NPTI APPROACHES FOR DENO_X-SYSTEMS

Dr. J. Czerwinski, AFHB
Dr. A. Mayer, TTM
Th. Lutz, ETHZ

Focus Event, 22. Nanoparticle Conference, ETHZ 21.06.2018

Bern University of Applied Sciences
Biel-Bienne Switzerland
AFHB | IC-Engines and Exhaust Gas Control

HD vehicles with DPF + SCR TeVeNO$_x$

2012-2013

Bern University of Applied Sciences
Biel-Bienne Switzerland
AFHB | IC-Engines and Exhaust Gas Control

TeVeNO$_x$ …

Testing of Vehicles with NO$_x$-Reduction Systems

SAE Paper 2014-01-1569

3 Types of vehicle tests

Test type 1

- HD Chassis Dynamometer

Test type 2

- Real World Operation on the Road

Test type 3

- Simple Function Test
  (short operation on the road)

Investigated vehicles

Investigated vehicles:

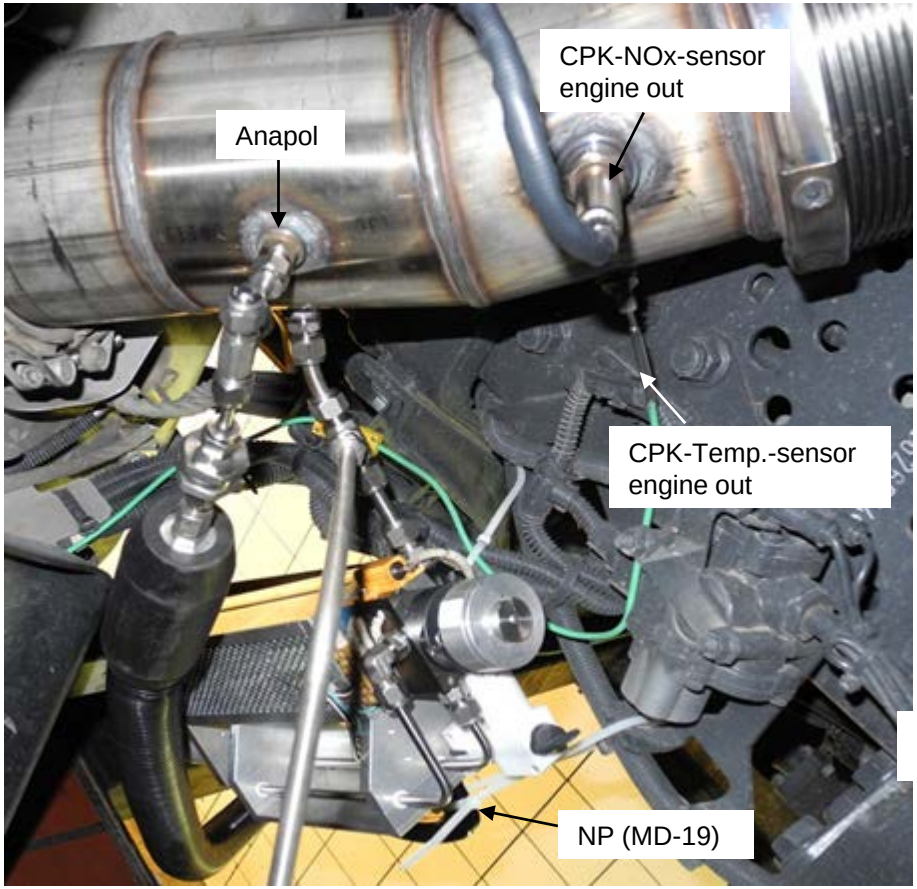
Vehicles		Exhaust system
A	Bus Volvo 180 kW	DINEX DPF+SCR retrofit
B	Bus volvo Hybrid 158 kW	OEM DPF+SCR
C	Mercedes Actros 300 kW 570 km	OEM SCR
D	Mercedes Actros 300 kW 500520 km	OEM SCR
E	MAN TGS 397 kW 220 km	OEM SCR + DPF retrofit

Vehicles		Exhaust system
F	Mercedes Actros Blutec 6 330 kW 12000km	OEM CRT+SCR
G	DAF Truck 340 kW	OEM SCR
H	MAN TGS 400 kW	OEM SCR 00KM
I		OEM SCR 84.9 T km
J	Mercedes Actros 260 kW	NOxOFF DPF+SCR retrofit

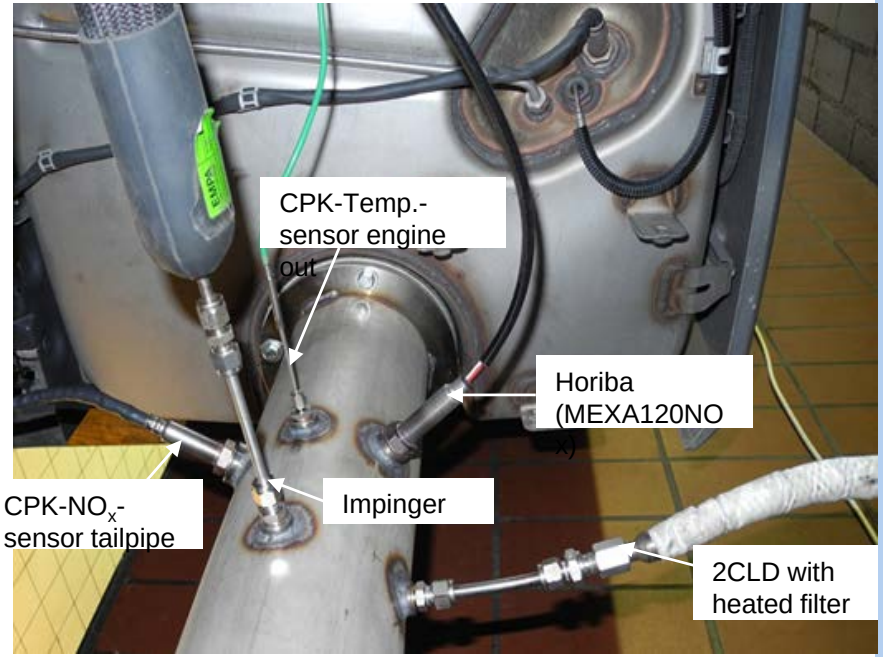
Vehicle E on the MAN HD chassis dynamometer with OEM SCR & retrofitted DPF

