# Particles Emitted During Braking-A preliminary study

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## INTRODUCTION

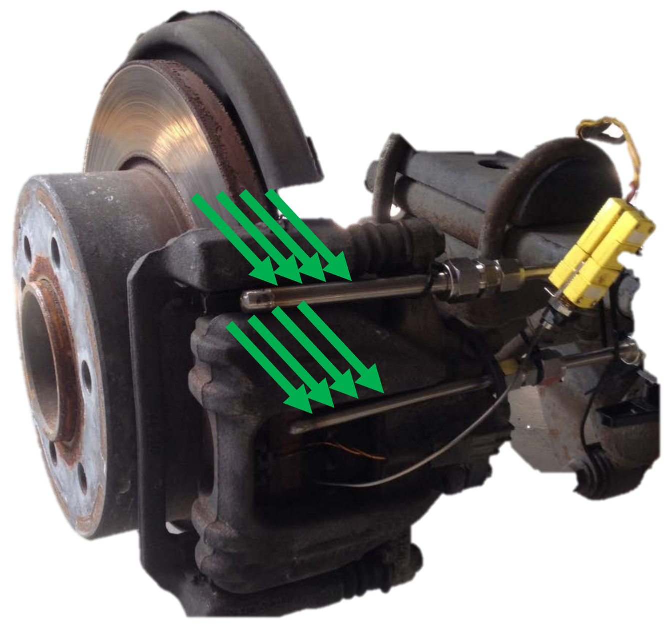
One of the most important non-exhaust traffic-related source is considered to be brake wear, with studies at urban environments reporting contribution to non-exhaust traffic-related PM10 emissions up to 55% by mass (*) and to total traffic-related PM10 emissions up to 21 % by mass (**)

The objective of this work is to initiate research at our laboratory on the assessment and characterizations of particle emissions from brake wear. To this end measurement campaigns with a vehicle (Mobile Laboratory, MOBILAB) running on a chassis dynamometer. were realized. Brake particle emissions were measured by employing a custom sampling arrangement, with two sampling points, at the front and rear sides of the brake pad / brake caliper system. A CPC and an ELPI was used to obtain particle concentrations and size distributions. Measurements were conducted at JRCs VELA 2 chassis dyno. A preliminary assessment of the data indicates that there are distinct emission events of nanoparticles during braking. A parametric study is underway but it is already evident that brake wear particles can be assessed and differentiated.


## Methods-Results

### Custom Sampling System

The sampling system consisted of two ¼'' stainless steel tubes connected together with a T-connector at one end towards the measurement equipment. At the other end, 4x2mm holes were drilled along the length of each tube, facing towards the brake pad/disc through the slots of the caliper. A thermocouple was installed within the brake pad material by means of a small drilled hole.

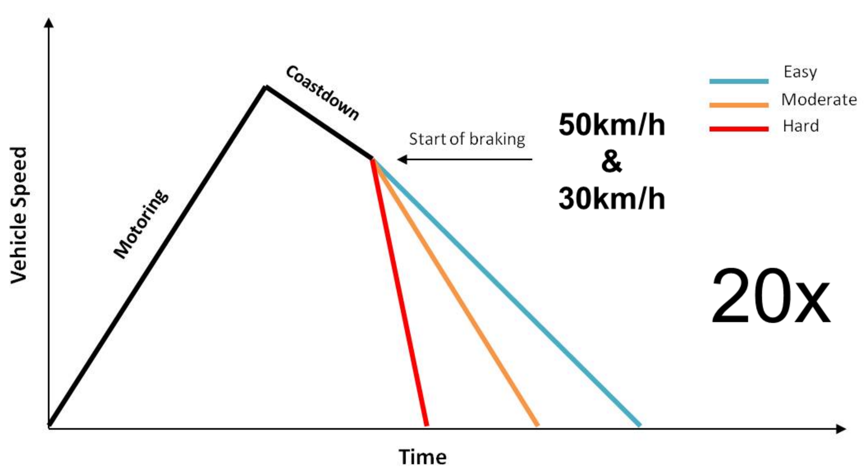


### Apparatus

- TSI CPC 3775 (4nm - >3μm)
- DEKATI ELPI (63nm - 10μm)
- OBD reader for data acquisition of Brake Hydraulic Pressure and Wheel Speed.
- Thermocouple for Brake Pad Temperature.

