In-Car Filter Efficiency of HVAC Systems with real Ambient Aerosols in Beijing

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Keywords: in-car filter efficiencies, HVAC, aerosol instrumentation, urban aerosols, ultrafine particles

Introduction

As part of new automobile developments and driven by the awareness of people regarding the high pollution level of PM and ultrafine particles in cities, in-car filter efficiencies are of increasing interest. Audi AG together with Grimm Aerosol Technik GmbH and the Laboratory for Environmental Measurement Techniques at Duesseldorf University of Applied Sciences carried out a measurement campaign at Beijing in march, 2015. For the first time car filter efficiencies have been investigated with real urban aerosols under different air pollution levels and different settings of the heating ventilation air conditioning system (HVAC).

Objectives

The main objectives of the campaign were the determination and comparison of in-car filter efficiencies of different car segments for mass fractions as PM10, PM2.5 and PM1 but also for different particle sizes. The comparison should result in valuable and useful information about the filter efficiencies for real urban aerosols depending on different set-ups of the HVAC system as airflow, air conditioning and ionization, the status of the filter (new-used), the driving conditions (dynamic-static) and last but not least depending on the pollution level of particles outside the car.

Instrumentation and set-up

The instrumentation were aerosol spectrometers of GRIMM, a wide range aerosol spectrometer (MINI-WRAS) for particle size distributions between 10 nm and 35 µm in 41 sizes channels and two optical particle counters (OPC) measuring particles from 250 nm to 35 µm. Figure 1 shows the set-up of the two OPC outside and inside the car.

Figure 1: Setup of devcices

Measurement results

Over 100 measurement cycles with cars of three manufactures (Audi, BMW, Mercedes) and different segments have been carried out. For comparable results always cars of similar segments were investigated during one measurement cycle. Figure 2 shows filter efficiencies for segment B. Settings of the HVAC were the same for all cars during one cycle, in this case fresh air flow. Strong differences of in-car filter efficiencies for PM10, PM2.5 and PM1 were measured.

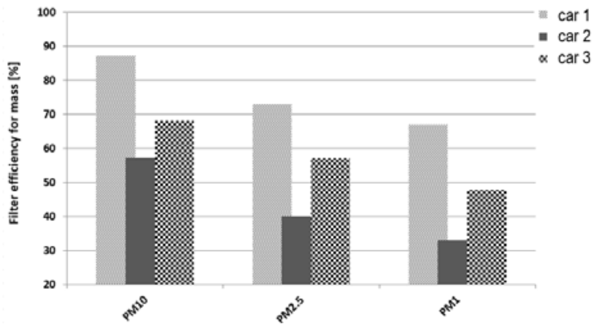

Figure 2: In-car filter efficiencies for PM10, PM2.5 and PM1 (fresh and low air flow)

Fresh air flow caused most often significant higher particle concentrations in comparison to recirculating air flow. In the best car of segment B (figure 3, solid curve) as an example, the particle number concentration strongly decreased from approx. 45000 P/cm³ outside to 140 P/cm³ inside. PM10 also decreased from 195 µg/m³ to 0,5 µg/m³. The low values are close to the detection limit of the devices.

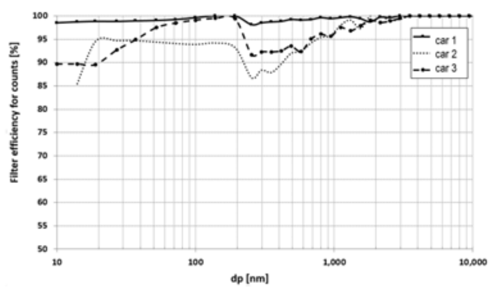

Figure 3: In-car filter efficiencies (recirculated air flow)

Conclusions

Significant differences have been observed between cars of different manufactorers and different set-ups of the HVAC. Recirculating air flows have often shown lower particle mass and particle number concentrations inside the car in comparison to fresh air flows.

An automatic control of the HVAC system depending on onbord measurements of real aerosol concentrations outside and inside the car should be a major objective for future automotive developments.