ADVANCED AEROSOL NEUTRALIZER MODEL 3088

NEUTRALIZE AEROSOLS EFFECTIVELY WITHOUT A RADIOACTIVE SOURCE

The TSI Advanced Aerosol Neutralizer Model 3088 offers an alternative to traditional radioactive neutralizers frequently required for aerosol measurement applications. Due to increasingly stringent local, state and national regulations, obtaining licensing to acquire and use radioactive sources is often difficult and in some cases prohibited. Fully compliant with US FDA, CDRH* standards, the patented** Model 3088 provides an attractive alternative, with sizing performance virtually identical to TSI's Aerosol Neutralizer Model 3077A.

Applications

This new aerosol neutralizer was specifically designed to interface with TSI's new Electrostatic Classifier Model 3082. Like its predecessor Model 3087, it can be applied where radioactive neutralizers have been traditionally used. Since the Model 3088 can be easily turned on and off, there are no transportation restrictions, making it a good choice for mobile studies, field studies, and other applications where the aerosol neutralizer will need to be moved from place to place.

+ Submicron Aerosol Sizing
+ Mobile and Field Studies
+ Aerosol Charging Investigations
+ Monodisperse Aerosol Generation

Features and Benefits

+ Nonradioactive alternative to ^{85}Kr, ^{210}Po, and ^{241}Am aerosol neutralizers
+ Virtually identical sizing to radioactive neutralizers: geometric mean diameters and geometric standard deviations within 5%
+ No transportation restrictions simplifies buying, using, and handling aerosol neutralizers
+ No particle generation
+ Compatible*** with TSI's SMPS™ spectrometers Models 3938, 3936 and 3034 and TSI's Electrostatic Classifiers Models 3082 and 3080
+ Electronic device-easily turned on and off with 7-s response time
+ Bipolar diffusion charger with balanced levels of positive and negative ions
+ Neutralizes particle concentrations up to 10^7 particles/cm^3

* US FDA, CDRH - United States Food and Drug Administration, Center for Devices and Radiological Health.
** Kaufman, "Aerosol Charge Conditioner," US Patent 7,796,727. 14 September 2010.
*** Built-in operation in Models 3082 and 3938; all other systems: external, stand-alone operation.

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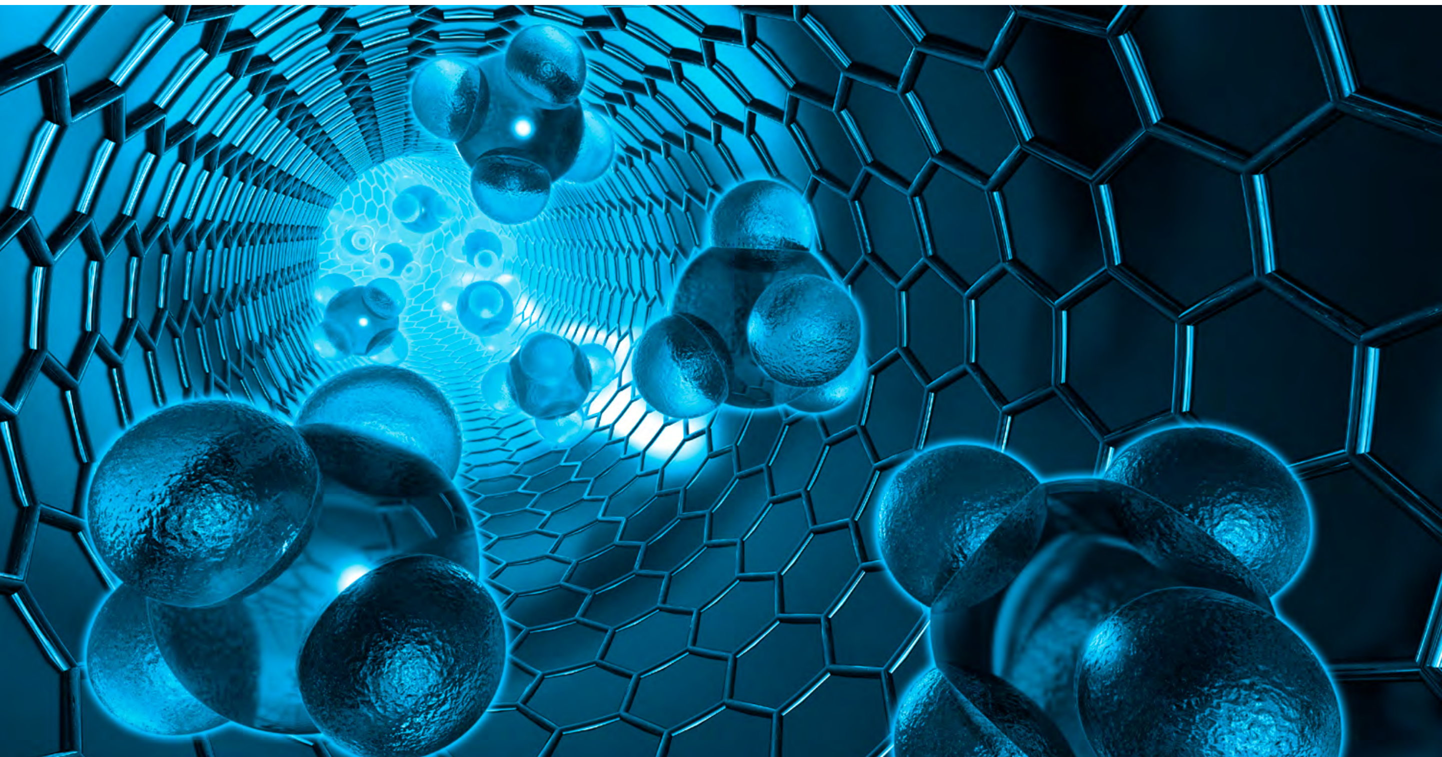
Aerosol Charge Distributions and SMPS Measurements

