Evaluation of measuring methods for particle emission from modern diesel vehicles in periodic emissions control – Studies and Results

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Introduction
As Work package 2 of the EMVOC Partimission project (68/2011, to 08/2014) two metrological institutions (PTB [DE], METAS [CH], MIKES [FIN]) and the JRC-IE evaluated measuring methods for periodic emissions controls of modern diesel vehicles. After the specification of consistent requirements for the novel measuring Instruments a call of Instruments were launched in March 2012 to appraise. Fifty European manufacturers and their associations for automotive emission testing Instruments. Finally six manufacturers provided prototypes of their new developed Instruments which were the following. Three Light scattering instruments (1, 12, 13) which were developed for the periodic emission tests according to the German VDA 18-8.9. Two Instruments which works with the diffusion changing principle (DOC, DOC) and are already commercially available for other applications and one tonation Chamber (CC) as an early stage prototype, based on a house hold smoke alarm detector. In the frame of a research program. All tested Instruments were prototypes for this application. The evaluation of the Instruments included laboratory tests, field measurements at the JRC-IE as well as user handling tests under service conditions. This work will establish the metrological background to support the efforts to bring the regulatory emission control equipment in line with the recent advances in diesel after treatment technologies. The scope of the project was the development of periodic emission control for modern diesel vehicles in the future.

Tasks and Objectives
- Future procedures will have to cover emission of conventional light-emitting diesel vehicles and DPF -equipped vehicles (more than three of order of magnitude lower).
- If the purpose of a inspection check is to identify malfunction of the emission control device, in particular checks in the DPF, different procedures should be appropriate for non-DFP- and DPF-equipped vehicles.

Requirements for the laboratory tests
- DPF needs to be assessed through comparison to Particle Number and/or Optical-based Instruments.
- Checks should be performed over a large range of number concentrations and light extinction coefficients using a range of size distributions typical for light-duty diesel exhaust.
- Tested parameters should be sensitivity, linearity, size response, response to particles below 100 nm, response to volatile particles.

Summary of selected results:

- The measurements were performed as usual periodic emission tests at DEKA, Stuttgart (Germany) with three different vehicles:
  - Audi A4 (Euro5) with a full functioning DPF
  - VW Passat (Euro6) with a broken DPF
  - VW Multivan (Euro4) with an upgraded DPF

- The test were performed at 80 km/h maintained at 150 rpm, performed at METAS using CAST aerosol.

- Linear measurements at MIKES at 60 km/h using diesel aerosol with low number concentration.

Field test in VelA1 at JRC-IE

- Sampling performance during the practical viability tests at DEKA, Stuttgart, single sampling tubes for each instrument were clamped on an extension tube behind the exhaust pipe.

- Response of the reference instrument (DOC, DOC) shows the peak absorption coefficient and the biggest difference between this single values, measuring mode (DOC, DOC) and the instruments under test to the total particle concentration (primary vertical adsorption coefficient in dependency of the vertical axis, particle size).

Conclusions

Future regulations regarding the periodic emission control for diesel vehicles should be based on opacity measurement. Summary concentration (PM2.5) measurements. The Instruments under test are able to display the two measured (2) or only PM10 (13) depending of the measurement principle. The results of the laboratory tests demonstrated that the Diffusion charger as well as the Kinization chamber was more sensitive to small particle sizes (below 20 nm) and very low concentrations (below 200 ng/ml) than the Laser scattering Instruments. The tests under service conditions at DEKA have shown that all tested measurement principles were able to detect EDF failures and the emissions of a Euro5 vehicle equipped with an upgraded DPF. The emitted particle concentration of the full functioning Euro 5 vehicle was too low to be detected by any Instrument under test. The outcome field tests according the type approval testing in VelA1 at JRC-IE with vehicles equipped with a full functioning aftertreatment system is that the emitted particle concentration of the Euro 5 vehicles during the high emission tests (free acceleration, according the periodic emission test) can be detected by all measurement principle but not by all Instruments. The response of the Light scattering Instruments were not detectable respectively don’t correspond very well to the reference. Therefore, if the future approach in the periodic emission test should be the measurement of the particle concentration in the range of the values detected in the type approval, a complementary detector method (e.g. Diffusion charger or ionisation chamber) should be considered apart from the established opacimeter or its successor to meet the very low limit values.

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