Comprehensive investigation on the effect of different brake profiles and temperature on the brake wear particle emissions

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In the last years, particulate matter (PM) emissions from the vehicles have been correlated to the engine exhaust. However, in recent years, the use of even more efficient after-treatment systems and of low/free-carbon fuels as well as the wide spreading of the hybridization of the vehicles have driven down the particle emissions from the internal combustion engines giving more importance to other PM vehicle sources such as the brake and tyre wear debris.
Particles emitted from exhaust (EP) are localized and can be easily collected through a dilution tunnel connected to a sampling system. On the other hand, the measure of brake and tyre wear particles, known as non-exhaust particles (NEP) is more complex since the pathways by which the particles reach the environment are more extended.
Several numerical and experimental studies have been carried out on NEP. Anyway, the results reported in the literature are not consistent and are often difficult to compare because of the different test methodologies, measurement techniques and sampling procedures. In addition, the driving conditions also have a great influence on the extent and characteristics of brake particles.
With regards to the brake particles, they are mainly due to abrasion processes occurring during typical driving conditions and resulting in micron size particles. Moreover, in strong braking conditions, the rising of temperature can pyrolytically generate sub-micron particles.
The aim of this study is to evaluate the effect of different brake profiles and the temperature on the particle number and size. The investigation was performed on a commercial brake typically mounted on light-duty vehicles to which a braking torque has been applied according to a speed profile typical of urban driving conditions. Test were carried out with two different layouts. An open system was realized to simulate conditions as similar as possible to the real ones. A box that contains the brake was also designed to reduce the dispersion of particles in the environment thus improving the reproducibility of the measurements. An EEPS and an OPS were used to measure the particles in the size range from 5.6 nm to 10 µm. The disk temperature was measured by means of an InfraRed camera. The results highlighted that the brake wear particles range between 30 nm and 10 µm. They show a bimodal distribution with a first peak at around 30 nm and a second one at 200 nm. The particle concentration is affected by the brake profile, stronger the braking event, higher the particle emissions. Analogously, the particle number increase with the temperature. No significant difference in the particle size were instead observed between the different test conditions.

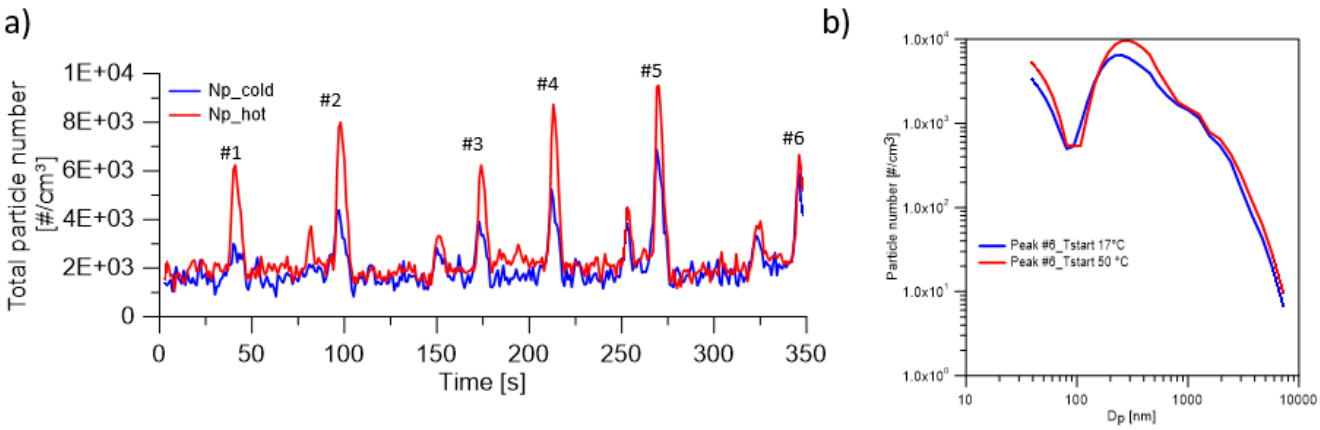

Figure 1.a) Prticle concentration and b) PSD due to the brake wear at two different disk temperatures.

[1] Maricq MM. Engine, aftertreatment, fuel quality and non-tailpipe achievements to lower gasoline vehicle PM emissions: Literature review and future prospects. Sci Total Environ 2023;866:161225. https://doi.org/10.1016/j.scitotenv.2022.161225.

[2] Grigoratos T, Mamakos A, Arndt M, Lugovyy D, Anderson R, Hafenmayer C, et al. Characterization of Particle Number Setups for Measuring Brake Particle Emissions and Comparison with Exhaust Setups. Atmosphere (Basel) 2023;14. https://doi.org/10.3390/atmos14010103.