Investigations of SDPF – Diesel Particle Filter with SCR Coating for HD-Applications

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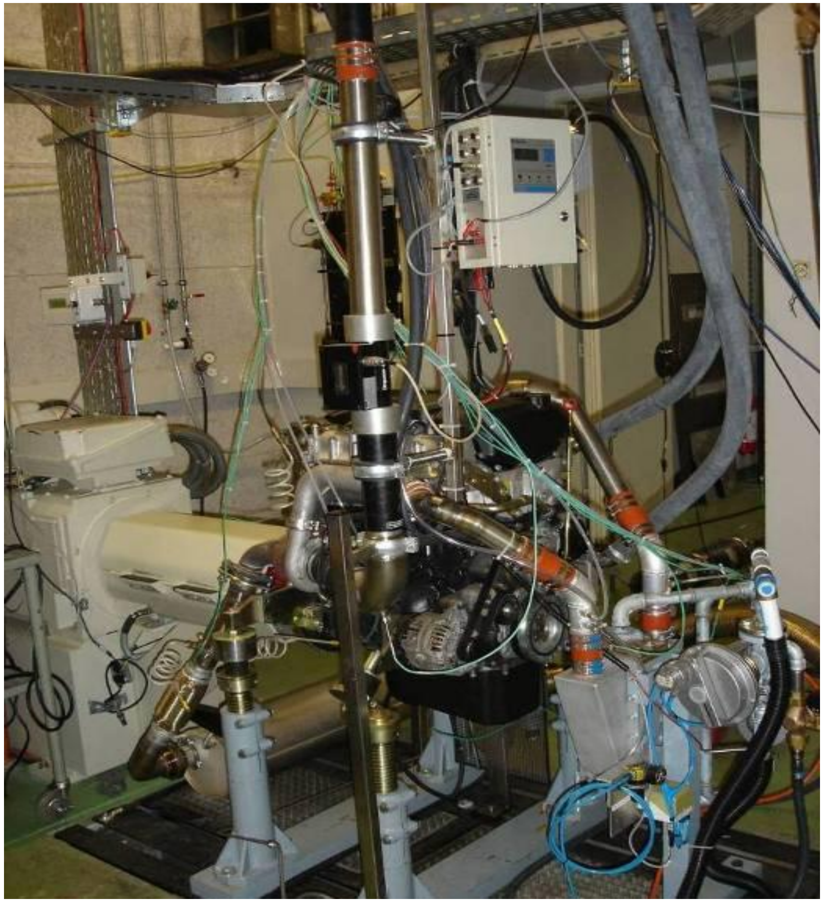
SDPF = SCR + DPF