### Testing

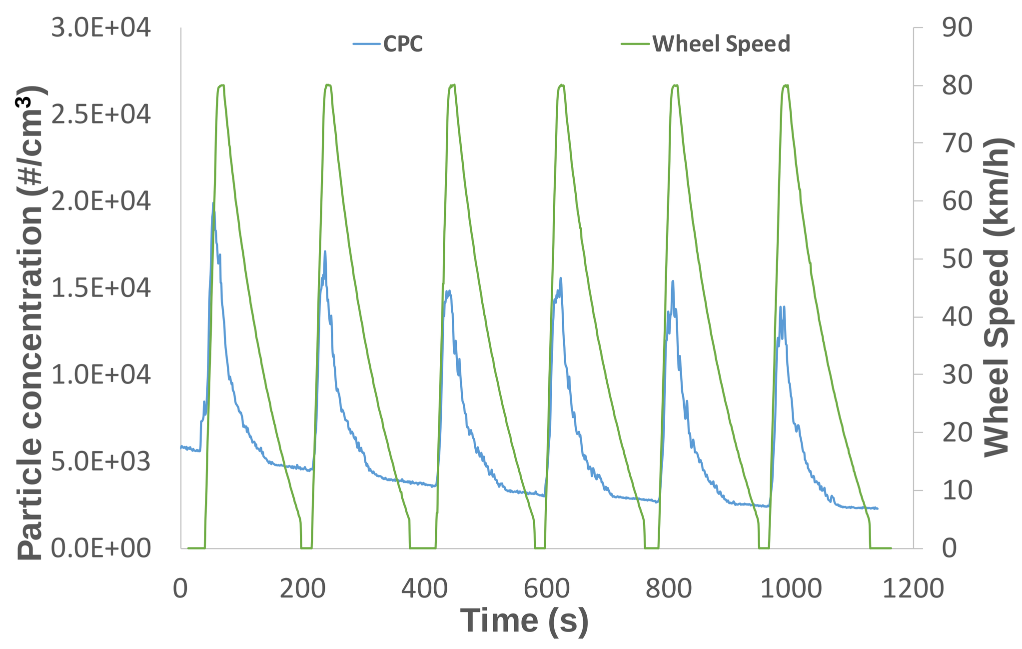
The chassis dyno testing consisted of 20 identical braking events within a test cycle. In total 6 different test cycles were done at 2 vehicle speeds 50 & 30 km/h (start of braking), and 3 deceleration rates (0.5, 1.5 and 2.5m/s$^2$). A Background cycle was run without braking, only with the acceleration and the coastdown part. Test cycle #5 and #6 were repeated at lower ambient temperatures 15C and 0C.
JRCs Real braking Driving cycle was run at 3 ambient temperatures 25C, 15C and 0C to




| Test cycle (#) | Start of braking speed (km/h) | Deceleration (m/s$^2$) | Ambient Temperature (C ) |
|---|---|---|---|
| 1 | 50 | 0.5 | 25 |
| 2 | 30 | 0.5 | 25 |
| 3 | 50 | 1.5 | 25 |
| 4 | 30 | 1.5 | 25 |
| 5 | 50 | 2.5 | 25, 15, 0 |
| 6 | 30 | 2.5 | 25 ,15, 0 |
| BACKGROUND | Run cycles without braking | 0 | 25 |

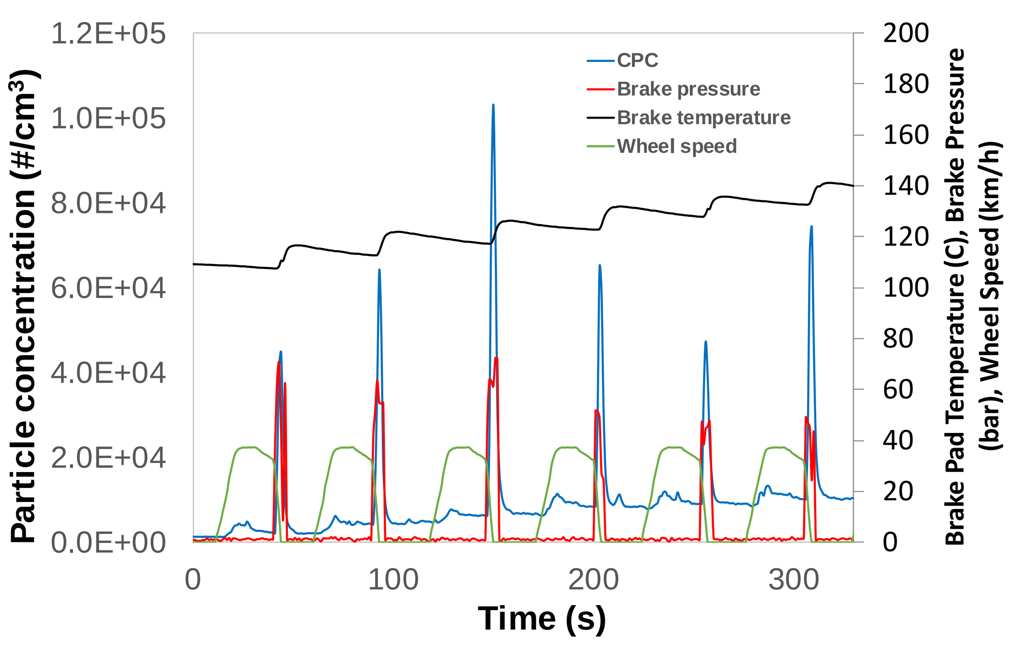
### Test Cycle Background Particles measurement

