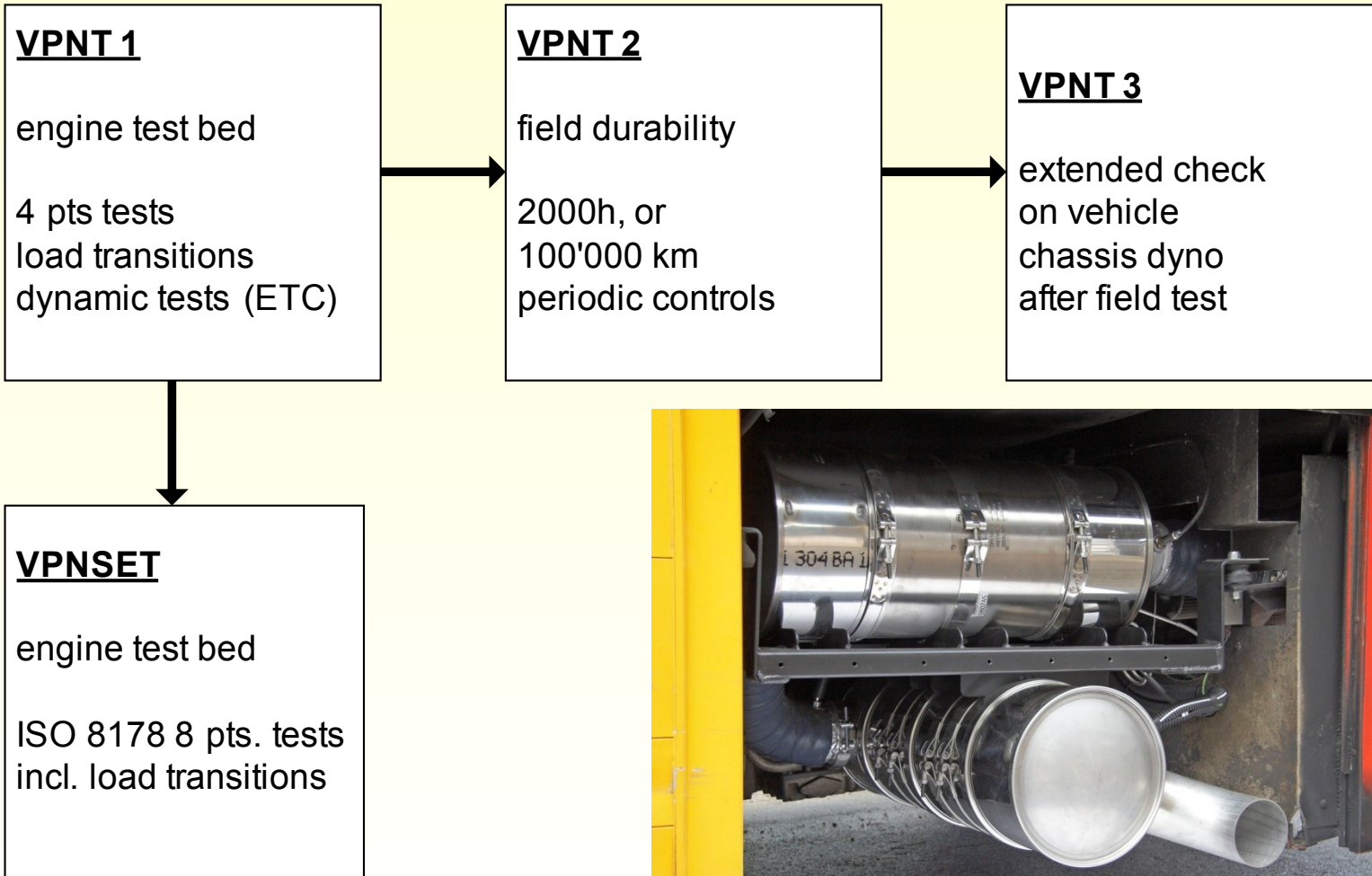




Reduction of Emissions and Unregulated Components with DPF+SCR

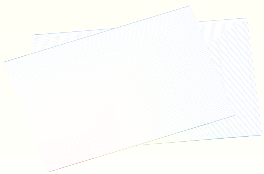
Jan Czerwinski, /AFHB
Andreas Mayer/TTM,
Zbigniew Stepien/INIG
Stanislaw Oleksiak/INIG
Otto Andersen/WNRI

VERTdePN test procedures for product standards of combined systems (DPF + SCR)





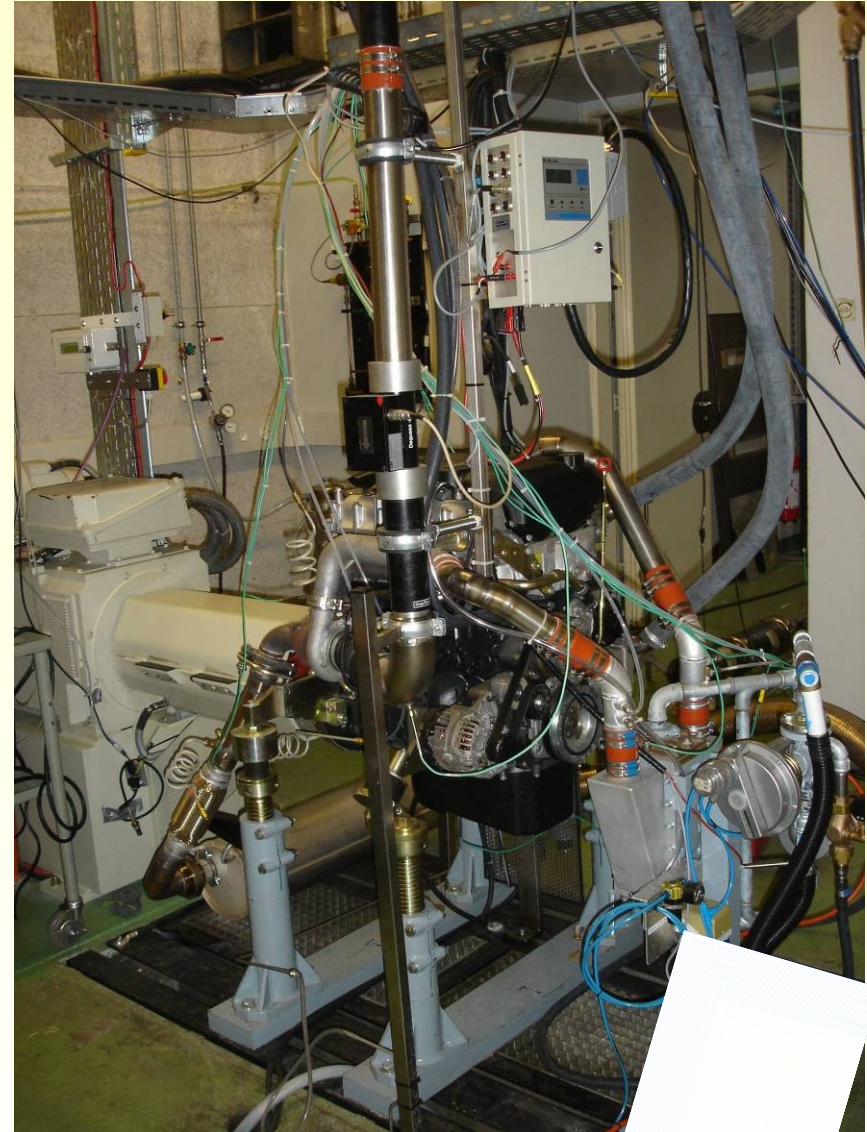
Measuring Set-up



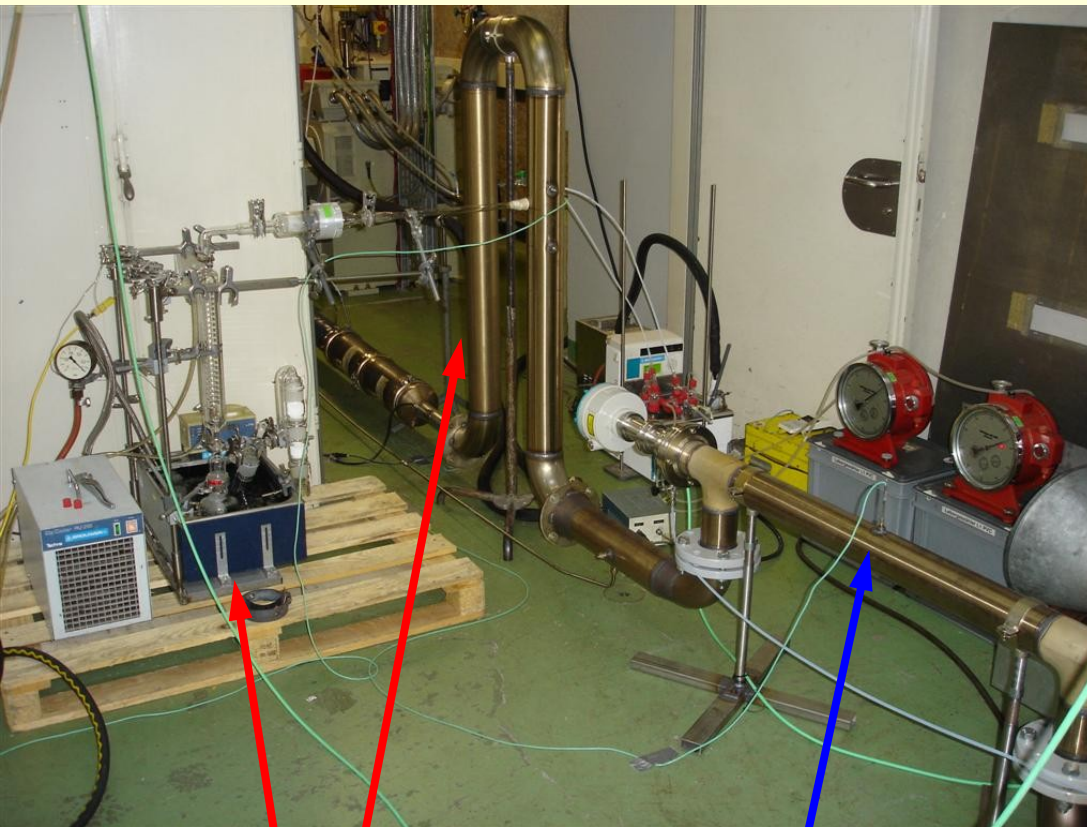


TEST ENGINE

Manufacturer: Iveco, Torino Italy
Type: F1C Euro3
Cylinder volume: 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

