



**World's fastest CPC – counting down to 2.5 nanometers**

### Features and Benefits

- 2.5 nanometer detection
- Single particle counting to 400,000 particles/cm<sup>3</sup>
- < 100 millisecond rise time response
- Sheath flow with high aerosol flow rate for enhanced counting statistics
- Convenient, VOC-free water as working fluid
- 1/10<sup>th</sup> second data reporting
- Built-in SMPS™ spectrometer compatibility
- USB flash drive data storage option
- Built in Ethernet capability
- 6" color touch screen with graphical interface

### Nano Water-Based Condensation Particle Counter N-WCPC

#### Model 3788

TSI's N-WCPC Model 3788 is designed for investigators interested in detecting the smallest nanoparticles. This sophisticated particle counter utilizes state-of-the-art water based condensation technology and features the highest activation energy and lowest detectable particle size of the WCPC family. With less than 0.1 second rise time, the Model 3788 is the fastest CPC commercially available and its high sample flow rate provides low diffusion losses and low Poisson noise. The unique combination of fast response time and high sample flow in this instrument enables fast SMPS™ spectrometer size scans. Other important elements include a thermodynamically optimized growth region and enhanced optical and detection design for impressive signal to noise ratios.

#### Applications

TSI's N-WCPC is suitable for most particle counting applications, but its ability to detect down to 2.5 nanometers, make this WCPC ideally suited for:

- Particle formation and growth studies
- Nanotechnology research or process monitoring
- Inhalation or exposure chamber studies
- Combustion and engine exhaust studies





## Second Generation WCPC Technology

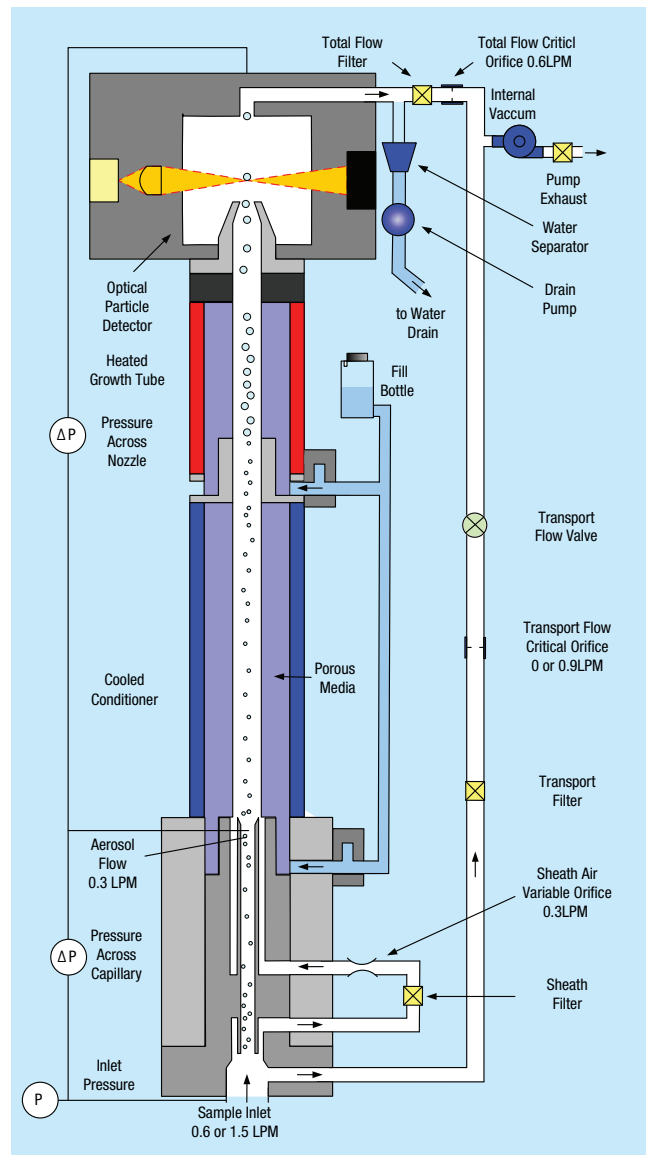
Building from the successful introductory line of WCPCs, the Model 3788 takes WCPC design to the next level combining precision measurements with robust field performance. This instrument delivers a research quality measurement, but it's modern, intuitive user interface and flexible data acquisition options make the N-WCPC suitable for a variety of industrial applications as well. Newly engineered from the ground up, the Model 3788 features an air flow scheme utilizing protected critical orifices, a new water handling system with optimized wicking and active water removal, and improved optical and detection design for superior signal detection. A host of on-board instrument diagnostics including a laser reference detector, nozzle pressure transducer and inlet pressure transducer allow remote, real time monitoring of instrument status. Other unique features include a removable wick cartridge for easy wick replacement and a field swappable optics module. Manufactured at TSI's ISO 9001 certified facility and calibrated using NIST traceable analytical tools, each Model 3788 that leaves the factory is built for longevity, backed by TSI's commitment to quality, and supported by our worldwide network of committed TSI professionals.

