Effects of Various Car Ventilation Settings on Size Distribution and Lung Deposition of Ultrafine Particles

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The objective of this study was to find the effects various air ventilation settings have on ultrafine particle burden inside the passenger cabin of a car. Measurements were taken while driving through a 3.4 km long highway tunnel system consisting of two separate sections. The data obtained were then applied to a lung deposition model, to observe which effects the different ventilation settings have on passengers inside the car.

Measurements took place on several days during the week and on weekends. The sampling campaign involved a BMW (330 D Touring), operating at three different ventilation settings: (1) ventilated air [VA], (2) recirculating air [RCA] and (3) recirculating air with air-condition [RCA/AC]. In addition, the tunnel air [TA] was sampled as a reference to determine the filter efficiency of the built-in particle filter within the ventilation system.

On all measurement days, the VA setting showed a strong filtering effect on the air being brought into the passenger cabin from the tunnel, with a further significant reduction in the particle burden by applying the RCA setting.

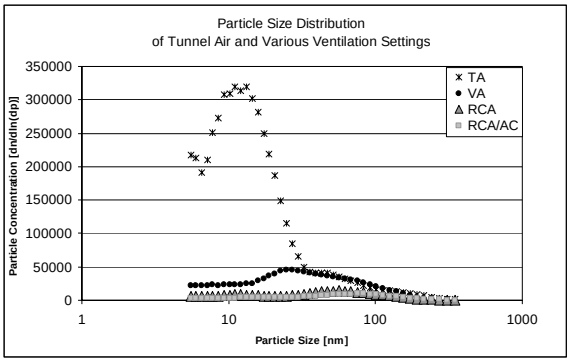

Figure 1. Particle distribution of tunnel air (outside) and inside the car using various ventilation settings

The RCA setting reduces the amount of ultrafine particles by about 5 times compared to the amount of the VA setting, particularly in the size range of 5–40 nm. This factor decreases with particle size to a factor of 2 at the larger end of the sampled size range. Applying the RCA/AC reduces the particle burden by another 50% compared to RCA in the same size range. This difference also decreases with particle size and is not existent anymore at a particle size of 100 nm.

While it is clear that the reduction in particle concentration in the VA and RCA setting is a result of fewer aerosols entering the car, the RCA/AC setting does influence the particle concentration in some other way. It is likely that condensation and coagulation processes take place, supported by changes in temperature and humidity as a result of conditioned air (Ashgarian, 2004). The apparent drop in the particle burden starting at around 300 nm is caused by the fact that fresh vehicle exhaust emits only few particles in this size range (Imhof et al.,2005).

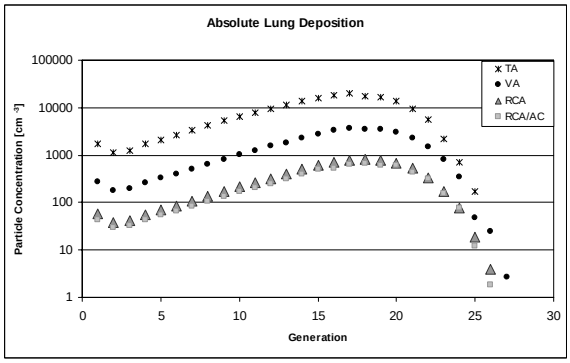

Figure 2. Predicted total lung deposition of tunnel air and cabin air using various ventilation settings

Applying the data to the lung deposition model shows a deposition peak past the 15th generation for all ventilation settings. This alveolar deposition is common for hydrophobic particles such as urban traffic exhausts. It has been proposed that alveolar deposition is associated with increased cardio-circulatory problems, as the immune system is the primary organ to remove entrapped particles (Donaldson et al., 1988). Therefore, our observations suggest the usage of the recirculating air setting when driving through poorly ventilated systems to reduce the inhalation burden of ultrafine particles on car passengers.

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