Common project

Liebherr, EMPA, TTM, AFHB

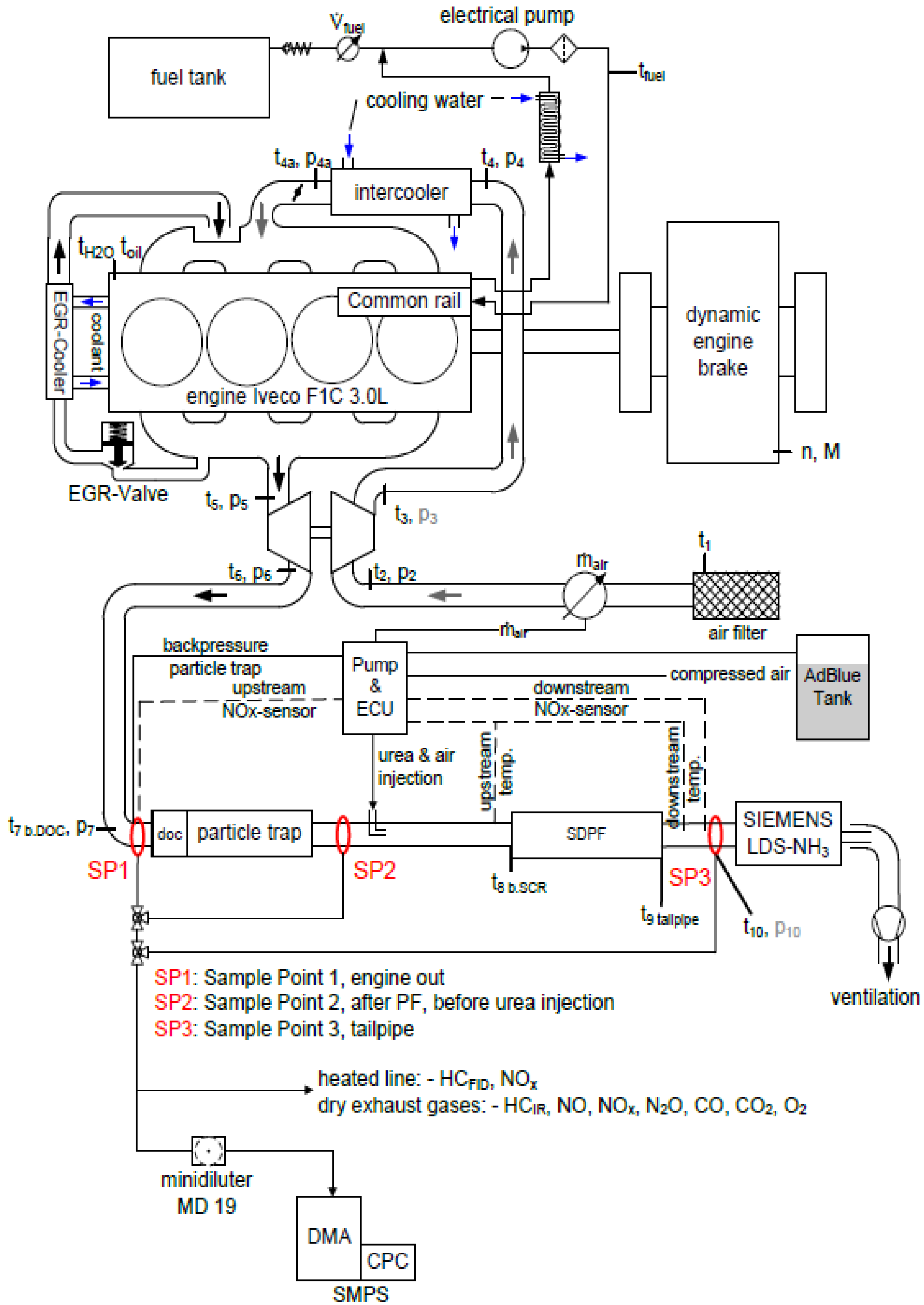


IVECO engine F1C and dynamic engine dynamometer in the engine room.

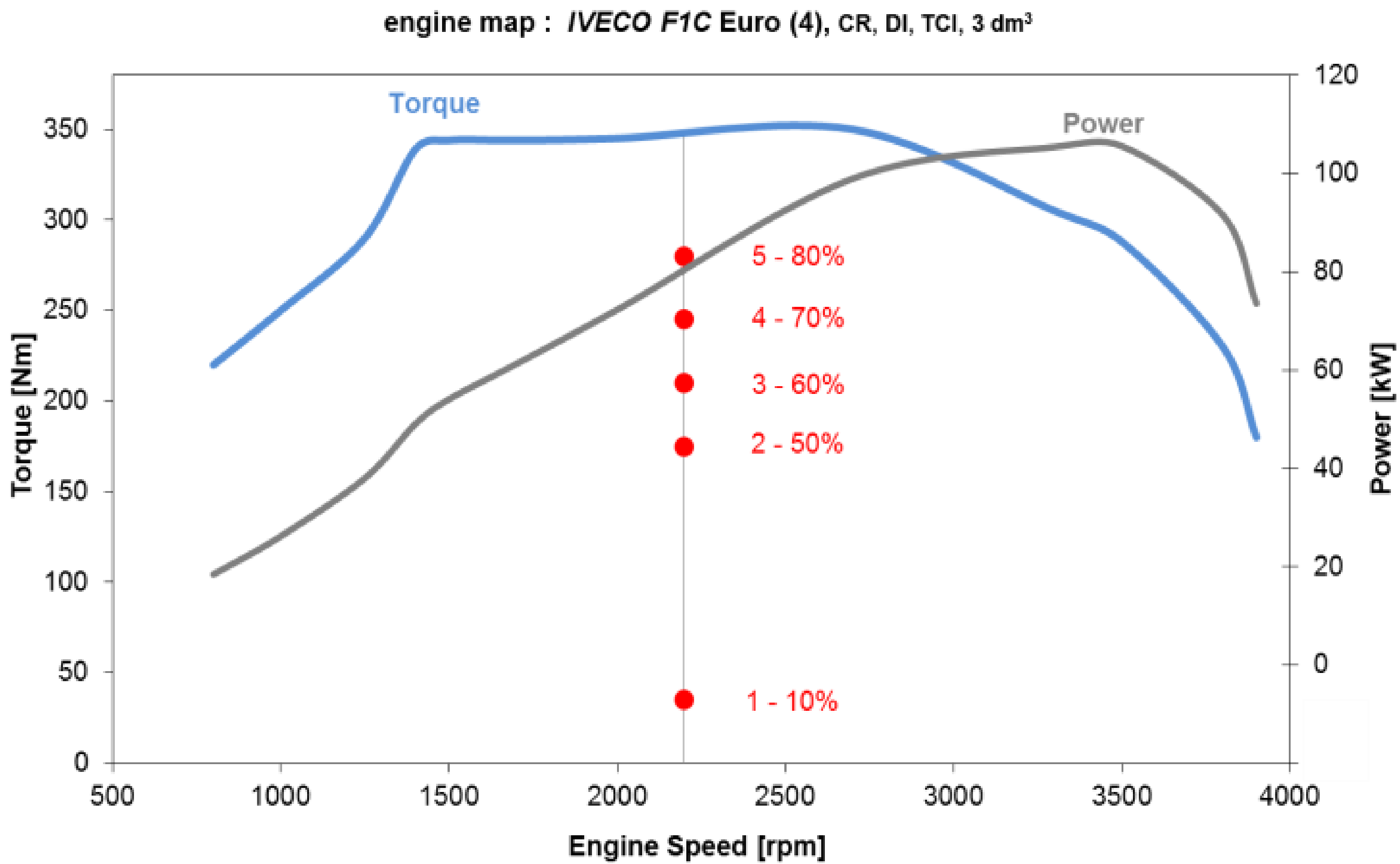
Manufacturer:	Iveco, Torino Italy
Type:	F1C Euro3
Displacement:	3.00 Liters
Rated RPM:	3500 min^{-1}
Rated power:	100 kW
Model:	4 cylinder in-line
Combustion process:	direct injection
Injection system:	Bosch Common Rail
Supercharging:	Turbocharger with intercooling

Main engine data.