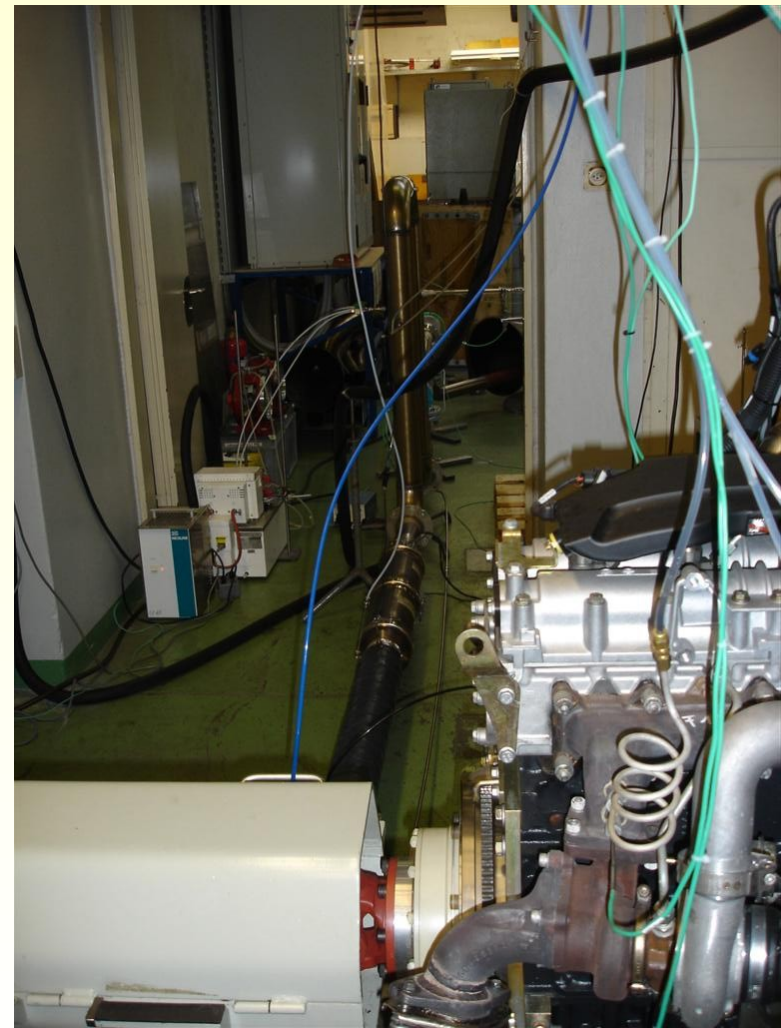


Exhaust line prepared for adaptation of dePN-systems and special exhaust gas analysis

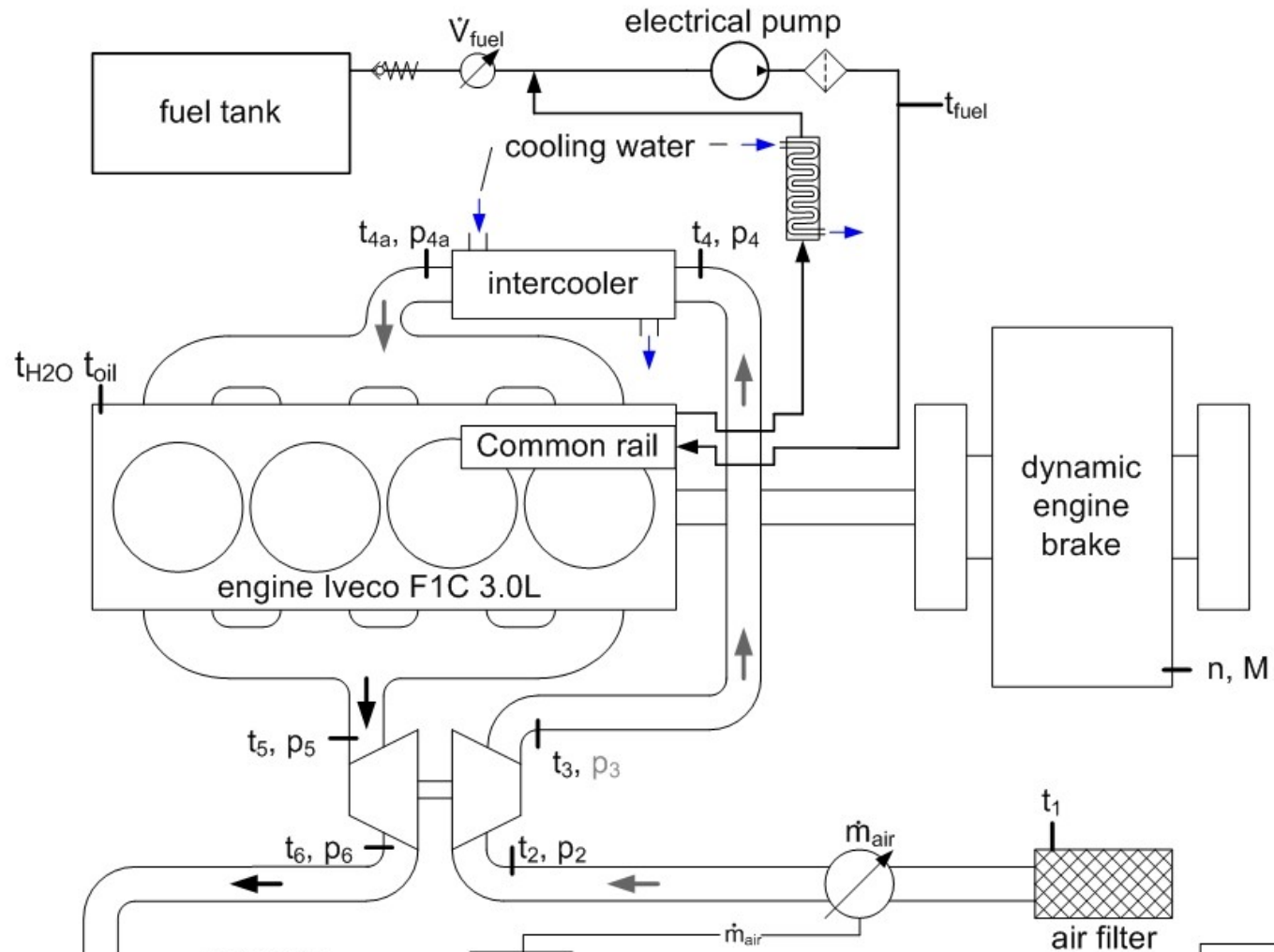


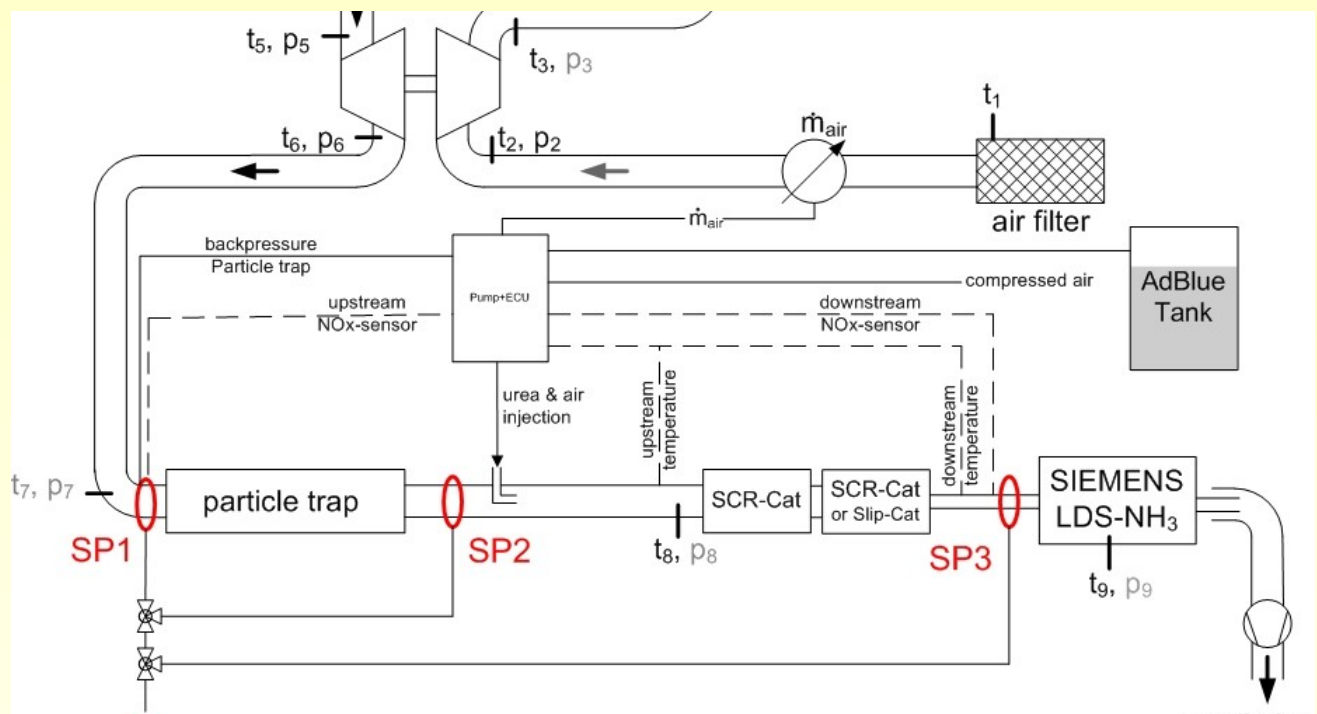
DPNSSET-Sampling

LDS



Measuring set-up (1)

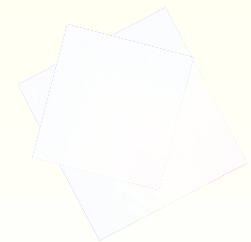
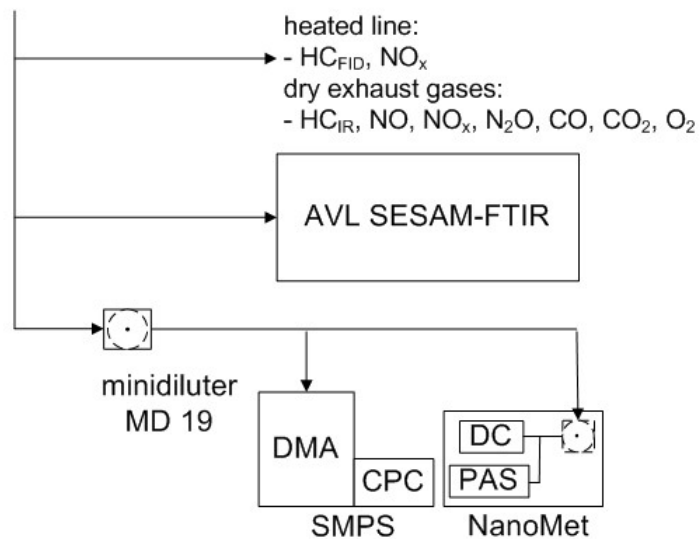




