

Particulate matter emission from bi-fueled vehicles powered by compressed natural gas and gasoline

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Abstract

The paper presents results of emission tests for vehicles in urban traffic. The tests were conducted on a several-kilometers-long part of the road in similar traffic conditions and data so acquired contained information about operational emissions of the vehicles. The results were used for determining road emissions that might be used for ecological assessment of the vehicles in terms of exhaust emission.

Vehicle characteristic

The objects of the tests were vehicles with bi-fuel engines (powered by gasoline or compressed natural gas – CNG) fitted out with manual gearboxes. The vehicles with mileage of 15,000; 75,000 and 500,000 km complied with Euro 4 or Euro 5 standard (four-cylinder engine with capacity of 2.0 dm³ and three-way catalysts) and were factory-adapted to compressed natural gas.

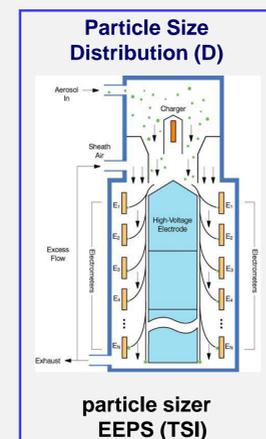
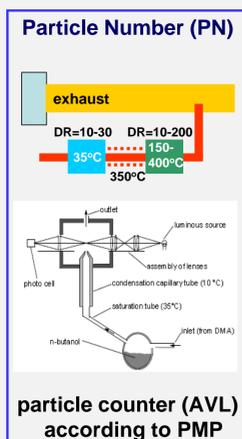
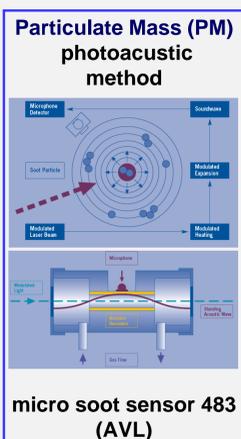
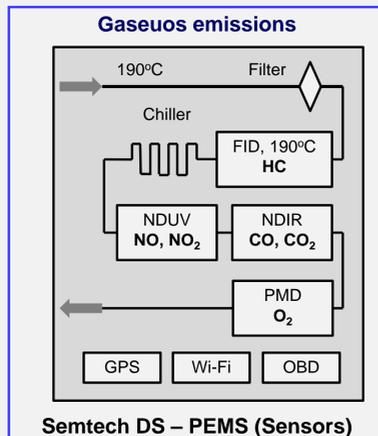
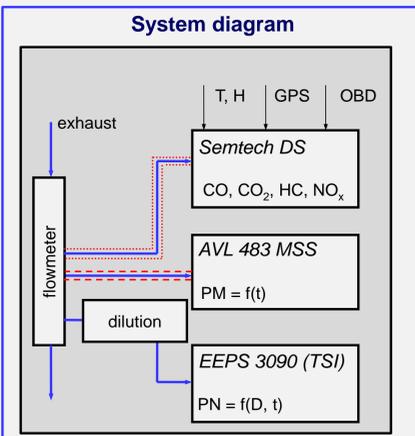
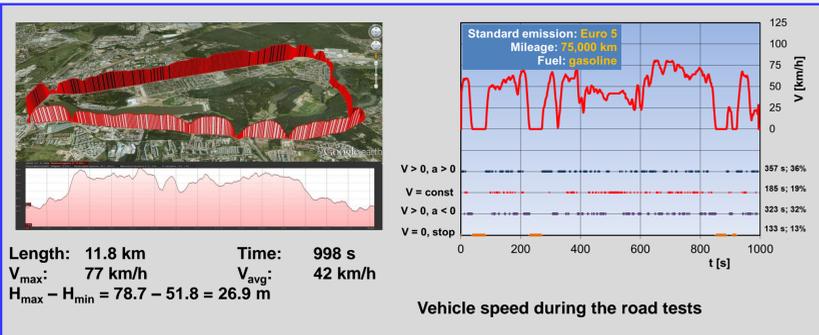


