The on-road particle emissions characteristics of vehicles fitted with diesel

JACEK PIELECHA
Poznań University of Technology
ul. Piotrowo 3, 60-965 Poznan
Jacek.Pielecha@put.poznan.pl

The paper presents the results of on-road exhaust emission tests of Sport Utility Vehicles fitted with diesel engines, and a DPF (diesel particulate filter). Under such conditions the authors could determine the actual vehicle emissions. The tests were performed on a road portion of a hundred kilometers or so – these tests provide information on the on-road emissions and are a basis for their ecological evaluation.

For the measurement of the particle size distribution (as a dependence of their diameter) a mass spectrometer by TSI Incorporated – 3090 EEPS (Engine Exhaust Particle Sizer™ Spectrometer) was used. The analyzer continuously measures the distribution of the PM size. It also measures the discrete range of particle diameter (from 5.6 to 560 nm) based on their different velocities. The range of the electrical motility of the particles changes exponentially and the measurement of the PM takes place with the frequency of 10 Hz.

The diluted exhaust gases of proper temperature were directed to the particle counter and mass spectrometer. Hence, the overall number of particles and the qualitative and quantitative distribution were given in each size range.

Additionally within the on-road tests in real traffic a size-related analysis of the PM was performed. For the comparison the ranges of engine operation were used that are most frequently utilized under real traffic conditions. They correspond to four areas of operation: 1 – idle speed, 2 – medium engine speed–low load, 3 – medium engine speed–medium load, 4 – high engine speed–high engine load. The vehicles were fitted with different powertrains, hence the selected ranges of operation do not overlap (similar areas were compared: as a criterion of similarity the relative engine speed and relative engine load were selected referred to the maximum values) – Fig 1 and 2.

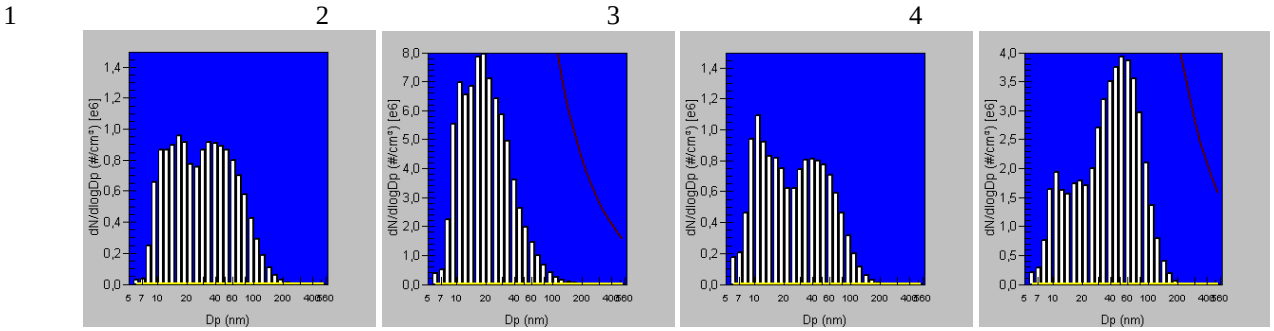

Fig. 1. On-road test PM size distribution under traffic conditions for vehicle A without DPF: 1 – idle speed, 2 – medium engine speed–low load, 3 – medium engine speed–medium load, 4 – high engine speed–high load