Nearly all aerosols have some level of electric charge[1] unless they have been allowed to age in a charge-neutral environment for an extended period of time. Submicron particle sizing using a differential mobility technique – as is the case with TSI's Scanning Mobility Particle Sizer™ spectrometer Model 3938 – relies upon particles having a well-defined charge level as a function of particle size[2]. This charge level is achieved via a bipolar diffusion charging process. Ions of both positive and negative polarity are generated, and through the process of diffusion, particles and ions interact and exchange charges[2]. As long as the residence time (t) and the ion concentration (N) are sufficient, a known charge distribution is achieved[3]. Traditionally, radioactive neutralizers have been used to generate the ions. The Advanced Aerosol Neutralizer Model 3088 uses a soft X-ray technique to generate the bipolar ions needed to achieve a steady-state[4] charge distribution.

Bipolar Diffusion Charging Using Soft X-Ray

The Model 3088 Advanced Aerosol Neutralizer uses a low-energy (<9.5keV) soft X-ray* source to generate high concentrations of ions with positive and negative polarity. The soft X-rays ionize air molecules, creating nearly equal numbers of positive and negative charges. Aerosol enters the neutralizer from the inlet port, and the air ions are attracted to oppositely charged particles. The ions quickly interact with the particles and neutralize excess charges. At all operating flow rates, the Model 3088 has sufficient residence time to effectively induce a steady-state charge distribution on the incoming aerosol. Soft X-rays are a very efficient source for charge neutralization because they have energies much higher than the ionization threshold of all molecules, thus creating an abundance of active ions. Soft X-rays also have low penetration into solid matter, so they are easily shielded.



TSI's Advanced Aerosol Neutralizer Model 3088 vs. TSI's Aerosol Neutralizer Model 3077A

TSI's Advanced Aerosol Neutralizers Models 3087 and 3088 share the same soft X-ray source and neutralizer chamber. Therefore, the bipolar diffusion charging processes as well as the resulting steady-state, equilibrium bipolar particle charge distribution of both non-radioactive neutralizers are identical. Advanced Aerosol Neutralizers (AAN) were compared to Aerosol Neutralizers Model 3077A, frequently used radioactive neutralizers which utilize the inert gas ^{85}Kr. The neutralizers were used in TSI's Scanning Mobility Particle Sizer™ (SMPS) spectrometer. A thorough test matrix was carefully executed. Different particle types, particle sizes, carrier gas types, and particle generation techniques were tested. The effect of flow rate and concentration was investigated. Particles were charged with a unipolar charger prior to SMPS™ spectrometer sizing, and both highly pre-charged negative and highly pre-charged positive aerosols were tested. The impressive results are detailed in Figure 1. For the entire test matrix, the geometric mean particle sizes and geometric standard deviations for the two systems were within 5%. The gold standard for submicron particle sizing is accurate with either an Advanced Aerosol Neutralizer Model 3088 or with the Model 3077A.

