University of Applied Sciences
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IC-Engines and Exhaust Gas Control

Effects of Cabin Filter on Ultrafine Particle Concentrations inside Passenger Cars

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Introduction

Vehicle emissions that include particles and harmful gases negatively influence the cardiovascular, respiratory and immune systems, thus increasing the risk of stroke and cancer. Ultrafine particles (UFP) were found to be penetrating through the blood cells into the human brain, liver etc. with respective negative health effects.

UFP after being emitted from the vehicle's exhaust system remain in the air and enter the vehicles cabin, thus exposing the driver and the passengers.

Objectives

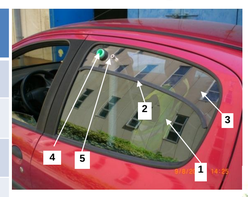
Study of UFP in-cabin concentrations in vehicles of various makes under different ventilation conditions and different initial UFP concentrations in the vehicle cabin.

Assessment of cabin filter effects on UFP concentrations inside a vehicle

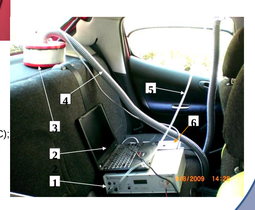
Methodology

- Measurements without an OEM air filter, with genuine OEM-made filters of different types and a non-OEM air filter, influence of a retrofit high efficiency particle air filter .
- Effects of: ventilation mode, fan speed, outside UFP concentrations, vehicle age, initial UFP concentrations in the vehicle cabin, etc.
- UFP measurement –with DiSC type measuring device

Vehicle	Body Style	Cabin Volume, m^3	Air Filter
New Vehicle 1	Hackback	2.568	Yes, OEM
	Station Wagon	2.718	Yes, OEM
New Vehicle 2	Hackback	2.633	Yes, OEM
New Vehicle 2	Hackback	2.633	Yes,non-OEM
New Vehicle 3	Hackback	2.490	Yes,OEM
New Vehicle 4	Sedan	2.893	Yes, low efficiency
Old Vehicle	Sedan	~ 2.5	Without any filter

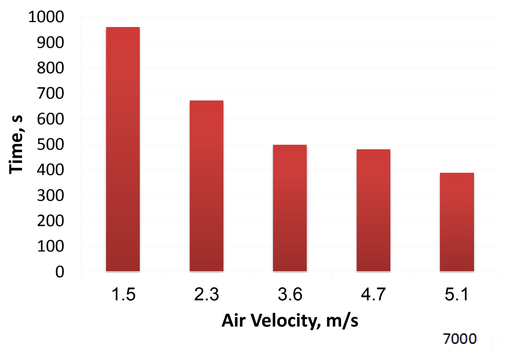


1 – vehicle original window;
2 – seal;
3 – insertion window;
4 – air inlet to in-cabin air purifier;
5 – air inlet DiSC



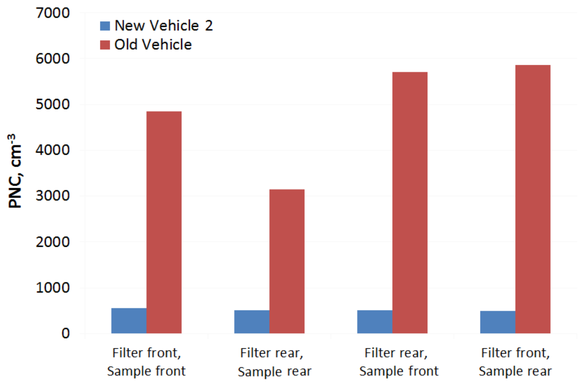
1 – diffusion size classifier (DiSC);
2 – laptop with DiSC software;
3 – in-cabin air purifier;
4 – air purifier inlet line;
5 – DiSC sample line;
6 – air purifier control unit.

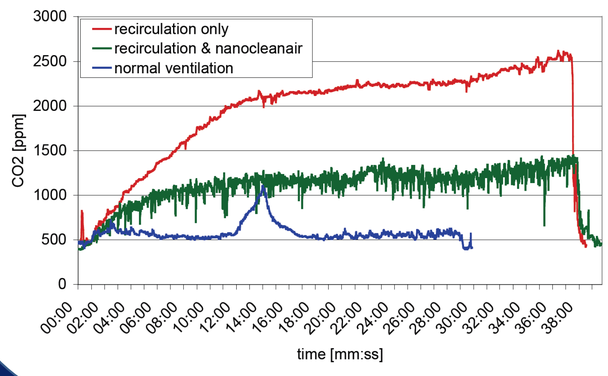
Results



Time to reach 4000 cm^{-3} (clean-office value) of UFP concentrations from an initial value of 90000 cm^{-3} for various speeds of the air exiting the ventilation channel

Comparison of UFP steady-state number concentrations between the new and old vehicle at various sampling locations. Measurements with a retrofit HEPA filter

