SOFT-X-RAY NEUTRALIZER CHARGE DISTRIBUTION IN AEROSOL INSTRUMENT MANAGER® SOFTWARE VERSION 9 FOR SMPS™ SPECTROMETER

Background and Motivation

TSI's Scanning Mobility Particle Sizer™ (SMPS™) Spectrometer is widely used as the standard for measuring aerosol particle size distributions. A new version of SMPS Spectrometer based on a novel classifier was introduced in 2013. This SMPS Model 3938 spectrometer is controlled by a new version of the Aerosol Instrument Manager Software, which considers a different charge matrix for radioactive ^{85}Kr-Neutralizer and Soft-x-ray based neutralizers. This Application Note describes the steps how to use the charge matrix for soft-x-ray neutralizer as an alternative to the default Kr-neutralizer charge matrix in older SMPS systems (Model 3936, based on Electrostatic Classifier 3080 or 3071) running with Aerosol Instrument Manager software (version 9).

Neutralizer for Charging the Aerosol

Bringing the aerosol into charge equilibrium by charging or neutralizing is a crucial conditioning step before the particles can be separated or sized in a Differential Mobility Analyzer (DMA). The particle charge distribution used in the data reduction for the SMPS spectrometer is based on a theoretical model developed by Wiedensohler [1986, 1988] and is an approximation of the Fuchs [1963] diffusion theory for particle sizes in the submicrometer range. TSI offers two different options of bipolar neutralizer that are suitable to fit into the classifiers: radioactive ^{85}Kr-sources (Model 3077 with 74 MBq (2 mCi) or Model 3077A with 370 MBq (10 mCi)) or Advanced Aerosol Neutralizer (AAN) based on soft-x-ray radiation (former Model 3087 and current Model 3088, identical properties of their ion generation source with soft x-rays < 9.5 keV).

Using Soft X-Ray Advanced Aerosol Neutralizer

All TSI verification and validation tests have shown that these AAN neutralizers work well for different particle concentrations and pre-charges. The charging capability of a 370 MBq Kr-85 Neutralizer (Model 3077A) is approximately 10% better in terms of particle concentration or pre-charge that can be neutralized. It is; however, also true that the ion characteristics (positive and negative ion masses and ion mobility) vary slightly between ^{85}Kr and soft x-ray based neutralizers, see Kallinger et al. [2012]. A small difference in the resulting charge distribution can be observed: it is less asymmetric (positive versus negative charges in equilibrium condition) for the AAN. This does not matter at all when the AAN is used in an Electrostatic Classifier serving as a source for monodisperse particles. For SMPS spectrometer measurements, where the equilibrium charge distribution is used for the data inversion, we have found excellent agreement of the measured median diameter and geometric standard deviation for all kinds of aerosols. The total number

concentration resulting from the data inversion can differ up to 15%, which must be attributed to the more symmetric equilibrium charge distribution. Meanwhile, an accordingly modified charge table for Aerosol Instrument Manager Software data inversion software is available from TSI. This modified table for x-ray neutralizers compensates these differences and is implemented in the new Aerosol Instrument Manager Software (version 10) for SMPS 3938 spectrometer. This charge fraction matrix is based on the empirical data and evaluations from Tigges, et al. [2015].
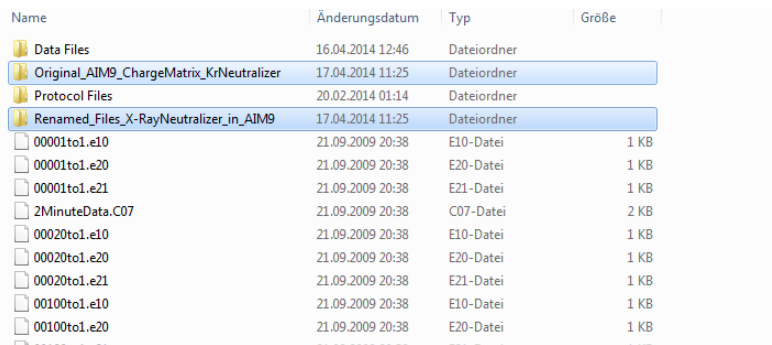
Using Old Classifiers with AAN

The AAN Models 3087 or 3088 are designed to be used in the classifier Model 3080 (or newer); they can also be used with the single box SMPS Model 3034 spectrometer.

Charge Fraction Matrix File Replacement Procedure

Aerosol Instrument Manager SMPS software (version 9) always loads the charge fraction matrix from two system files named ChargeAIM.dat (positively charged particles) and ChargeNEG.dat (negatively charged particles). These two system files must be **REPLACED** by the corresponding files containing the charge fraction data for the X-ray AAN. To do so, follow these steps:

1. Retrieve from your TSI representative the file called "**AIM9_ChargeMatrix_X-RayNeutralizer.zip**" which contains all needed files in subfolders.

2. Go to the folder on your hard drive where Aerosol Instrument Manager Software (version 9) is installed. The default folder is: **C:\TSI\Aerosol Instrument Manager**.

3. Extract/unzip file into the Aerosol Instrument Manager Software folder, you will find then the following subfolders:

4. Copy the files "**ChargeAim.dat**" and "**ChargeNEG.dat**" from **C:\TSI\Aerosol Instrument Manager\ Renamed_Files_X-RayNeutralizer_in_AIM9** and paste them into the main folder: **C:\TSI\Aerosol Instrument Manager**.

   Windows® operating system will tell you that these files exist already and ask if you really want to replace existing files → confirm/yes.

5. Run Aerosol Instrument Manager Software (version 9) as usually done and it will use the modified version of the charge matrix for the x-ray Advanced Aerosol Neutralizer now.

There are two options how to get back to the original version of Aerosol Instrument Manager Software (version 9) and the charge matrix for [85]Kr-neutralizer. One option is to copy the files "ChargeAim.dat" and "ChargeNEG.dat" from **C:\TSI\Aerosol Instrument Manager\ Original_AIM9_ChargeMatrix_KrNeutralizer** and paste them into the main folder: **C:\TSI\Aerosol Instrument Manager** and replace the existing files. The other option is to delete and reinstall Aerosol Instrument Manager SMPS software (version 9) completely.

References

Kallinger, P., Steiner, G. and Szymanski, W. [2012] "Characterization of four different bipolar charging devices for nanoparticle charge conditioning" *J Nanopart Res* (2012) **14**:944

Tigges, L., J., Wiedensohler, A., Weinhold, K., Gandhi, and Schmid, H.-J. (2015) "Bipolar charge distribution of a soft X-ray diffusion charger."

Wiedensohler, A., E. Lütkemeier, M. Feldpausch, and C. Helsper [1986] "Investigation of the Bipolar Charge Distribution at Various Gas Conditions," *Journal of Aerosol Science,* **17**:413.

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Wiedensohler, A., and H.J. Fissan [1988] "Aerosol Charging in High Purity Gases." *Journal of Aerosol Science*, **Vol. 19**.