1 – CNG, 2 – gasoline tank, 3 – reductor, 4 – injector

Methodology

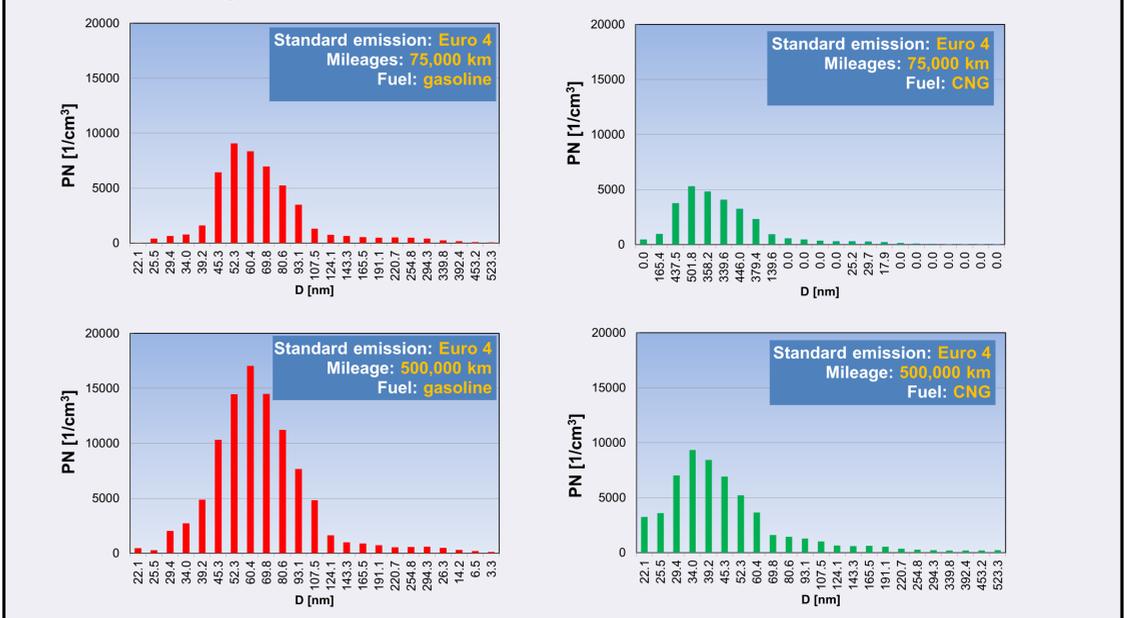


Parameter	Euro 4	Euro 5
Model year	2008	2009
Mileage [km]	75,000 500,000	75,000 500,000

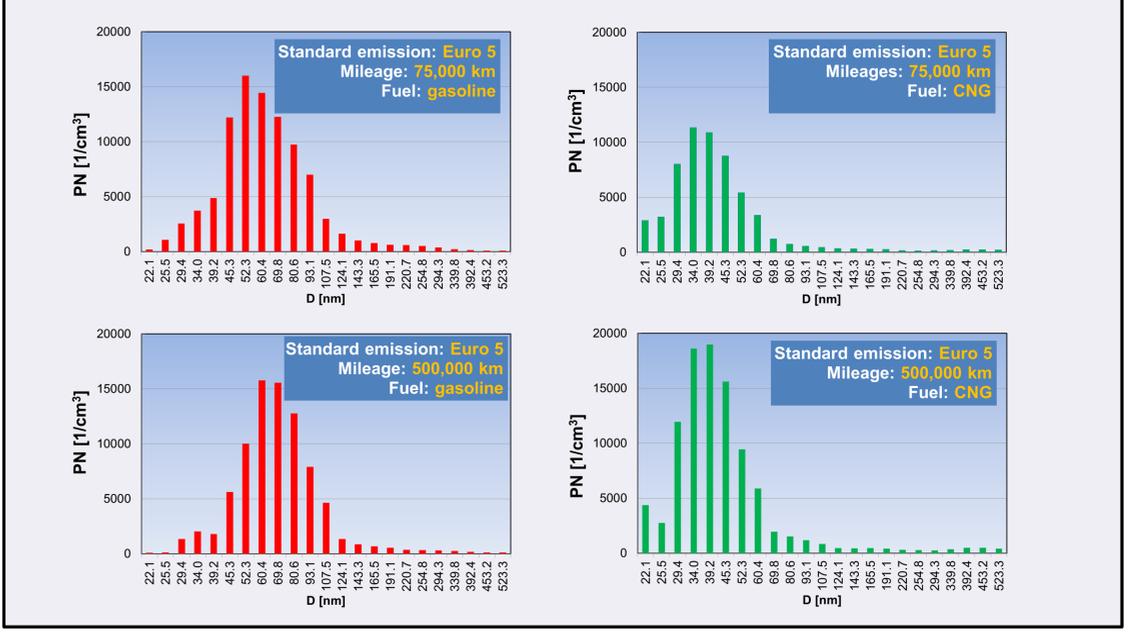


Results

Determination of the road emission of particulate matter (in terms of its mass) showed that its value was several times lower for CNG-powered engines compared to gasoline-powered vehicles. It is associated mainly with the type of the fuel (liquid and gas), but it also enables to pose the thesis that a long-term operation of CNG-powered engines has an adverse effect on formation of particulate matter in such engines. However, from the comparison of the values obtained for Diesel engines complying with standards emissions (for which emission of particulate matter of 5 mg/km is acceptable) it might be concluded that the emissions are about ten times lower for vehicles with mileage of at least 500,000 km.



The obtained values of particle numbers for vehicles of different emission classes and with different mileages showed insignificant difference in results. However, correlating the results with particle number allows a conclusion that the number of bigger particles (with bigger mass) from vehicles with significant mileages is much greater than the number of particles from vehicles with small mileage. To explain this issue thoroughly, particle size distribution was presented here in relation to nominal diameter for vehicles with different mileages (averaged value for the whole measured part of the road). From the analysis of the graphs it might be concluded that for the gasoline-powered engine the characteristic diameter of the particles (the diameter of the largest number of particles) ranges from 40 to 70 nm, while for CNG-powered engines it is the range from 30 to 40 nm.



Conclusion

While determining values for road emissions of pollution from gasoline- and CNG-powered vehicle, with the increase of the mileage a bigger emission of harmful substances was observed (for vehicles of Euro 4 and Euro 5 class). In urban conditions, the particulate matter emission (taking into account particles' mass) for the CNG-powered vehicle compared to gasoline-powered vehicle was about ten times less (independent of the mileage). In assessment of ecological characteristics of the tested vehicles the changes of mass, number and characteristic diameter of the emitted particles were indicated. The increase of the mileage of the gasoline-powered engine resulted in the decrease of the particles with small diameters and the increase of particles with big diameters. As a consequence the total number of particles stays on similar level. In CNG-powered engines it is different, as wear of CNG-injectors results in formation of just slightly bigger particles but in bigger number.