AEROSOL NEUTRALIZATION ISSUE
MODEL 3077(A)

APPLICATION NOTE 3007-001

Introduction

When operated standalone or within an Electrostatic Classifier Model 3082with date code May 2014 or earlier, at certain flow rates, Radioactive Neutralizers Model 3077 and 3077A may not sufficiently charge the sample aerosol to an equilibrium distribution.

This issue has occasionally been observed in the past (Liu and Deshler [2003] *Aero. Sci. Technol.* 27:916-923) but the root cause was unclear. We are happy to report a thorough investigation and solutions to the issue. The following document explains it in detail and can be used to determine whether a specific experimental setup may or may not be affected. The use of a 3077(A) neutralizer in a 3080 classifier is ***not*** affected by this issue.

What is the issue?

The 3077(A) aerosol neutralizer may have reduced neutralization efficiency at certain flow rates when operated outside a classifier or within a 3082 classifier with date code May 2014 or earlier. In these configurations, the flow through the neutralizer may be laminar causing fluid near the centerline of the flow to pass through the neutralizer body rapidly while fluid near the outer edges of the flow recirculates within the neutralizer. The discrepancy in residence time within the neutralizer causes insufficient neutralization of the aerosol along the neutralizer centerline. Depending on the state of charge of the aerosol being measured, insufficient neutralization can lead to inaccurate size distributions and number concentrations. As shown in Figure 1, for a highly pre-charged aerosol, between sample flow rates of 0.7 L/min and 2.5 L/min, the insufficient charging of the 3077(A) neutralizer installed in a 3082 classifier results in incorrect total concentration measurements. Figure 2 shows the overestimation dependence on particle size for a highly pre-charged example aerosol.

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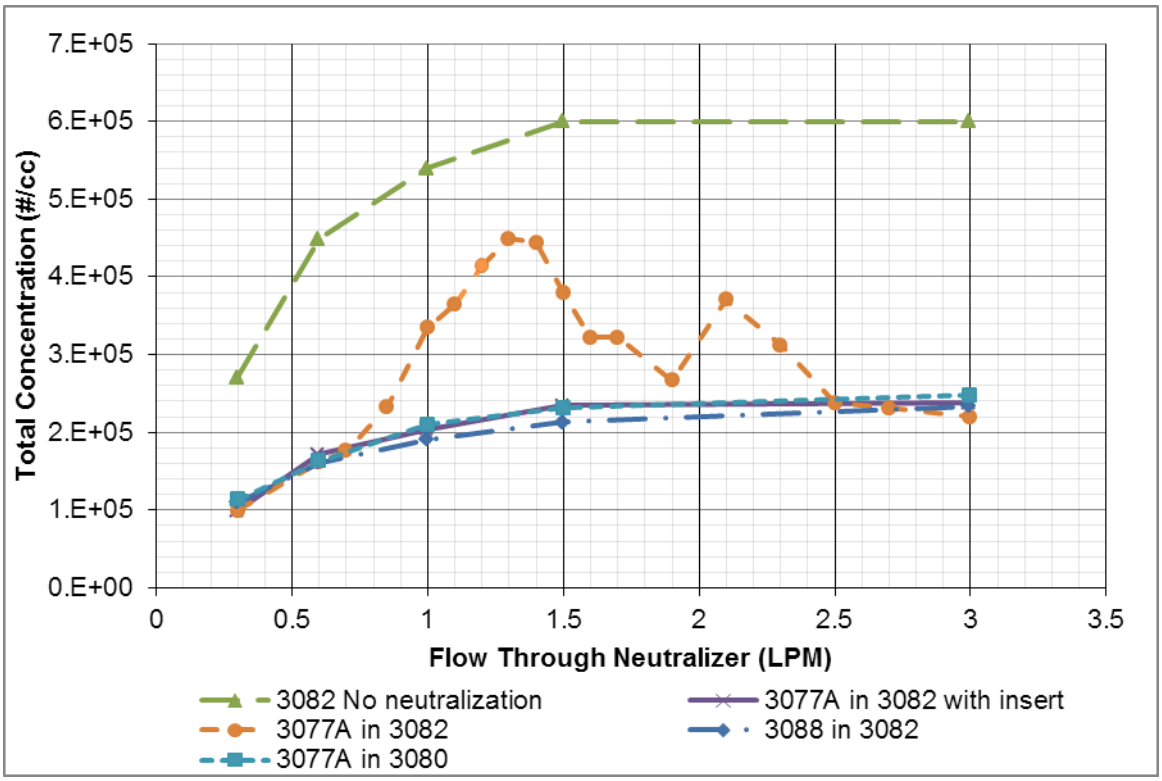