Sampling positions on vehicle F

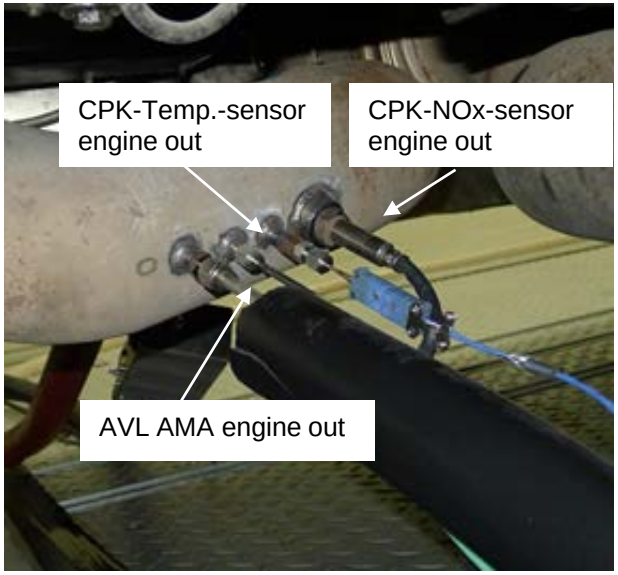
engine-out



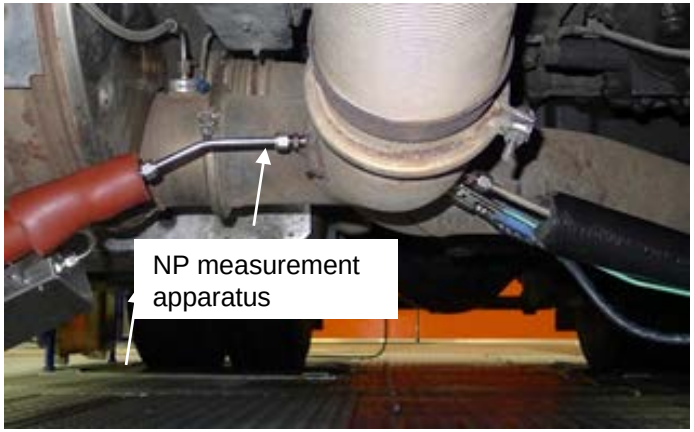
tailpipe

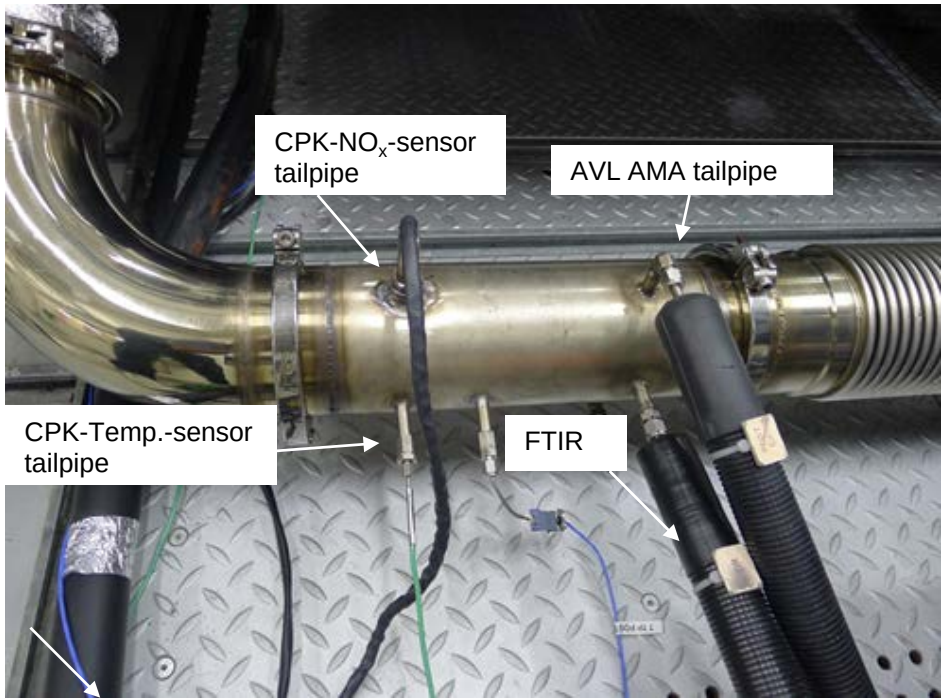


Measuring set-up with vehicle G



