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PN-PEMS: Testing Emissions of Diesel Passenger Cars in Laboratory and On-Road

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Abstract

PEMS – portable emissions measuring systems were introduced in the last stage of exhaust gas legislation for HD-vehicles in order to measure and to limit the real driving emissions (RDE). PEMS were also confirmed by EU to be applied for the LD-vehicles in the next legal steps.
PN-PEMS include the particle number (PN) testing in the on-road real world application.

In the present poster some results and experiences of measurements of two Diesel cars with PN-PEMS on the chassis dynamometer and on-road are presented.

The PN-PEMS consisting of AVL M.O.V.E and Matter-Testo-NanoMet3 was installed on each vehicle and the tests on the chassis dynamometer in the standard test cycles: NEDC, WLTC and CADC and on-road were performed.

As reference, the results of the stationary laboratory equipment (CVS and Horiba MEXA 7200) were considered.
For the real-world testing a road circuit was fixed: approximately 1h driving time with urban/rural and highway sections.

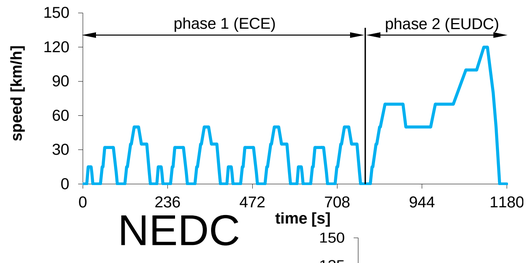
Tested Vehicles

Diesel	Vehicle 1	Vehicle 2	Vehicle 3
Engine	R4	R4	R4
Displacement cc	1560	2143	1994
Gear box	m6	a5	m5
First registration	2015	2010	1998
Exhaust	Euro 6b	Euro 5a	Euro 2
Aftertreatement	DPF	DPF	-

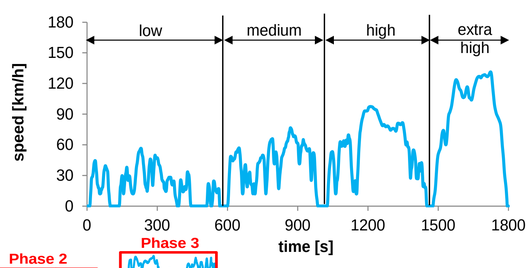
Repeated test on the same road circuit produce dispersing emission results depending on the traffic situation, dynamics of driving and ambient conditions. Also the calculated portions of urban, rural and highway modes are varying according to the traffic conditions.

PN-PEMS showed an excellent correlations with CPC in the tests on chassis dynamometer and it indicated very well the efficiency of DPF in eliminating the nanoparticles in real world driving.