Figure 1: Effect of sample flow rate and neutralization on total concentration

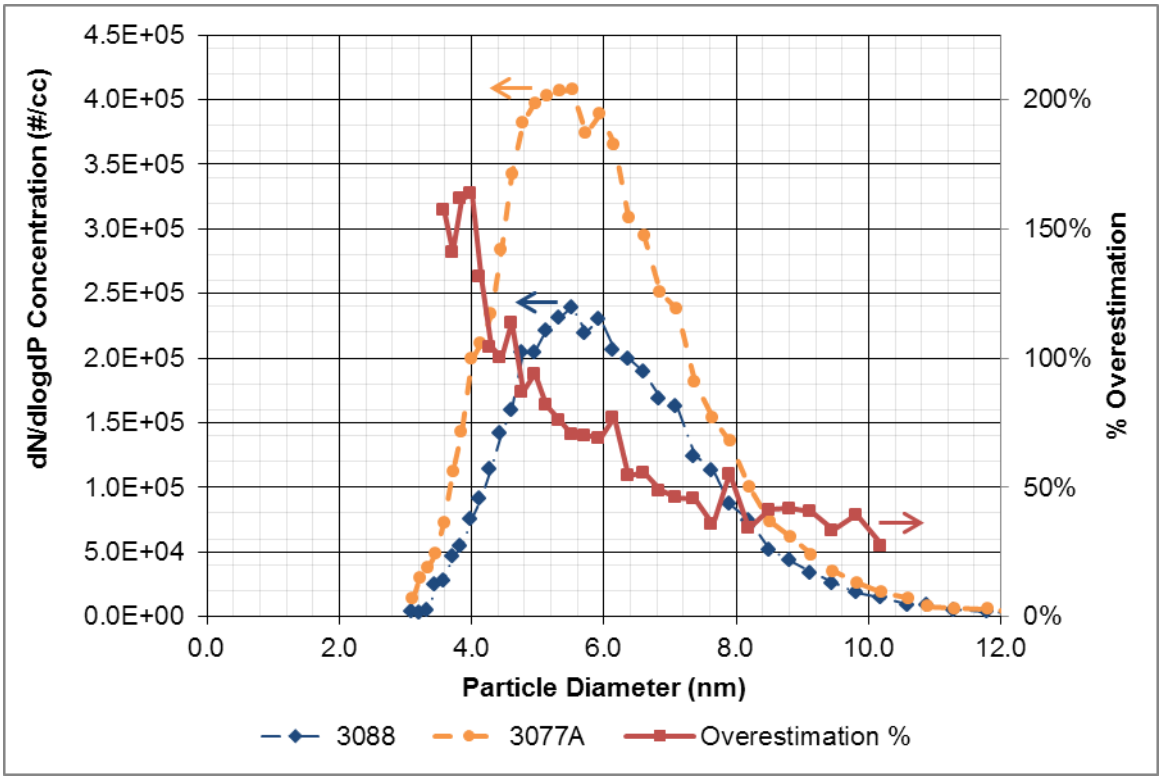


Figure 2: Concentration overestimation as a function of particle size at 1.5 L/min aerosol flow, NaCl aerosol

Am I affected by this issue?

The following applications of the 3077(A) neutralizer may be affected by this issue:

- The TSI 3077(A) neutralizer is used to neutralize a highly charged aerosol outside of a classifier and flow through the neutralizer is in the 0.7 L/min to 2.5 L/min range.
- The TSI 3077(A) neutralizer is used to neutralize a highly charged aerosol within a 3082 Classifier and the flow through the neutralizer is in the 0.7 L/min to 2.5 L/min range.

Experimental setups similar to those listed above in which the aerosol is not highly charged (such as ambient monitoring) or in which the aerosol is neutralized upstream of the classifier may not suffer from this issue.

What is the solution to this issue?

TSI has developed, tested, and implemented two solutions to correct the insufficient neutralization issue. Both solutions work equally well.