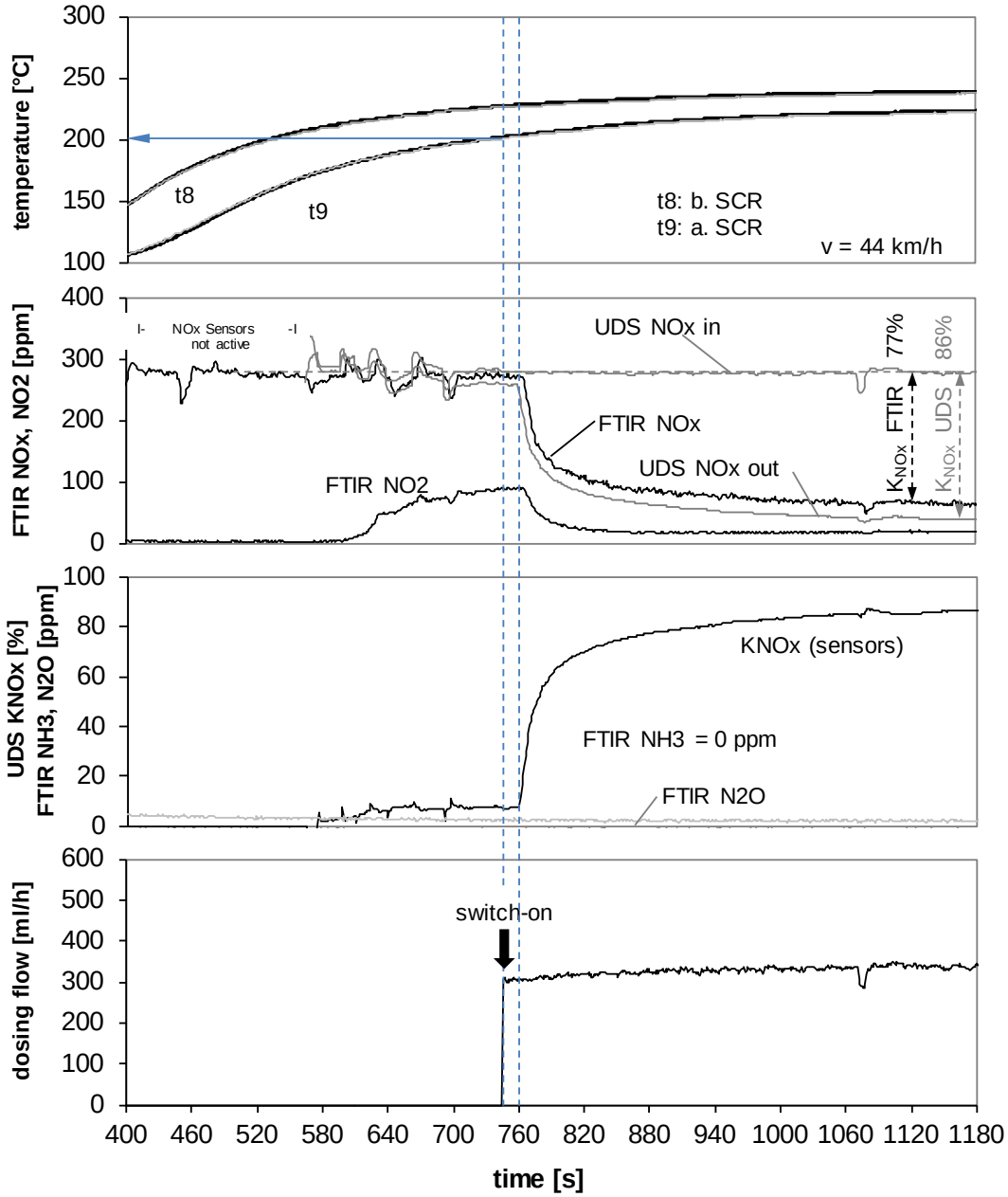
engine-out





tailpipe

Some results

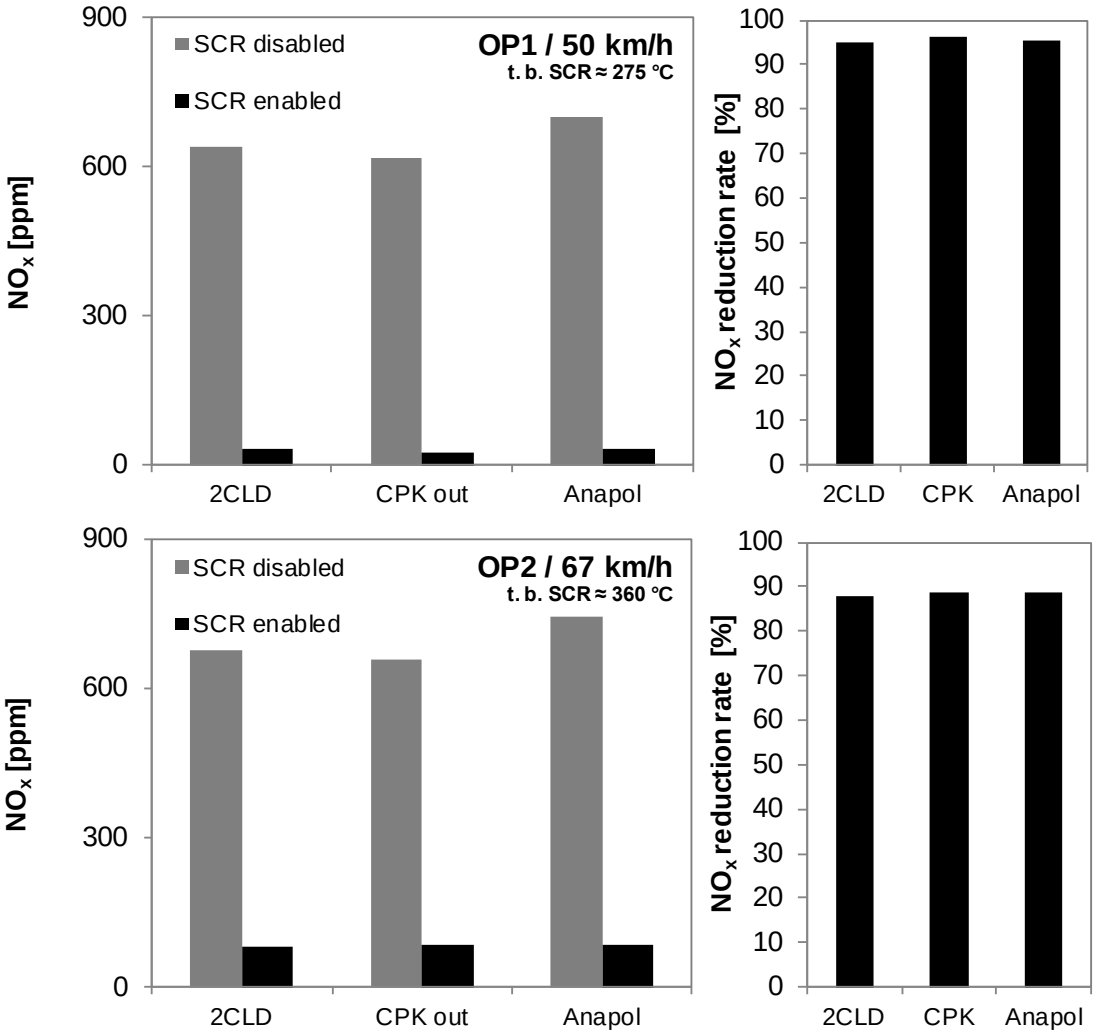


Switch-on dosing

retrofit system cDPF & SCR; α = 0.75
vehicle A; ULSD; Chassis Dyno

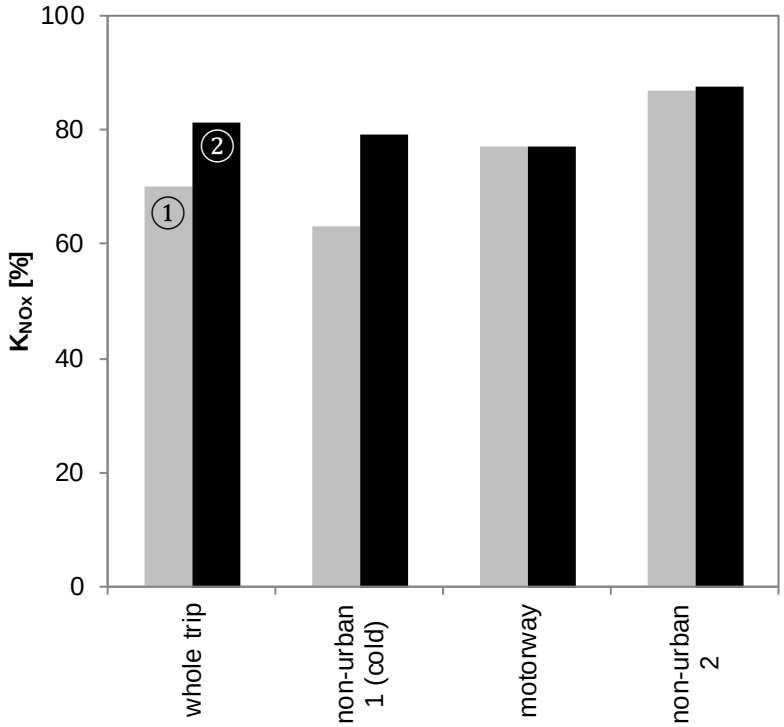
K_{NOx} with different analyzers at stationary operation

OEM SCR; dosing & dosing not activated
vehicle C, ULSD; Chassis Dyno LARAG



Comparison of KNOx-values from different periods of the trip: 2CLD whole trip → CPK & SCR active time