Engine dynamometer and test equipment



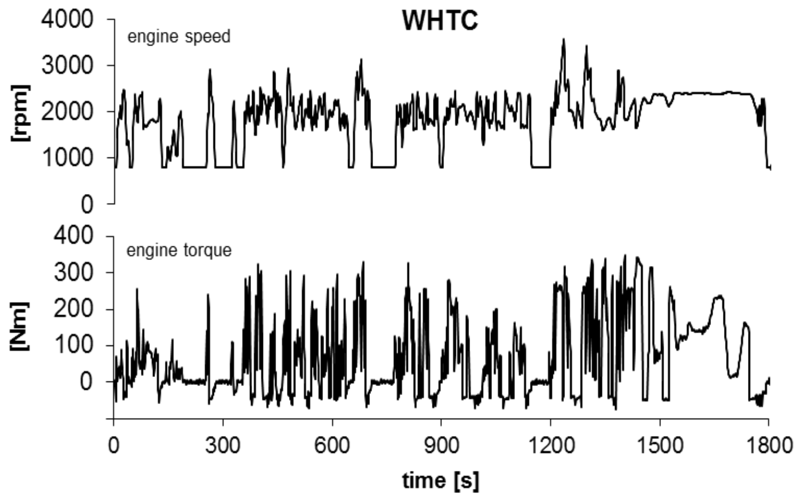
Engine map of the Iveco F1C engine and tested OP's

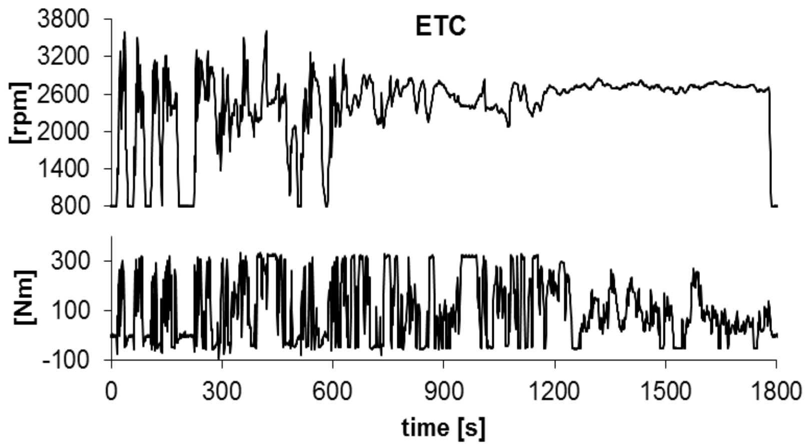


Adaptation of engine parameters for quicker soot loading.

2200 rpm / 50 Nm	Original (reference)	Adapted
FSN [-]	0.5	2.2
T. b. cDPF [°C]	197	243
Rail pressure [bar]	600	300
Inj. b. TDC [°CA]	5.7	9.5
Air flow [mg/hub]	750	500
EGR	closed	active

Engine torque and speed in the WHTC & ETC (Iveco F1C, 3.0l).





Variants of exhaust aftertreatment systems

System	Elements
SYS01	DOC cDPF$_{\Delta}$ SCR SCR
SYS03	DOC$_{\Delta}$ SDPF
SYS05	DOC cDPF$_{\Delta}$ SDPF

