Second generation of Diffusion Size Classifier for Oncoming Motor Vehicle Regulations

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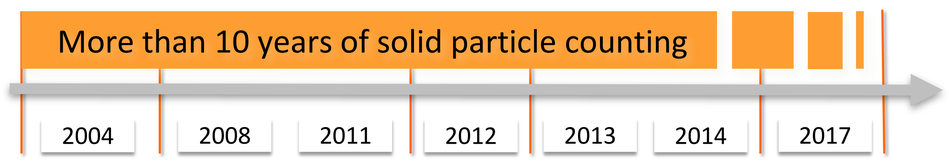
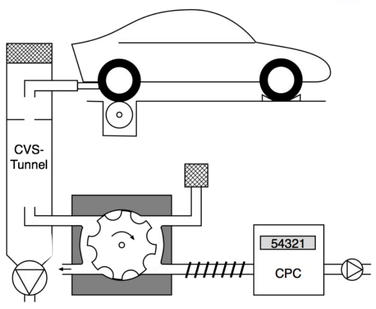
INTRODUCTION and MOTIVATION

With an eye on real driving measurements of ultrafine particles proposed in forthcoming European Emission Standards and periodic control on the field, Testo AG presents new portable emission measurement systems PEMS for solid nanoparticle counting and classification. This innovative instrumentation based on second generation of Diffusion Size Classifier DiSC technology measures particle number, average diameter and LDSA in a wide range under real world conditions.



- 2004 Matter delivers the Golden Instrument for the PMP tests
- 2011 Euro 5b PN for type approval diesel LDV
- 2012 WHO classified diesel soot as most dangerous pollutant
- 2013 PN in EU for type approval HDV,
  Swiss periodic control on field for construction machinery
  EU requests feasibility study of PEMS-PN for RDE
- 2014 Euro 6 for GDI LDV,
  Matter delivers the golden instrument for PEMS-PN,
  EU proposal of PN for type approval of NRMM
- 2017 RDE Real Driving Emissions within EURO 6c

PMP conditioning



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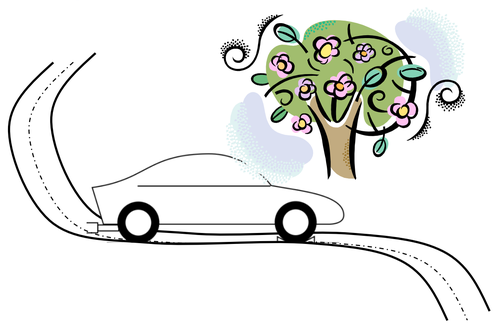
On-road measurements



PEMS-PN: testo NanoMet3

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Figure 1: NanoMet3, PEMS-Particle Number counter for oncoming legislation

MEASUREMENT METHOD

Post-dilution Thermo-conditioning

NanoMet3 separates sampling and conditioning of the aerosol. Conditioning of the raw gas is carried out according to PMP requirements:

1. Unique dilution of combustion engine emissions from tail pipe or CVS with a Rotating Disk Diluter. The dilution takes place in a rotating disk-block minimizing thermophoretic losses.

2. Removal of volatile particles in the Evaporation Tube. No recondensation takes place in the cooling down zone.

Particle Measuring Principle

NanoMet3 is equipped with a Diffusion Size Classifier - DiSC sensor.

- Particles are labeled with positive charges in a unipolar charger.
- Particles are deposited by diffusion and detected as an electrical current.
- Remaining particles end up in a second stage, filter stage, and also the current is measured.
- The ratio of the two currents is a measure of the average particle size and is determined during the instrument calibration.
- Because the charge per particle is a function of particle diameter, once this is known, the particle number can be computed from the total current and flow rate.

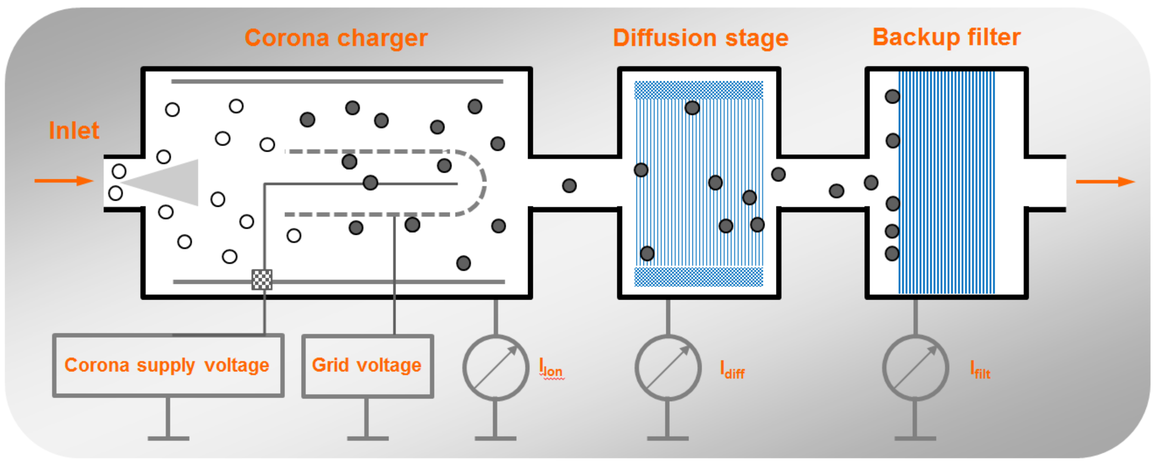


Figure 2: Setup of the particle sensor DiSC

EXPERIMENTAL RESULTS

The latest results, published by JRC during the evaluation of the PEMS-PN measurement technology on behalf of the European Commission [1], highlighted the optimal operability of this technology under real driving conditions and the very good correlation of particle number in comparison with PMP-Benchmark systems on the chassis dynamometer.

