Effect of SMPS Neutralizers on the Accuracy of Particle Size Distribution Measurements

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Cambridge Particle Meeting, Cambridge, UK, June 2016
Goal

- The overall goal of our research is to establish a guidance document on how to best use size distribution measurement instruments for:
  - Number, Surface Area, and Mass concentration of combustion generated particles
    - Example of Such Instruments: SMPS, EEPS and DMS500
- The first goal is to focus on the SMPS
  - The SMPS is a widely used instrument and can be used as a reference for other number-weighted size distribution measurement instruments
- The second goal is to focus on a series of instrument comparison that includes:
  - SMPS, CPC, EEPS, DMS500, MSS, OC/EC, CPMA, EAD, QCM, LII, filter mass, etc…
SMPS/Neutralizers: Current Work

- Krypton 85 neutralizers are widely used in an SMPS
  - They are used to bring the charge level on particle to a minimum in accordance with Boltzmann distribution of charge
    - There is desire to understand their lifetime function and how they affect different moment of particle measurement
    - There is also a desire to use less safety restrictive radioactive sources such as:
      - Polonium 210
      - Non-radioactive sources such as Soft X-ray, where the activities can be turned on or off as desired

- In this work, we looked at the effect of different neutralizers on SMPS number-, surface area-, and mass-weighted size distributions using a Mini-CAST + Catalytic Stripper
  - Four repeated scans at each condition was performed
  - Up scan was 2 minutes, with down scan of 15 sec and waiting in between scans of 1 minute
  - Sheath air was 15 lpm and aerosol flow was 1.5 lpm
Six Neutralizers:

- 2008 Kr-85 3012A (10 mCi)
  - Designed for high flow

- Po-210 (two strips)
  - 0.5 mCi each

- 2005 TSI-3077-Kr-85 (2 mCi)
- 2016 & 2008 TSI-3077A-Kr-85 (10 mCi)

- 2015 TSI soft x-ray 3088
Experimental Setup
Size Distribution Measurement Using Different Neutralizers

- Difference were observed among different neutralizers
- Large neutralizer exhibited significant differences even after size distribution correction for particle losses
There seems to be three regimes of particle charging level:
  – 2002 and 2005, below 10 years half life, not enough charging
  – 2016, 2008, Po-210 and Soft x-ray performed similarly within +/- 7%
  – The large Kr-85 resulted in particle losses, but **more importantly due to coagulation** because of the high concentration at the inlet and long residence time ~1 minute
    - The CPC concentration was heavily diluted to be measured directly with the CPC.
      - It does not reflect the concentration at the inlet of the DMS500

The mini-CAST stripper produced charge level much higher than a Boltzmann minimum distribution of charge
  – We plan to perform this work with an engine to understand the difference between mini-CAST stripper charge and Engine/stripper charge
On a number basis, the Kr-85, Po-210 and soft x-ray gave similar results with +/- 15%. The geometric number mean diameter showed some difference that may influence higher moment calculation.
• 30 nm and 63 nm showed similar performance
• Relative to 2016 Kr-85, soft-x-ray, 2008 and Po-210 showed lower concentration suggesting better neutralization
• The large kr-85 is uncorrected for losses so it cannot be used without correction
30 nm and 63 nm showed similar performance

Relative to 2016 Kr-85, soft-x-ray, 2008 and Po-210 showed similarity with +/- 5%

The large kr-85 is uncorrected for losses so it cannot be used without correction
30 nm and 63 nm showed similar performance
Relative to 2016 Kr-85, soft-x-ray, 2008 and Po-210 showed similar concentration to within +/- 5%
The large kr-85 is uncorrected for losses so it cannot be used without correction
Conclusion

- Kr-85 up to 10 years old, Soft x-ray, and fresh Po-210 seemed to produce results with reasonable error for different moments of the size distribution:
  - Number, ~+/- 10%
  - Surface Area, ~+/- 5%
  - Volume, ~+/- 5%

- We will track the Po-210 as a function of time to see when it deviates in performance and recommend replacement for it
  - 5, 6, or 7 months?

- The soft x-ray seems to be a reasonable choice if radioactive sources cannot be used

- The large neutralizer may induce losses and also coagulation due to the long residence time. Work is under way to show that it can be used and corrected for under low inlet concentration where, coagulation is not significant
Next Step

- Our next step is to compare mass results by the SMPS to a reference and establish the correction needed.
- Compare various instruments to that of the SMPS using:
  - Minicast/Stripper
  - Engine/Stripper
- Provide a guidance document and establish a database, where data that are measured following the guidance document can be added to the database.
Acknowledgements

- This work was funded by the United States Environmental Protection Agency, Contract EP-C-15-006, Work Assignment 1-04