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(Report co-authored by: NRC Canada, University of Alberta and Rolls-Royce PLC)

apt 2026 aerosol & particle technology

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Better Accuracy & Automation of the CERMS for Calibrating Black Carbon Mass Analysers

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Keywords: metrology, black carbon, mass, laser induced incandescence

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The CPMA Electrometer Reference Mass System (CERMS, Symonds *et al*., 2013) uses a Centrifugal Particle Mass Analyser (CPMA) in conjunction with a unipolar charger and an aerosol electrometer (AE) as a calibration standard for instruments which measure particle mass concentration. Particles from any source are charged and then classified by mass-to-charge ratio in the CPMA. Particles at the single charge mass setpoint will gain 1 elementary charge, particles at twice that mass will gain 2 elementary charges, and so on. In this way each quantum of mass can be thought of as being tagged with one charge. By measuring the charge concentration downstream of the CPMA with the AE and multiplying it by the mass setpoint, the mass concentration exiting the CPMA can be directly calculated. By splitting the flow exiting the CPMA into an Instrument Under Test (IUT) the CERMS can be used as a calibration source for the IUT of known mass concentration.

The CERMS is an appealing method as it depends only upon easily traceable physical properties of the CPMA and AE, namely the CPMA voltage, speed and classifier radii, the AE current and the flow through it. Mehri *et al.* (2025) showed that the least reproducible element is the CPMA mass (10% between 3 systems) and given the ease of delivering accurate speed and voltage, the root cause here is likely to be uncertainty in the classifier dimensions, where gap between two independent cylinders must be precisely controlled. The recent development of mass certified polystyrene latex spheres (PSL) by AIST in Japan has enabled an "end to end" calibration of the CPMA for the first time, without needing to convert sizing standards to mass using an assumed density.

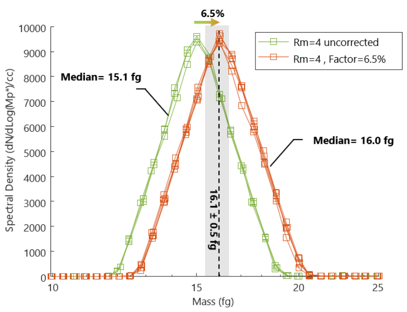

Figure 1. Calibration of a CPMA using mass PSL

The mass certified PSL (at 16.1 fg) is diluted, nebulised and dried and passed through a neutraliser and DMA to impart charge. The CPMA under calibration is scanned into a CPC. Data is fitted using a model of the transfer function of the CPMA. Figure 1 shows the result from one CPMA where a 6.5% deviation from the standard was observed. The CPMA is adjusted in software to change the assumed radii of the cylinders.

When calibrating a mass concentration instrument using the CERMS, it is usually required to deliver a range of mass concentrations to be able to fit a calibration function to the data. We show this is best achieved by firstly finding the peak mass concentration output of the CERMS by scanning the CPMA and then setting the CPMA to that particle mass value. Secondly a diluter is used after the particle source to progressively apply dilution to attenuate the mass concentration and therefore obtain a sweep to test the linearity of the IUT. The Cambustion AD60 is a continuously variable rotating disk diluter and this can be used under closed-loop control based on the CPMA-AE mass output to give a dynamic range of around two orders of magnitude. Software has been written to automate this entire process, and Figure 2 shows an example of this being used to check the calibration of an Artium LII 300 Laser Induced Incandescence instrument in under 10 minutes.

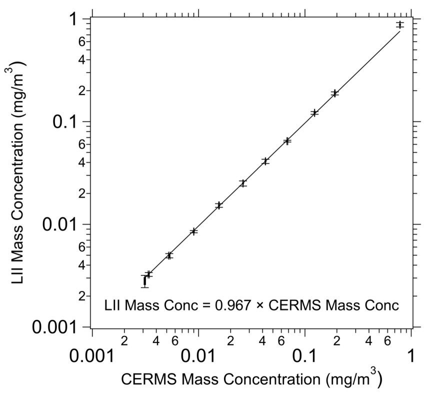

Figure 2. LII calibration using nebulised CB

Mehri R., Nishida R.T., Sipkens T.A. *et al*. (2025) *Aerosol Science and Technology*.

Symonds, J.P.R., Reavell, K.StJ., Olfert, J.S. (2013) *Aerosol Science and Technology*. **47**, i–iv.