$_{\Delta}$ *… position of RAI*

Filter weighing

Measuring the weight of DPF in function of the temperature

Repetitivity of Δm after soot loading SLSDPF

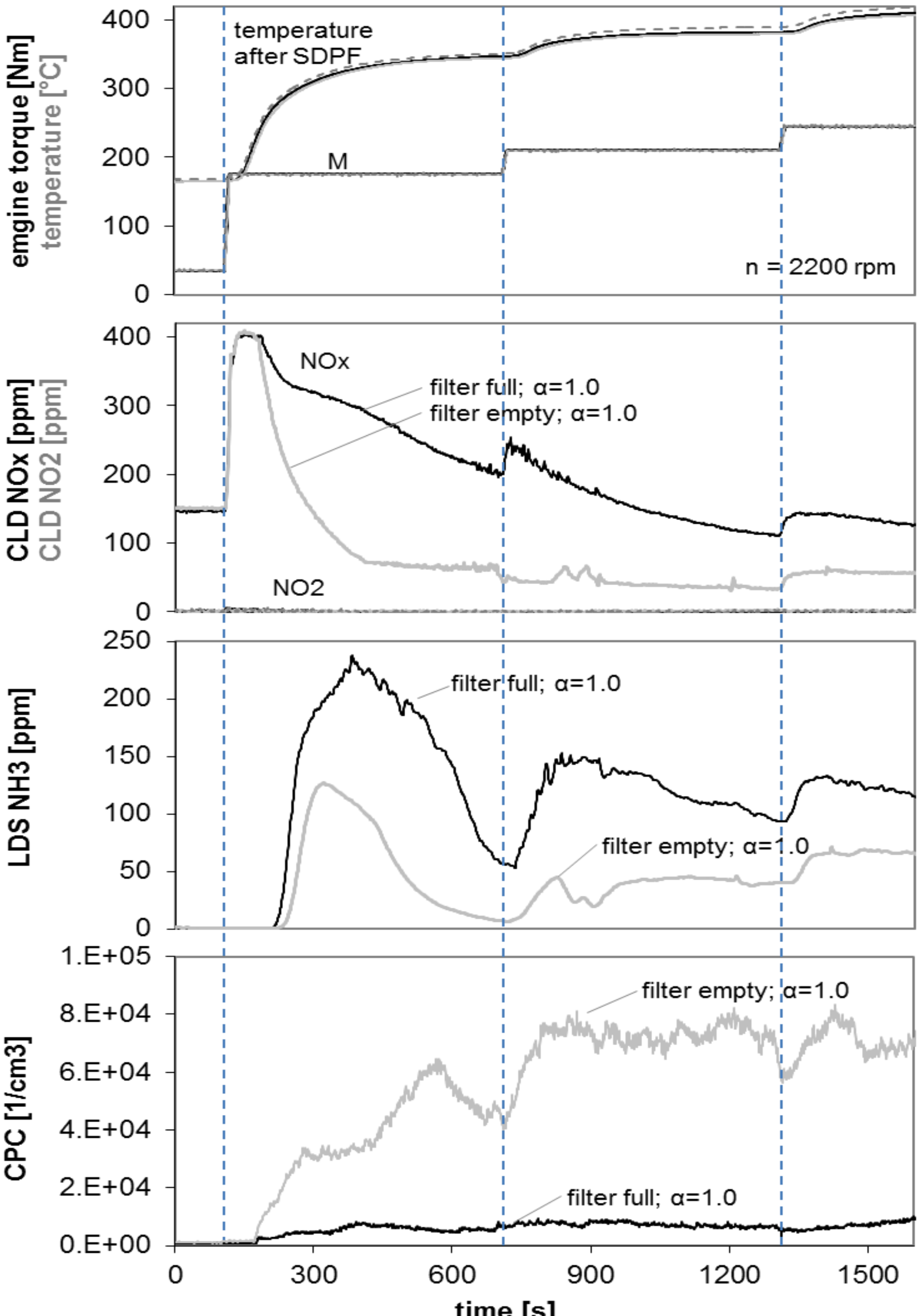
measurement	weight [g]	Δ mass [3] [g]	Δ back-pr. [mbar] [1)2)]
SLSDPF01	7267.4	19.3	14.9
SLSDPF02	7267.9	21.7	11.6
SLSDPF03	7265.2	21.4	14.7
SLSDPF04	7266.0	21.3	11.9
SLSDPF06	7262.4	20.9	12.1

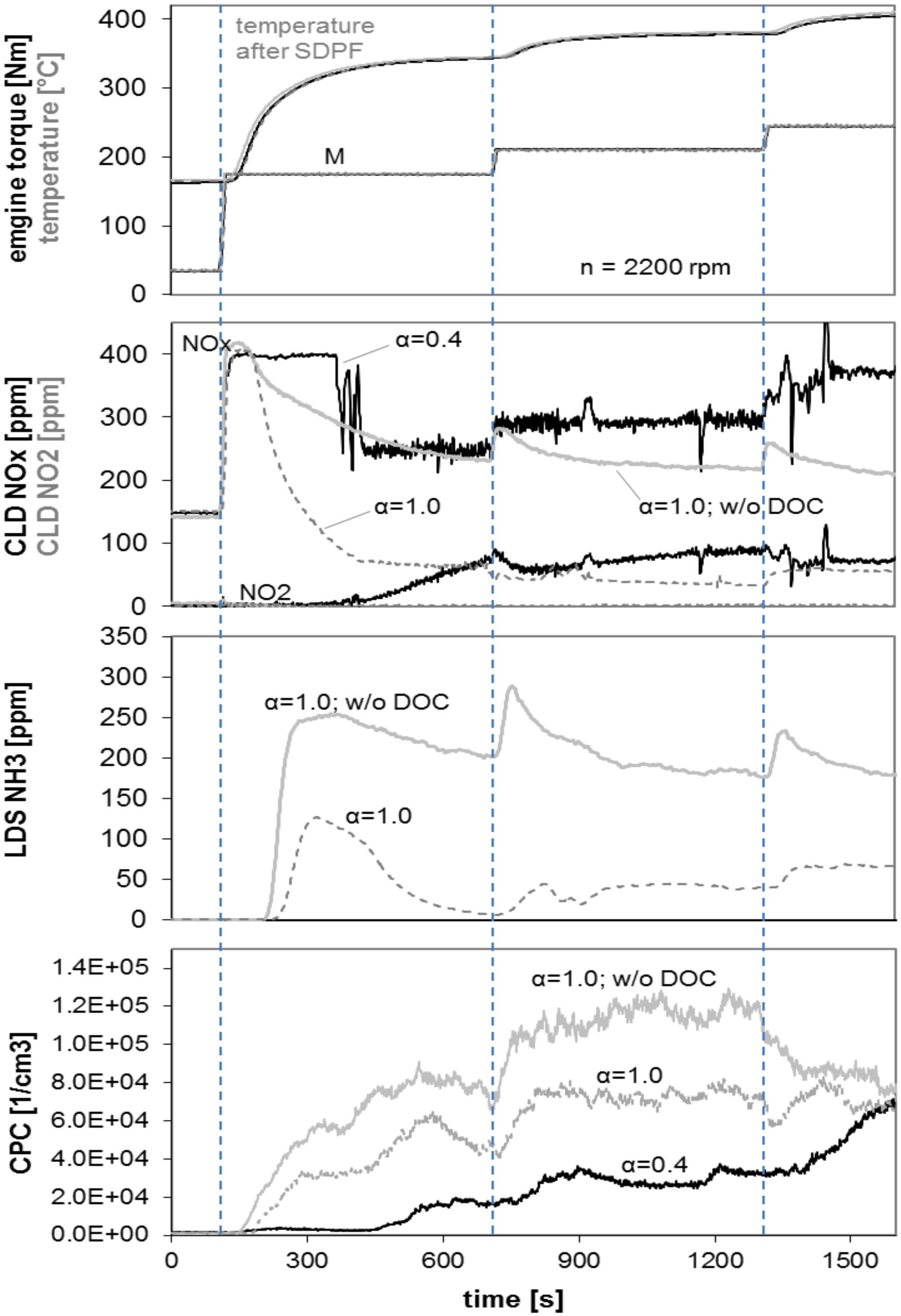
Influence of urea dosing on the passive regeneration with fully pre-loaded SDPF.

