Berne University of Applied Sciences
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AFHB | IC-Engines and Exhaust Gas Control

Analysis of ultrafine particle emissions by in-use buses of different generations

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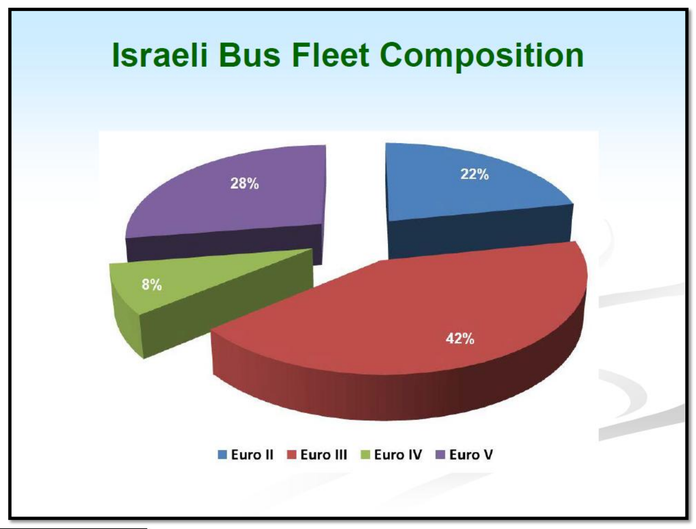
Abstract

Ultra-fine particles (UFP) are one of the major contributors of the heavy air pollution in the cities and big agglomerations worldwide. A substantial part of UFP-emissions results from road traffic and efforts of minimizing these emissions are in course in many countries.
Nanoparticles penetrate like gases in the human organism, causing several health hazards and premature deaths.
In the present study a comparative analysis of UFP-emissions at low-load regimes by buses of different technologies – from Euro II till Euro V EEV was performed. Additionally, the reduction potentials by means of retrofitting with a DPF-system (diesel particle filter) were demonstrated.
Comparison of the measured engine-out particle number concentrations (PNC) data for buses of different technology generations allows us to conclude that no substantial reduction of engine-out emissions at low-load operation modes is observed for newer bus generations.



Buses tested

Technology	Maker/ Model	Traveled distance, km	Engine type	Power, kW/Speed, rpm	Number of cylinders/ Displacement, cm³	EGR system, Yes/No	Exhaust gas aftertreatment
EURO II, interurban	MAN/ HOCL 1835	1,227,503	D2066LOH12	257/2200	6/10,518	NO	NO
EURO II, urban	Mercedes/ O-405	994,600	OM447-hLA	176/2,200	6/11,967	NO	NO
EURO III, urban	MAN/ NL 313F	595,560	D2866LUH24	228/1,900	6/11,967	YES	NO
EURO IV, urban	MAN/ NL 313F	328,990	D2066LUH12	228/1,700	6/10,518	YES	PM-KAT®*
EURO V EEV, urban	MAN/ NL 323F	162,283	D2066LUH47	235/1,900	6/10,518	YES	CRTec®**

* **PM-KAT** is a trade name of the Emitec partial flow filter with an upstream Diesel DOC
** **CRTec** is a trade name of the HJS-made continuously regenerating trap based on the wall-flow sintered metal filter with electronically controlled thermal management.

Methodology

Operation modes:

- Low idle
- High idle
- Partial load
- Free acceleration

Measured parameters:

- Particle number (PN) concentrations and summary active surface
- Concentrations of NO_x, CO, CO_2 and O_2
- Smoke
- Gas temperature and pressure at the DPF inlet
- Engine speed, vehicle velocity, power on the wheels

All the measurements - with and without DPF

Experimental setup

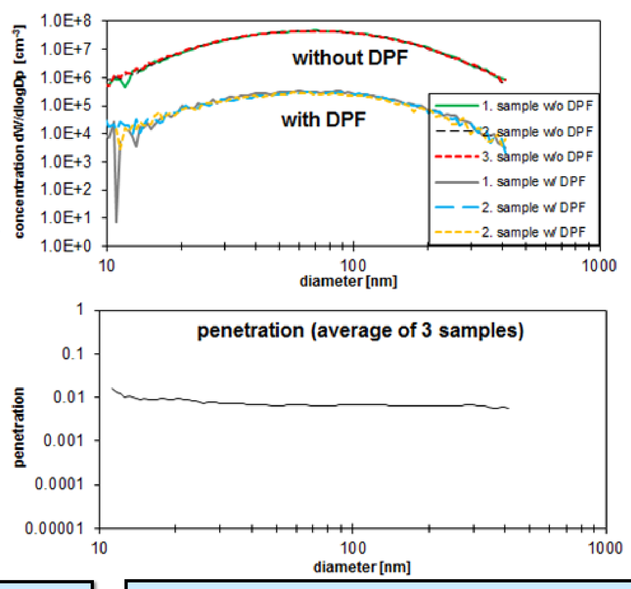
DINEX DiSiC DPF: left –assembled; right – with covers removed

DPF inlet and outlet surfaces

DPF inlet surface | DPF outlet surface

Only best available technology (BAT) and appropriately certified filters should be considered for retrofitting!

