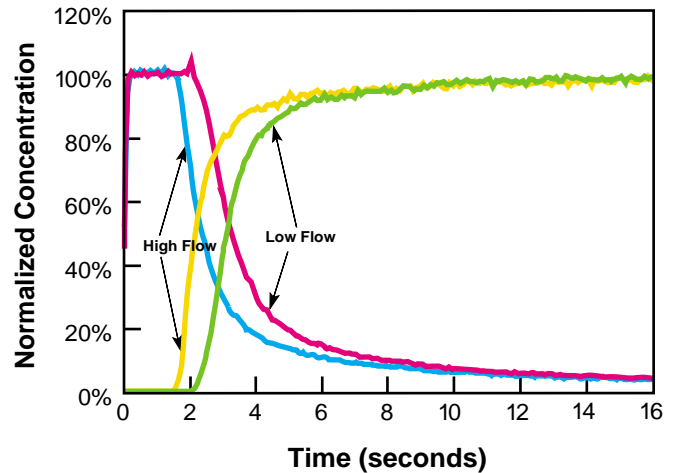
For concentrations below  $10^4$  particles per cubic centimeter, the detector counts individual pulses produced as each particle (droplet) passes through the sensing zone (single-count mode). Higher concentrations up to  $10^7$  particles per cubic centimeter are measured by detecting light scattered by all particles in the sensing zone at any one time and comparing the intensity of the scattered light with calibration levels (photometric mode).



Particle-detection efficiency, silver particles in nitrogen at 1500 cm<sup>3</sup>/min inlet flow, normalized data



Response-time for a concentration step-change at time = 0 (Quant et al. 1992)



## SPECIFICATIONS

### Particle size range

*Minimum detectable particle:* 50% of 7-nm particles

*Maximum detectable particle:* >3 μm

**Particle concentration range:** 0 to  $9.99 \times 10^6$  particles/cm<sup>3</sup>; counts single particles in concentrations from 0 to  $10^4$  particles/cm<sup>3</sup>, photometric calibration from  $10^4$  to  $10^7$  particles/cm<sup>3</sup>; provides running-average over 1, 2, 20, and 200 seconds depending on concentration range; display updated every second

**Concentration accuracy:** ±10% up to  $5 \times 10^5$  particles/cm<sup>3</sup>, ±20% from  $5 \times 10^5$  to  $10^7$  particles/cm<sup>3</sup>; coincidence less than 2% at  $10^4$  particles/cm<sup>3</sup>; live-time particle counting from  $10^3$  to  $10^4$  particles/cm<sup>3</sup> provides automatic correction for coincidence

**False background counts:** <0.01 particle/cm<sup>3</sup>

**Response time:** <13 sec for 95% response to concentration step change when sampling in high-flow mode; <20 sec for low-flow mode

**Aerosol medium:** Recommended for use with air; safe for use with inert gases such as nitrogen, argon, and helium (Performance specifications are for air.)

**Signal-to-noise ratio:** 25:1 nominal

**Light source:** Stable, 5-mW, 780-nm laser diode

### Flow

*Aerosol flow rate:*  $300 \pm 15$  cm<sup>3</sup>/min

*High-flow inlet:*  $1500 \pm 150$  cm<sup>3</sup>/min

*Low-flow inlet:*  $300 \pm 15$  cm<sup>3</sup>/min

*Flow control:* Automatic volumetric flow control calibrated using pressure drop across capillary to control an internal carbon-vane pump

### 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 (provided with instrument)

### Operating temperatures

*Saturator:*  $35 \pm 0.3$  °C

*Condenser:*  $10 \pm 0.3$  °C

*Optics:*  $36 \pm 2.0$  °C

### Communications

*Protocol:* Command set based on ASCII characters

*Interface:* RS-232, 9-pin, "D" subminiature connector, pinouts compatible with standard IBM-style serial cables and interfaces

### Outputs

*Digital display:* Concentration, total counts, status (temperatures, aerosol flow, photodetector voltage)

*Analog:* BNC connection, 0 to 10 volts, user-selectable function output (linearized concentration, log concentration, aerosol flow, pump control, photodetector voltage) (For use in TSI SMPS systems, a Host mode allows output to 11 volts.)

