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Description of BMI Aerosol Charge Neutralizer Body

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The purpose of the neutralizer is to impart a known distribution of electrical charge to sampled ambient aerosol so that the number fraction of particles of a given size selected by a differential mobility analyzer (DMA) can be related to the total ambient number concentration. The neutralizer can also be used to reduce particle losses in aerosol generation systems due to electrostatic precipitation. The DMA only selects particles that are electrically charged, under normal conditions, the vast majority of ambient particles carry no charge; some 10 to 25% carry a single charge with smaller number fractions of particles carrying multiple charges. In some cases however, for example during electrical storms or when sampling atomized aerosol, a significant fraction of the aerosol can be charged with an unknown distribution of charge as a function of particle size. The charging efficiency of particles is a strong function of particle size, especially for particle diameters smaller than 100 nm.

A photo of a disassembled neutralizer assembly is shown at the end of this document. The ion source of the neutralizer consists of two radioactive Polonium-210 strips (0.5 mCi each, Model 2U500, NRD LLC, Grand Island, NY, Tel: 800-525-8076) that emit alpha particle radiation that ionize the air molecules near the strips. *Note that the BMI neutralizer is not shipped with the ion sources installed, they must be purchased separately from NRD.* The half-life of Po-210 is 138.4 days. The range of the alpha particles in air is 3.8 cm and the radiation is incapable of penetrating the stainless steel body of the neutralizer. In fact, the alpha particles cannot penetrate the layer of dead skin (~50 micrometers thick) on the human body. The sources used in the BMI neutralizer do not require special handling precautions beyond those described in the NRD LLC technical literature. The positive and negative ions produced via the ionization process interact with the particles in the sample flow depending on the size of the particle and its electrical charge. The interactions between the ions and particles produce a known distribution of charge as a function of particle size.

The ability of the neutralizer to produce a known distribution of charge is limited by the residence time of particles inside the neutralizer, the density of ions produced by the radioactive sources and the maximum allowable number concentration of sampled aerosol. The neutralizer may not completely neutralize all particles when the total number concentration exceeds $10^5/\text{cm}^3$. One figure of merit for a neutralizer is the ratio of the particle residence time in the neutralizer chamber (6.4 seconds for 1 lpm flow) and the characteristic time to fully neutralize the particles (0.0025 sec). The value of the ratio should be significantly greater than one. The figure of merit for the BMI neutralizer is 2514. In comparison, a commercially available neutralizer using Krypton-85 gas as the

ion source has a figure of merit of 219. The advantage of Kr-85 is that it has a half-life of 10.7 years.

The useful life of the sources used in the BMI neutralizer is approximately three years from the date stamped on the Po-210 sources (not necessarily the same date as the source installation date). Given the relatively short half-life of Po-210, after three years the source activity will be reduced by a factor of 244. The figure of merit for the neutralizer after three years of service is 16, which is still appreciably greater than one but we recommend source replacement after three years of use. The date on the underside of the source as well as the source installation date should always be recorded on the outside surface of the neutralizer when sources are replaced.

If the neutralizer is operated under severe aerosol loadings for prolonged time periods the inside surfaces can become coated with particles. This can occur when airflows from aerosol atomizers are passed through the neutralizer. The effectiveness of the Po-210 sources can be greatly reduced if coated with particles. The 1.5" diameter neutralizer body is not designed to neutralize undiluted sample flows from atomizers. Unless high loadings are required during an experiment, the atomizer output should be diluted before entering the neutralizer to the lowest acceptable concentration level. Follow the cleaning instructions provided by the manufacturer of the radioactive sources used in the neutralizer to remove particle coatings from sources. Once the sources have been removed from the body, the body can be cleaned with isopropyl alcohol or methanol.

