Workshop Tehran – December 14th/15th 2016

I&M PROCEEDURES for FUTURE AFTERTREATMENT COMPONENTS DOC and SCR

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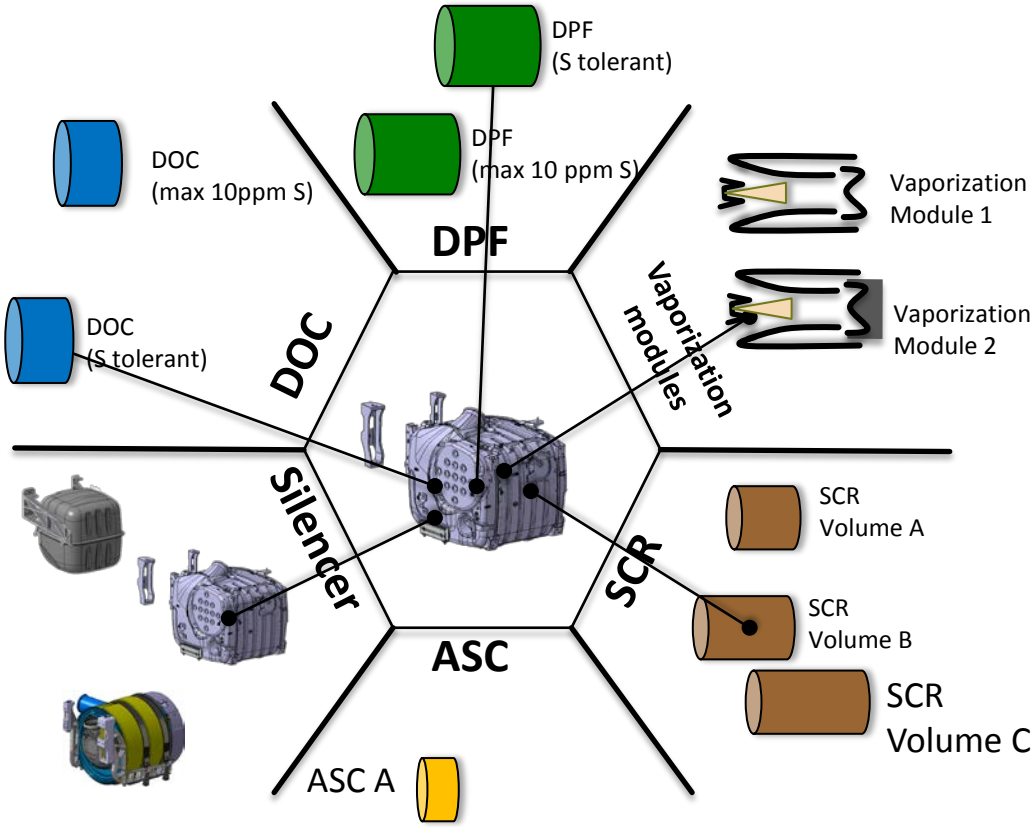
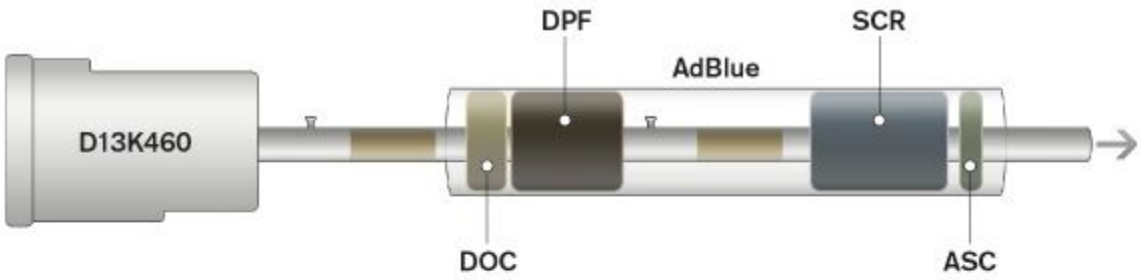
Aftertreatment Components for EURO IV + DPF