Left graphic of next figure shows the measuring performance during a NEDC transient driving cycle of NanoMet3 compared with PMP-Benchmark system. Time response of the NanoMet3 is fast enough to follow transient cycles. Right graphic shows the correlation of particle number between NanoMet3 and PMP-Benchmark.

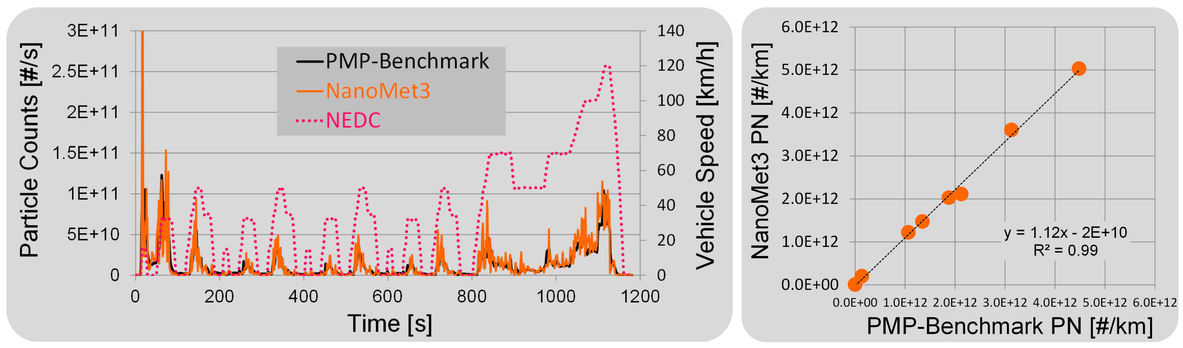
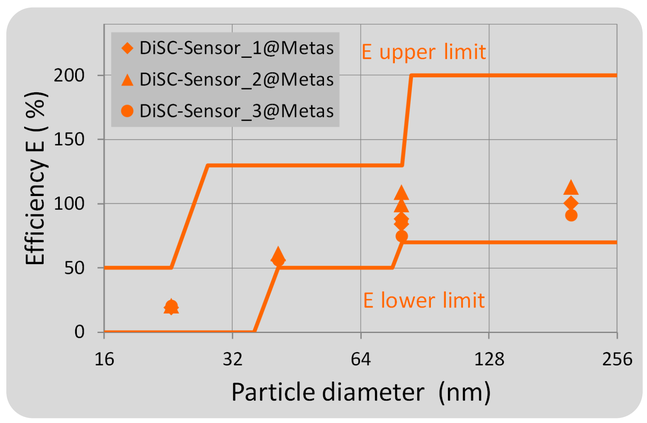


Figure 3: Number concentration and correlation measured with NanoMet3 and PMP-Benchmark on a New European Driving Cycle - NEDC



The second generation of Diffusion Size Classifier sensor has been recently examined by METAS in Switzerland (Figure 4) and found compatible with the required counting efficiency of the Ordinance on Exhaust Measurement Instruments. This efficiency is being discussed for harmonization of different non-laboratory applications.

Figure 4: Efficiency of three DiSC sensors at METAS

CONCLUSIONS

Portable nanoparticle instrumentation based on diffusion charging constitutes a new measuring procedure in automotive application to measure number concentration and diameter of nanometer sized particles in the size range 10 – 500 nm. Since its measuring principle uses electrical charging to count particles, not only it enhances the quality of the global measurement, but also the cost of acquisition and costs per test are significant lower. The instrumentation is compact, easily portable and provides on-line response. Due to these properties it is a suitable technology for particle number concentration measurements in non-laboratory settings. It is battery operated and therefore appropriate for on-board and field measurements.

REFERENCES

[1] Giechaskiel, B., Riccobono, F., Bonnel, P., “Feasibility study on the extension of the Real Driving Emissions (RDE) procedure to Particle Number (PN)” Luxembourg: Publications Office of the European Union, 2014, ISBN 978-92-79-44651-1.

SPECIFICATIONS

NanoMet3 provides a complete data string (1Hz) with following values:

- particle number concentration (#/cm³)
- average size (nm)
- calculated particle mass (mg/m³)
- LDSA – Lung Deposition Surface Area (µm²/cm³)

The communication is carried out via:

- AO, RS232, AK protocol
- USB, Secure Digital Memory Card, LAN/Ethernet port, and optional WLAN

Following are some of the specifications:

- raw gas particle concentration range: 1E4...3E8pt/ccm
- particle size: 10...700 nm (within mode diameter of 10...300 nm)
- dilution factor: 10, 100, 300 (optional customized dilution factor)
- power supply: 12VDC - 24 VDC / 100 VAC - 240 VAC