

CONDENSATION PARTICLE COUNTER MODEL 3772-CEN

FOR THE MONITORING OF ULTRAFINE
PARTICLES IN ATMOSPHERIC AEROSOL

- COMPLIANT TO CEN/TS 16976
- RELIABLE AND PROVEN 24/7 OPERATION



The Model 3772-CEN Condensation Particle Counter (CPC) is fully compliant to the new CEN* Technical Specification CEN/TS 16976:2016. This Technical Specification defines the performance characteristics of instruments to be used in a standard method for determining the particle number concentration in atmospheric aerosol. This CPC counts airborne ultrafine particles (UFP) from 7 nm in diameter at an aerosol flow rate of 1.0 L/min. It employs single particle counting to measure concentrations up to 50,000 particles/cm³. The 3772-CEN is easy to setup and operate, and data are automatically output to the CEN data string. The 3772-CEN is designed for 24/7 operation in monitoring stations to provide reliable and quantitative data on ambient ultrafine particle concentration.

Application

- + Ultrafine particles with diameters $d < 0.1 \mu\text{m}$ contribute insignificantly to the mass of atmospheric particles yet are emitted in high numbers from combustion and other processes. In order to assess the impact to human health it appears necessary to supplement gravimetric air quality measurements - PM_{2.5} or PM₁₀ - with a time resolved measurement of particle number concentration.
- + The 3772-CEN CPC is built on the experience from using the Model 3772 CPC but improved for this application of ambient monitoring.
- + The 3772-CEN CPC is verified and calibrated by the World Calibration Centre for Aerosol Physics, Leibniz Institute for Tropospheric Research (TROPOS).
- + A CEN/TS 16976 compliant sampling system that ensures representative sampling of the aerosol regardless of wind speed, wind direction, or humidity is offered as an accessory.

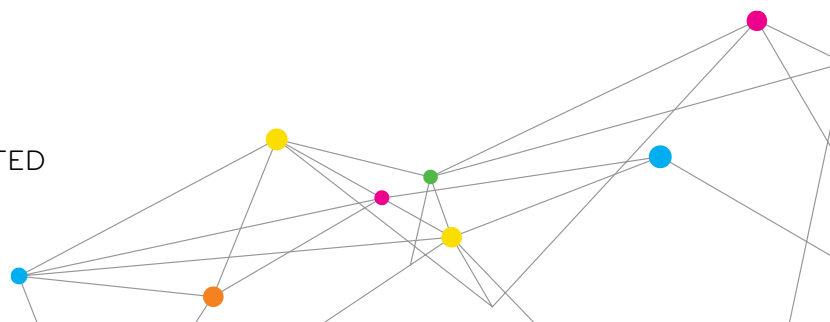
Features and Benefits

- + CEN/TS 16976:2016 compliance
- + UFP counting from 7 nm
- + Pulse height monitor to ensure data accuracy
- + Single particle counting up to 50,000 particles/cm³
- + Advanced instrument diagnostics
- + 1 second sampling, 1 minute reporting interval
- + Easy to operate and install
- + 24/7 operation
- + Unattended monitoring, low maintenance
- + Auto recovery from power failure
- + CEN data record

* CEN stands for European Committee for Standardization. CEN is an association - officially recognized by the European Union and by the European Free Trade Association - that brings together the National Standardization Bodies of 33 European countries. CEN is committed to develop European Standards for various kinds of products, materials, services and processes.



UNDERSTANDING, ACCELERATED



PRINCIPLE OF OPERATION

The 3772-CEN is a laminar-flow, alcohol-based condensation particle counter (CPC). Aerosol particles which are too small to scatter enough light to be detected by a conventional optical method are grown to larger size droplets by condensing alcohol on them. While these droplets can then be detected optically through light scattering the size information is lost.

In this instrument, an air sample is continuously drawn through the inlet via an external pump where the volumetric flow rate is controlled accurately and reliably using an internal critical orifice.

While passing through the instrument the aerosol particles are counted in a 3-step process:

Saturation

The aerosol sample is drawn continuously through a heated saturator. In this saturator, alcohol from a liquid reservoir soaks a wick. Due to the high temperature the alcohol in the wick is vaporized and diffuses into the sample stream.