Concentration

There is a slight difference in measured concentration between the Advanced Aerosol Neutralizer Model 3088 and the Aerosol Neutralizer Model 3077A. This difference is likely due to the fact that air ions from soft X-ray neutralizers have similar, but not exactly the same electrical mobilities as air ions generated from radioactive neutralizers.[5 & 6] This difference is most likely not due to incomplete charge neutralization, e.g., due to ion depletion. Whatever the cause, typically there will be a small concentration difference (commonly on the order of 10-20%) between SMPS systems using the different neutralizers.

Figures 2 and 3 show comparison data of the two neutralizers taken on atmospheric aerosol, demonstrating excellent correlation and approximately 17% bias in concentration. If ultimate absolute concentration accuracy is of utmost importance to a project, it is recommended that a Condensation Particle Counter from TSI be used as a concentration reference in addition to an SMPS™ system.

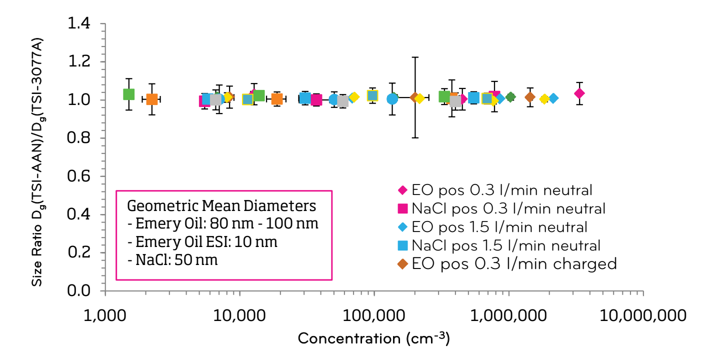


Figure 1: Ratio of the geometric mean diameter calculated from SMPS size distributions measured using a component system with a TSI Advanced Aerosol Neutralizer (AAN) versus a system with a TSI Aerosol Neutralizer 3077A.

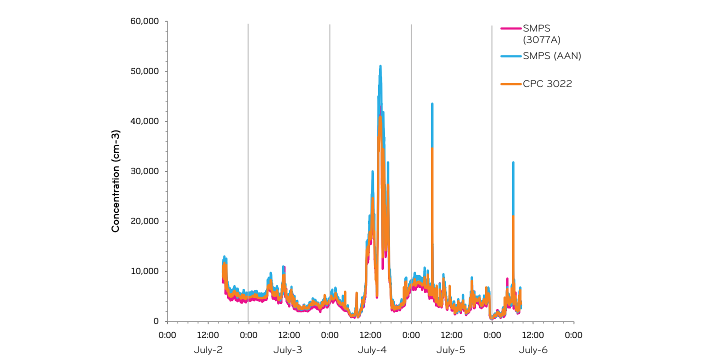


Figure 2: Particle concentration versus time of atmospheric ambient aerosol, data taken July 2 to 6, 2010 in Shoreview, Minnesota downstream of a PM10 inlet and a PM1 cyclone.

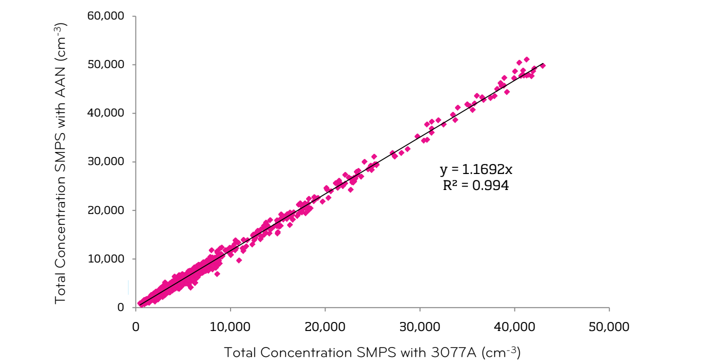


Figure 3: Total particle concentration correlation between SMPS™ spectrometer data taken with the Aerosol Neutralizer Model 3077A and the Advanced Aerosol Neutralizer.

