

Brake Wear Emission Measurements

ELPI[®]+ systems use one measurement method and one instrument throughout the complete size range

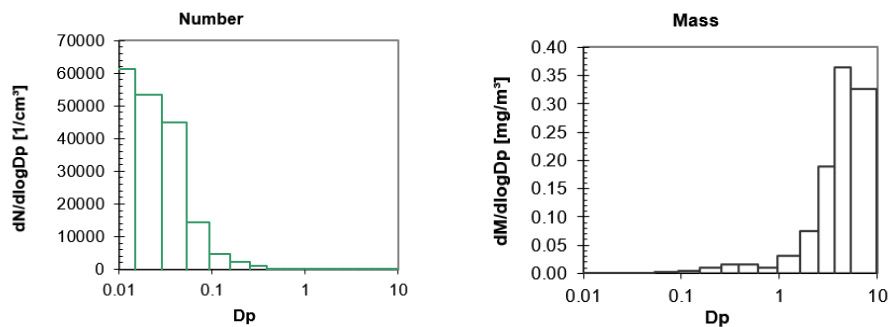


ELPI[®]+ and High Resolution ELPI[®]+

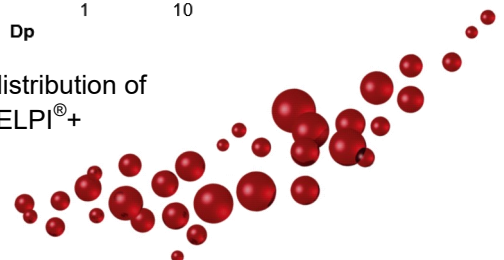
- Particle concentration
- Particle size distribution
- Up to 500 size fractions
- 6 nm - 10 μm
- Up to 10 Hz real time data
- Particle collection for further analysis
- Long term measurements with minimum down time

As exhaust emissions from engine tailpipe have been decreasing in recent years through development of engines and exhaust after-treatment systems, non-exhaust emissions have become a major contributor to total particle emissions from vehicles. Non-exhaust emissions have been estimated to contribute to almost 50 % of total PM_{2.5} and PM₁₀ emissions from vehicles and one of the main sources of non-exhaust emissions is particles emitted from brake wear. Particle emissions from the brakes not only affect air quality and human health but can also have effect on operation and safety of the brakes themselves.

Typical braking system is based on friction between a disc and brake pads. The frictional contact between the disc and the pad generates particles of various sizes and wears off the brakes so that they need to be replaced periodically. Braking is a very dynamic and fast process with many contributing factors such as duration and force of the braking which both have effect on heat generation and therefore temperature of the brakes. All these factors influence the size and concentration of the emitted particles. Mechanical abrasion generates mostly micron-sized (typically > 1 μm) particles but emissions typically also include nucleation particles from volatile matter, typically 10 - 200 nm. Since the particle emissions from the brake wear are formed through different mechanisms and contain particles of various sizes, an instrument with a very wide particle size range is needed to accurately characterize these emissions.

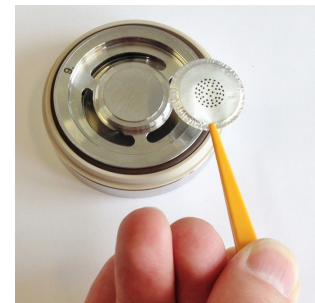
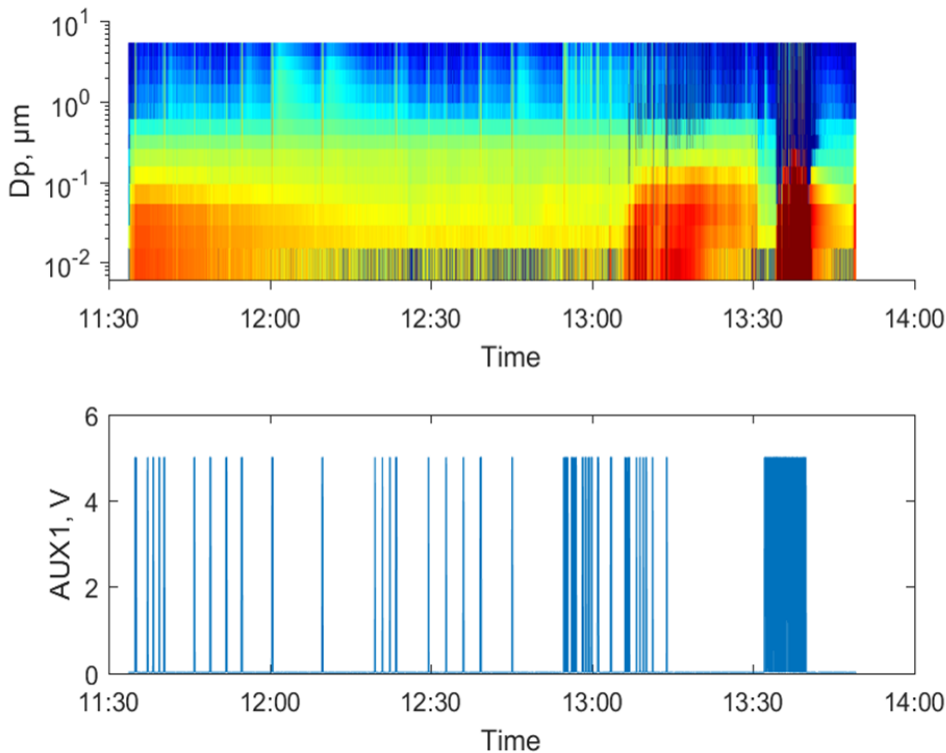