measurement name	loaded mass [g]	feed-factor α [-]	reg. eff. [%]	BP grad / 280 Nm [mbar/min]	dosing
REGSTEPS16	19.3	0	82	-2.059	without
REGSTEPS18	21.7	0	81	-0.732	
REGSTEPS24	20.9	0	79	-1.454	
REGSTEPS19	21.9	0.4	66	-0.021	with
REGSTEPS20	21.3	1.0	42	-0.047	

NO_x / NH_3 after SWON

Repeated comparison of emissions in steps-tests with full & empty SDPF; SYS03; dosing α =1.0.





Comparison of emissions in steps-tests with empty SDPF with and without DOC; SYS03; dosing α =0.4/1.0.

Nanoparticles after SWON

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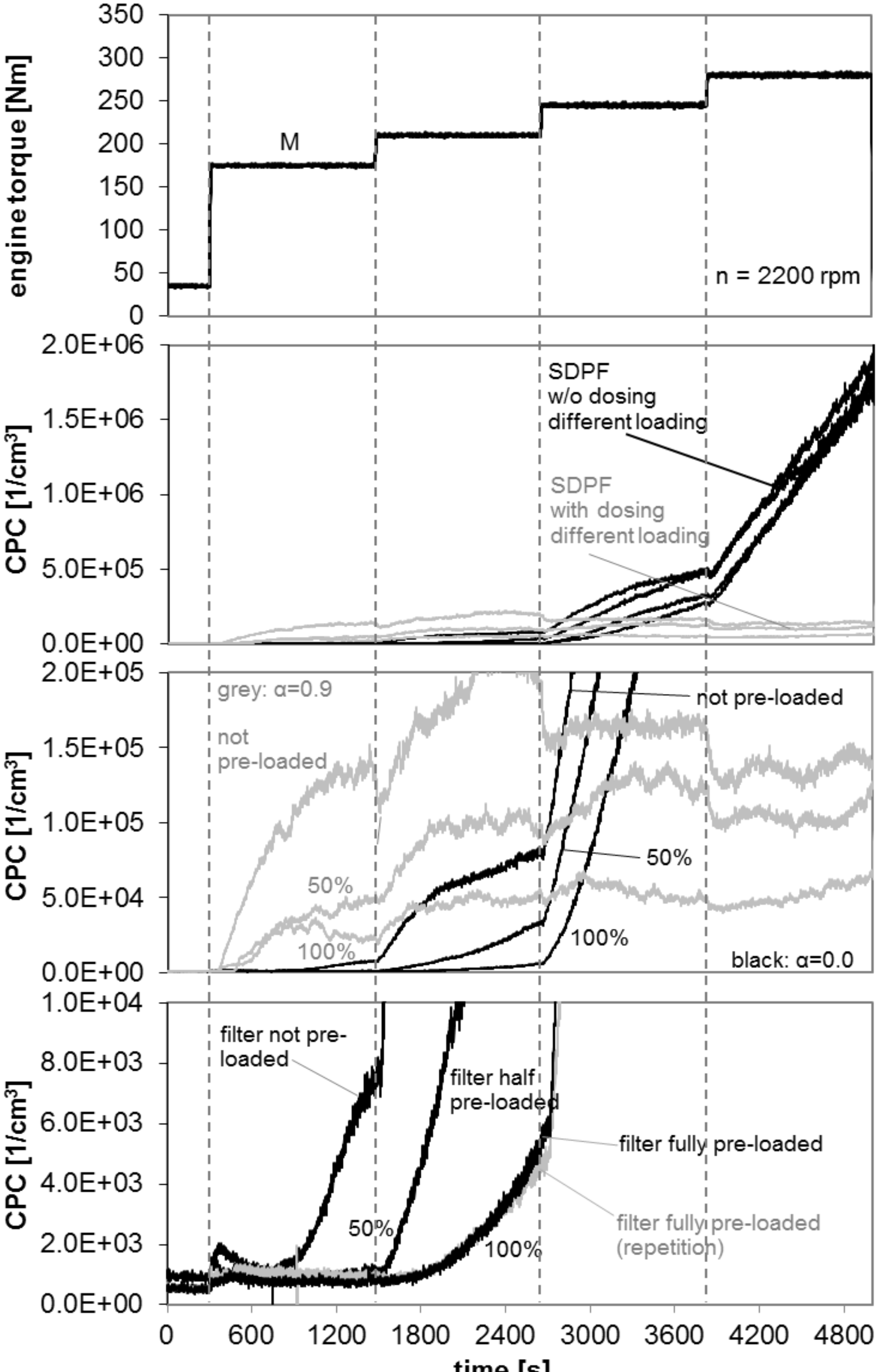
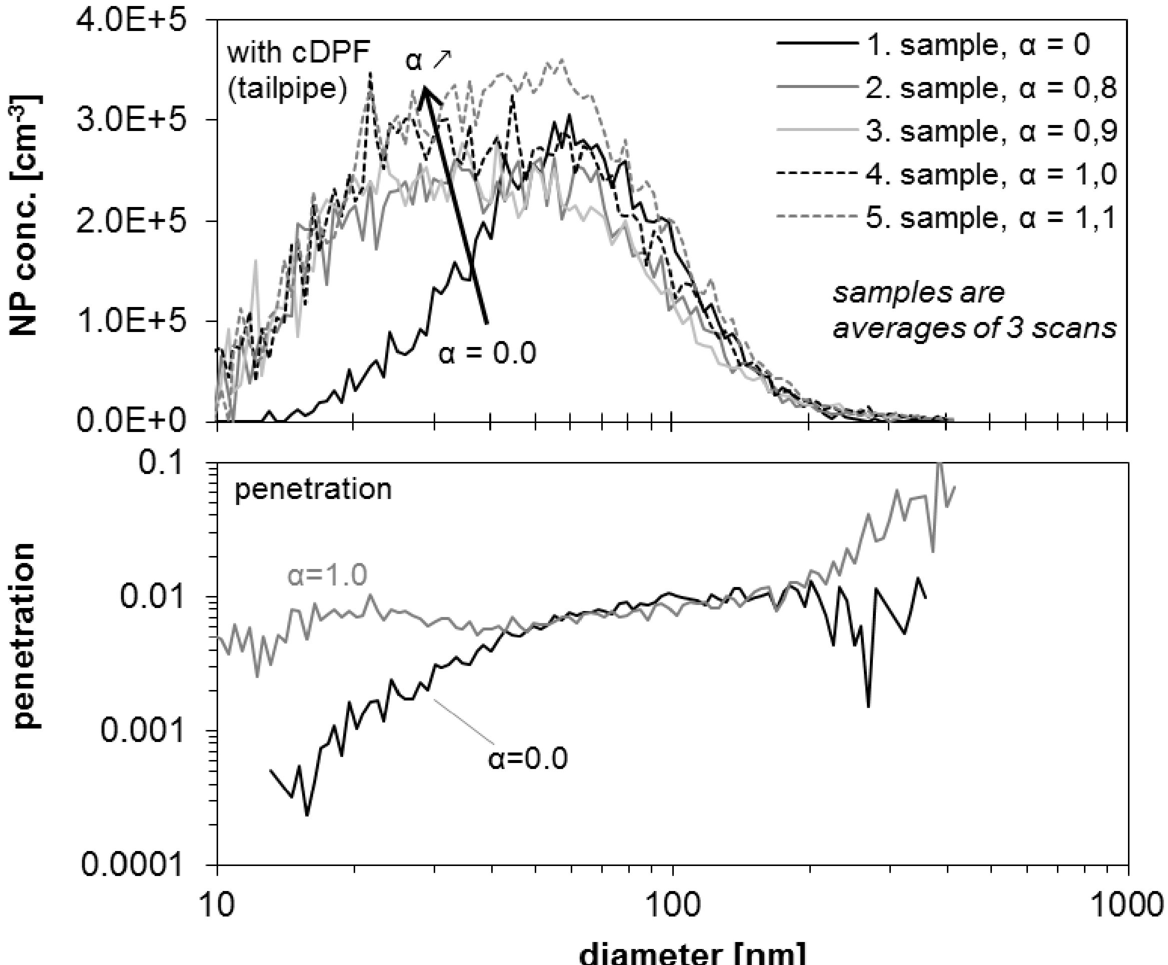
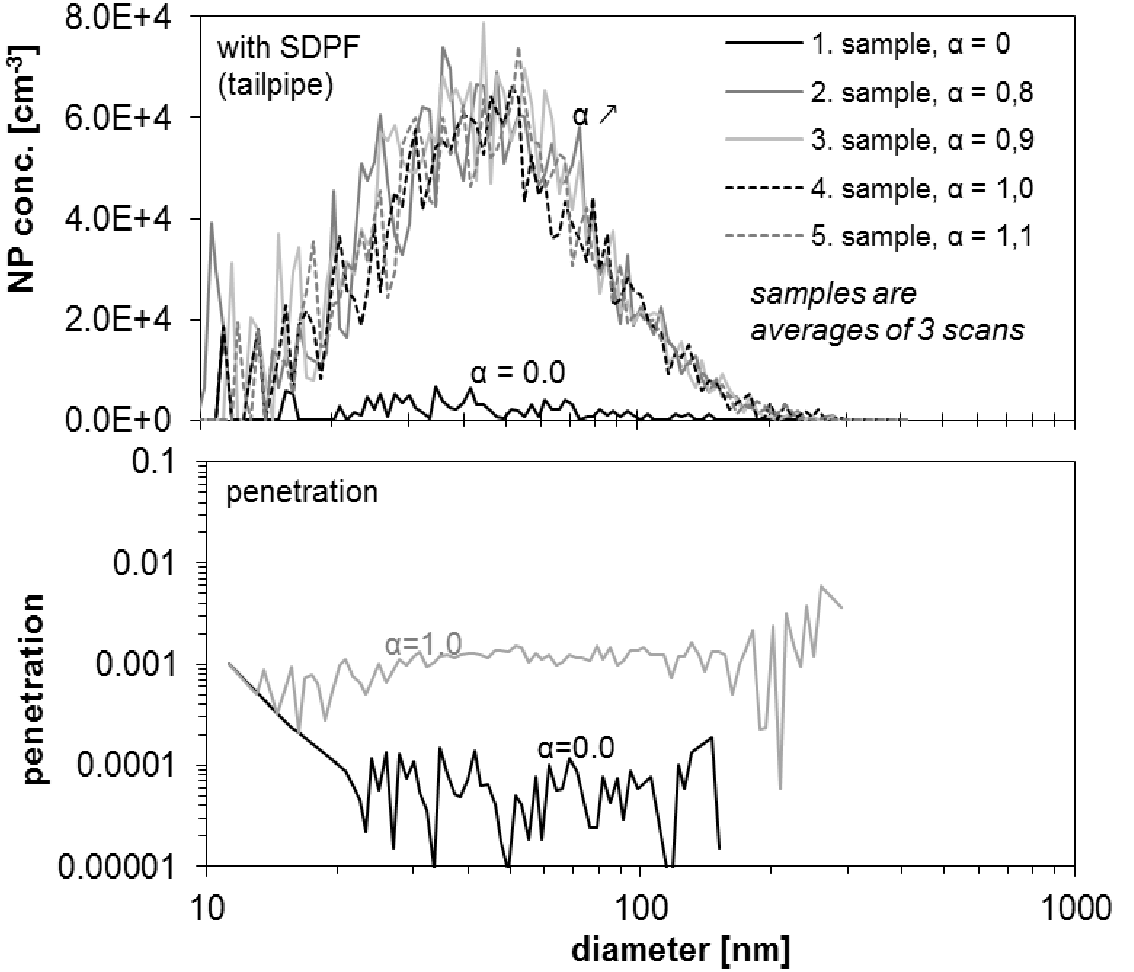