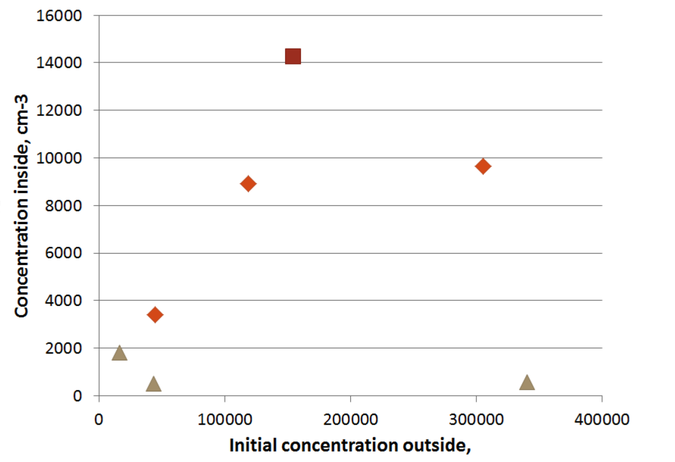


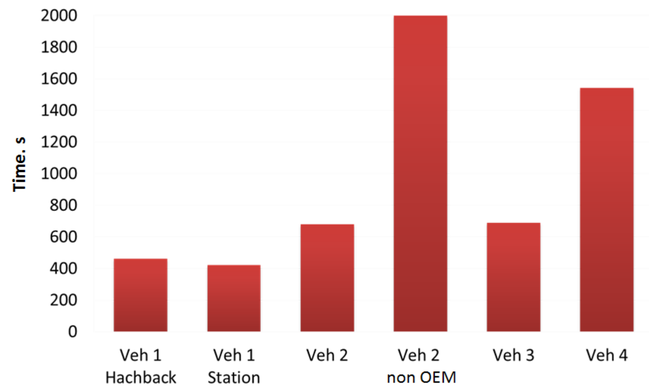


CO_2 concentration outside and inside the cabin with different ventilation modes.

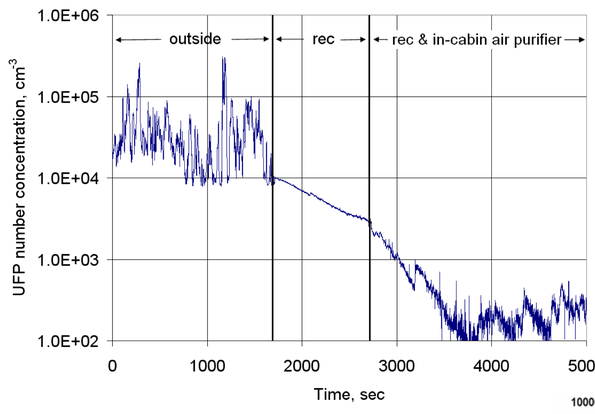
Results (Continuation)

UFP levels when the critical value of CO_2 (1500 ppm) is reached inside the cabin.



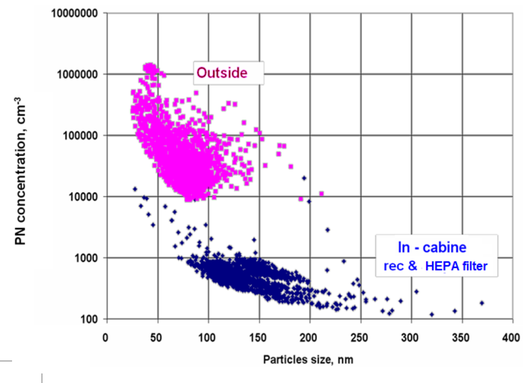


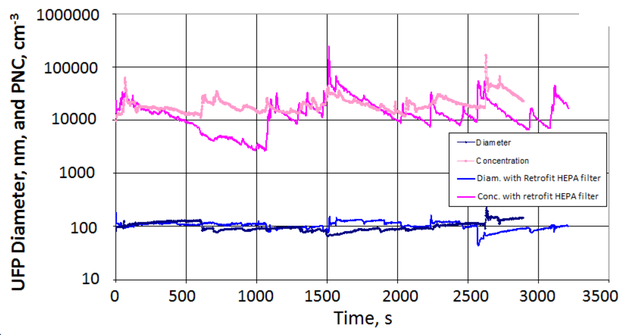
Time to reduce the concentration from 100000 to 4000 UFP per cm^3 for different vehicle types and sizes



UFP concentration outside and inside the cabin, with AC in recirculating mode and after starting the-retrofit HEPA filter

Example of UFP size and nr. concentration measured outside and inside a vehicle's cabin with the retrofit HEPA filter functioning





Effects of in-cabin retrofit HEPA filter, inside a shuttle taxi that frequently opens its door for passengers

Conclusions

- The age of the car has an influence on the in-cabin UFP concentration.
- Increasing the ventilation intensity from 1.5 to 3.6 m/s significantly reduces the exposure time to high UFP concentrations.
- Application of the retrofit HEPA filter allowed a further reduction in the UFP number concentrations inside a car. In average, 17-20 min is required to achieve the maximal cleaning effect.
- Using the AC in the recirculation mode may result in increasing the CO_2 concentration to unacceptable levels.
- To achieve maximal efficiency of the cabin air filter, its size and design should be adapted to the vehicle type and its usage pattern.

Acknowledgements

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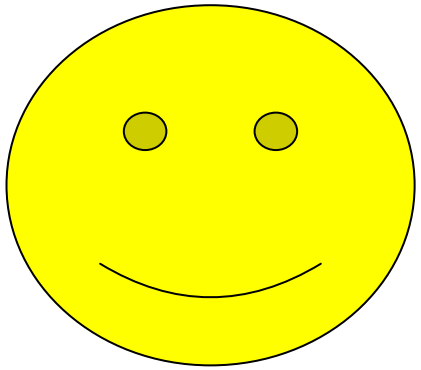
Index



Contents