Measuring set-up (2)

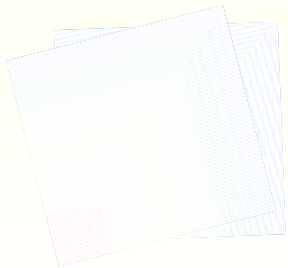
- SP1:** Sample Point 1, engine out
- SP2:** Sample Point 2, after PF, before urea injection
- SP3:** Sample Point 3, tailpipe

Investigated (DPF+SCR) system



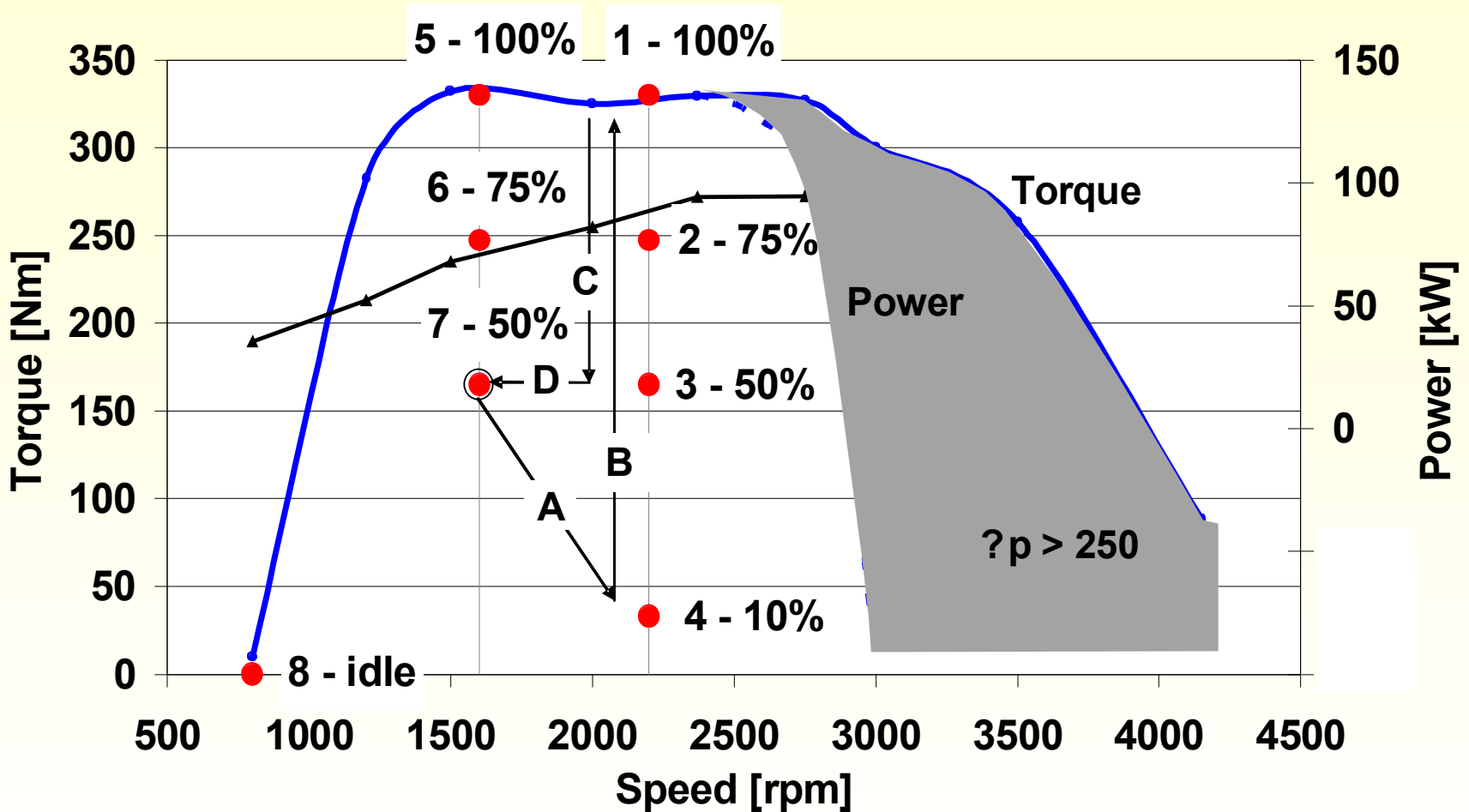


Test Procedures



8pts. test (ISO 8178) and the VPNT1 4pts. test

engine map : IVECO F1C CR, DI, TCI, 3 dm³

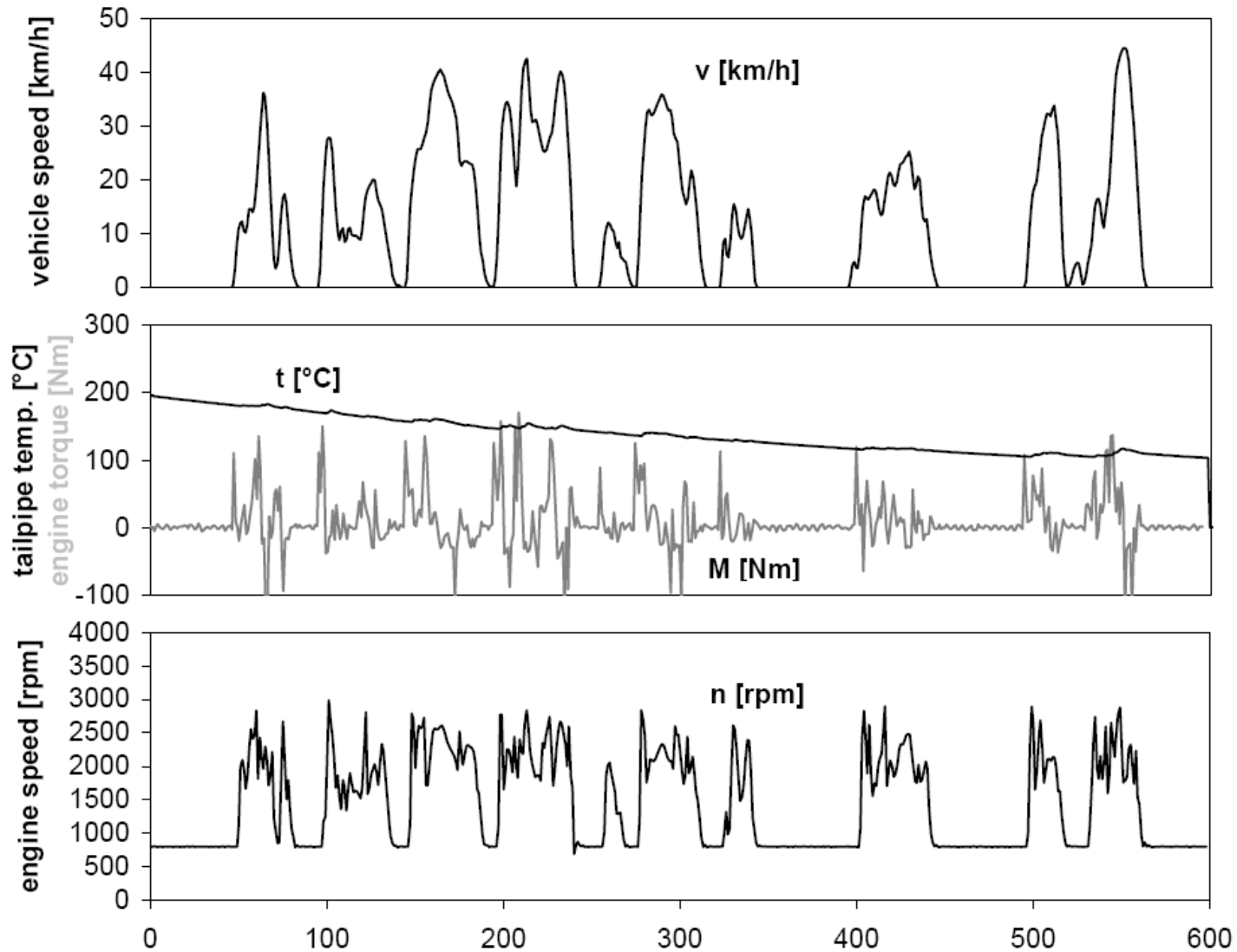




ETC for the limited version of engine map, IVECO F1C

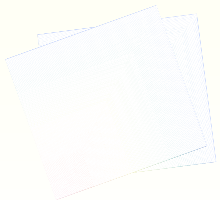


Driving Speed and Engine Parameter in the NYCC