Source: Scania

Aftertreatment Components
Typical Arrangement



DOC = Diesel Oxidation Catalyst

DPF = Diesel Particulate Filter

AdBlue or ***DEF*** = Diesel Exhaust Fluid

SCR = Selective Catalytic Reduction

ASC = Ammonia Slip Catalyst

Source: Volvo

Chemistry

CRT-System (Continuously Regenerating Trap) = **DOC + DPF**

DOC: $NO + 0.5 \cdot O_2 \rightarrow NO_2$

DPF: $2NO_2 + \mathbf{C} \rightarrow 2NO + CO_2$

SCR + ASC – System

AdBlue:	$(NH_2)_2CO \rightarrow \mathbf{NH_3} + HNCO$	Thermolysis
	$HNCO + H_2O \rightarrow \mathbf{NH_3} + CO_2$	Hydrolysis
SCR:	$4 \cdot NH_3 + 4 \cdot NO + O_2 \rightarrow 4 \cdot N_2 + 6 \cdot H_2O$	Standard reaction
	$4 \cdot NH_3 + 2 \cdot NO_2 + 2 \cdot NO \rightarrow 4 \cdot N_2 + 6 \cdot H_2O$	Fast reaction
	$4 \cdot NH_3 + 5 \cdot O_2 \rightarrow 4 \cdot NO_x + 6 \cdot H_2O$	Undesired reaction
	$4 \cdot NH_3 + 4 \cdot NO \rightarrow 4 \cdot N_2O + 6 \cdot H_2O$	Undesired reaction

(ASC: $4 \cdot NH_3 + 3O_2 \rightarrow 2 \cdot N_2 + 6 \cdot H_2O$)

Potential of NOx-Reduction by SCR

- SCR can reduce NOx by > 98% – **2 orders of magnitude –** at the NH_3 slip limit (20 ppm) – whithout any negative effect on power or fuel economy –

  if the exhaust temperature is above 230 °C

Below 230°C ?

- EGR with cleaned exhaust gas
- Water added into intake air
- Charge air cooling to very low temperatures
- Engine tuning to low Nox
- Cool combustion
- LNT = Lean NO_x Trap

…..and the Risks of DeNOx by SCR

Engine manufacturers use this high DeNOx capability and tune the engine to much higher raw NOx-emissions
→ NOx increase (engine out)
→ Reduction of fuel comsumption, 6-8% with Euro VI

DeNOx-technology is easy to manipulate by electronic emission strategies and tampering

If the SCR fails by aging, poisoning, lack of Adblue etc. or by intentional tampering → NOx emissions jump up to high levels

→ These systems require regular inspection

Potential of the Oxidation Catalyst DOC

- DOC converts gaseous HC, CO by 99%
- DOC also converts engine out NO to NO_2 by >70% (which is more toxic, 10-100 times) but
  - needed for the DPF regeneration and
  - needed for the fast SCR-reaction

….and the Risks of DOC

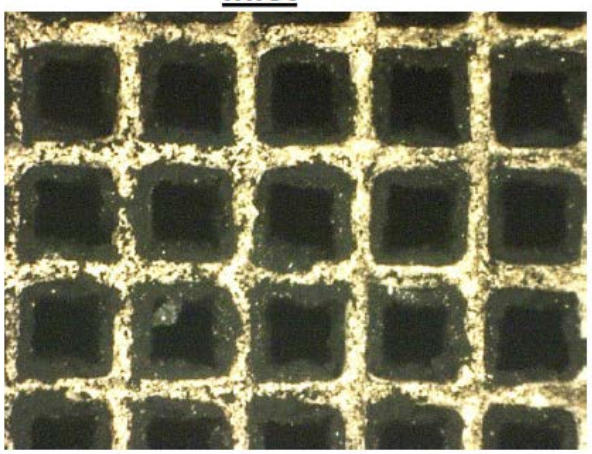
If the DOC gets aged, poisened, contaminated, dismantled, destroyed or is just not adequately coated

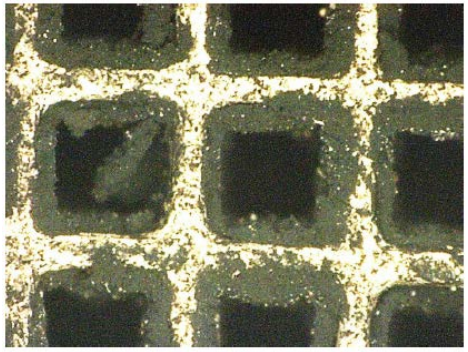
- HC and CO emissions increase (moderately)
- The DPF regeneration fails
- The SCR function fails