Nanoparticles emissions in steps-test with SDPF, with / without dosing (zoomed representation); SYS03; dosing α =0.9.

NP size spectra with conventional DPF+SCR at stationary OP 2200 Nm / 175 Nm; SYS01; not pre-loaded

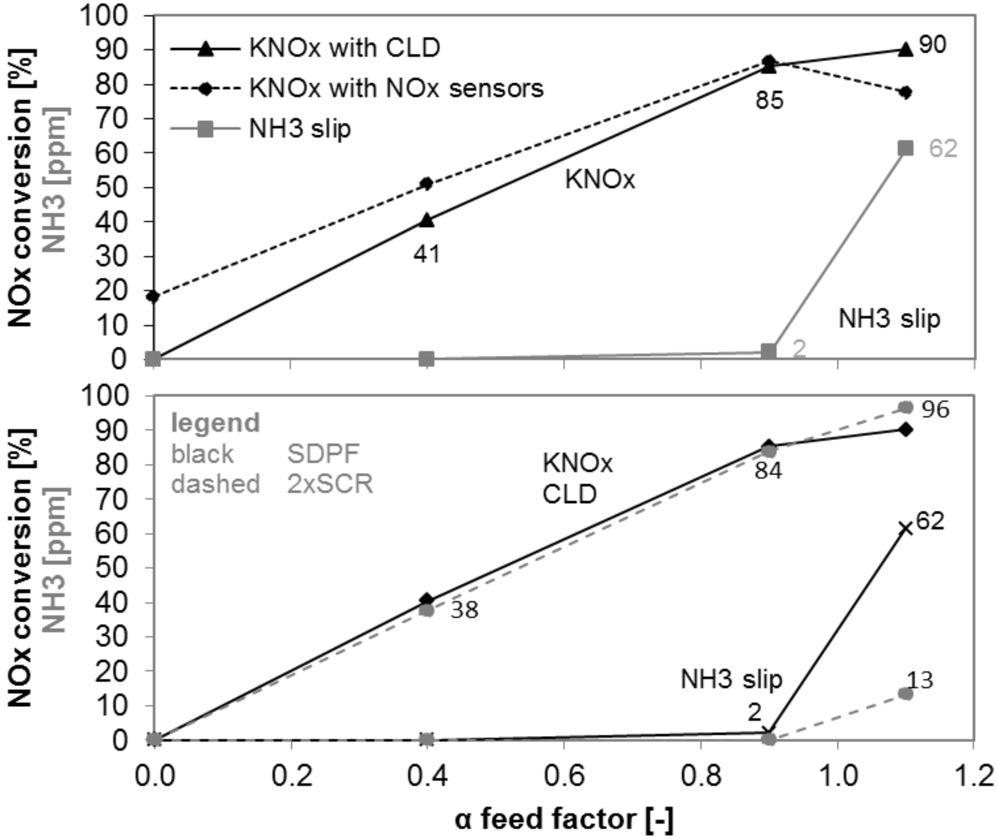


NP size spectra with SDPF at stationary OP 2200 Nm / 175 Nm ; SYS03; not pre-loaded.