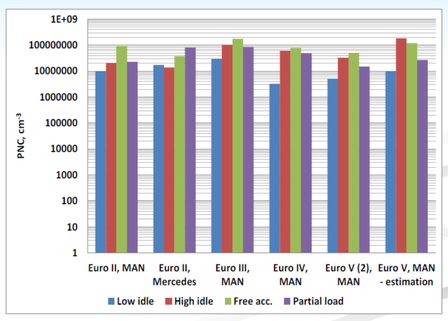
DPF VERT Quality



PMFE [%]						
operating point	5	7	3	1	5 (r.)	
speed	1480	1480	2250	2250	1480	rpm
torque	1310	650	490	1010	1310	Nm
DPF delivery state	91.21	94.78	94.26	93.97	86.74	%
average of all points	92.19					

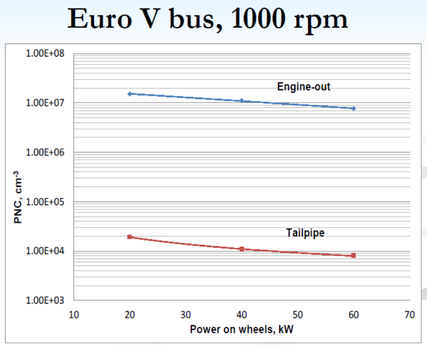
PCFE [%]						
operating point	5	7	3	1	5 (r.)	
speed	1480	1480	2250	2250	1480	rpm
torque	1310	650	490	1010	1310	Nm
DPF delivery state	98.75	99.32	99.42	99.19	99.08	%
average of all points	99.15					

Nanoparticle number concentrations



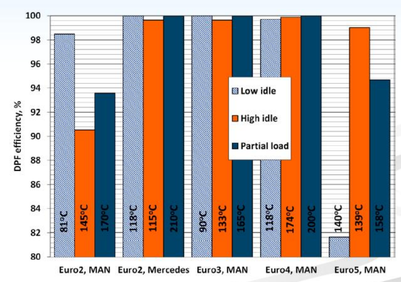
Influence of load on UFP number concentrations

Euro V bus, 1000 rpm



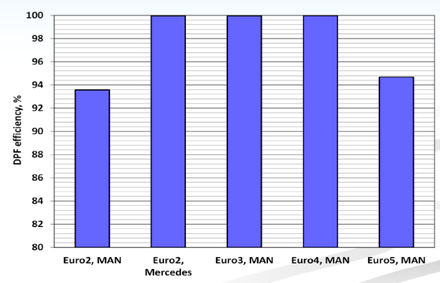
DPF efficiency

Steady-state regimes



DPF efficiency

Free acceleration



CONCLUSIONS

- A comparison of engine-out PN emission of the EURO V bus with those of the Euro II and III buses provides an indication on very high engine-out PN emissions of the EURO V bus. This most probably is a result of high EGR ratios applied in this engine.
- A danger of extremely high PN emission by the EURO V buses in case of the DPF malfunction
- A strong correlation between PN levels under high idle and free acceleration operation regimes was observed
- Ratios of PN concentrations at free acceleration and high idle operation modes were substantially higher for the older buses and decreased with advancement of the engine's technology
- High efficiency of DPF in reduction of nanoparticle emissions by all buses was confirmed
- DPF efficiency with all buses at almost all operation regimes was above 94% and in some cases reached near 99.9%

Acknowledgments

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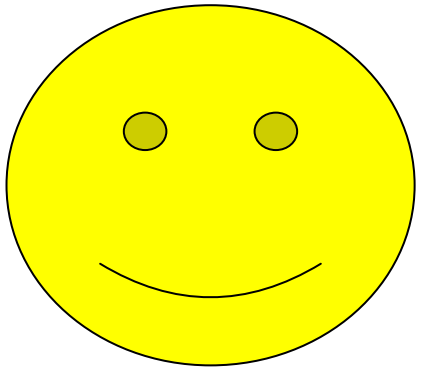

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