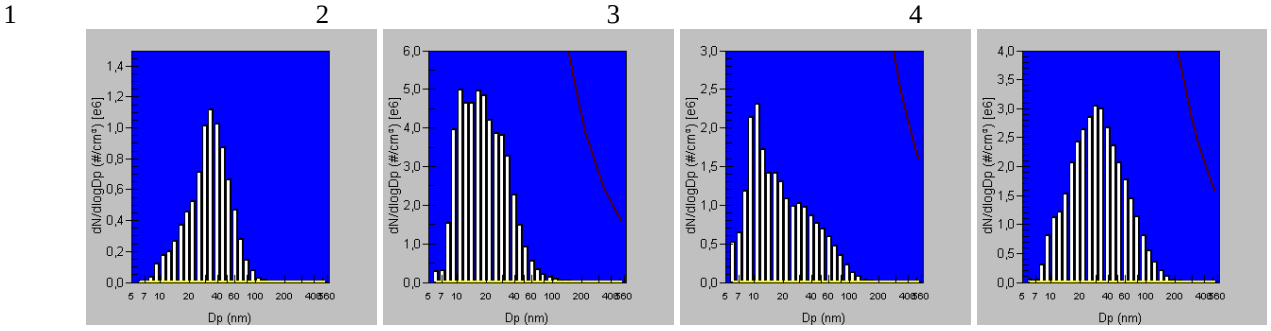

Fig. 2. On-road test PM size distribution under traffic conditions for vehicle B fitted with DPF: 1 – idle speed, 2 – medium engine speed–low load, 3 – medium engine speed–medium load, 4 – high engine speed–high load

For the measurement of particulate matter (mass) the authors used a portable analyzer by AVL 483 (Micro Soot Sensor) that enables a continuous measurement of PM in diluted exhaust gases. The principle of operation of this device uses a photoacoustic method that allows a measurement of PM starting from the value of 5 μg/m³. The measurement of PM (the device measures the carbon part of the particle) with the photoacoustic method consists in a significant absorption of the laser light by the soot particles. This results in a periodical (interchanging) heating and cooling of the working gas (change in the pressure in the measurement chamber) and the generated sound wave is recorded by the microphones.

The obtained emission indicators for the whole test (for vehicles A and B) characterize the vehicle on-road emission level against the emission standards that applied to a given vehicle (Fig. 3). The emission indicator of PM (k_{PM} = $emission_{road}$/$emission_{test}$ = 0.7–0.9) for the tested vehicles confirms that the vehicles do not exceed the average emissions in the on-road operation against the emission standards.

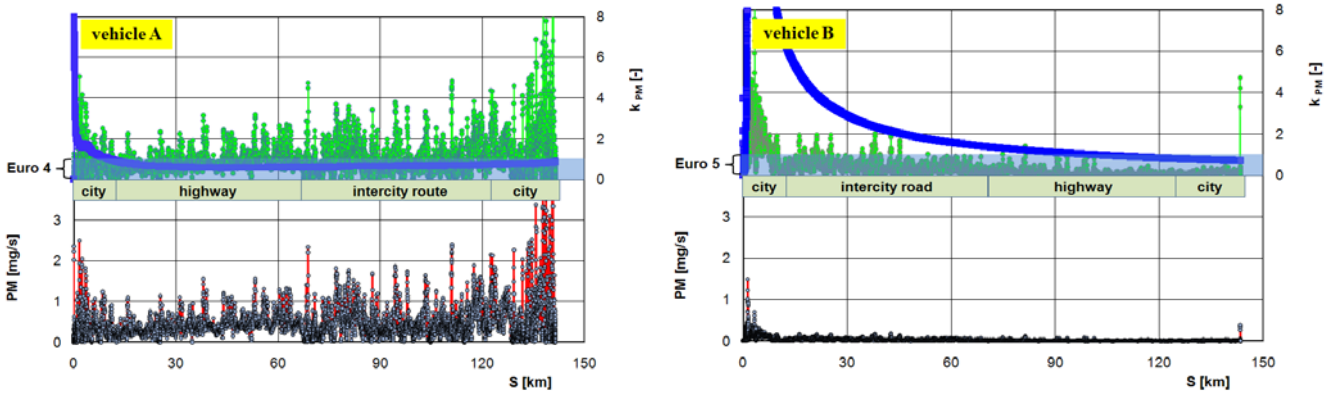

Fig. 3. PM characteristics of the on-road exhaust emissions for vehicles A (w/o DPF, Euro 4) and B (with DPF, Euro 5) as functions of the covered distance

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ABSTRACT

The paper presents the results of on-road exhaust emission tests of Sport Utility Vehicles fitted with diesel engines, and a DPF (diesel particulate filter). Under such conditions the authors could determine the actual vehicle emissions. The tests were performed on a road portion of a hundred kilometers or so these tests provide information on the on-road emissions and are a basis for their ecological evaluation.

