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 ENV2021 PattM技术服务 project (B5/2011, to S5/2014) four metrolological institutions (PTB (DE), METAS (CH), MIKES (FIN) and the JRC-EI evaluated measuring methods for periodic emissions control 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 (L1, L2, L3) which were developed for the periodic emission tests according to the German VDI 18-19. Two instruments which works with the diffusion charging principle (DC2, DC2) and are already commercially available for other applications and one kinetisation Chamber (CI) as an early stage prototype, based on a house hold smoke alarm detector, developed 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-EI as well as user handling tests under service conditions. This work will establish the metrolological background to support the efforts to bring the regulatory emission control equipment in line and to make progress with regard to the recent advances in diesel after treatment technologies.

Tasks and Objectives

- Future procedures will have to cover emissions of conventional high emitting diesel vehicles and DPF-equipped diesel vehicles (more than three orders 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 may be appropriate for non-DPF- and DPF-equipped vehicles.
- Determination of technical requirements for novel instruments (prototypes).
- Evaluation in laboratory tests
- Applicability of novel measuring instruments for periodic emissions control in field tests
- Tests under controlled conditions similar to the type approval testing
- Tests under service conditions

Requirements for the laboratory tests

- EUT needs to be assessed through comparison to Particle Number and/or Opacity-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 time to volatile particles

Selected results of the laboratory tests

Summary of PTB opacity measurements for the light scattering instruments

Summary of the detection efficiencies measured at METAS

Test under service conditions

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 (Euro 4) with an upgraded DPF

Field test in Velat1 at JRC-EI

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

Linearities at 80 nm performed at METAS using CAST aerosol.

Linearities at MIKES at 60 nm using diesel aerosol with low number concentration

Conclusions

Future regulations regarding the periodic emission control for diesel vehicles should be based on opacity measurement and number concentration (JPA) measurements. The instruments under test are able to display the two measured (L1 or only PN (DC) depending on the measurement principle. The results of the laboratory tests demonstrated that the Diffusion charger as well as the Kinetisation chamber was more sensitive to small particle sizes (below 30 nm) and very low concentrations (below 10⁴ particles/cm³) than the light scattering instruments.

The tests under service conditions at DEKA showed that all tested measurement principles were able to detect DPF failures and the emissions of a Euro5 vehicle equipped with an upgraded DPF. The emitted particle concentration of the full functioning Euro5 vehicle was too low to be detected by any instrument under test.

The outcome field tests according the type approval testing in Velat1 at JRC-EI with vehicles equipped with a full functioning aftertreatment system is that the emitted particulate concentration of the Euro 5 vehicles during the high emission tests (free acceleration, according the periodic emission test can be detected by all measurement principles 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, in the future approach in this periodic emission test be the measurement of the particle concentration in the range of the values detected in the type approval, a complementary detection method (e.g. Diffusion charger or anionisation chamber) should be considered apart from the established system or its successor to meet the very low limit values.

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References