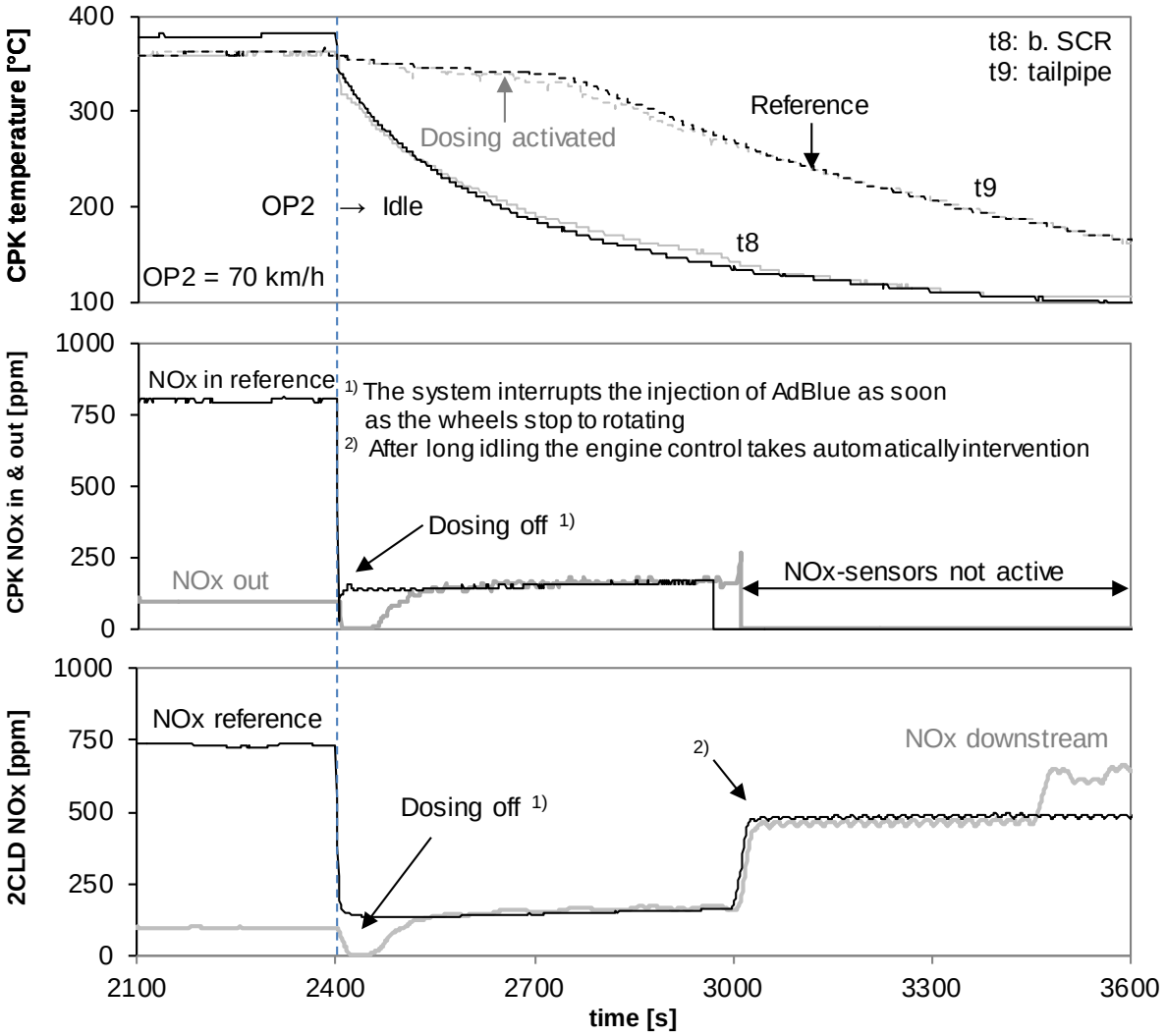
Vehicle F; ULSD; AdBlue; Dosing activated



① 2CLD whole trip, average trips 4,5,6
② CPK only active periods, average trips 4,5,6

SWOFF - intervention of ECU after long idling

OEM SCR; dosing activated
Vehicle D; ULSD; Chassis Dyno LARAG



Experiences in TeVeNO$_x$ (1)

De-NO$_x$ Rates		PCFE
Bus A	80-85%	99.9%
Bus B	30-70%	DPF not tested
Truck C	88-95%	no DPF
Truck D	42-88%	no DPF
Truck E	84% (OP1)	99.5%
Truck F	63-94%	99.9%
Truck G	28-70% Diesel 19-55% D/CNG	no DPF
Truck H	20-84%	no DPF
Truck I	20-92%	no DPF

General conclusions TeVeNOx

- The foundations for the quality verification procedures of SCR-systems are established,
- The SCR-systems are not active at lower temperatures < 200°C,
- SCR-testing on vehicle is a better approach than on engine dyno,
- simple & low-cost quality check is possible.