If so, checking of the DOC is part of maintenance

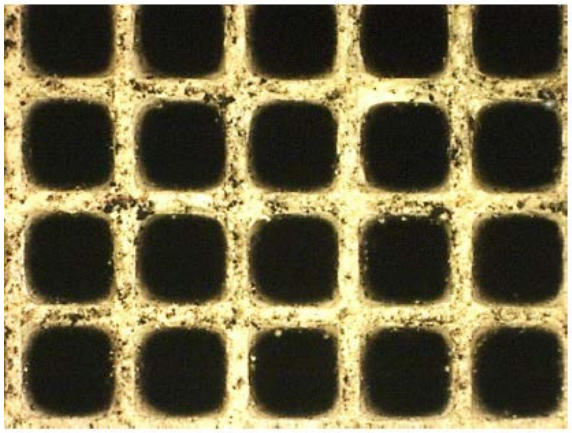
SOOT COVERED DOC

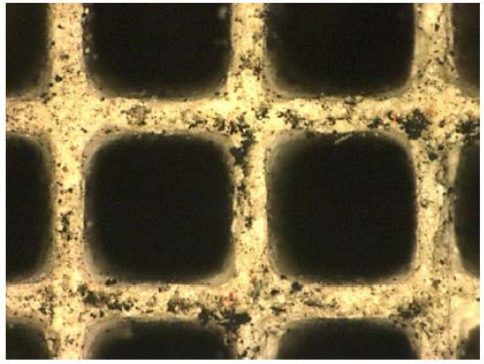
Inlet





Outlet





Cost Effective Control of In-useVehicles

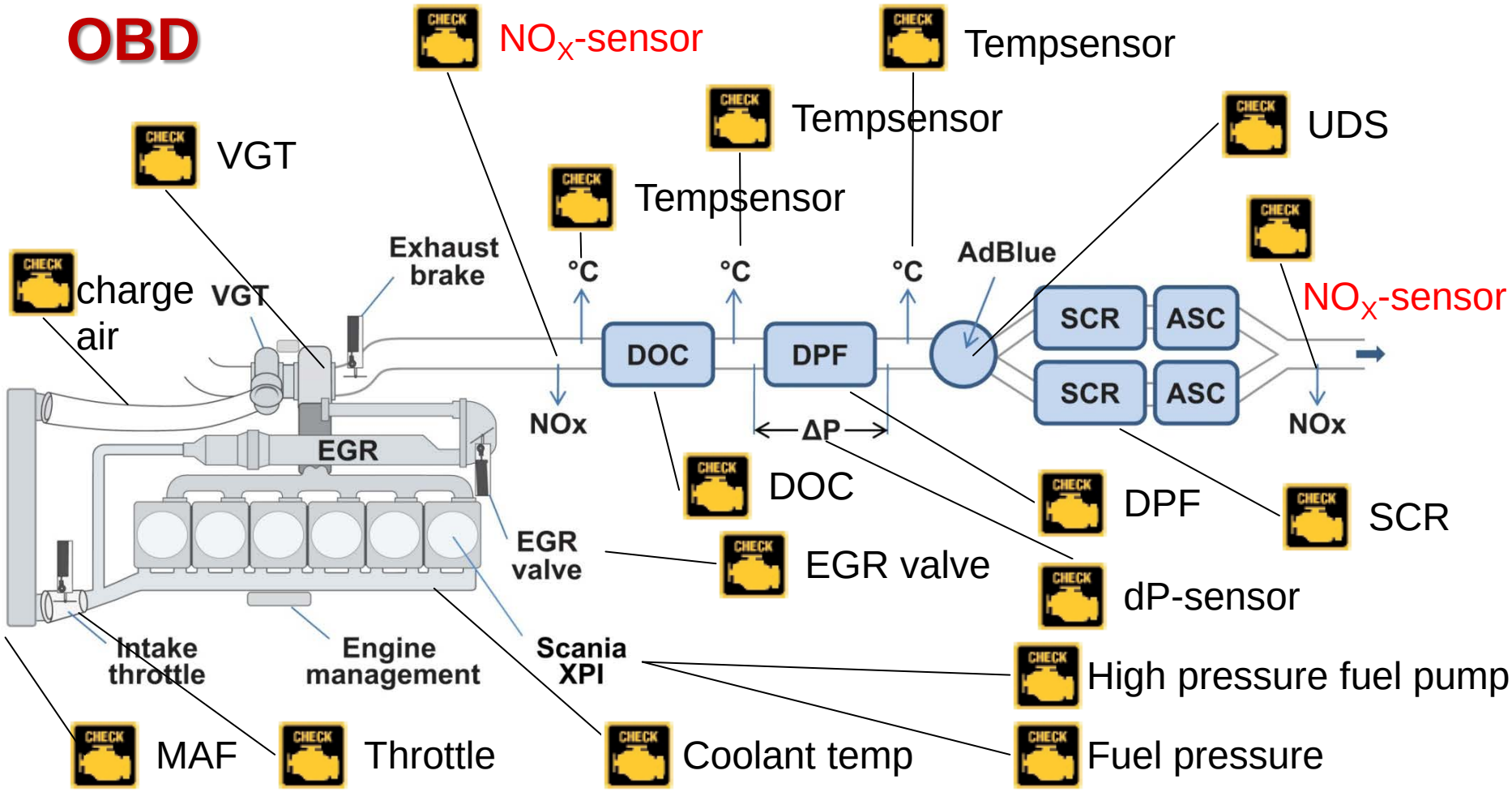
- **PN-Test at low idle for DPF**
- **Load-step from 100°C to 300°C at average RPM**

