Measuring Particle Number during Periodic Technical Inspection
In the Exhaust of Passenger Cars

Introduction
- Discrepancies between emissions over a driving cycle and real driving emissions show the need for a compulsory annual emissions test.
- Exhaust aftertreatment systems (diesel particulate filters) may fail due to aging, poor maintenance, poisoning or manipulation [2].
- Opacimeters are too insensitive to detect DPF errors in the latest vehicle generations, i.e. EURO 5/6.
- The measurement technology in our proposed instrument is a condensation particle counter (CPC), already proven in automotive applications:
  - Used for the type approval of new vehicles according to EURO 5b/6 since 2011 [3].
  - Preferably used for PEMS measurements of vehicles in real operation (RDE).
  - Switzerland: Certified portable system (NPET) for particle number measurement on construction machinery in field operation (SR 941.242).

Measurement Technology
The measuring system is designed such that only solid soot particles are measured:
- Sampling probe with immediate dry air dilution prevents condensation of water.
- 1 µm cyclone with water trap prevents large particles or water droplets from interfering with the measurement or contaminating the measuring system.
- Catalytic Stripper removes volatile components of the exhaust emission.
- Condensation Particle Counter detects and counts each individual particle. A working liquid (Isopropanol) is used to convert the particles into much larger droplets and measure them with optical light scattering. It also keeps the sensor clean and reduces maintenance.

Calibration and Validation
- Implemented for PEMS measurement systems by JRC [5] (see Fig. 2).
- Measurement results correlate with type approval (see Fig. 3).

Measurement Results
- Measurement campaigns in Belgium (GOCA) and Holland (TNO).
- Comparison of measurement results between
  - Automotive Particle Emission Tester (APET) - developed for PTI.
  - Nanoparticle Emission Tester (NPET) - certified by METAS.

Summary
- Presentation of a measuring device for particle number concentration in tailpipe exhaust for use in workshops and test centers.
- The use of the proven CPC measurement technology means:
  - Accurate counting of every single particle in tailpipe exhaust.
  - Insensitive to size changes in exhaust due to aging engines.
  - No interference from large particles or urea injection for the SCR.
  - Maintenance-free measurement system (period ≥ 1 year).
  - The liquid helps keeping the sensor clean inside.
  - Comparable and reliable results due to traceable calibration according to ISO 27891.
- Future-proof technology also suitable for gasoline vehicles, stricter requirements, and counting particles down to 10 nm.

Literature