*Pulse:* BNC connection, 13V square pulse, typically 3.3 μsec wide

**Software:** Supplied with CPCCount™ Software

**Calibration:** Recommended annually; calibrated with 50-nm monodisperse NaCl using primary differential mobility analyzer method

**Power requirements:** 100/120/230/240 VAC, 50/60 Hz, 200 W maximum

### Physical features

*Front panel:* 12-digit LED-pixel display, aerosol sample inlet, indicator lights (particle, laser, flow, temperature, liquid status), operating buttons

*Rear panel:* Power connector, fuse, 9-pin serial connector, three BNC connectors, fan, liquid-fill and drain connectors, makeup-air port, pump-exhaust port, fill bottle with bracket

**Dimensions (LWH):** 24 cm × 38 cm × 20 cm (9.5 in. × 15 in. × 8 in.), not including fill bottle and bracket

**Weight:** 12.5 kg (27 lb)

### Environmental operating conditions

*Ambient temperature range:* 10 to 35 °C

*Ambient humidity range:* 0 to 90% RH, noncondensing

Specifications are subject to change without notice.

## TO ORDER

Specify	Description
3022A	Condensation Particle Counter with CPCCount™ Software
3022A-S	Condensation Particle Counter with Fast-scanning EPROM and CPCCount™ Software
EP3022-S	Fast-scanning EPROM only (for upgrading Model 3022)
EP3022A-S	Fast-scanning EPROM only (for upgrading Model 3022A)

The Model 3022A-S is a standard component in selected Scanning Mobility Particle Sizer (SMPS) systems. Ask your TSI representative for additional information on SMPS systems.

## Accessories

Specify	Description
376060	Particle Size Selector
376061	Additional screens for Particle Size Selector (set of 12)

Accessories must be ordered separately. TSI, the TSI logo, and CPCCount are trademarks of TSI Incorporated. IBM is a trademark of IBM Corporation.

## COMPARISON CHART

TSI CONDENSATION PARTICLE COUNTERS	3010	3022A	3025A	3760A	3762
Minimum particle size (50% efficiency, nm)	10	7	3	11	11
Aerosol flow rate (cm <sup>3</sup> /min)	1000	300	30	1500	3000
Upper concentration limit (particles/cm <sup>3</sup> )	10 <sup>4</sup>	10 <sup>7</sup>	10 <sup>5</sup>	10 <sup>4</sup>	5 × 10 <sup>8</sup>
Lower concentration sensitivity (particles/cm <sup>3</sup> )	0	0	0	0	0
False background counts (particles/cm <sup>3</sup> )	<0.00001	<0.01	<0.01	<0.00005	<0.00005
Response time (sec for 95% response)	<5	<13	1	<3	<1.5
Vacuum source	External	Internal pump	Internal pump	External	External
SMPS compatibility	Yes	Yes	Yes	No	No



TSI offers the most complete set of scientific CPCs available anywhere. (Model 3762 is not pictured. It has the same appearance and dimensions as Model 3760A.) The comparison chart, above, lists the major differences between our CPCs. Contact your TSI representative for more information.

## BIBLIOGRAPHY

Agarwal JK and GJ Sem, Continuous Flow, Single-Particle-Counting Condensation Nucleus Counter, *J. Aerosol Sci.*, 11(4):343-57 (1980). (TSI paper A23)

Agarwal JK, GJ Sem, and M Pourprix, A Continuous Flow CNC Capable of Counting Single Particles, Atmospheric Aerosols and Nuclei, ed. AF Roddy and TC O'Connor, (*Proceedings of the 9th International Conference on Atmospheric Aerosols, Condensation, and Ice Nuclei*; Galway, Ireland; September 21-27, 1977) Galway University Press: 118-122 (1981). (TSI paper A2)

Liu BYH and DYH Pui, A Submicron Aerosol Standard and the Primary, Absolute Calibration of the Condensation Nuclei Counter, *J. Colloid Interface Sci.* 47:155 (1974). (TSI paper A81)

Quant FR, R Caldow, GJ Sem, and TJ Addison, Performance of Condensation Particle Counters with Three Continuous-Flow Designs, *J. Aerosol Sci.* 23:S405-S408 (1992). (TSI paper A79)

For the most current information available on this instrument, go to [www.tsi.com](http://www.tsi.com) and select "Particle Instruments."



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