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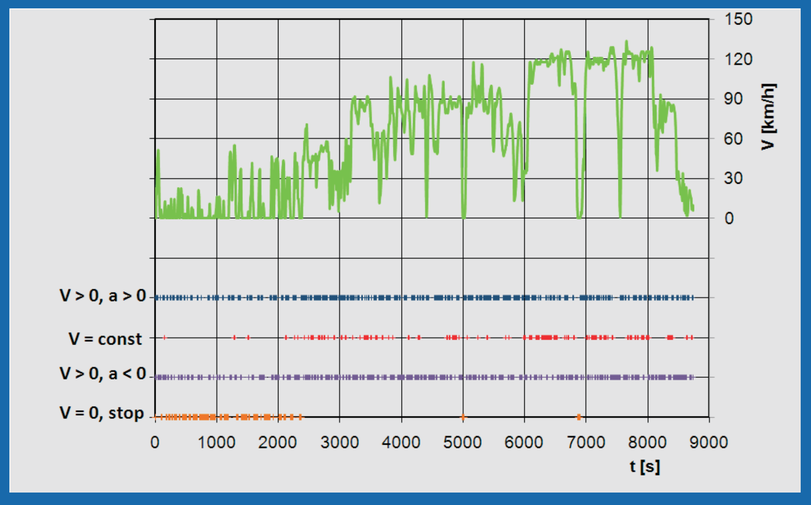
METHODOLOGY

Vehicle A, Euro 4, w/o DPF

Vehicle A, Euro 5, with DPF

MEASUREMENT

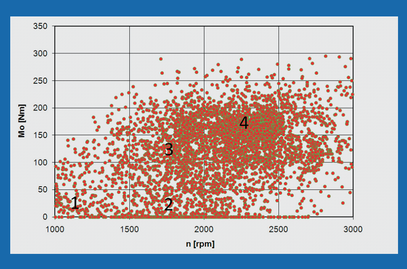


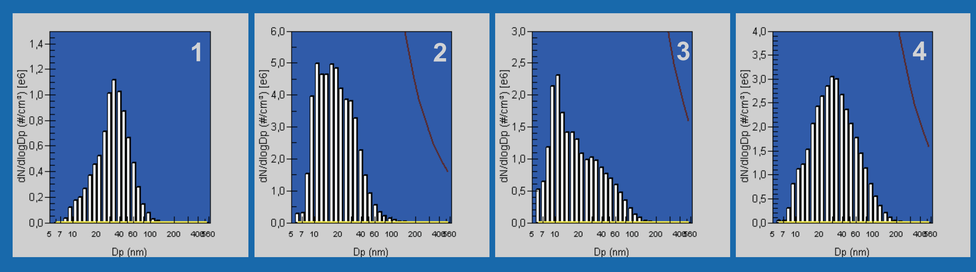
Vehicle speed during road test

Engine operating conditions

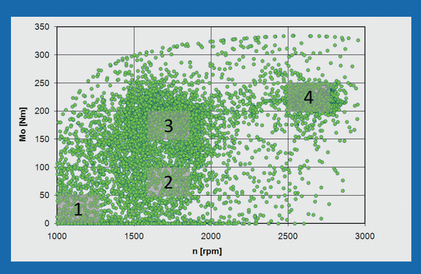
On-road test PM size distribution under real road conditions