Condensation

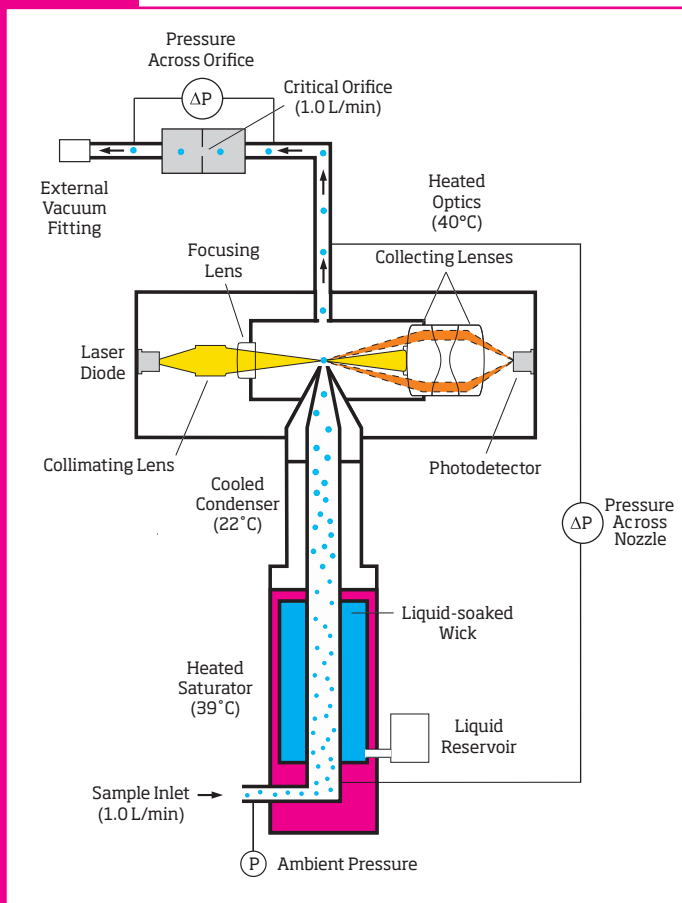
The aerosol sample and alcohol vapor pass into a cooled condenser where the alcohol vapor becomes super saturated and ready to condense. Particles present in the sample stream serve as condensation nuclei. Once condensation begins, particles that are larger than the activation diameter grow quickly into larger, micron sized droplets.

Optical Detection

The droplets pass through a laser beam. As each droplet passes through the sensing zone it scatters the light which is detected by a photo detector as individual pulse and counted. In this technique particle concentration is measured by counting every single particle in a known volume of air stream.

The height of the pulses correlate to the size of the grown droplets. In normal operation the particles grow to about the same droplet size, and as a result the pulse height is almost the same for all droplets. Under certain conditions (e.g. not enough alcohol in the wick that is vaporized) particles do not grow to this droplet size and as a result the pulse height is decreased. The pulse height analyzer in the model 3772-CEN CPC sets an error flag when pulse height decreases enough to indicate a problem with the measurement.

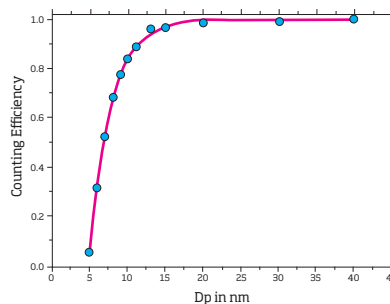
A high signal-to-noise ratio and continuous, live-time coincidence correction provide great measurement accuracy, from very low to very high concentrations.



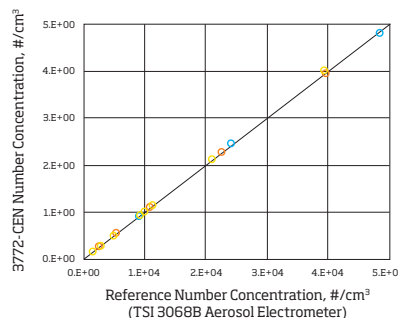
ENGINEERING INNOVATION: TAKING PARTICLE COUNTER DESIGN TO THE NEXT LEVEL

As a result of many years of experience with the Model 3772 being used in ambient monitoring, feedback from expert researchers, and rigorous testing, the new Model 3772-CEN CPC offers proven features and noticeable improvements:

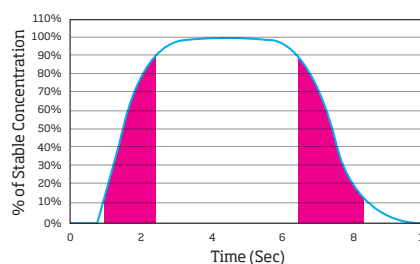
Enhancement	Design Feature
Concentration Accuracy	Pulse height analyzer to monitor wick health, supersaturation state, and instrument status
	Low concentration: full flow measurement with improved statistics
	High concentration: optimized coincidence and dead time correction
	Inlet nozzle optimization for improved counting efficiency
Flow Rate Stability	Critical orifice air flow scheme (no need for flow control orifice)
Reliable Operation	Inlet pressure monitor to prevent flooding
	Data logging to CEN data record
	Data backup on SD/MMC flash memory card
	Easy to integrate into centralized data acquisition systems
	Automated Butanol filling
Precision Measurements	Enhanced zero count stability
	Real time clock
On-board Instrument Diagnostics	Nozzle pressure transducer to monitor nozzle health
	Laser health monitor
	Extended instrument status information



Counting efficiency for silver particles that are generated with the evaporation/condensation method.