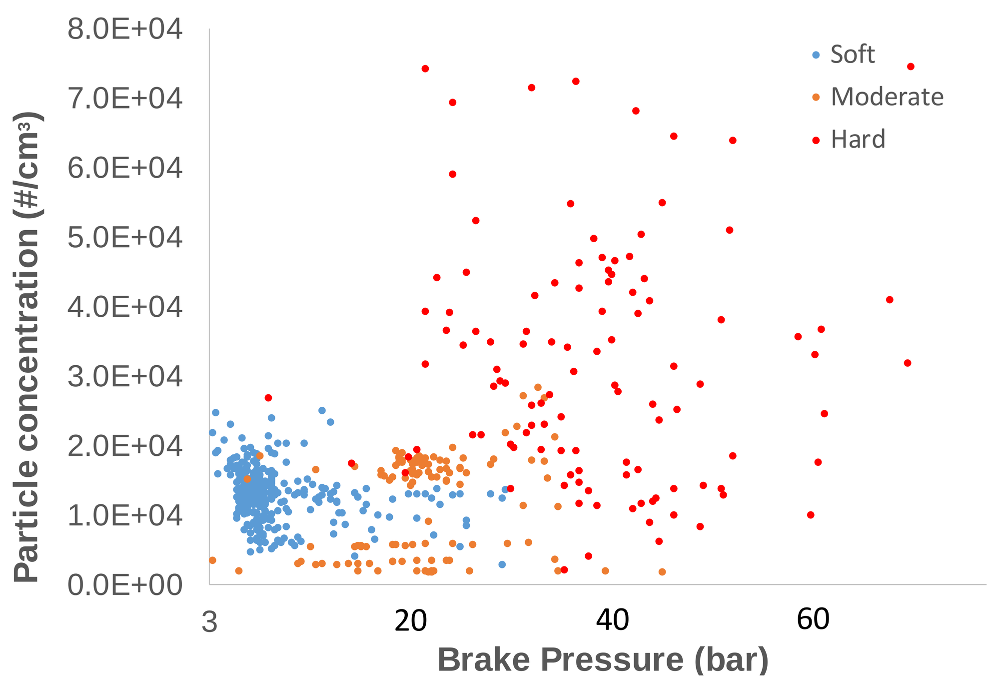
The background particle test cycle was done in order to investigate whether particles are emitted beside the braking event, like tyre particles and resuspended braking particles. The background cycle from 50-0km/h showed particles at the acceleration part, which is a strong indication of tyre particles. For this reason test cycles (#1, #3, #5) are further investigated and not shown here.