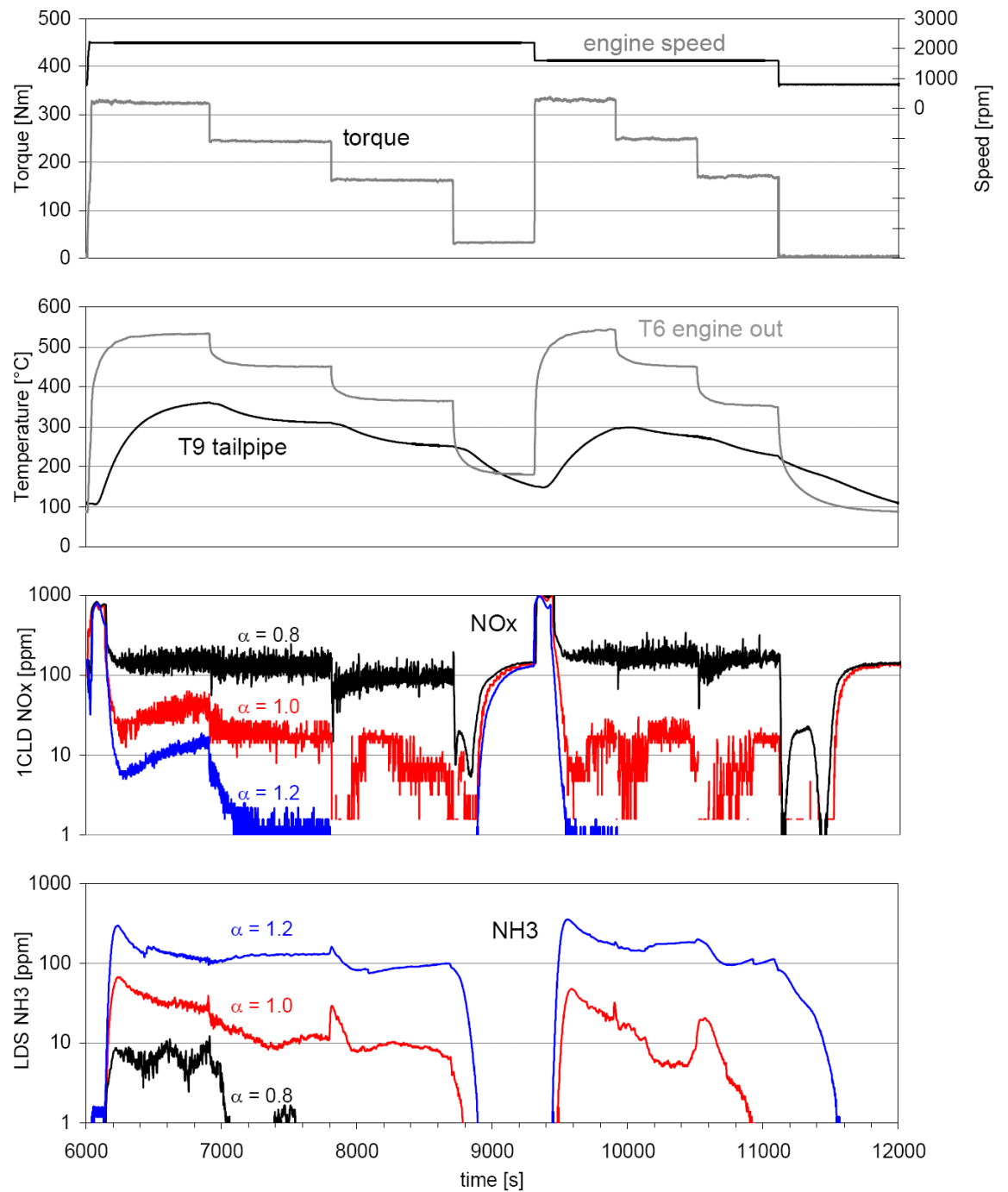
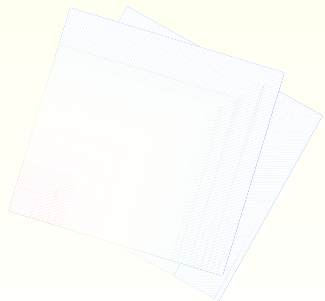


Stationary engine operation

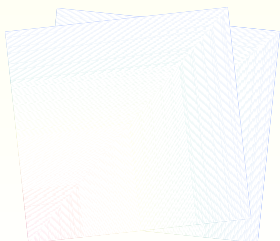
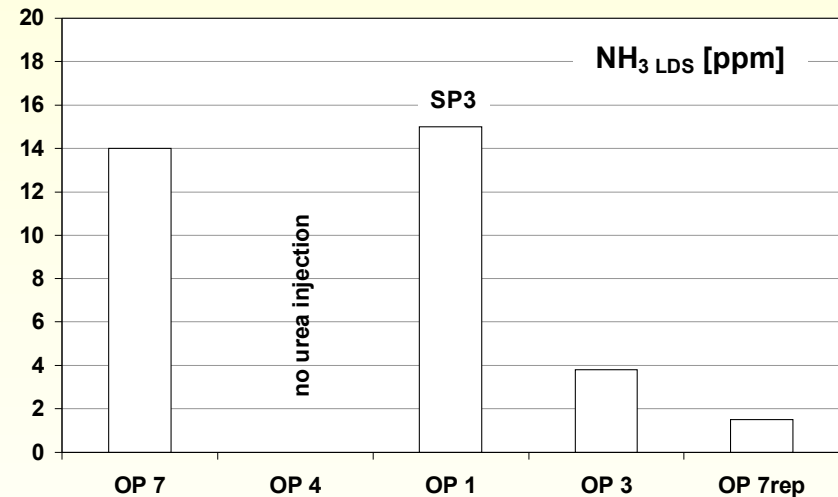
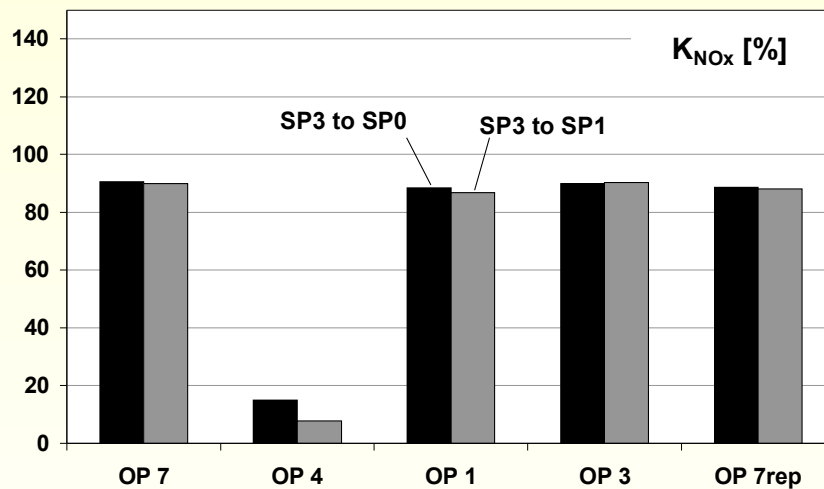


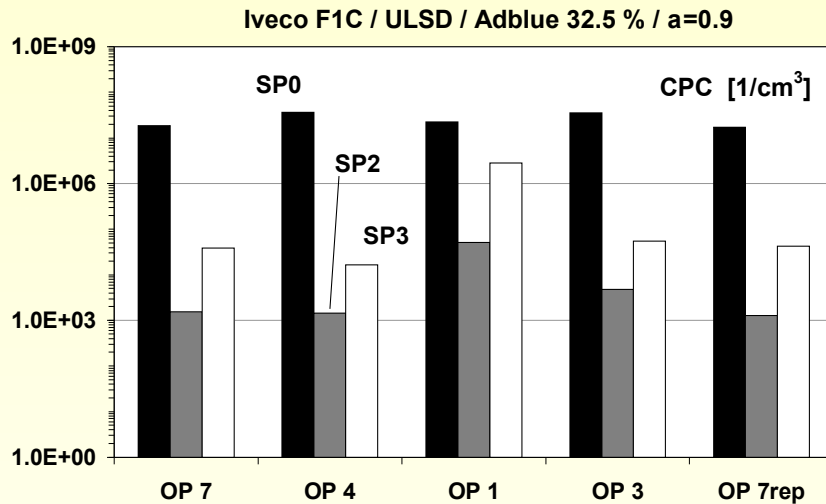
8-points test

Comparison of results with different α

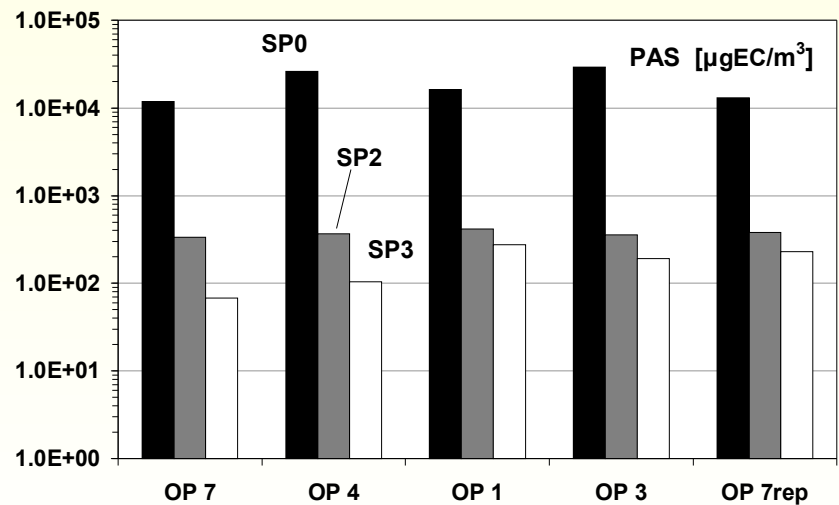
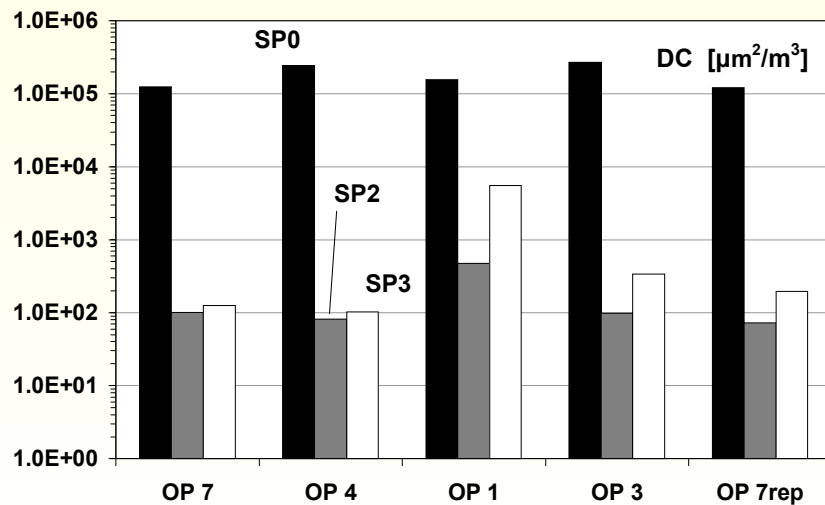


NO_x conversion at different SP's & NH₃ tail pipe





Secondary nanoparticles at 4pts. test (w/o slip cat.)