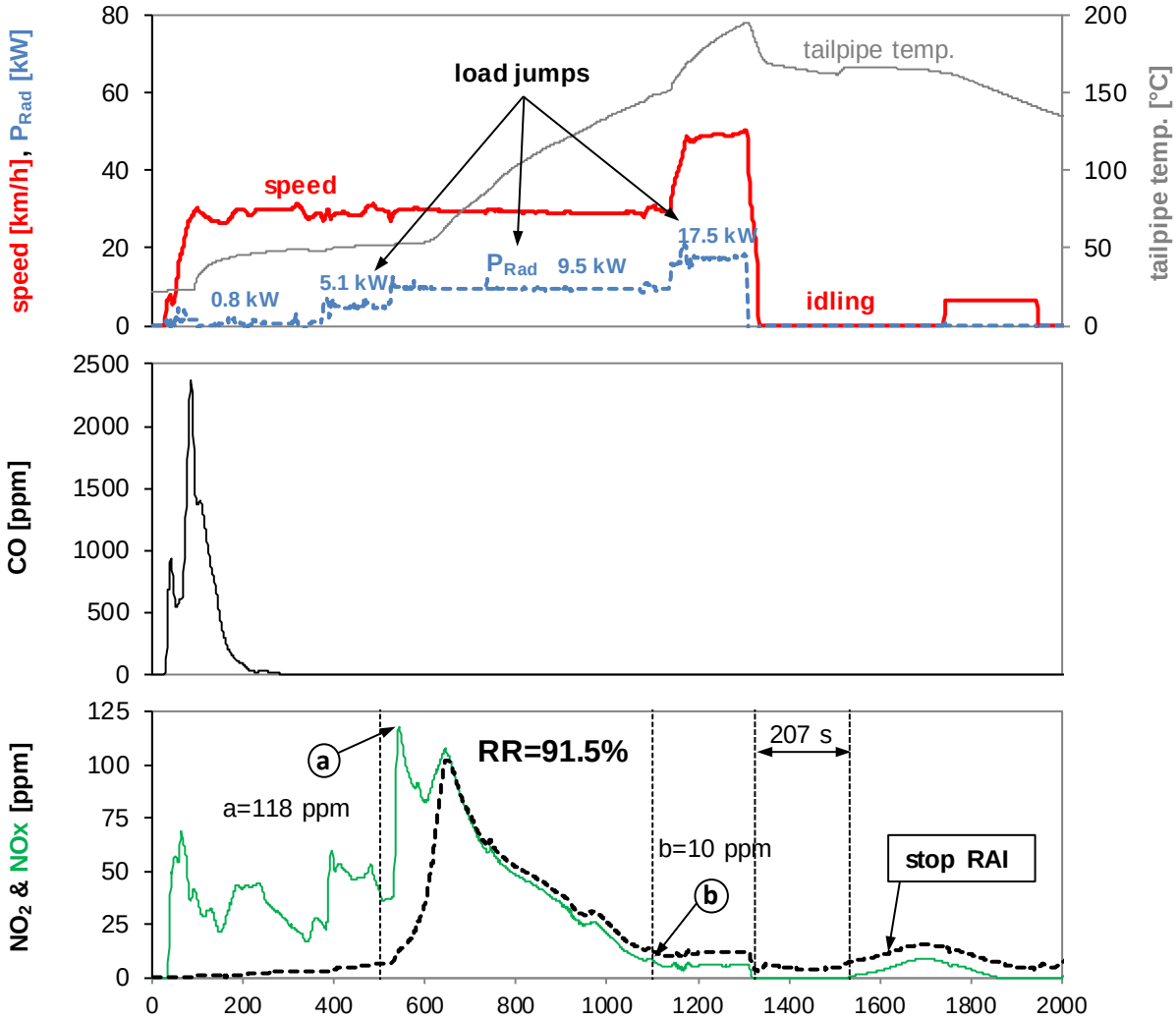
Bern University of Applied Sciences
Biel-Bienne Switzerland
AFHB | IC-Engines and Exhaust Gas Control

LD vehicles with DPF + SCR

IUCD…I*n Use Control Diesel*

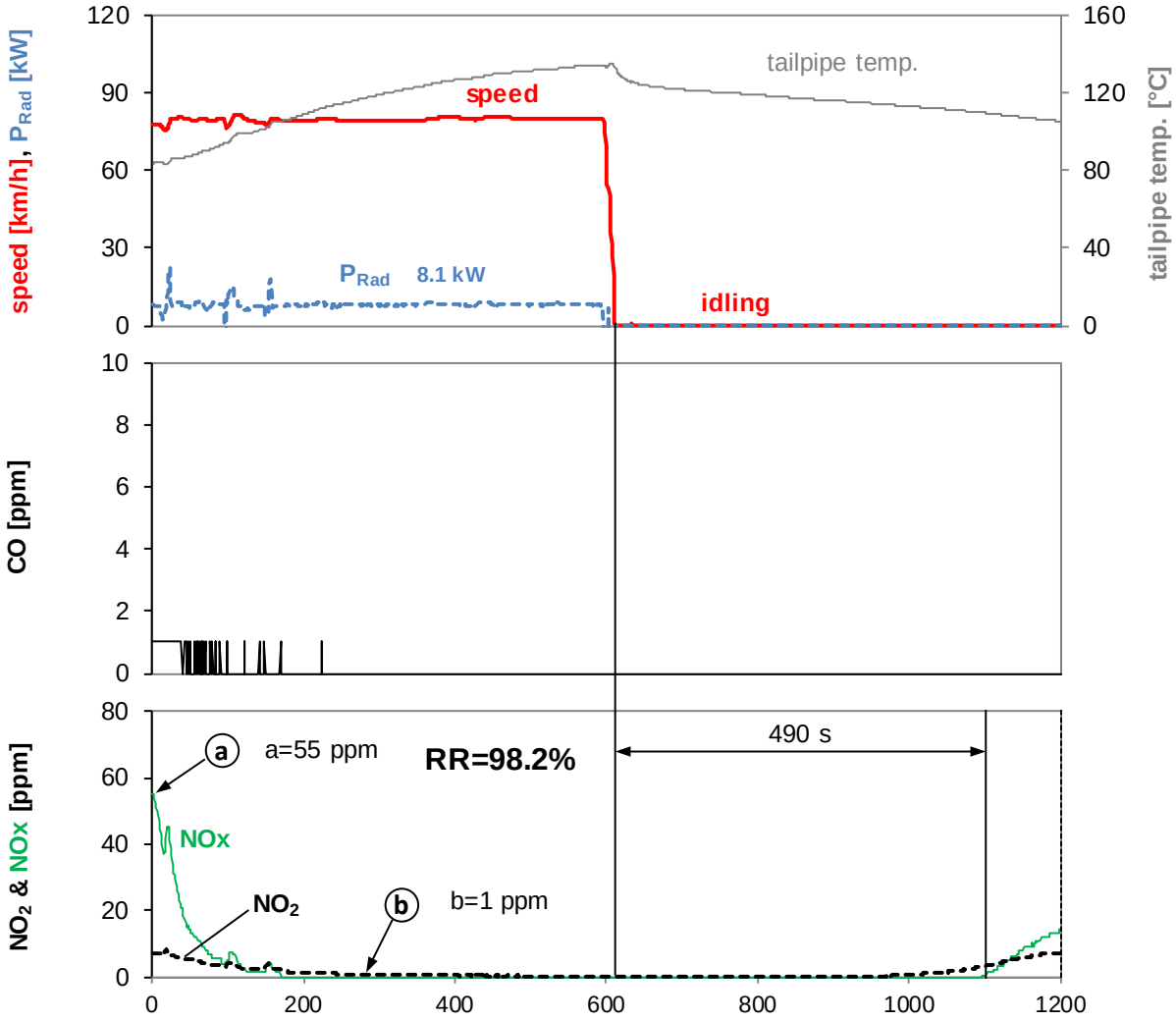
IUCD: exhaust emissions during const. speed, with cold start