## Operation

The N-WCPC utilizes a patented\* laminar-flow, water-based condensational growth technique, which results in less particle loss and more precise temperature control when compared to mixing CPCs. Particles that are too small to scatter enough light to be detected by conventional optics are grown to a larger size by condensation. In this instrument, an air sample is continuously drawn through the inlet via an internal pump. The aerosol sample flow rate is continuously measured to provide the basis for the concentration calculations. A portion of the flow is used as clean sheath air to surround the aerosol sample. The use of sheath air focuses the particle stream to allow detection of smaller particles and protects the optics from contamination. The aerosol sample is pulled through a cool region saturated with water vapor where its temperature is equilibrated. The sample then passes to a growth section with heated, wetted walls where the small cool particles in the flow stream act as nuclei for condensation and grow into micron sized droplets. The droplets are passed by a laser and the particle pulses are detected and counted. The N-WCPC counts single particles with continuous, live-time coincidence correction up to 400,000 particles/cm<sup>3</sup>.

## Uniform Particle Growth

The geometry of the growth tube in the N-WCPC was optimized to kinetically limit droplet growth with the intent of preventing particles from growing to different sizes as a function of concentration. This, in addition to changes to the optical design and electronics signal detection components which significantly improve signal to noise ratios enable the N-WCPC to measure accurately at high concentrations without using a photometric mode.



\*US Patent Number 6,712,881

## CPC Software and SMPS™ Spectrometer Capability

The N-WCPC is supplied with Aerosol Instrument Manager® Software for CPCs. This Microsoft® Windows® 7 64 bit compatible software controls instrument operation and provides file management capabilities. Live data graphs and data tables can be viewed from the PC. The data can be weighted by any moment of the number concentration including surface area and mass, and the software automatically calculates statistics on every data set. The Nano-WCPC is compatibility for use in TSI SMPS™ spectrometers, which collectively, are capable of providing size distributions from 0.0025 to 1 µm.

## Pulse Height Analyzer

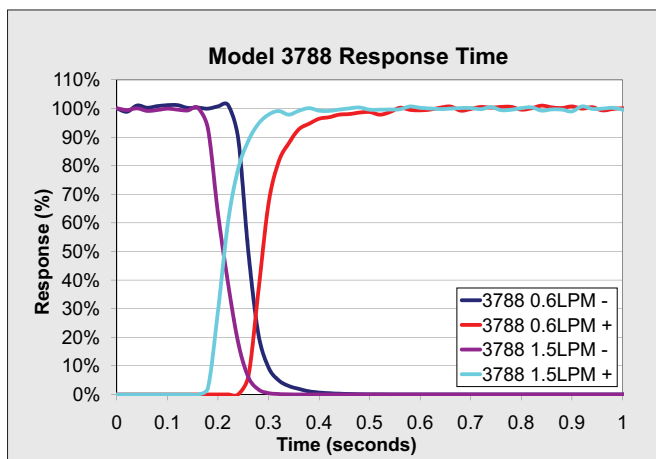
The Nano WCPC Model 3788 utilizes a pulse height analyzer to monitor instrument health and supersaturation state as a safeguard for measurement accuracy. In well functioning condensation particle counters the particles all grow to a similar size and the analog pulses all have a similar height. The Model 3788 monitors and displays the amplitude of the analog pulse height on the status screen of the instrument. A warning will trigger if the pulse height amplitude falls below a threshold value.