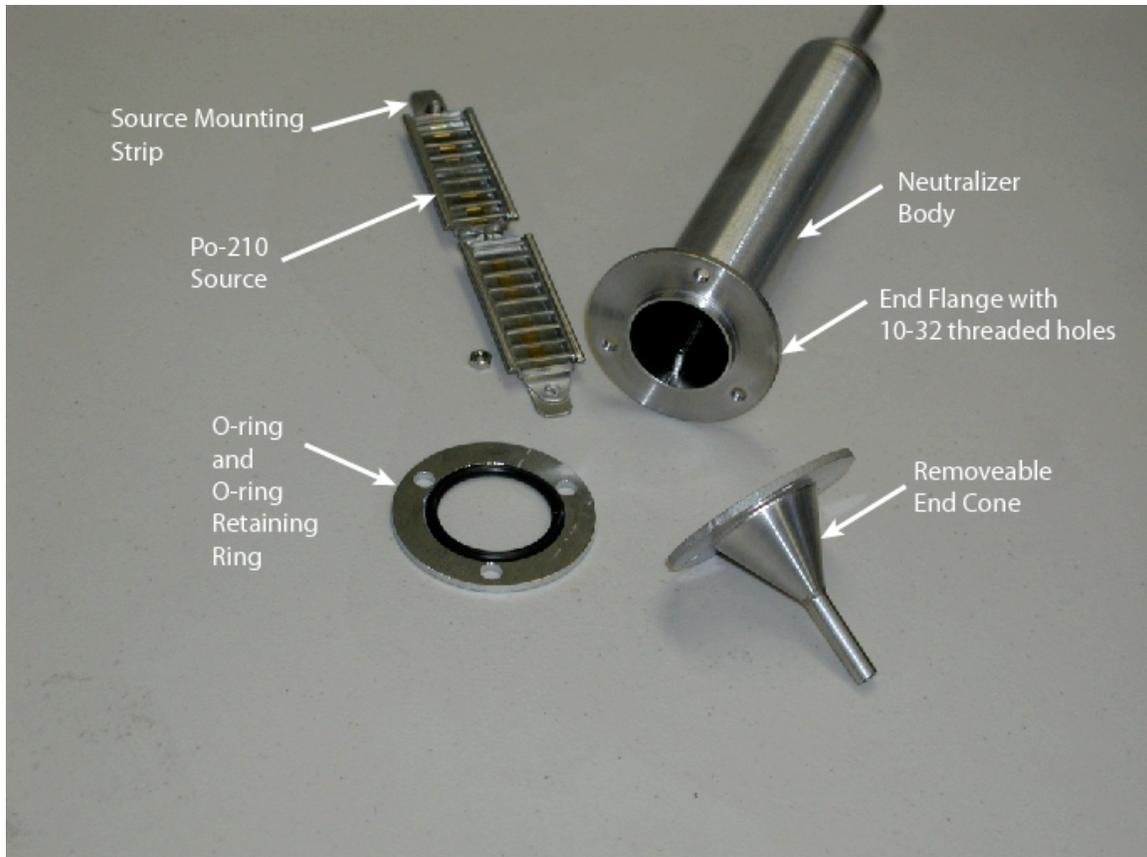
Procedure for removing/installing and replacing Po-210 sources:

Remove the complete neutralizer assembly from instrumentation prior to replacing the sources. Using a backing wrench on the swagelock union fitting, loosen the swagelock nuts on each end of the neutralizer closest to the neutralizer body. If a body-mounting clamp was shipped with the unit, remove the two screws of the clamp holding the neutralizer body to the instrumentation and set aside the piece of the clamp that comes loose. With the swagelock nuts loose, it should be possible to gently pry the instrument sample tubing ends away from the neutralizer body so that it can be lifted out of the instrument. Do not exert undue stress on the stainless steel tubing at the ends of the neutralizer body – the material is annealed and considerably softer than typical stainless steel.

Once the neutralizer body has been removed, access to the sources is gained as follows (reference the picture of the disassembled neutralizer assembly at the end of this document). Remove the three 10-32 screws holding the removable end cone and separate the end cone from the neutralizer body. A small amount of black grease has been applied to the screws to prevent binding. The grease is somewhat tenacious so take care not to spread it on to surfaces of the instrument or your skin. Using a ¼" box-end wrench, remove the small nut and lock washer inside the neutralizer body holding the source mounting bracket. Once this nut is removed, the loose end of the source-mounting bracket may be grasped between the thumb and index finger and gently lifted so it just clears the brazed threaded stud. Pull the source-mounting bracket out of the neutralizer body. The far end of the source-mounting bracket is captured by a brazed bracket and has

no removable hardware. Once the source-mounting bracket has been removed, remove the hardware holding the old sources to the bracket, remove the old sources, and replace with new sources using the same hardware. Note that small 6-32 thread nuts have been used to hold the sources in place; standard 6-32 nuts are too large to fit in the space allowed between sources. Do not misplace the small 6-32 nuts.

Installation of the new sources is accomplished by following the above removal procedures in reverse. Apply a small drop of 'non-locking' medium strength Loctite to the source mounting threaded studs on the bracket and to the threaded stud inside the neutralizer body before replacing the 1/4" nut and lock washer holding the source-mounting bracket to the neutralizer body. This will help to ensure the source-mounting bracket will not vibrate loose during use of the neutralizer. Remove the 1.5" O-ring and apply a very thin coating of vacuum grease. Replace the O-ring after applying the grease. Replace the end cone of the neutralizer after positioning the aluminum spacer plate around the O-ring so the clearance holes for the 10-32 screws match the positions of the 10-32 threaded holes in the neutralizer flange. When tightening the 10-32 screws and lock washers holding the end cone to the body, the aluminum spacer plate as well as the body design prevents over-compression of the O-ring and warpage of the flange. Therefore, damage to the O-ring due to over-tightening of the flange screws cannot occur. Apply 'non-locking' (blue) Loctite to the 10-32 screws before installation. Tighten the 10-32 screws so only a small gap is seen between the end cone flange and metal spacer. Replace the neutralizer into the instrument.



Picture of disassembled BMI neutralizer. Note that the two Po-210 sources must be purchased separately from NRD LLC.

Neutralizer technical specifications:

Overall length: 10.375"

Body outside diameter: 1.25"

Body length: 6"

Outside diameter of end cone mounting flange: 2.25"

Outside diameter of stainless steel end tubulations: 0.25"

Material: Stainless steel, ultra-high vacuum brazed

Power: None required

Weight: <1.5 lb

Feel free to contact me with any questions/comments you might have:

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Happy neutralizing!