Linearity: Data points show data for 4 units, black line shows $y=x$



Response time: Shown are $t_{rise} < 2\text{ s}$ and $t_{fall} < 2\text{ s}$ for the 3772-CEN CPC

References

- + CEN/TS 16976:2016 Ambient air - Determination of the particle number concentration of atmospheric aerosol
- + Jaakko Yli-Ojanperä, Hiromu Sakurai, Kenjiro Iida, Jyrki M. Mäkelä, Kensei Ehara & Jorma Keskinen (2012). Comparison of Three Particle Number Concentration Calibration Standards Through Calibration of a Single CPC in a Wide Particle Size Range, Aerosol Science and Technology, 46:11, 1163-1173, DOI: 10.1080/02786826.2012.701023
- + Hermann, M., Wehner, B., Bischof, O.F., Han, H.-S., Krinke, T.J., Liu, W., Zerrath, A.F. and A. Wiedensohler 2007. Particle counting efficiencies of new TSI condensation particle counters. Journal of Aerosol Science 38, 674-682, doi:10.1016/j.jaerosci.2007.05.001
- + Caldwell, R.C., M.R. Palmer, and F.R. Quant "Performance of the TSI Model 3010 Condensation Particle Counter," paper presented at the American Association for Aerosol Research Conference, San Francisco, California, October 1992. (TSI paper A83)



SPECIFICATIONS

CONDENSATION PARTICLE COUNTER MODEL 3772-CEN

Particle Size Range	
Min. Detectable Particle (D50)	7 nm ± 0.7 nm, calibrated with sintered Silver particles
Max. Detectable Particle	> 3 µm
Particle Concentration Range	
0 to 50,000 particles/cm ³ , single particle counting with continuous, live-time coincidence correction	
Concentration Response	
Slope	1 ± 0.05
Linearity	All residuals < 4% of the measured value
Detection efficiency	
> 95% within the particle size range	
Response Time	
< 2 seconds to 90% in response to concentration step change	
Flow	
Aerosol Inlet Flow Rate	1.0 ± 0.05 L/min
Flow Source	External vacuum
Flow Control	Volumetric flow control of aerosol flow by internal critical orifice; differential pressure across nozzle and critical orifice is monitored ensuring ≤ 2% variation of flow to factory-certified flow rate
Zero Count Rate	
< 1 count per minute based on 12-hr average (equal to false background counts < 0.001 particle/cm ³)	
Aerosol Medium	
Intended 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) Average rate of consumption: less than 1 liter in two weeks
Filling System	Electronic liquid-level sensor initiates automatic filling as needed, requires connection to fill bottle (included with instrument)
Communications	
Protocol	Command set based on ASCII characters, measurement data can be output to CEN data string
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), 60 seconds is standard setting	
Analog Inputs	
Two BNC connectors, 0 to 10 V (data recording for external sensors)	

Specifications are subject to change without notice. Design specifications for the Model 3010, the predecessor of the Model 3772 and Model 3772-CEN, are covered in U.S. patent number 4,790,650.

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Outputs	
Digital Display	Concentration, time and total counts, status (temperatures, pressures, laser power, etc.) and user settings
Analog	BNC connector, 0 to 10 V, user-selectable function output (linear/log concentration or DMA voltage control)
Digital	Data download using USB, Ethernet or RS-232 serial interfaces
Pulse	BNC connector, TTL level pulse, nominally 350 nanoseconds wide
Software	
No software included as this model is intended for use with data acquisition systems. Parameters are set through instrument's user interface or with serial commands. SMPS instrument manager support offered at a future date.	
Calibration	
Recommended annually	
Required Utilities	
Power	100 to 240 VAC, 50/60 Hz, 200 W maximum
Vacuum	60 kPa (18 in Hg) minimum gauge
Physical Features	
Front Panel	Aerosol sample inlet (1/4" or 6mm ID tubing), LED indicator lights (status, particle), 2-line LCD display, 6 operating buttons, flash memory card slot
Rear Panel	Power connector, USB, Ethernet, two 9-pin D-sub serial connectors, two BNC inputs, two BNC outputs, fan, butanol-fill connector, butanol-drain connector, external vacuum port (1/4"), fill bottle and bracket
Dimensions (H x W x D)	
26 x 18 x 25 cm (10 x 7 x 10 in), not including fill bottle and bracket	
Weight	
5.5 kg (12 lbs)	

TO ORDER

3772-CEN Condensation Particle Counter

Specify	Description
3772-CEN	Condensation Particle Counter compliant to CEN/TS 16976 for UFP ambient monitoring with calibration by the World Calibration Centre for Aerosol Physics (TROPOS)

Optional Accessories

Specify	Description
3032-EC	Vacuum Pump, 230 V (Europe only)
3032-1	Vacuum Pump, 230 V/50 Hz
3032	Vacuum Pump, 115 V
1031515	Maintenance Kit for 3772 and 3771 CPCs (includes 2 micropump filters, 3 butanol fill/drain filters, and 2 saturator wicks)
1031514	Replacement Saturator Wick Kit for 3772 and 3771 CPCs (includes 2 saturator wicks)

Environmental Enclosure Please contact for details
Accessories must be ordered separately