Vehicle 1; EGR, DOC, DPF, SCR; fuel: Diesel; tailpipe.



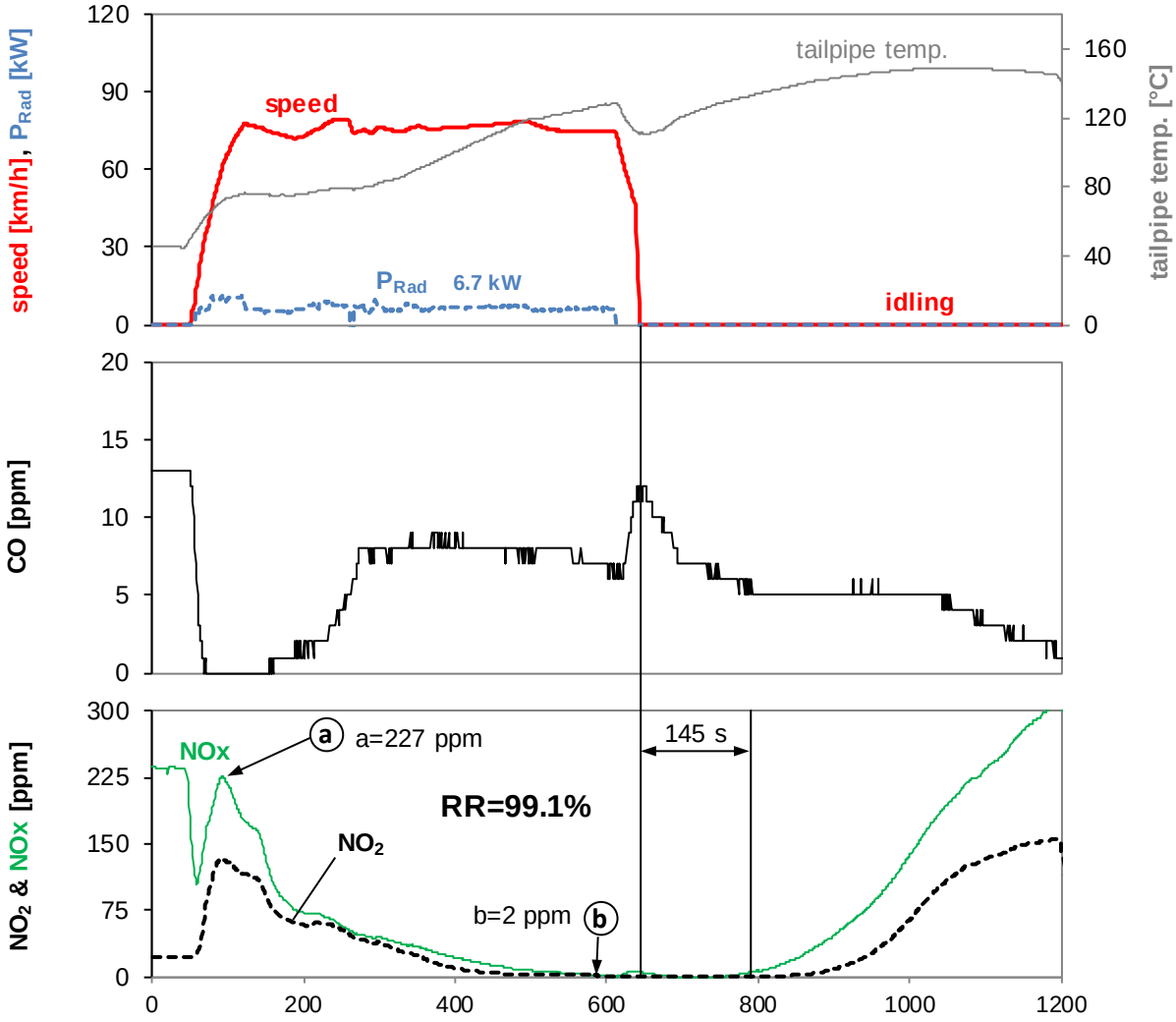
IUCD: exhaust emissions during const. speed and idling.

Vehicle 2; EGR, DOC, DPF, SCR; fuel: Diesel; tailpipe.