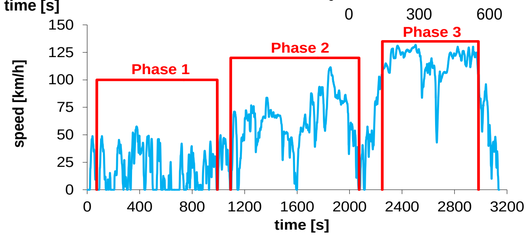
Driving cycles on chassis dynamometer



NEDC

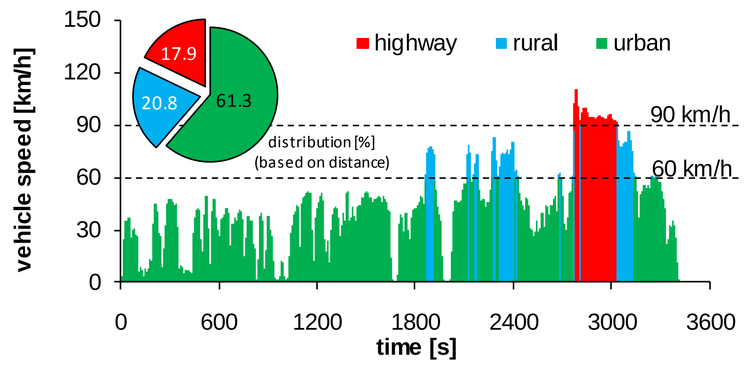


WLTC



CADC

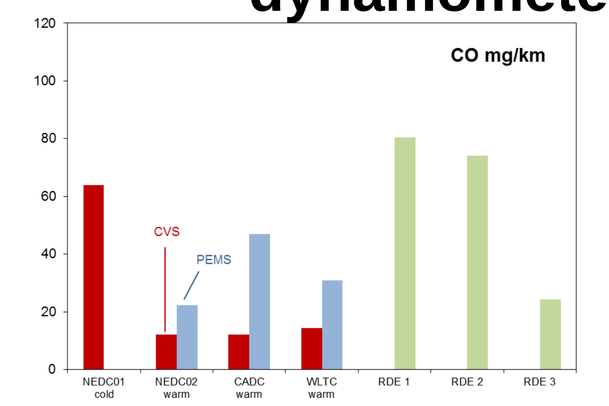
Road tests

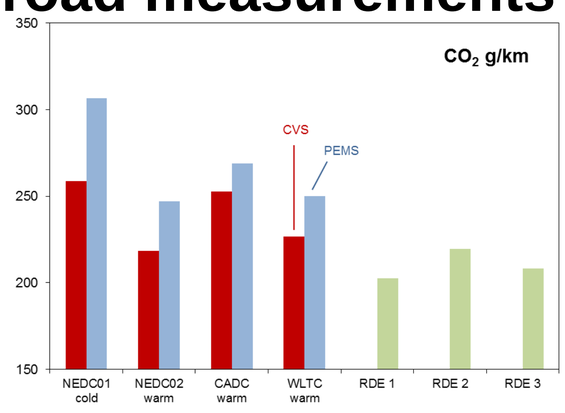


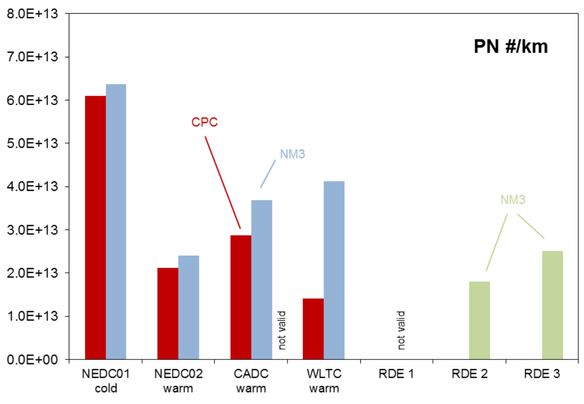
distance		time		average speed	
urban	23.9 km	urban	44.8 min	urban	29.8 km/h
rural	8.1 km	rural	6.7 min	rural	72.5 km/h
highway	7.0 km	highway	4.4 min	highway	95.6 km/h
total	**38.9 km**	stops	0.9 min	max	110.8 km/h
		total	**56.8 min**		

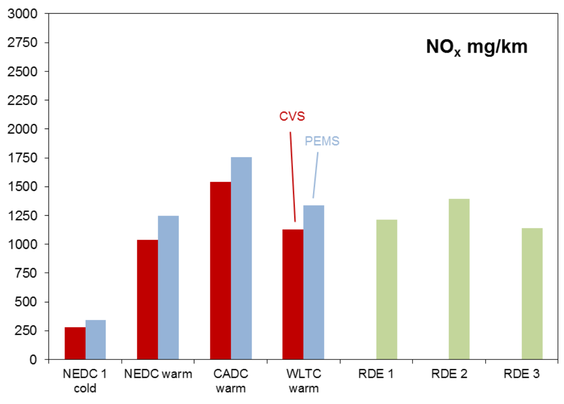
AFHB Road-Test Route. PEMS 2.

Emission results of a Diesel vehicle 2 on chassis dynamometer and in road measurements









PN-PEMS (Diesel Cars)

What can be the reasons of these deviations?

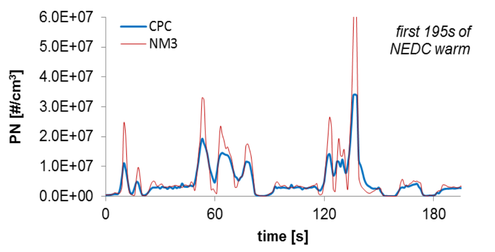
The mass flow ( ) of an emissions component "x" is calculated as:

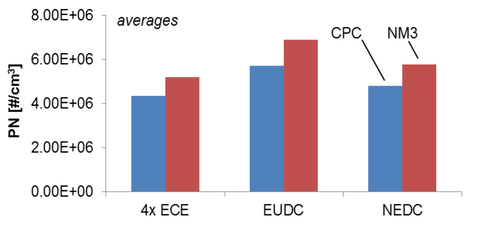
$$\dot{m}_x = \dot{V}_{exh} \cdot k_x \cdot \varrho_x$$