## Nano-WCPC Response Time

The response of the N-WCPC to a step change in concentration was measured and is plotted below. The ~250 millisecond time to a 95% response in concentration in high flow rate mode includes a flow rate based pipe delay. Under normal operation with constant flow, the traditional rise time (10-90%) is < 100 milliseconds. The time constant ( $\tau$ ) of the Model 3788 is ~43 milliseconds.

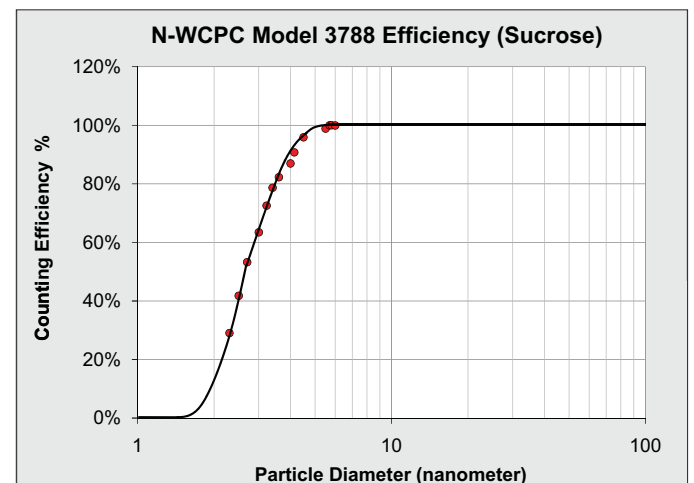
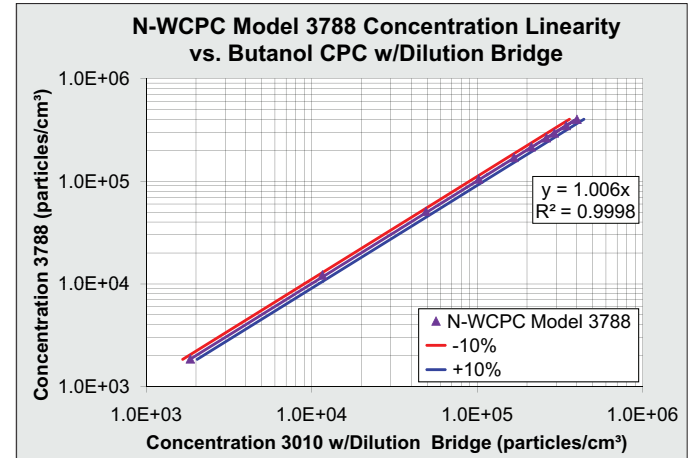
## Extended Single Particle Counting

The Model 3788 employs optimized optics design, more controlled particle growth and advanced electronics processing to extend the single particle counting range of condensation particle counters. Single particle counting gives greater data consistency and is in principle, a more fundamental measurement than other techniques used to increase concentration ranges in CPCs.



## Efficiency and Concentration Linearity

The minimum detectable particle size efficiency curve was measured using sucrose aerosol generated by a Model 3480 Electro Spray and size classified using the Model 3080 Electrostatic Classifier. Concentration comparisons were made on the N-WCPC versus both a butanol CPC with a dilution bridge and an electrometer using classified salt aerosol showing excellent agreement.