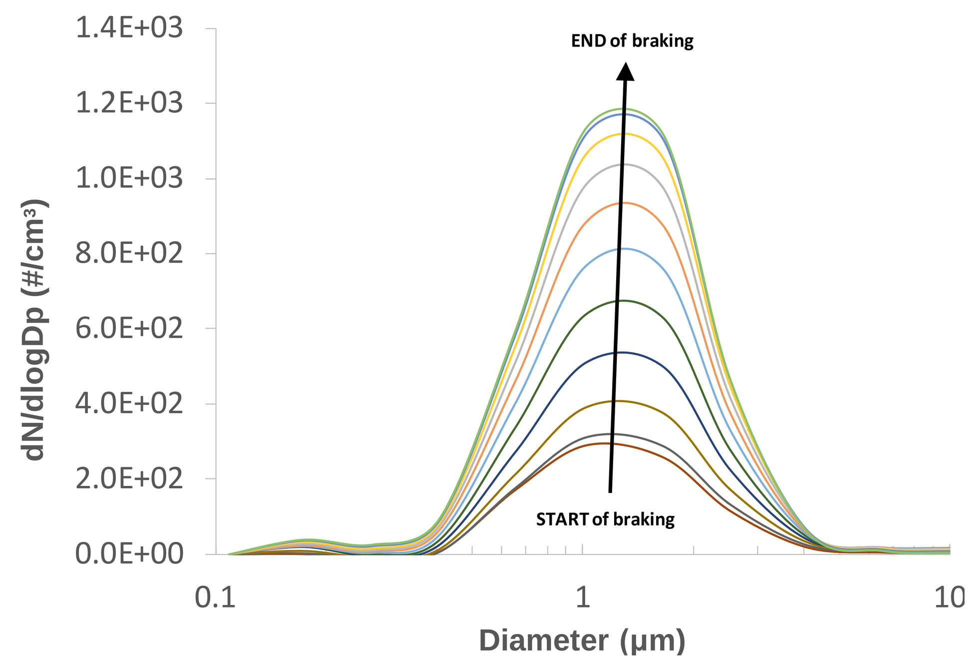



### Results

Results show distinct peaks at the braking event. Correlation of particle number concentration versus brake pressure for the three braking rates at 30-0km/h indicates increased particles emitted at harder braking. The mean aerodynamic diameter of the braking particles emitted is approximately 1μm and has no shift during the braking event.

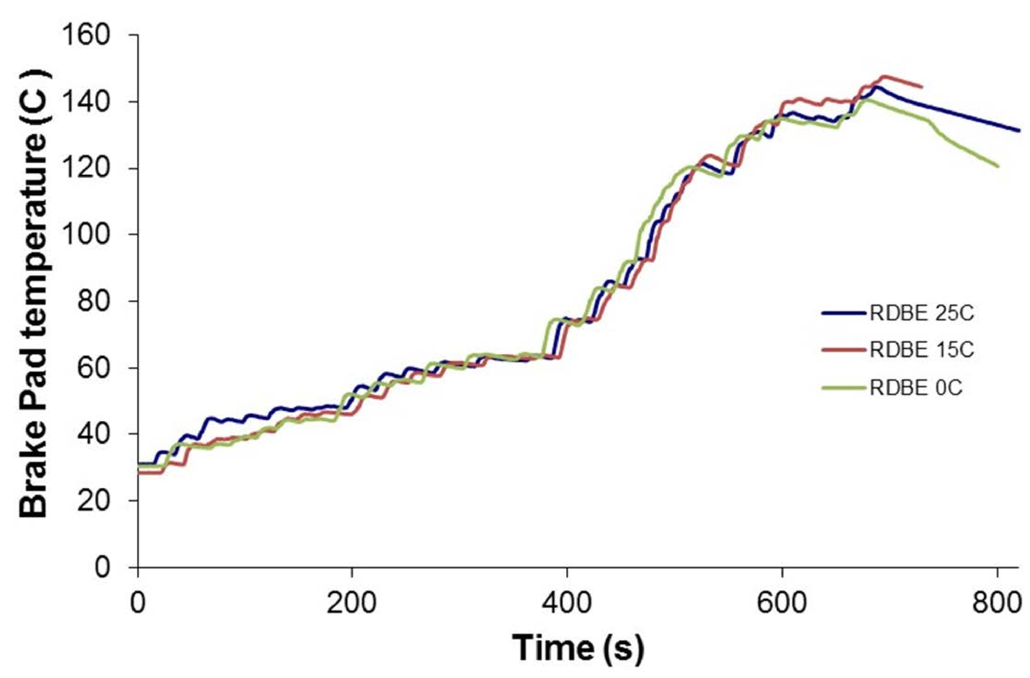



### RDBE at different ambient temperatures

Ambient temperature has no significant effect on the brake pad temperature rise during the RDBE cycle.




## FUTURE WORK

- Chemical and surface analysis of new and worn brake pad material
- Study with more detail the particles emitted at the test cycles braking from 50-0km/h

## REFERENCES

* Harisson et.al 2012
** Bukowiecki et.al 2009a;Gasser et.al 2009;Lawrence et.al 2013

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