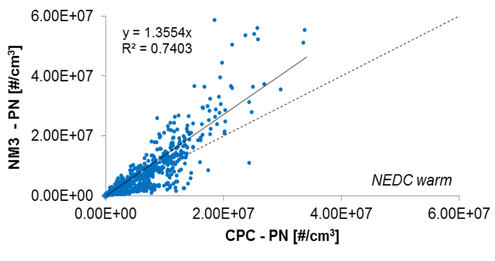
$$\left[\frac{kg_x}{s} = \frac{m^3_{exh}}{s} \cdot \frac{m^3_x}{m^3_{exh}} \cdot \frac{kg_x}{m^3_x}\right]$$

$\dot{V}_{exh}$ … volumetric flow of exhaust gas
k_x … volumetric concentration of component "x" in the exhaust gas
ϱ_x ... density of the component "x"

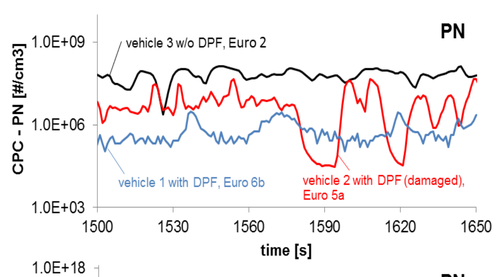
For dynamic measurements with PEMS in the real-world transient operation there is a challenge to synchronize well the signals of all three parameters, which are continuously changing with the operating conditions. (The instantaneous density varies with the pressure and temperature of exhaust gas).

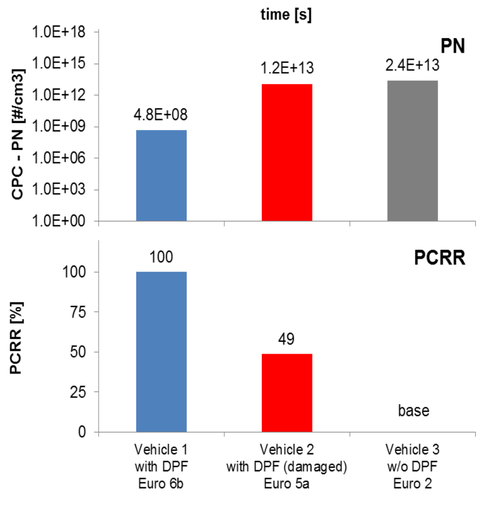






Particle counts concentrations measured simultaneously at tailpipe with NanoMet 3 (NM3) and with CPC.





Effects of DPF on Diesel Passenger Cars in WLTC (hot) Success of DPF Technology

Conclusions

Following conclusions can be mentioned:

- in NEDC with cold start there are higher CO- and CO_2-emissions than with warm start,
- in NEDC warm and in all investigated test cycles with warm start there are significantly higher NO_x-values, than in the legal test procedure with cold start – this is caused by the electronic control of the engine,
- the emissions CO, CO_2, NO_x measured with PEMS are generally higher than the same emissions measured in the same driving cycle on the chassis dynamometer (CVS) - the principal reason of the differences is the dynamic exhaust mass flow measurement and the synchronization of the transient parameters of PEMS,
- emissions measured with PEMS in repeated road driving circuit are generally well repetitive; exceptions can happen due to traffic situations or due to special activity of the vehicle electronic control (like DPF regeneration),
- RDE cycle, which is performed on chassis dynamometer (CD), shows less CO_2-emission in the low-speed parts of the cycle (lower driving resistances on CD),
- modern vehicles with automatic gears adapt the gear shifting strategy to the driving requirements and this causes a randomly variable engine behavior in the same driving circuit,
- both tested PN-PEMS (NM3 and NM3PS) correlated very well to each other; comparing with the CPC 3790 they are more sensitive and tend to indicate higher average PN-values,
- there are quite numerous requirements for a trip validation of the RDE-procedures. The road traffic influences some of the validation parameters. It is recommended to select a "flexible" road circuit, which can be adapted on the actual traffic situation,
- the tests performed with AVL M.O.V.E. on the engine dynamometer showed several positive effects, like good correlations of concentration measured at stationary operation; nevertheless, at transient operation there is a considerable lower correlation between PEMS and ECU.

The PEMS and RDE testing is a new challenging task for the test laboratories. Further research and development are recommended.

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