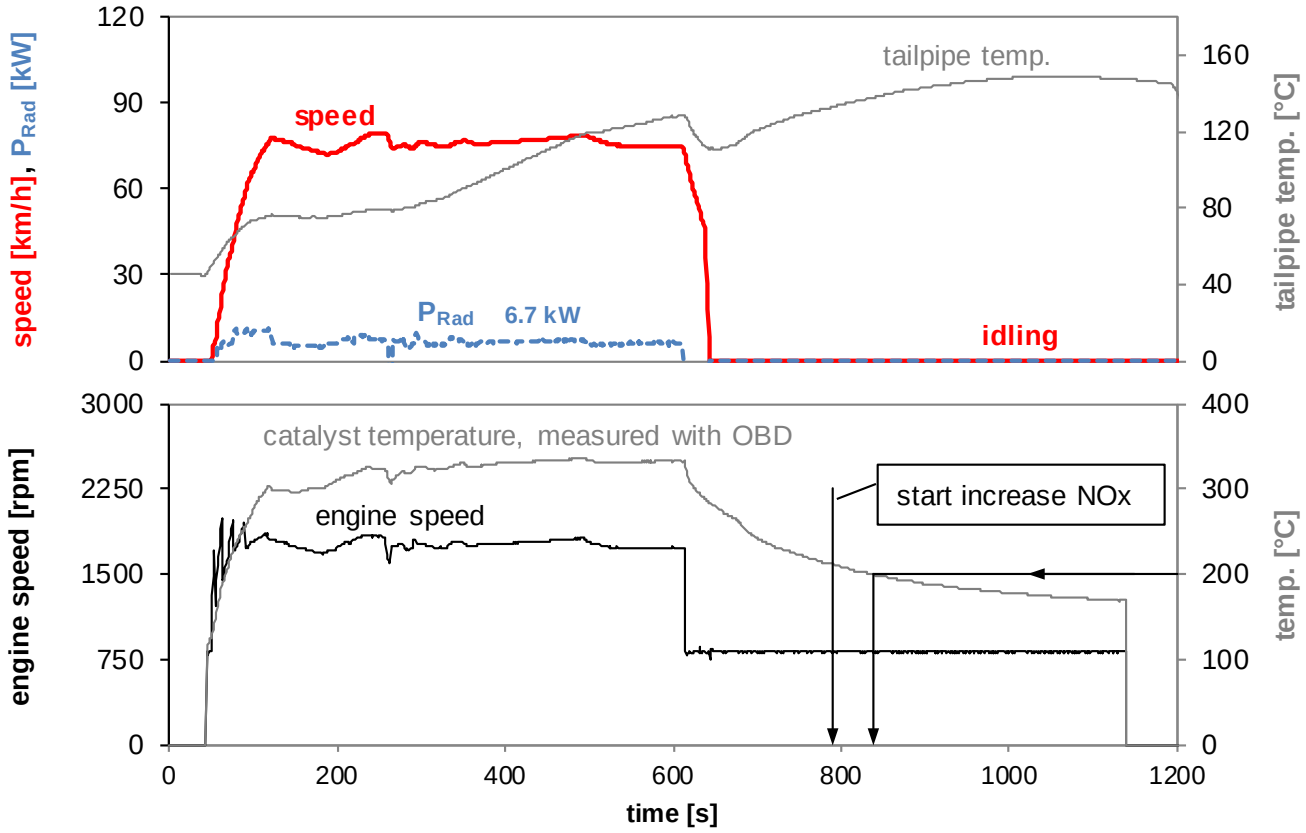
IUCD: exhaust emissions during const. speed and idling.

Vehicle 3; EGR, DOC, DPF, SCR; fuel: Diesel; tailpipe.



IUCD: catalyst temperature during const. speed and idling.

Vehicle 3; EGR, DOC, DPF, SCR; fuel: Diesel; tailpipe.



Complementary information

(to be required)

- OBD data, NO_x-sensors
- AdBlue indication
- AdBlue purchasing and consumption
- Visual control of AdBlue system

Open questions

- Fixing of the minimum limit value of NO_x reduction rate (RR)
- Solution of the question “wheel-stop → RAI-stop”,
- fixing of the time to drive after load jump for LD and for HD
- More testing for statistical robustness
- Testing of LNT
- Testing with failures

Bern University of Applied Sciences
Biel-Bienne Switzerland
AFHB | IC-Engines and Exhaust Gas Control

VERTdeNO$_x$ certification protocol

For HD/LD SCR-retrofit

Bern University of Applied Sciences
Biel-Bienne Switzerland
AFHB | IC-Engines and Exhaust Gas Control

VERTdeNO$_x$ Testing Procedures for HD/LD SCR-retrofit

Vehicle equipped with a VERT-conform DPF-system

VdeNO$_x$1

Step-tests

on chassis dynamometer

- light-off
- max. gas flow
- max. temp.
- K_{NOX}
- gaseous emissions incl. NH_3

VdeNO$_x$2

RDE

on road circuit

- 3 repetitions
- Gas PEMS
- PN PEMS

VdeNO$_x$3

Durability

in customer application

- data logging
- AdBlue consumption
- control after 10'000 km

VdeNO$_x$4

End check

on road circuit

- results from VdeNO$_x$3
- short RDE
- simple function test

Abbreviations

HD … heavy duty
LD … light duty
K_{NOx} … NO_x conversion efficiency
PN ... particle number
RDE ... real driving emissions
PEMS ... portable emission measuring system

Conclusions

- With DPF, SCR and GPF, it is possible to:
  - Eliminate PN and
  - Reduce NO_x below the legal limits
- Quality control in-use is possible
  (for deNO_x PTI more efforts are necessary)
- Quality procedures for deNO_x systems are elaborated


Thank you for
your attention !