SPECIFICATIONS

ADVANCED AEROSOL NEUTRALIZER MODEL 3088

Mode of Operation
Bipolar diffusion charging by soft (low energy) X-rays

Ion Generation Source
Soft X-rays < 9.5 keV

Flow Rate Range
0.3 to 5.0 L/min

Equivalent X-ray Dose
< 0.3 µSv/h (0.03 mRem/h) at 0 cm distance
< 0.2 µSv/h (0.02 mRem/h) at 5 cm and 10 cm distance
Measured at outlet port without tubing

Particle Production
< 0.01 particles/cm3
For flow rates ≥ 0.3 L/min, using clean air. Air containing reactive and/or condensable gases or vapors can lead to higher particle production rates.

Maximum Particle Concentration
10^7 particles/cm^3

Aerosol Medium
Air or N_2 only

Operating Conditions

Temperature Range	0°C to +33°C
Humidity Range	0 to 60% RH non-condensing
Altitude	Up to 2000 m a.s.l. (6,500 ft)

Storage Conditions

Temperature Range	-10°C to +60°C
Humidity Range	0 to 80% RH non-condensing

Differential Pressure Range
±70 kPa (±10 psi)
measured from inlet or outlet port to ambient

Power

3082 operation	Thru DB9 connector
Stand-alone operation	Universal AC adapter
Input:	100 to 240 VAC, 50/60 Hz,
Output:	12 VDC, 2.5A

Communication

3082 operation	Thru DB9 connector
Stand-alone operation	N/A

Weight
1.6 kg (3.5 lb)

Dimensions

L x H x W	35.3 x 12.4 x 5.0 cm (13.9 x 4.9 x 2.0 in.)

Aerosol Ports

Inlet and outlet tubes	¼ in O.D.

Device Construction Materials

Aerosol Path	Stainless steel and PTFE
Do Not Dispose	Source contains a beryllium window. It must be properly recycled

Regulations
Some countries have no regulations governing soft X-ray devices, while others do. While it is universally true that all countries have less stringent regulations regarding soft X-ray devices versus radioactive devices, like most issues, each region has unique rules. For the most up to date information, contact your local TSI representative or send an e-mail inquiry to particle@tsi.com.

Source Lifetime and Service
The soft X-ray source in the Advanced Aerosol Neutralizer Model 3088 has a lifetime of approximately 8,760 operating hours (one year of continuous use). Since the device can be turned off when not in use, the neutralizer has an operating lifetime of many years for most applications. Elapsed operating lifetime is indicated by a blinking LED. If used in a Model 3082 Electrostatic Classifier, the accumulated operating hours can be displayed. When the operating lifetime is reached, return the neutralizer to TSI for repair and calibration.

Bibliography

[1] Whitby, K.T and Liu, B.Y.H (1966) Aerosol Science (Edited by Davies, C.N.) Academic Press, London.
[2] Reischl, G.P, Makela, J.M, Karch, R., and Necid, J. (1996) Journal of Aerosol Science 27 931-949.
[3] Liu, B.Y.H and Piu, D.Y.H. (1974a) Journal of Aerosol Science 5 465.
[4] Fuchs, N.A.(1963) Geofisica Pura Applicasa 56, 185-193.
[5] Lee, H.M., Kim, C.S., Shimada, M., Okuyama, K.,(2004) Journal of Aerosol Science 36 813-829.
[6] Kallinger, P., Steiner, G. and Szymanski, W.W.; Characterization of four different bipolar charging devices for nanoparticle charge conditioning. J Nanopart Res (2012) 14: p. 944 ff

TO ORDER

Aerosol Neutralizer

Specify	Description
3088	Advanced Aerosol Neutralizer

Optional Accessories

Specify	Description
RO-3088DISP	Disposal of Advanced Aerosol Neutralizer
RO-3088	Repair and calibration of Advanced Aerosol Neutralizer including replacement of soft X-ray tube

Accessories must be ordered separately.

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