- The first solution is an updated inlet block for the 3082 classifier. It includes a flow mixing element upstream of the neutralizer. The flow mixing element sufficiently alters flow patterns inside the neutralizer such that flow recirculation is avoided. It is present in all 3082 classifiers with date code June 2014 or later and will be installed in any 3082 classifier that is returned to TSI for service.
- The second solution is an insert for the 3077(A) neutralizer (part number 3007022) shown in Figure 3 which can be installed in the inlet of the neutralizer. This insert sufficiently alters flow patterns inside the neutralizer such that flow recirculation is avoided. Current 3077(A) owners who wish to use the insert can obtain a free insert by registering with TSI at www.tsi.com/3077kit with the serial number of the neutralizer.

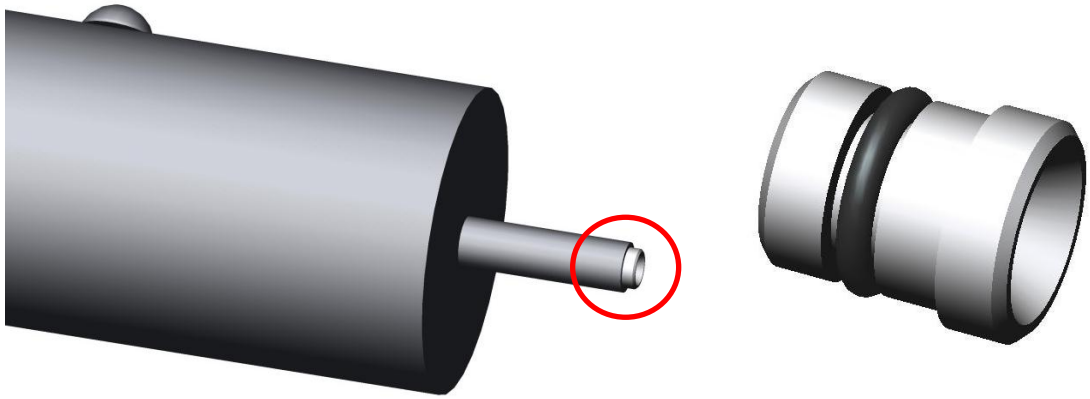


Figure 3: 3077(A) insert part number 3007022

When should the neutralizer insert be used?

The neutralizer insert should only be used in the two following situations:

- Those using a 3077(A) standalone, outside of a classifier, should use the neutralizer insert.
- Users who are using a 3077(A) neutralizer in a 3082 classifier with date code May 2014 or earlier that have not received the inlet block upgrade should use the neutralizer insert.

Frequently Asked Questions

What is the date code of my classifier?

Each classifier has a sticker above the power switch on the back of the classifier containing the model, manufacture date code, and serial number as shown in Figure 4.

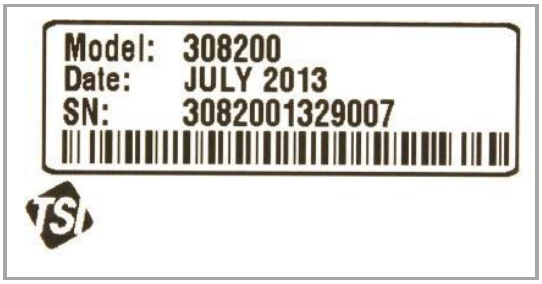


Figure 4: Example 3082 classifier date code sticker

How do I know if I have the new inlet block or the old inlet block?

To verify that you have the new inlet block, remove the impactor and look down the aerosol flow path. If the internal diameter is ¼", then the old inlet block is installed. If the internal diameter reduces to about $^1/_8$" then the new inlet block is installed.

If I purchased my Electrostatic Classifier Model 3082 after May 2014 do I need to use the insert?

No. The geometry of the new 3082 inlet block contains a flow mixing element that makes it unnecessary to use the insert.

Do I need to use a flow mixing insert if the neutralizer is installed in an Electrostatic Classifier Model 3080?

No. The geometry of the 3080 aerosol flow path sufficiently alters flow patterns upstream of the neutralizer such that flow recirculation within the neutralizer does not occur.

Do I need to use a flow mixing insert with a TSI Soft X-Ray Neutralizer Model 3088 or 3087?