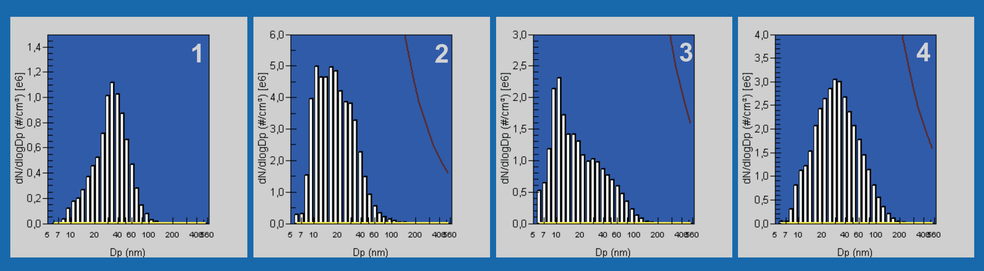
Euro 4





Euro 5, DPF



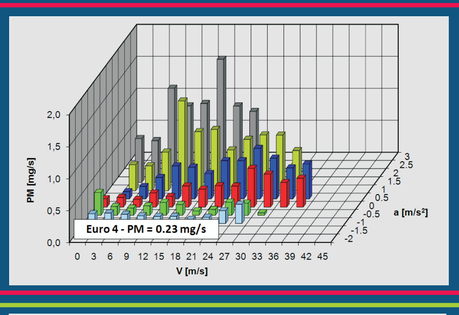


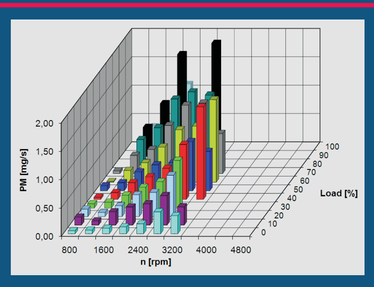
Vehicle characteristic

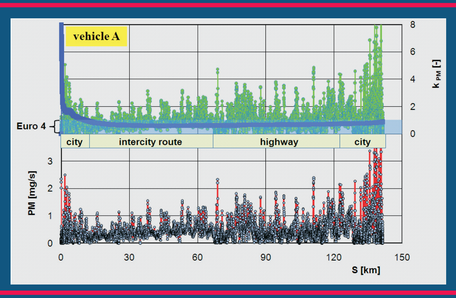
Engine characteristic

PM emission

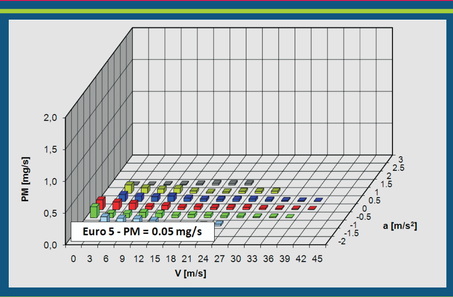
Euro 4

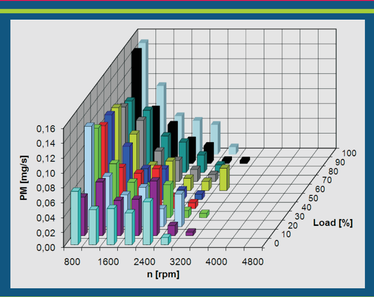


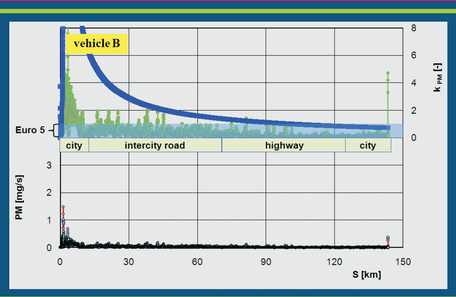




Euro 5, DPF

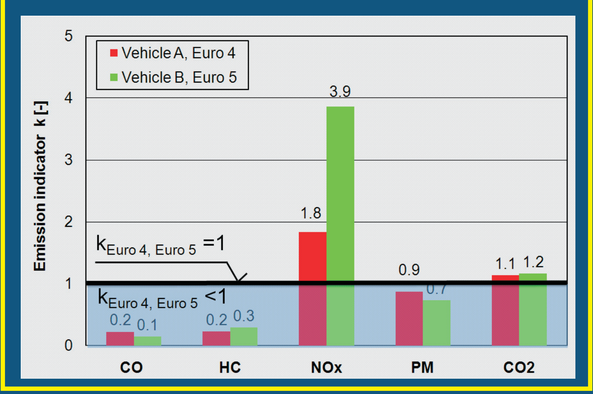






Emission indicator:

$$k = \frac{\text{Emission (road)}}{\text{Emission (NEDC)}}$$



CONCLUSION

From the analysis of the data it results that the normative emission values for the tested SUV vehicles meeting different Euro emission standards and the on-road exhaust emission vary. The obtained emission indicators for the whole test (for vehicles A and B) characterize the vehicle on-road emission level against the emission standards that applied to a given vehicle. The emission indicator of PM ($k = \text{emission}_{road}/\text{emission}_{NEDC}$ = 0.7-0.9) for the tested vehicles confirms that the vehicles do not exceed the average emissions in the on-road operation against the emission standards. The course of the changes of the emission indicator is different for the two vehicles: vehicle A was characterized by a very quick reaching of the indicator $k < 1$ (PM limit for Euro 4 is 25 mg/km) and for vehicle B the indicator lower than 1 was reached after approximately 80 km despite the fact that the vehicle was fitted with DPF; this is due to a very low value of the limit for the Euro 5 standard (5 mg/km).