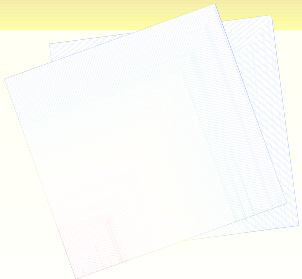




Quasi dynamic engine operation



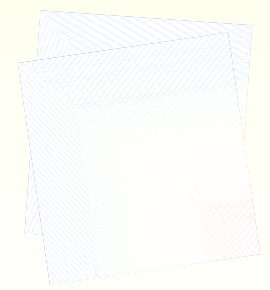
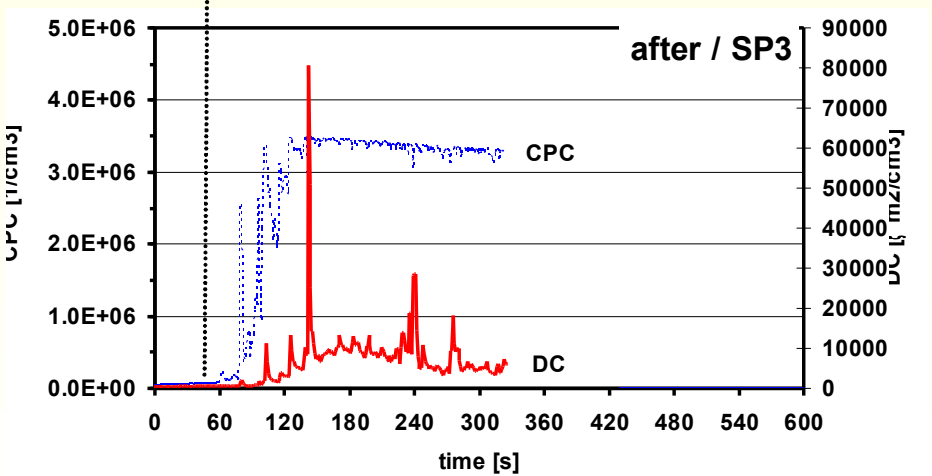
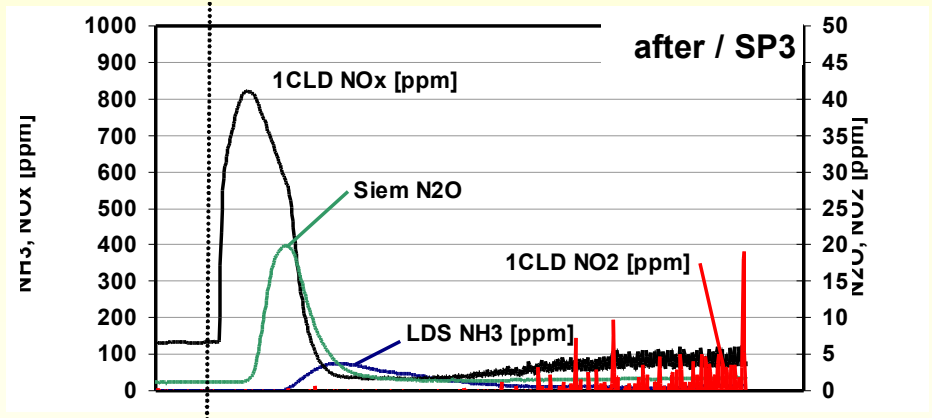
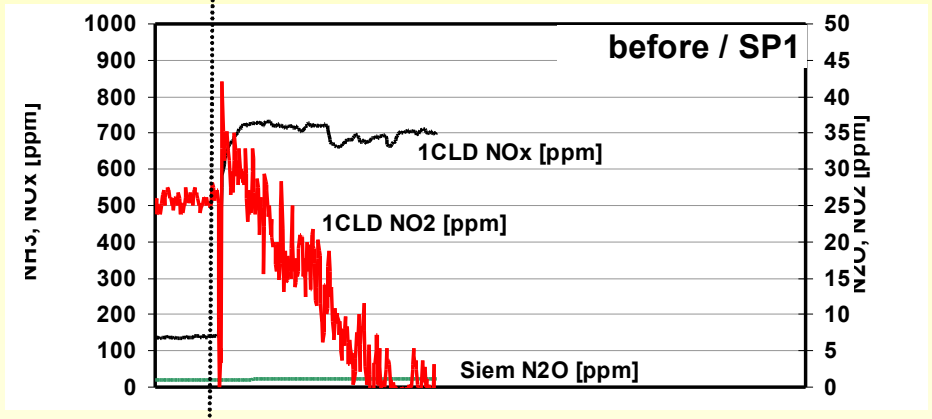
Load transitions



Load transition: 2200 rpm
10%L to 100%L

Adblue injection switch on

**Load transition B:
from 2200 rpm / 10%L
to 2200 rpm / 100%L
with measurements
before and after
DPF + SCR**

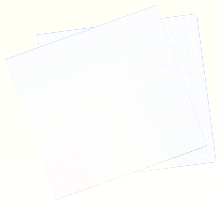




Dynamic engine operation



ETC



ETC's with limited engine map

ETC 1 with slip
with cat

ETC 3
w/o slip cat

ETC 4
Ref.
w/o DPF + SCR

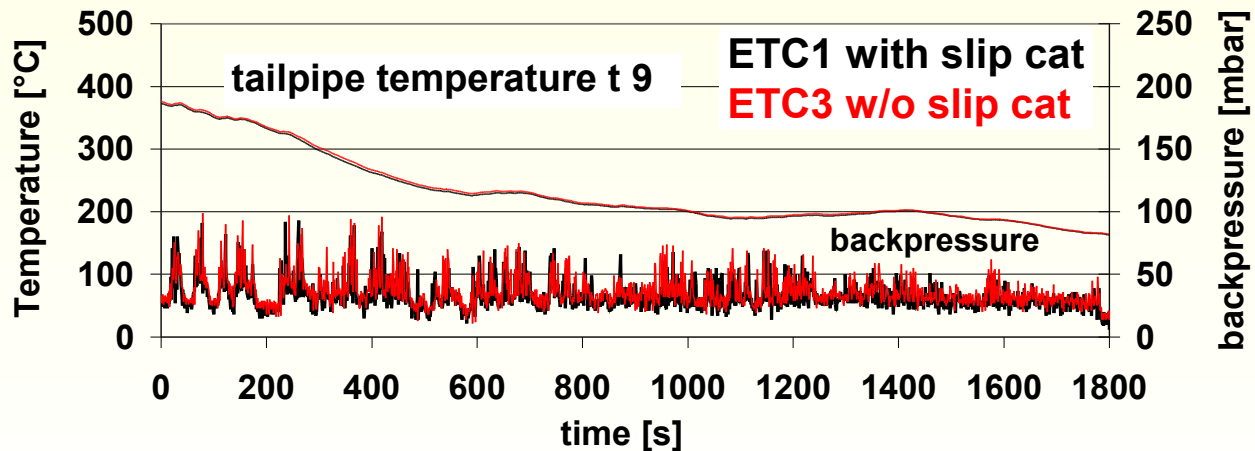
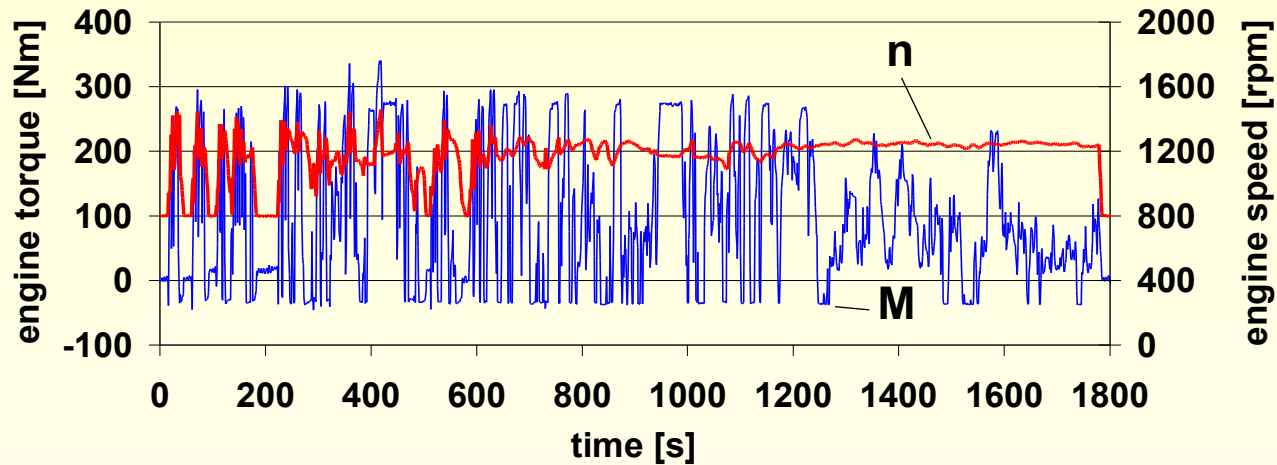
Conditioning before ETC

