

## Particles from road traffic - emission trends, reduction measures and contribution to ambient particle concentrations

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When talking about particulate air pollution, vehicle emissions, in particular those from diesel engines, are an important topic. The contribution of different engine types (spark ignition-, direct injection spark ignition-, diesel engines) is very different. Gasoline engines have considerable emissions during acceleration phases, but not during steady state operation, even at high speed and load. Due to their higher efficiency direct injection gasoline engines (lean engines) have been introduced in the past years. However, the reduction of fuel consumption is accompanied by a significant increase in particle emissions, in particular in low load conditions. Emissions from diesel engines depend on engine speed and load and may be high also under steady state operating conditions. The influence of operating conditions for the different engine types will be discussed.

Great effort has been taken to reduce gaseous and particulate vehicle emissions. This is done on the one hand by an optimization of the combustion process. In the case of diesel engines as main particle emitters means therefore are increased injection pressure, multiple injection, exhaust gas recirculation, improvement of fuel (mainly lower sulfur content) and lubricant oil. These measures allowed to reduce the total particle mass emissions significantly. However, the number concentration of the particles remained fairly constant. The main effect of optimization is a shift of the particle size distribution to smaller sizes.

Besides engine optimization aftertreatment devices as catalysts and particle traps are applied. Traps allow a dramatic reduction of mass and number concentration. If efficient wall flow filters are used (as introduced for passenger cars by PSA some years ago) the number concentration can be reduced by two to three orders of magnitude. Meanwhile 'open filters' are applied by some manufactures. These filters are by far less efficient, usually less than 60%. As the traps collect the particles, they have to be regenerated from time to time by burning the soot, accumulated in the trap. The main role of catalysts is assisting this regeneration process.

Applying aftertreatment devices not only reduces particle mass- or number concentration, but also changes the nature of the particles. The volatile fraction passes a particle trap in the gas phase, whereas the solid material is precipitated. For an effi-

cient trap this means that downstream the trap mainly volatile material remains, which may nucleate and form new particles when cooling down (Burtscher, 2005). Catalytically active devices may oxidize SO<sub>2</sub> and other species, which again increases the probability of nucleation. If nucleation occurs, the number concentration may be dominated by particles in the nucleation mode, which mainly consist of volatile material (sulfur compounds and hydrocarbons). An undesired side effect of catalysts may be the formation of NO<sub>2</sub> from NO which increases the emission of the more toxic NO<sub>2</sub>.

Most results for vehicle emissions are obtained from engine test bench and chassis dynamometer measurements of more or less well tuned and maintained engines. Not so many results from field measurements are available. However, there is strong evidence that few very high emitters (super-polluters) are responsible for a considerable part of the total emissions. The conclusion of a recent study by Kurniawan & Schmidt-Ott (2006) is that about 5% of (old or malfunctioning) cars cause 40% of particle emissions. An efficient measure to reduce total emissions would therefore be detecting and repairing these superpolluters.

Current legislation for emissions and ambient air particle concentrations only limits the total mass. As particles emitted by vehicles are very small, their contribution to PM<sub>10</sub> is small. Even in areas with high pollution, the contribution of vehicle emissions to PM<sub>10</sub> is only about 20%, but 50% to PM<sub>0.1</sub>. A study by Imhof et al. (2007) shows that the daily variation of PM<sub>10</sub> close to a road with heavy traffic is merely related to traffic density, whereas the number concentration shows a strong correlation. On the other hand in particular ultrafine particles from combustion are considered to cause severe health effects. This lead to a very controverse discussion on the relevance of vehicle emissions for the ambient air particle pollution on the one hand and what the appropriate metric is on the other hand. Recent suggestions for new European limits include a limitation of the number concentration of solid particles in addition to the existing mass limits.

Burtscher, H. (2005) *J. Aerosol. Sci.* 36, 896-932.

Imhof, D. (2007) Personal communication

Kurniawan, A., & Schmidt-Ott, A. (2006) *Environ. Sci. Technol.* 40, 1911-1915.