

Field comparison of two hand-held devices to assess airborne ultrafine particle concentrations

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Ultrafine particles (UFP) are associated with adverse pulmonary and cardiovascular health effects (Schmid et al. 2009). Handheld devices for detection and quantification of UFP are an important tool for characterizing potential hazards under real world conditions.

In a study investigating the particle exposure of highway maintenance workers who spend up to 8 hours per day in traffic, we compared two handheld ultrafine particle counters. The two devices compared were 1) the TSI P-TRAK 8525, which is a condensation particle counter designed to measure ultra fine particles (UFP) in a size range from 0.02 to 1 micrometer and a concentration range from 0 to 500'000 particles/cm³, and 2) the miniature diffusion classifier (miniDiSC) developed at the University of Applied Sciences Northwestern Switzerland (FHNW) designed to measure UFP in a size range from 0.01 to 0.3 micrometer and a concentration range from 1'000 to 1'000'000 particles/cm³. The miniDiSC is now commercially available as "DiSCmini" from Matter Aerosol.

To compare the UFP counts we used the P-TRAK and the miniDiSC simultaneously over five 8-hour work shifts. UFP counts were averaged over 1 minute intervals. Both devices were fixed on a trolley that was taken along to the different workplaces on the highway. The sampling tube inlets were attached to the handle of the trolley in a distance of about 10 cm. The extensible trolley handle was about 120 cm above ground when on the roadside (extended) and in the head space when inside the service vehicles (retracted). Sampling with the P-TRAK was performed with the standard inlet screen and the sample tube provided with the instrument. For sampling with the miniDiSC we used the 0.8 mm-cutoff impactor and Nalgene 180 clear plastic tubing. From a total of 2470 observations (1-minute means) on 5 work-shifts we had to exclude 165 (7%) values because one of the instruments did not log the particle number (P-TRAK stopped logging because of tilt: 6%, miniDiSC was measuring zero-offsets: 1%)

Results: Both devices measured similar UFP-concentrations (counts/cm³) with the same peak episodes. UFP counts were generally elevated during maintenance work on the highways, in the garage of the maintenance centers and while driving. Low UFP concentrations were measured during work in clean office buildings and break times. The overall correlation of the two devices over the five work shifts was $R^2=0.83$. However, the P-TRAK measured 8-h mean UFP-concentrations that were 25% to 40% lower than the values from the miniDiSC. The comparison of the P-TRAK/miniDiSC-ratio with the mean particle size measured by the miniDiSC shows that the P-TRAK underestimates particle number with decreasing particle diameter.

Our results are in agreement with earlier studies where the P-TRAK was compared with general-purpose (table-top) CPCs and an SMPS (Chan et al. 2004; Zhu et al. 2006). An underestimation of the particle counts by the P-TRAK was described especially for highway influenced sites where freshly emitted particles with small geometric mean diameters are present (Zhu et al. 2006).

During our measurements the miniDiSC reported mean particle diameters from 41-59 nm. These small particle diameters and the increasing underestimation of the P-TRAK with decreasing particle diameters support the hypothesis that small particles were not well detected by the P-TRAK, explaining the higher values of the miniDiSC.

References:

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Background

- Ultrafine particles (UFP) are associated with adverse pulmonary and cardiovascular health effects (Schmid et al. 2009)
- Handheld devices for detection and quantification of UFP are an important tool for characterizing potential hazards under real world conditions

Objective and Method

Comparison of two handheld UFP measurement devices during highway maintenance work:



miniDiSC*



CPC TSI P-TRAK 8525

- Devices were fixed on a trolley that was taken along to different workplaces on the highway
- P-TRAK sampling with the standard inlet screen and sample tube; miniDiSC sampling with 0.8 µm-cutoff impactor and Nalgene 180 clear plastic tubing
- Comparison of 2300 one minute means during 5 work shifts

*miniDiSC developed at the University of Applied Sciences Northwestern Switzerland (now commercially available as DiSCmini from Matter Aerosol)

Results

- P-TRAK and miniDiSC measured similar UFP-number-concentrations with the same peak episodes

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Fig. 1: Example time series of UFP counts during an 8 hour work shift (including lunchtime)

- Overall correlation $R^2=0.83$ (comparison of 2300 one-minute means over 5 work shifts)
- P-TRAK particle number counts are 25% to 40% lower than the miniDiSC counts (work shift means)

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Fig. 2: Scatterplot of UFP counts during 5 work shifts

- P-TRAK shows significantly lower UFP counts with decreasing mean particle size

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Fig. 3: ratio P-TRAK / miniDiSC as a function of the mean particle size measured by the miniDiSC

(preliminary data – not yet audited for quality)

Conclusions

- UFP counts of both devices show very high correlation
- P-TRAK number counts are lower than miniDiSC counts
- P-TRAK underestimates particle number with decreasing particle diameter

Outlook

- Comparison of both devices with the particle size distribution measured by an independent SMPS

Reference

- Schmid et al.: Dosimetry and toxicology of inhaled ultrafine particles. Biomarkers 2009, 14 Suppl 1:67-73.