Particle number size (left) and mass size (right) distribution of brake wear emission measurements using ELPI[®]+



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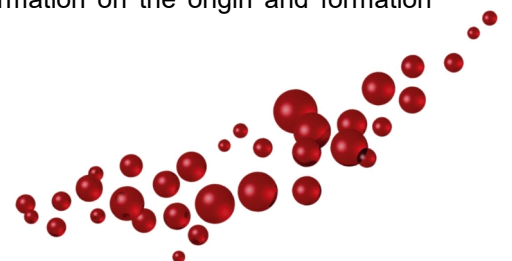
Dekati[®] ELPI[®] and Dekati[®] High Resolution ELPI[®] are unique instruments ideal for brake wear emission measurements. Both instruments can measure particle size distribution between 6 nm and 10 μm in real-time covering the complete size range needed to characterize brake wear emissions. The ELPI[®] systems use one measurement method and one instrument throughout the complete size range eliminating the need for complicated calculation routines needed to combine data from several different instruments into one size distribution result. The ELPI[®] instruments additionally collect the particles in 14 size fractions during the real-time measurement; these collected particles can be analyzed after the real-time measurement with different chemical or physical analysis methods to gain further understanding on the composition and source of the particles in different size fractions.



Particles in 14 size fractions can be analysed after the real-time measurement

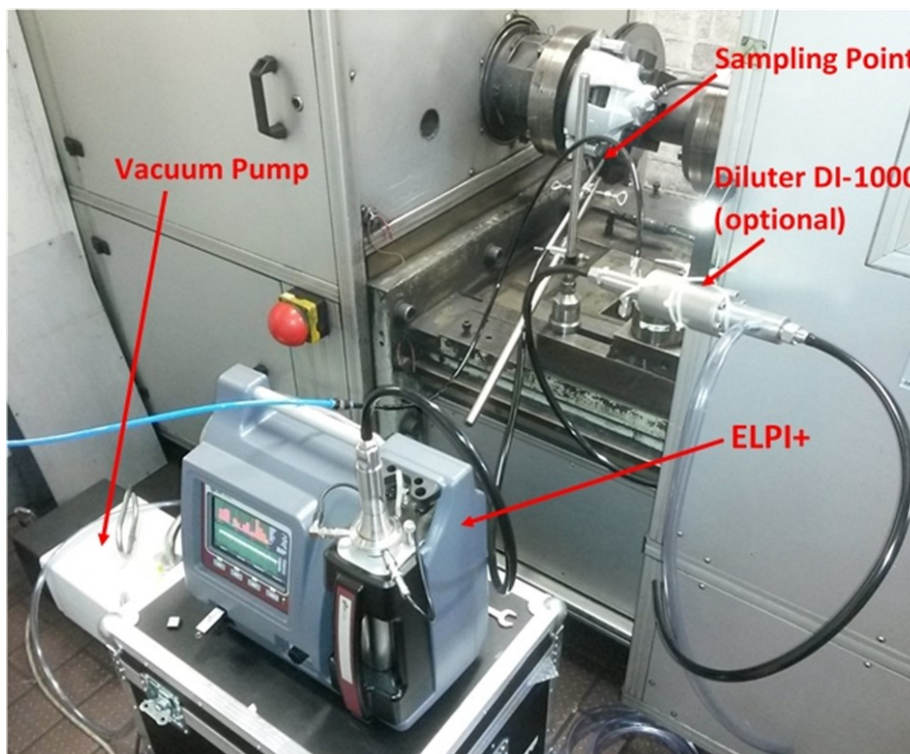
Particle size and concentration measured by ELPI[®] above and braking pattern in the figure below

As can be seen from the figures above, mainly large particles (1 - 10 μm) are generated during braking. When there are several braking episodes or high energy deceleration, temperature increases in the disc and pads and also small nucleation particles (6 - 200 nm) are formed. Particles with different size can have different origin and particle composition analysis gives valuable information on the origin and formation mechanisms of the particles.



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The wide particle size range of brake wear emissions can also be a challenge to sample conditioning systems. The sample conditioning and dilution system needs to be designed so that particle losses through diffusion, impaction, gravitation and electrostatic phenomena are minimized. A commonly used dilution system in brake wear measurements is e.g. the Dekati[®] ejector Diluter with dilution factors between 1:8 and 1:100 available. Dekati also provides several other suitable sample conditioning systems for brake wear emission measurements including customized solutions that fulfill specific requirements of different measurement locations. Combined with the ELPI[®]+ products, we're able to provide a complete and accurate measurement solution for brake-wear emission characterization.



Real time particle size and mass concentration measurement setup using ELPI[®]+ and optional Dekati[®] ejection Diluter (DI-1000)



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