5 min → pt. 1 2200 rpm / 100 % Load

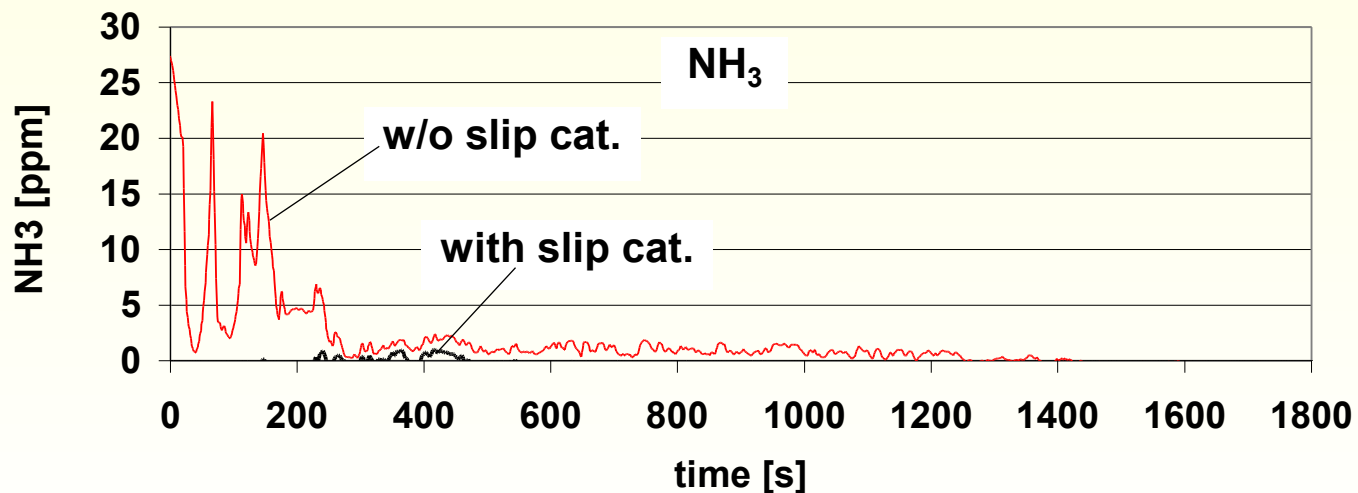
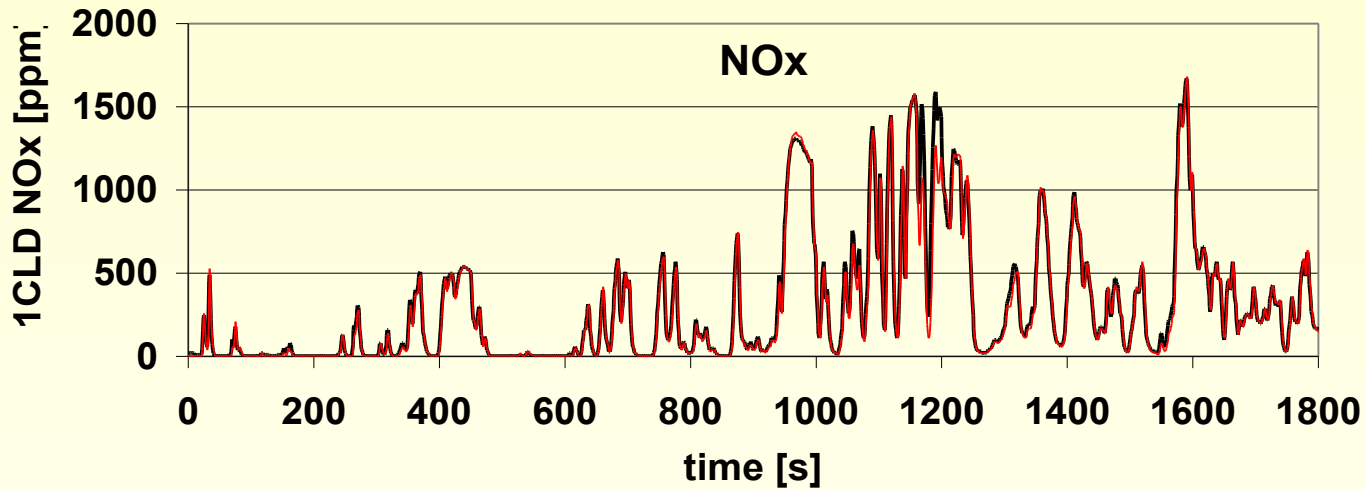
0.5 min → idle

Comparison of 2 ETC's (ETC1-ETC3), with & w/o slip catalyst , $\alpha = 0.9$

Iveco F1C - limited engine map - Diesel ULSD

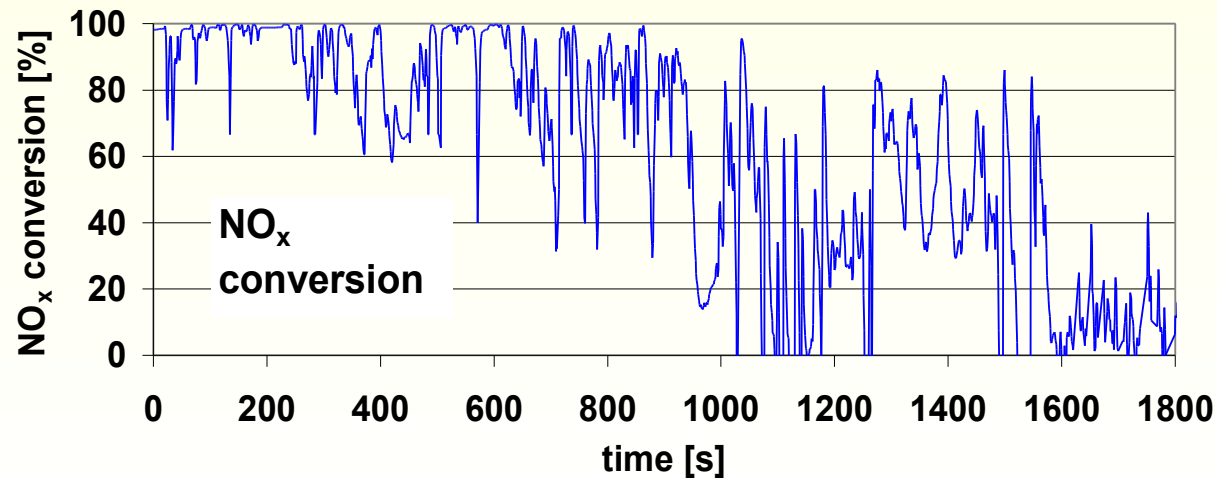
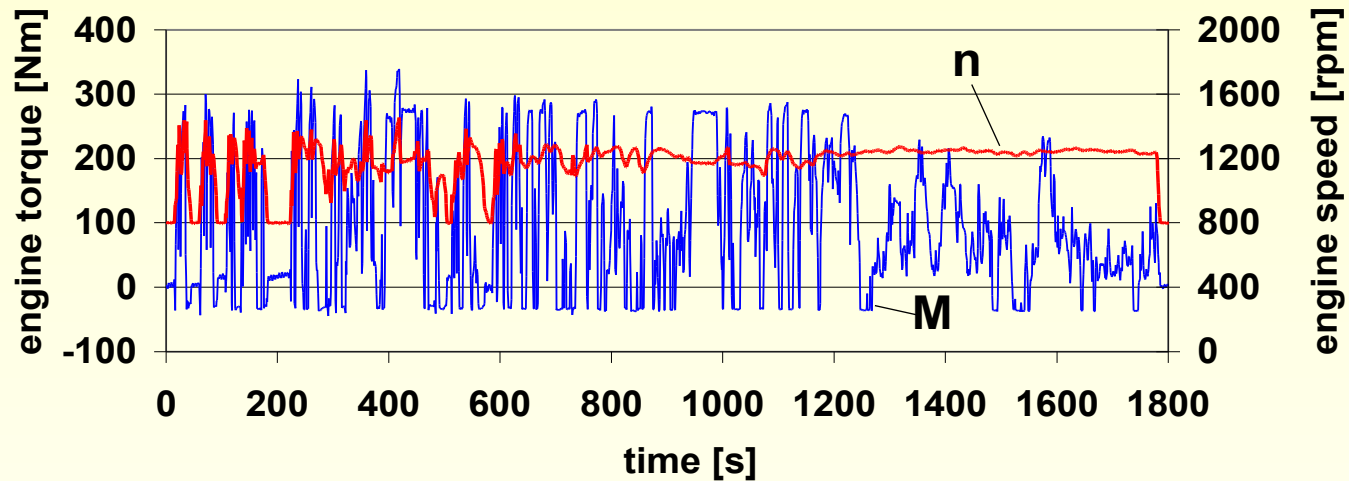


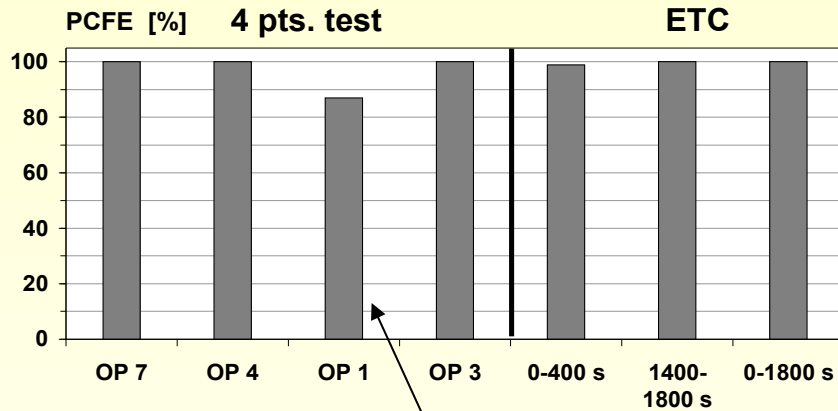
Comparison of 2 ETC's (ETC1-ETC3), with & w/o slip catalyst , $\alpha = 0.9$



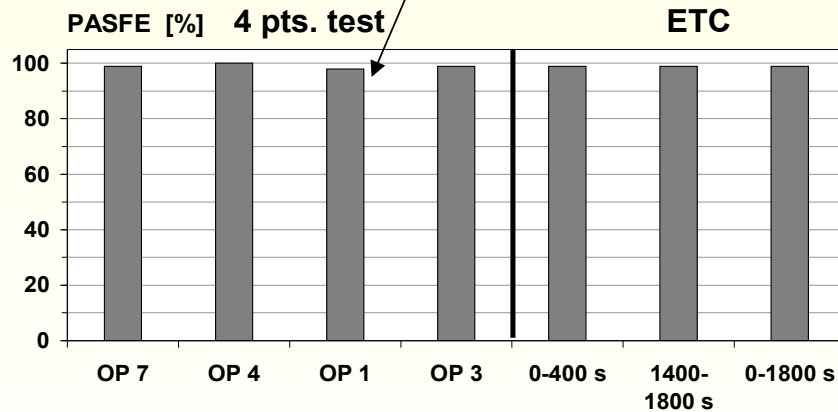
Comparison of 2 ETC's (ETC3-ETC4), reference & w/o slip catalyst , $\alpha = 0.9$