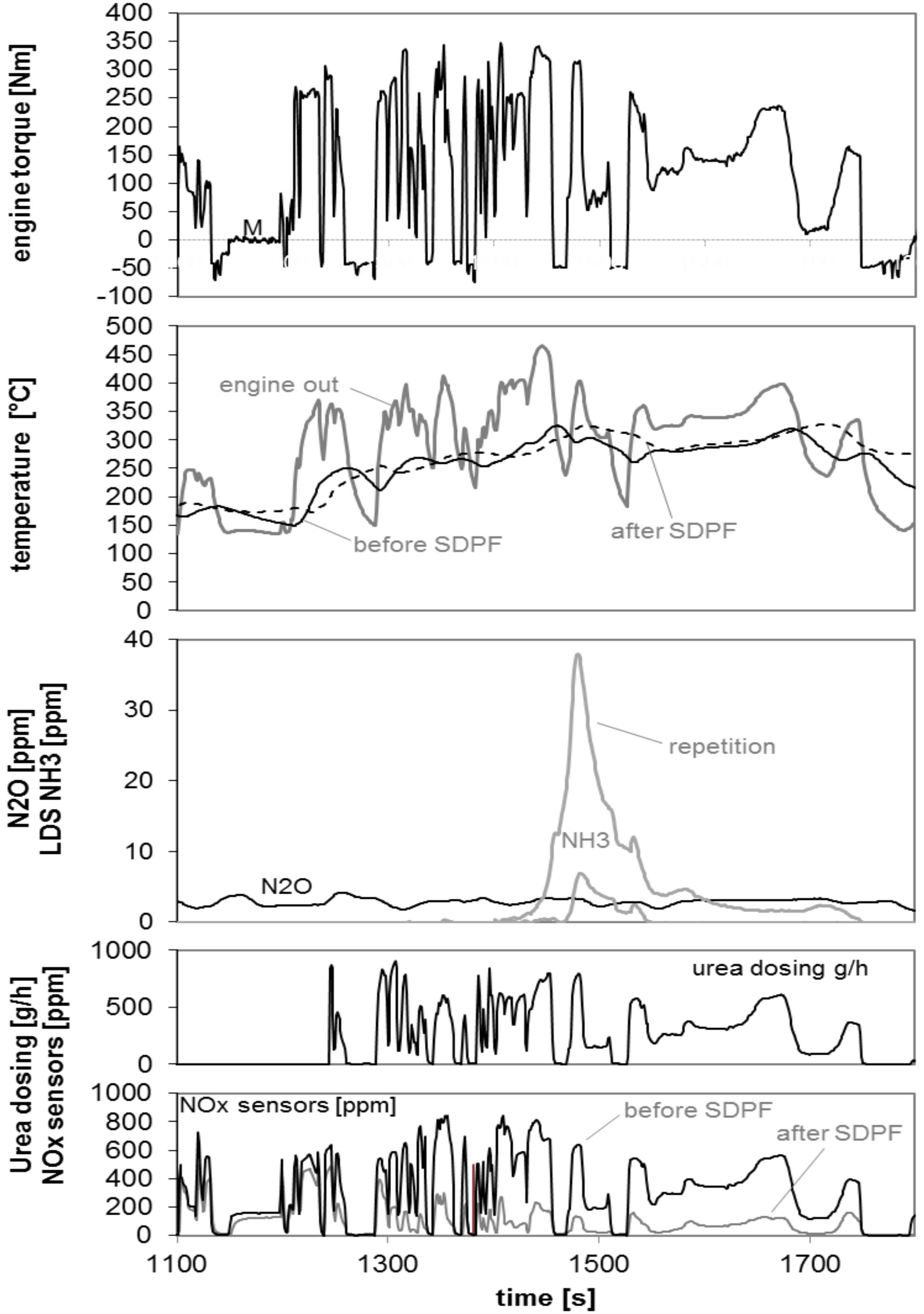


$deNO_x$-efficiency

SCR-efficiency of SDPF (SYS05) at stationary OP 2200 rpm / 175 Nm & comparison with 2xSCR (SYS01); filter not-pre-loaded; with dosing: α =0/0.4/0.9/1.1.



Dynamic operation



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NH_3 dispersion in two WHTC's with SDPF; SYS03; not-pre-loaded; with dosing: $\alpha = 0.9$

Conclusion (1)

- the emissions behavior of SDPF after urea switch-on (SWON) concerning NO_x reduction speed and NH_3-peak is always fluctuating, due to inhomogeneous distribution of urea, urea products and soot in the filter volume, this even with a carefully conducted conditionings
- the active urea injection with fully loaded SDPF causes a lower level of passive regeneration efficiency by mass and a slower backpressure drop in the last, highest step of the regeneration attempt

Conclusion (2)

- the loaded SDPF, compared with empty one shows: slower NO_x-reduction and higher NH_3 after SWON because of use of part of NO_2 for soot oxidation and consequently less NO_2-availability for the deNO_x-reactions; the secondary NP penetration after SWON is clearly lower with the loaded trap

- both investigated systems: SDPF and 2 x SCR attain nearly the same deNO_x-efficiency

- in WHTC with a lower level of exhaust gas temperature SDPF causes lower deNO_x-values (40-45% against 75% in ETC), but also lower NH_3-emissions


Thank you
for your
attention !