  - CO-Conversion > 80% → DOC OK

  - NOx-Conversion > 70% + NH3 < 20 ppm →SCR OK

The test supplies quantitative diagnostic information for the functionality of each emission control component and the engine as well and permits preventive repair and maintenance.

Precondition: OBD permits the test → Legislation



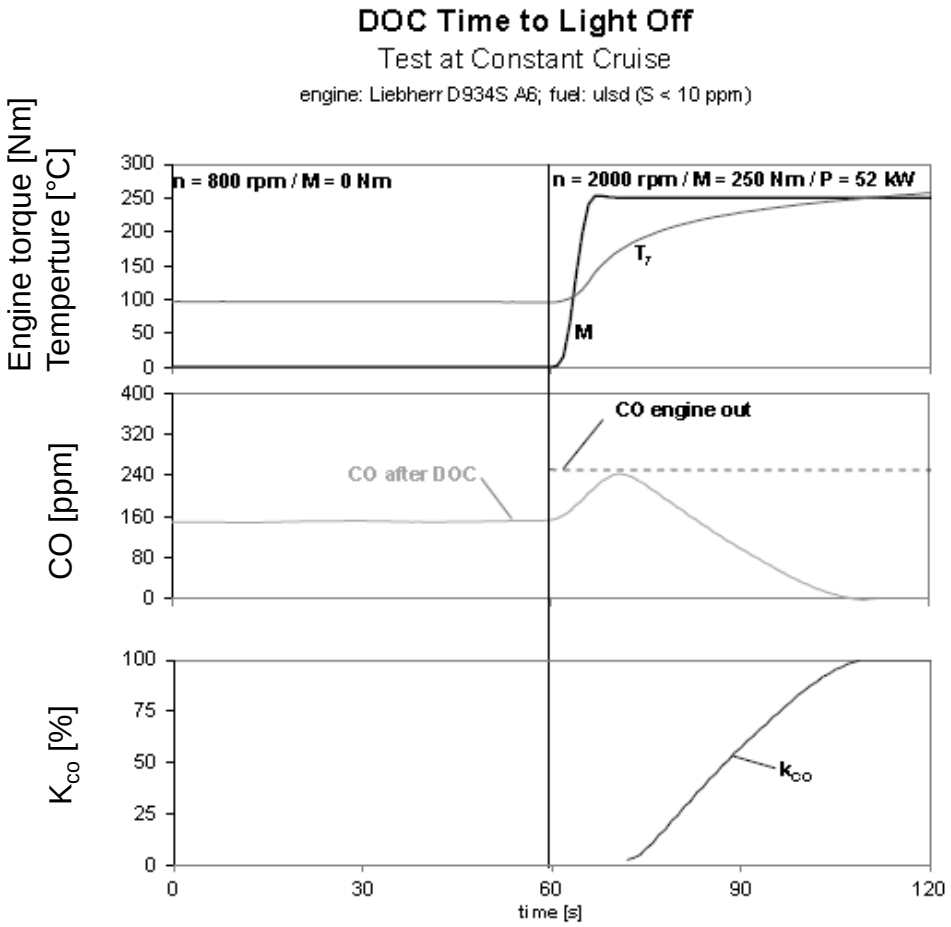
All components affecting emissions have to be monitored by OBD