Iveco F1C - limited engine map - Diesel ULSD



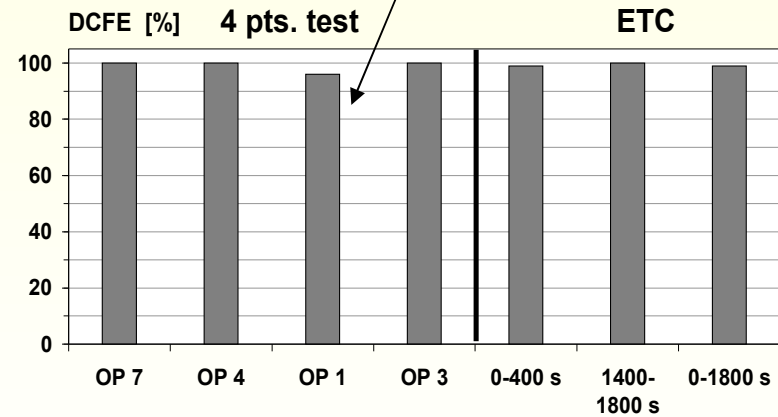


SCR secondary NP effects

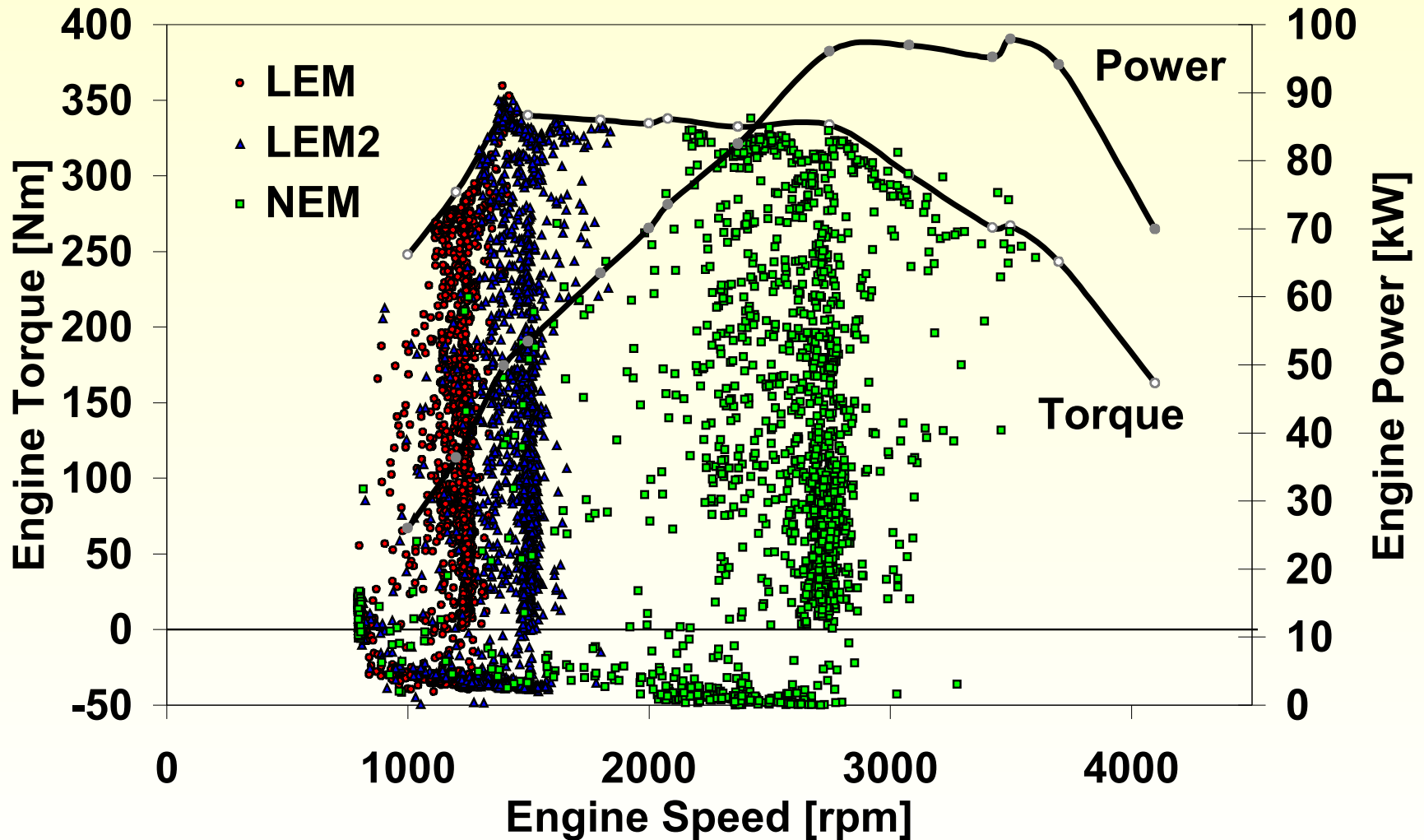


Filtration efficiencies of the combisystem after SCR – catalyst in stationary and dynamic engine operation

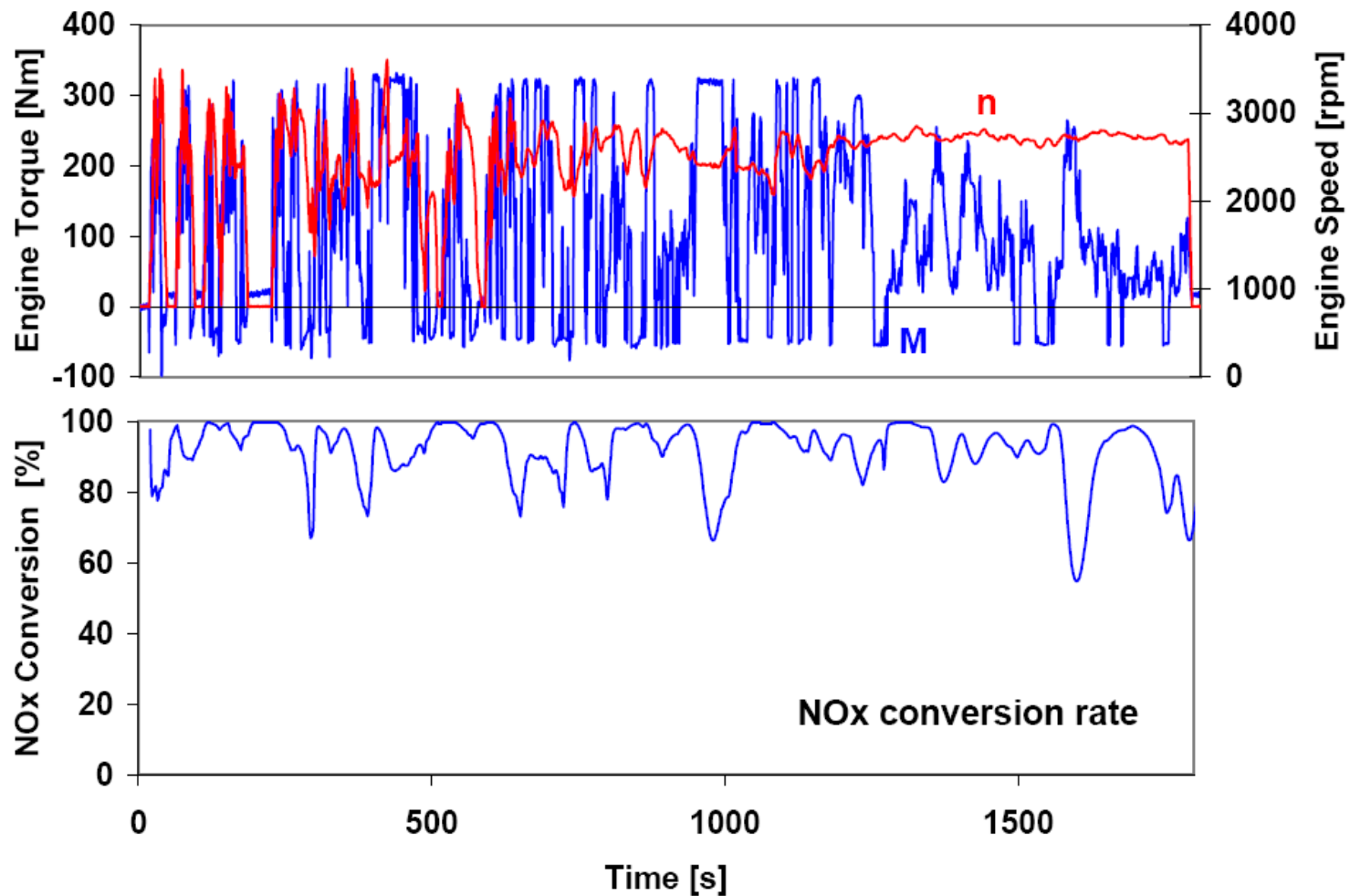
SCR secondary NP effects



Limited and Nonlimited Engine Map (LEM, NEM)



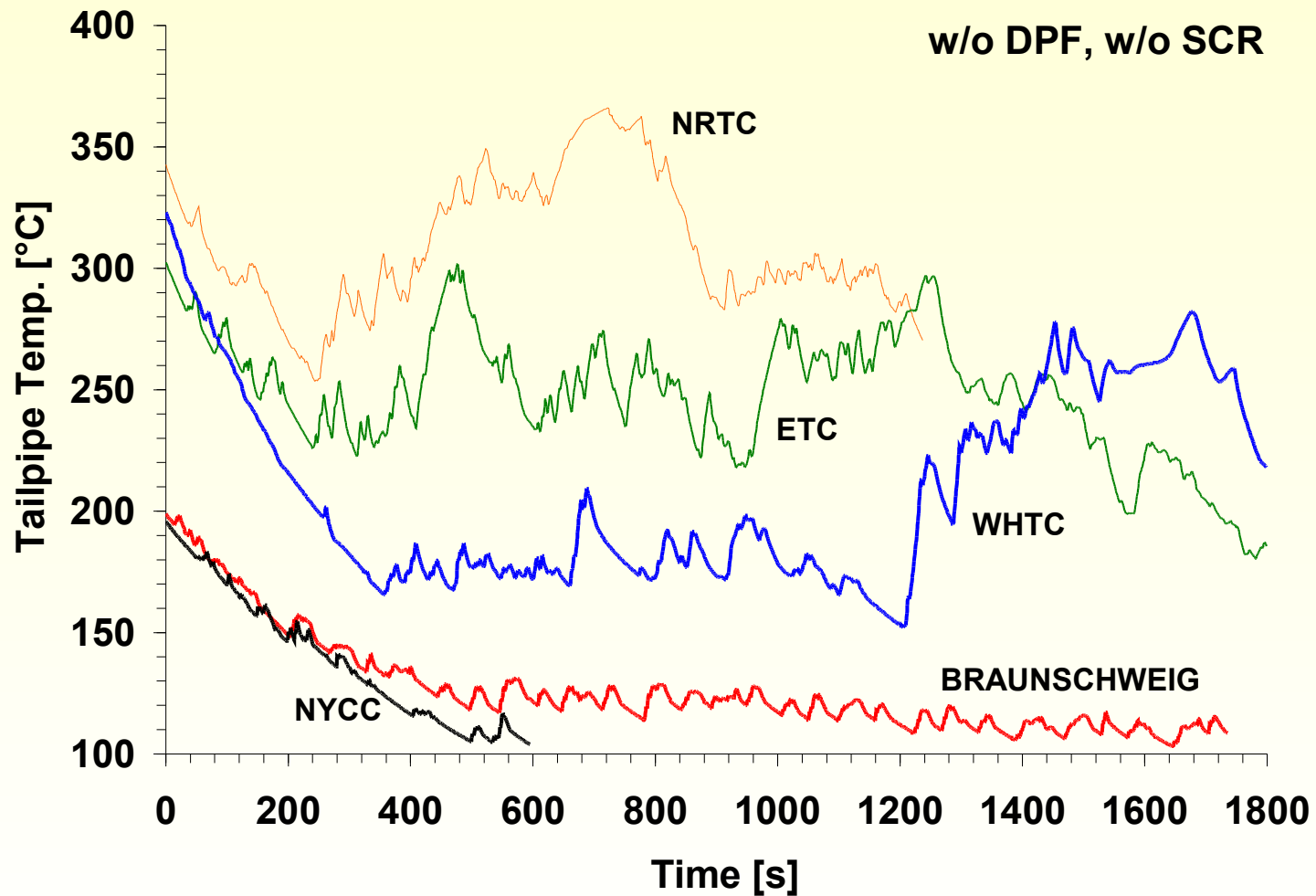
NOx conversion rate in ETC with full operating range of the engine, $\alpha = 0.9$, (NEM)





