Intercomparison of Condensation Particle Counters challenged by steady-state airborne DEHS particles produced in a “calibration tool” setup

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Number concentration is the most frequent characteristic used for airborne nanoparticle monitoring, task emission classification, or protective equipment performance evaluation against nanoparticles. In addition, this parameter is of great interest in the context of characterization of diesel exhaust. Although condensation particle counters (CPC) have been developed and widely used for a long time, few is known about their performance when multiple models are simultaneously challenged by an identical aerosol. Furthermore, the use of CPC for aerosol monitoring when nanomaterials are produced or handled has been recently recommended by several institutes (*e.g.* Methner *et al.*, 2010; Witschger *et al.*, 2012). Consequently, providing intercomparison data as well as calibrating and checking CPC are among the key elements to ensure reliable lab or field measurement campaigns. For this purpose, a reproducible aerosol source was developed by Koch *et al.* (2008, 2012). The working principle of the “calibration tool” is based on Brownian coagulation of liquid DEHS droplets in a continuously fed well-stirred tank reactor (~ 60 L in volume). Contrary to the primary calibration of a CPC based on the parallel measurement of aerosol current and number concentration at the exit of a Differential Mobility Analyzer (ISO, 2015), this protocol allows a wide range of number concentrations and particle sizes to be investigated and reproduced.

A first step of this study consisted in the characterization of the test aerosol produced. The results indicate that airborne particles present a modal diameter around 230 nm and range from 10 nm to 1 µm, once the steady-state regime is reached (~ 45 minutes). Besides, the total number concentration of the aerosol produced in the calibration tool is above 2.10^{7} cm^{-3}; this setup thus requires the use of a dilution step prior to performing measurements with a large number of CPC. The reproducibility of the “calibration tool” has also been investigated; a relative variation below 10 % in the total number concentration was observed over a period of 7 days.

The core of this work relies in the comparison of the number concentrations measured in parallel, at the exit of a flow splitter, by different CPC under study with regard to a reference CPC. The latter reference is a stationary butanol CPC (Grimm model 5.403) operated at a flow rate of 1.5 $L.min^{-1}$ (high flow mode) and calibrated prior to the different measurement series.

Figure 1 gathers the experimental results obtained for 9 handheld CPC (8 specimens of TSI model 3007, 1 P-Trak TSI model 8525). Numbers indicated in the top of Figure 1 correspond to the number of validated runs for each CPC. The variability in the number concentration reported by several specimens of handheld CPC 3007 can reach up to 25%, as shown in Figure 1 for CPC 3007 #2 and #6.

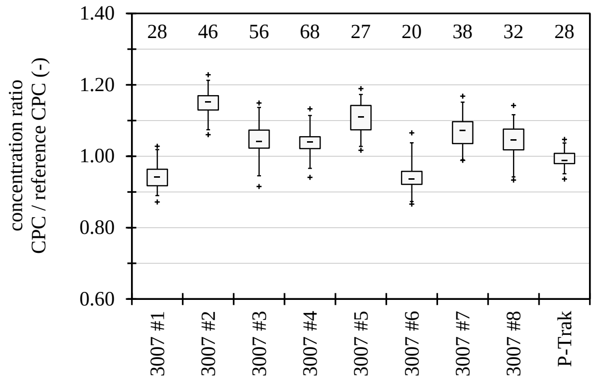

Figure 1. Intercomparison of several specimens of handheld CPC. Error bars correspond to the 95% confidence interval, signs (+) represent extreme values

To date, water-based (TSI model 3786, 3787) and stationary butanol-based (TSI model 3775, Grimm model 5.401, 2 specimens of Grimm model 5.403) CPC have also been investigated. The results suggest that this setup is not well-suited for water-based CPC when aerosols are produced at high number concentrations, due to the hydrophobicity of airborne DEHS particles. Besides, all butanol CPC were found in close agreement with the reference CPC. Additionally, 2 specimens of portacount (TSI model 8030) — devices used for fit testing — were studied. Further results obtained with other models of CPC will also be discussed.

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