## Partial Bibliography

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- Hering, S.V., et al. 2004, "Continuous, laminar flow water-based particle condensation device and method," US Patent # 6,712,881, March 30, 2004.

## Specifications

Nano Water-based Condensation Particle Counter  
(N-WCPC)

## Model 3788

## Particle Size Range

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

## Particle Concentration Range

Single Particle Counting 0 to 400,000 particles/cm<sup>3</sup>, with continuous  
 live-time coincidence correction

## Particle Concentration Accuracy

$\pm 10\%$  to 400,000 particles/cm<sup>3</sup>

## Flow

High Flow Rate 1.5  $\pm$  0.15 L/min  
 Low Inlet Flow Rate 0.6  $\pm$  0.06 L/min  
 Aerosol Flow Rate 0.3  $\pm$  0.03 L/min  
 Sheath Flow Rate 0.3  $\pm$  0.03 L/min

## Response Time (95% response to concentration step change)

High Flow (1.5 LPM) ~ 250 milliseconds  
 Low Flow (0.6 LPM) ~ 400 milliseconds  
 Rise Time (10 - 90%) < 100 milliseconds  
 Time Constant ( $\tau$ ) ~ 43 milliseconds

## False Background Counts

< 0.02 particles/cm<sup>3</sup>, 12-hour average Dew point < 30°C (i.e. < 35°C @ 75% RH)

## Aerosol Medium

Air only

## Environmental Operating Conditions

Ambient Temperature Range 10 to 35° C (50 to 95° F)  
 Dew point < 30° C (i.e. < 35° C @ 75% RH)  
 Ambient Humidity Range 0 to 90% RH, non condensing

## Inlet Pressure Operation (Absolute)

75 to 110 kPa (0.75 to 1.1 atm)

## Inlet Pressure (Gauge)

0 to -5 kPa (-20" H<sub>2</sub>O)

## Condensing Liquid

Water (distilled (<6 ppm) or HPLC water; tap water must not be used)

## Water System

External 1 L bottle used in recycle mode for up to 30 days of (continuous)  
 operation.

## Water Consumption

<33 ml/day

## Vacuum

Internal vacuum pump



## Outputs

## Interfaces

## Digital Display

## Analog Output

## Digital Output

## Protocol

RS-232, USB, Ethernet, or USB Flash Drive  
 6" color touch screen interface  
 BNC connector, 0 to 10V proportional to  
 concentration (log scaling)  
 Data download using USB or RS-232 serial  
 interface  
 Command set based on ASCII characters

## Power Requirements

100 to 240 VAC, 50/60 Hz, 200 W maximum

## Physical Features

## Dimensions (HWD)

30.5 x 16 x 36 cm (12 x 6.25 x 14.25 in.)  
 not including water supply bracket  
 8.2 kg (18 lbs)

## Weight

## Software

TSI Aerosol Instrument Manager® software for CPC included. TSI SMPS™  
 spectrometer software compatible

## Calibration

Recommended annually

*Specifications reflect typical performance and 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. TSI, the TSI logo, Scanning Mobility Particle Sizer, SMPS and Aerosol Instrument Manager are trademarks of TSI Incorporated.*

## To Order

## Nano Water-based Condensation Particle Counter

## Specify

## Description

3788

Nano Water-based Condensation Particle Counter with TSI  
 Aerosol Instrument Manager® Software for CPC

## Optional Accessories

## Specify

## Description

3031200

Environmental Sampling System (includes a standard PM10  
 inlet, a PM1 cyclone, a flow splitter and a Nafion dryer)

1188001

Model 3788 maintenance kit

376060

Particle Size Selector with 11 screens: adjusts 3788 lower  
 end efficiency cut-point between ~0.01 and ~0.2  $\mu\text{m}$

376061

Additional screens for Particle Size Selector, set of 12  
 adjusts Model 3788 cut-point up to ~0.45  $\mu\text{m}$

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