Other dynamic cycles

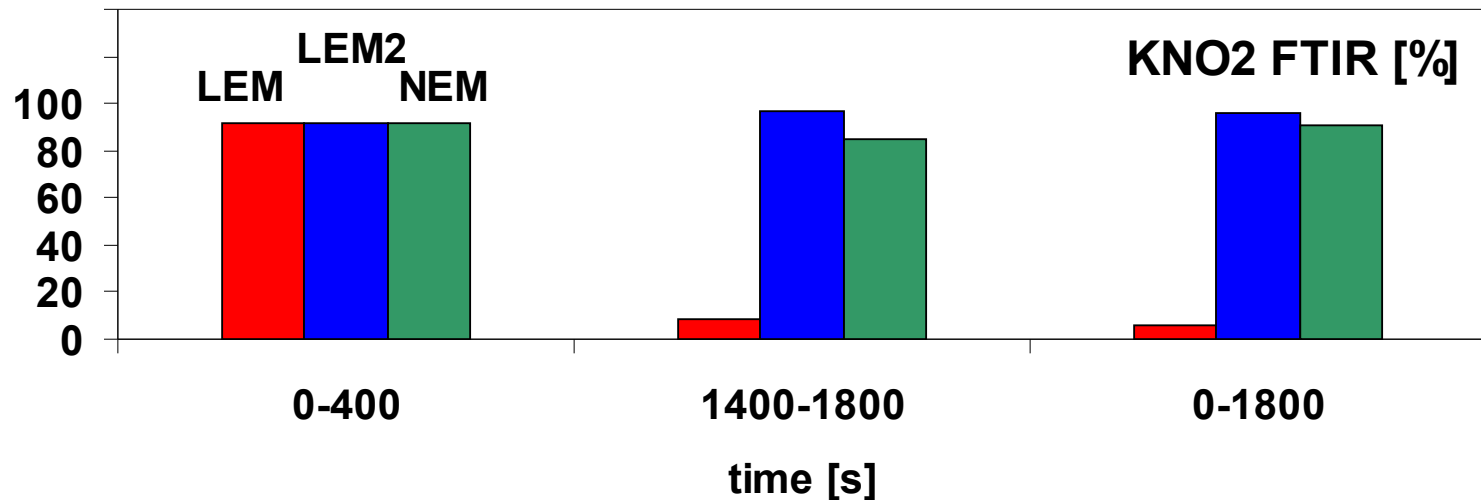
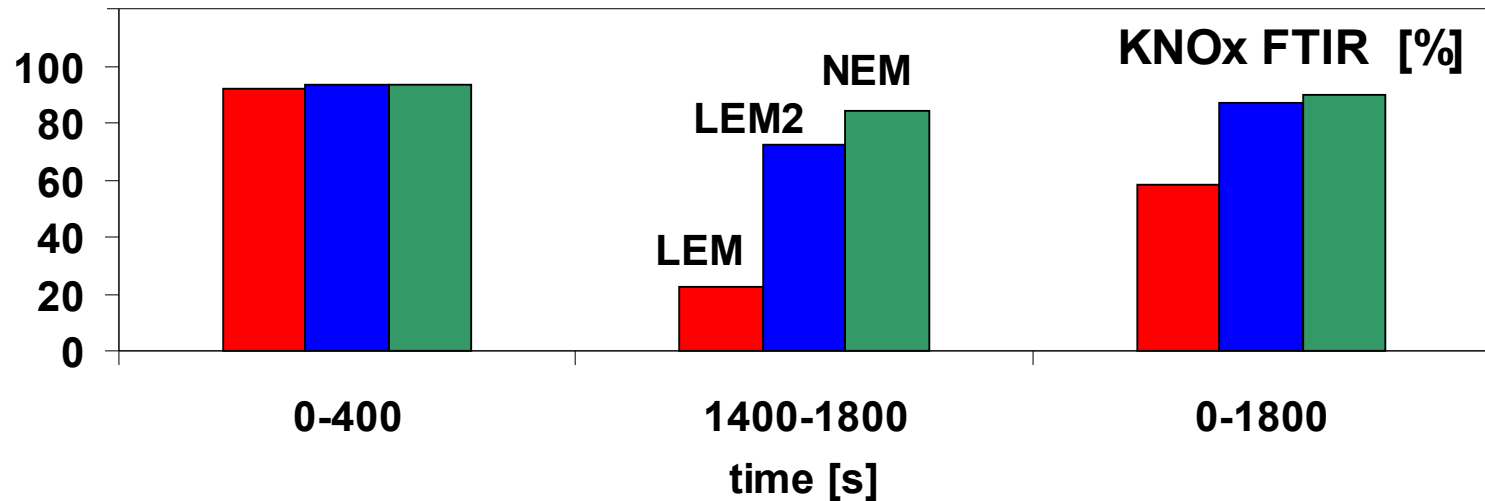
Exhaust temperature in other dynamic cycles



Emissions and conversion rates in other dynamic cycles

$RE_x = \frac{X_{w/o} - X_w}{X_{w/o}} \cdot 100$	RE [%]			
	ETC	WHTC	NYCC	BRAUN
NO _x 2CLD [ppm]	91	65	42	16
NO _x FTIR [ppm]	90	64	40	14
NO ₂ 2CLD [ppm]	93	33	87	76
NO ₂ FTIR [ppm]	91	35	98	92

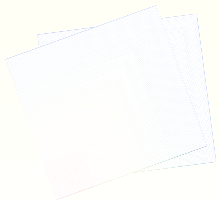
Integral Conversion Rates in ETC with different charge collective



Conclusion (1)

- $\alpha \uparrow \rightarrow \text{NO}_x \downarrow \rightarrow \text{NH}_3 \uparrow$ (w/o slip cat)
- urea switch on/off at lower t_{Exh}
- NO_x conversion rate in ETC dependent strongly on urea dosing = $f(t_{\text{Exh}})$

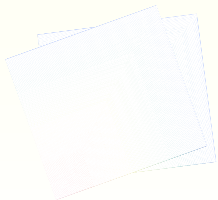
further research and evaluations in course



Conclusion (2)

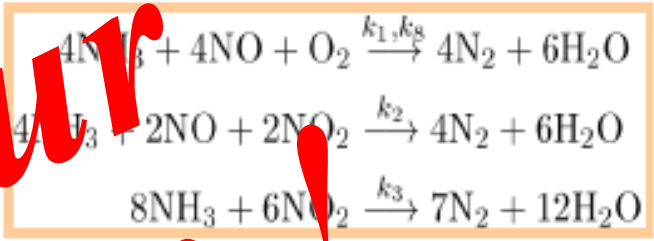
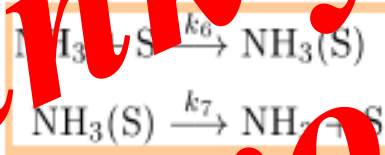
- **in ETC with $\alpha = 0.9$**
 - **average $\text{NH}_3 \leq 7$ ppm**
 - **average $\text{N}_2\text{O} \leq 3$ ppm**
- **secondary NP**
- **DPF filtration efficiency up to 100%**
stationary = dynamic

further research and evaluations in course

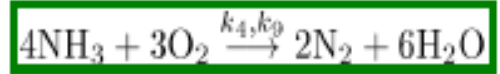
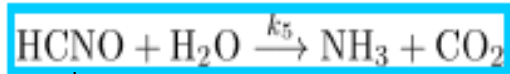
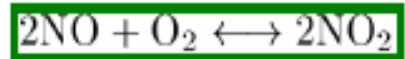
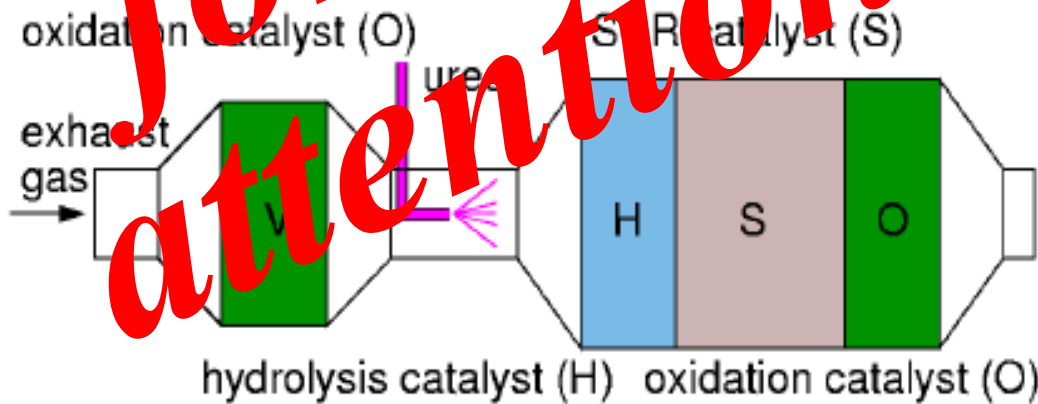
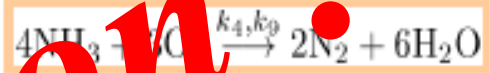
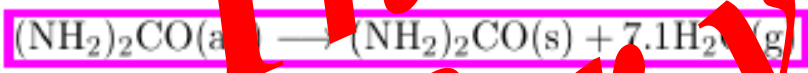


- Pre (Vor)-Catalyst
- Hydrolysis, SCR and Oxidation Catalyst

Thank you for your attention!



normal
rapid
slow



HNCO isocyanic acid