First Results of Vehicle Technology Effects on Sub-23 nm Exhaust Particle Number Emissions Using the **DownToTen** Sampling and Measurement System

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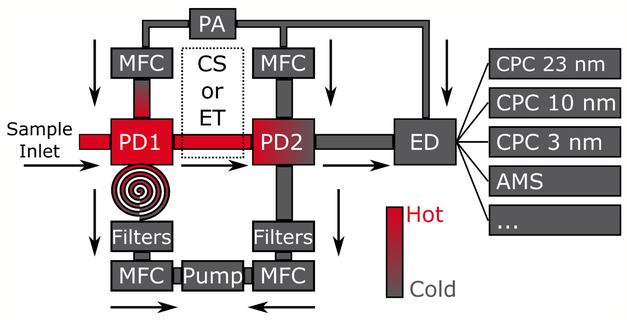
Introduction

Modern and near-future combustion engine vehicle technologies may emit notable levels of particles below the current particle size threshold (23 nm) of the European Particle Number (PN) emission standards. Studies suggest that sub-23 nm particles might be even more harmful to humans than larger particles. The Horizon 2020 funded project **DownToTen** (**DTT**) is developing a sampling and measurement methodology to characterize exhaust aerosol emissions down to at least ten nanometers. Laboratory experiments challenging different dilution and exhaust conditioning technologies with sub-23 nm particles revealed the most suitable components for a **DownToTen** sampling and measurement system.

This study presents the first prototype of a Portable Exhaust Particle Sampling system (PEPS) developed in the framework of the project together with preliminary results from the assessment of different vehicle technologies.

Sampling System

The performance of the double porous tube **DTT** PEPS was assessed in comparison to commercial regulation compliant sampling systems. It exhibited an excellent linear correlation with commercial systems. It met the requirements for Constant Volume Sampling (CVS)-based PN sampling, while also enabling measurement of sub-23 nm particles with low losses. Preliminary tailpipe measurements indicated the suitability of PEPS for Real Driving Emissions (RDE) measurements.



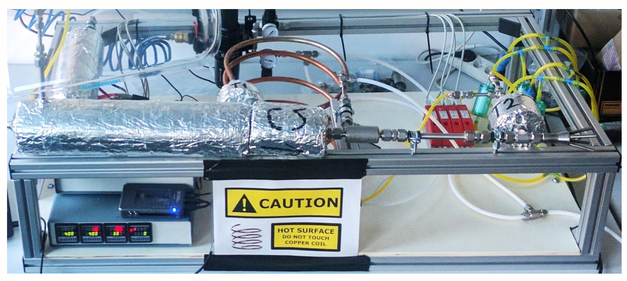


***Figure 1**: Schematic (top) and photo (bottom) of the **DownToTen** prototype of a portable exhaust particle sampling system .*

Results

In **standard cycles**, the majority of emissions below Euro 6c limit value ($6\text{x}10^{11}\,\frac{\#}{\text{km}}$) for PN > 7 nm.

Cycles containing **DPF** (**D**iesel **P**articulate **F**ilter) **regenerations** showed elevated PN emissions, exceeding the limit value up to a factor of 100 temporarily (Figure 2).

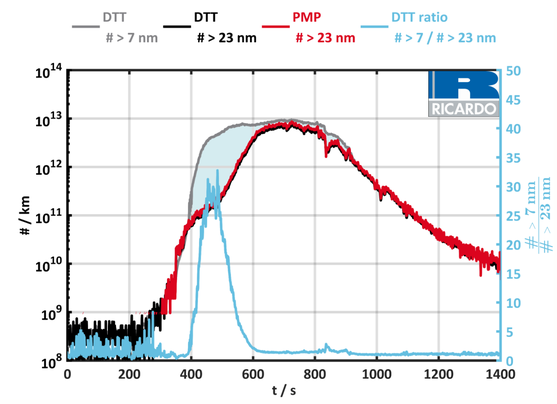


***Figure 2**: Emissions of particles measured with different sampling and measurement systems during a user-triggered DPF regeneration at a 100 kph cruise. The data shown in this figure was measured and processed by Ricardo UK Ltd.*

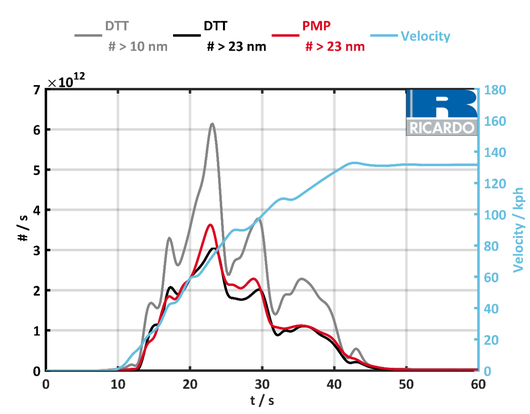


***Figure 3**: Particle emissions during a harsh acceleration of a three way catalyst equipped Gasoline Direct Injection (GDI) vehicle. The data shown in this figure was measured and processed by Ricardo UK Ltd.*

Full load accelerations are substantial particle production events (Figure 3). PN > 10 nm emissions exceed $10^{12}\,\frac{\#}{\text{km}}$ for a period of one minute.

A **bimodal size distribution** was observed. It showed a minor mode peaking at 12 nm being responsible for substantial particle levels below 10 nm.

Particles <23 nm may be produced from SCR systems, possibly from over-dosing of aqueous reductant.

Conclusion

DTT PEPS showed a good performance in the currently effective >23 nm regime as well as the sub-23 nm regime, **DownToTen** shines light on.

Specific events, from both spark ignition and diesel vehicles, were shown to generate substantial levels of <23 nm emissions. However, if the frequency of these events is taken into account, levels of > 7 nm emissions fall below the Euro 6c limit value of $6\text{x}10^{11}\,\frac{\#}{\text{km}}$.

PROJECT PARTNERS

In collaboration with:

The University of California at Riverside

National Traffic Safety and Environmental Lab (Japan)

National Metrology Institute (Japan)

HORIZON 2020

Call: H2020-GV-2016-2017
Technologies for low emission light duty powertrains

Action:
"Measuring automotive exhaust particles down to 10 nanometres – DownToTen"