No. TSI's soft x-ray neutralizers avoid flow recirculation with a tapered internal flow path.

What effect do the flow mixing elements have on pressure drop through the SMPS™ spectrometer?

The effect of pressure drop due to the addition of the neutralizer insert and new inlet block have been measured and determined to be negligible, up to 5 l/min aerosol flow.

What effect do the flow mixing elements have on particle losses through the SMPS spectrometer?

See Figure 5. The total aerosol concentration for the 3077(A) neutralizer with neutralizer insert was measured to be within ±10% of the reference total concentration down to 8 nm. At the smallest sizes (<8 nm), where diffusion losses are highest, diffusion losses due to the neutralizer insert are measurable but are an order of magnitude less than the overall diffusion losses of the SMPS system flow path. Losses due to the new inlet block (not shown) were also measured between 2 and 200 nm and are negligible (<2%).

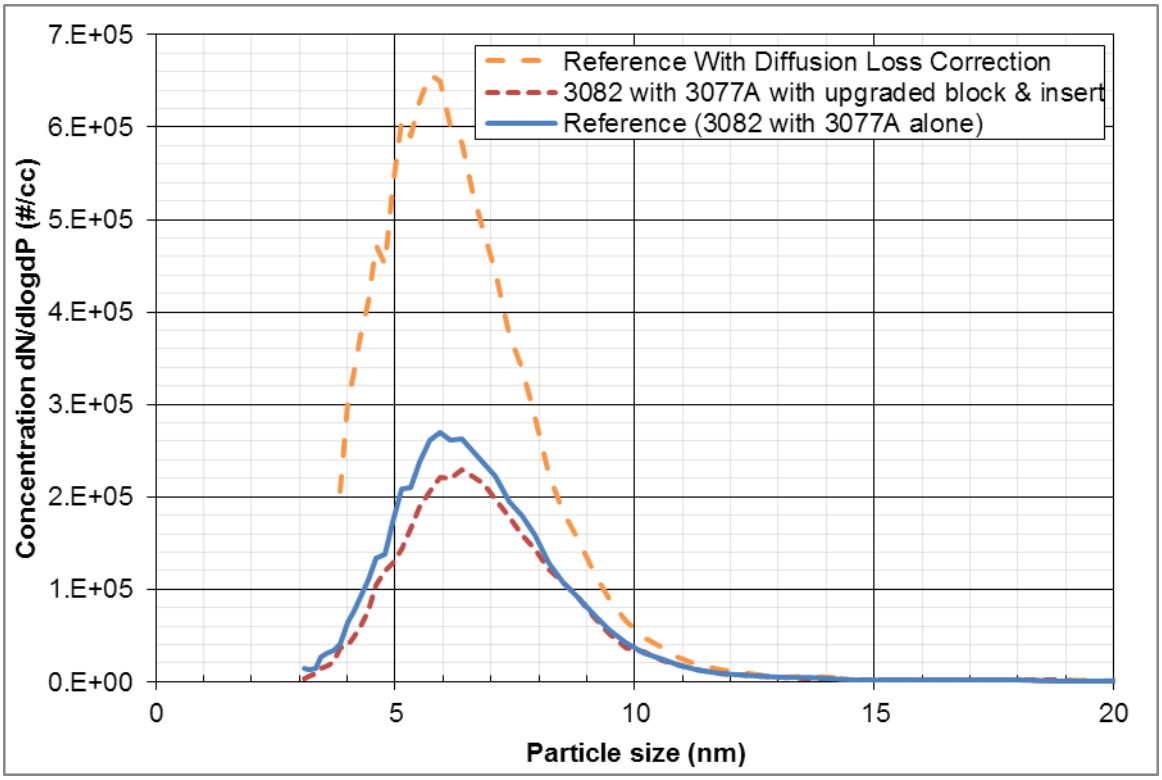


Figure 5: Flow mixing insert diffusion loss contribution at 1.5 L/min aerosol flow with pre-neutralized aerosol

What is the material of the neutralizer insert?

The insert is constructed of 316 stainless steel with a perfluoroelastomer O-ring.

Can I install the neutralizer insert myself?

Yes. Press the insert into the inlet of the neutralizer. The insert is held in with a radial-seal O-ring. The insert is removable for cleaning if necessary.

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