OBD = On board diagnosis

Source: SCANIA

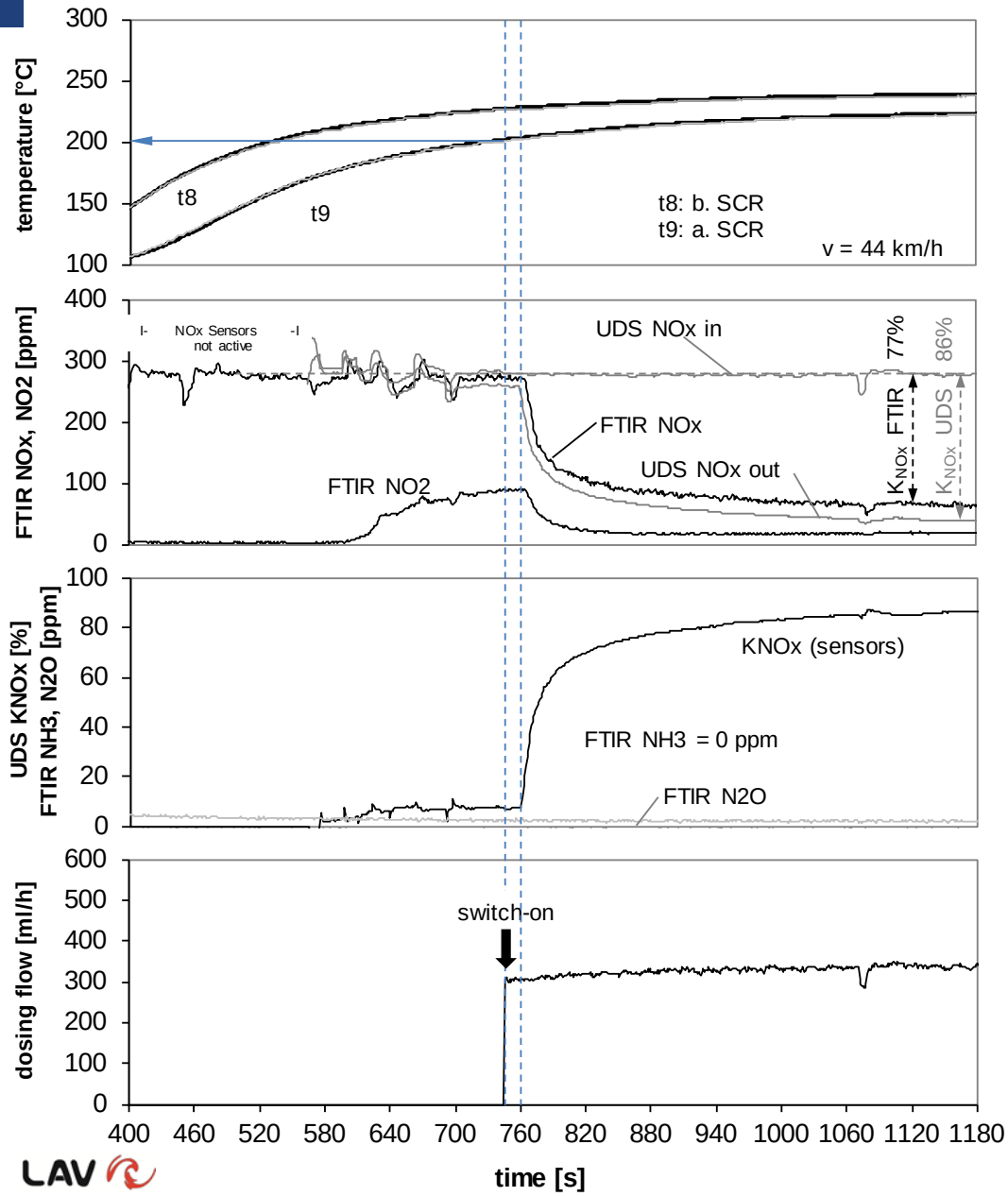
DOC Light off test during Load Step

(needs chassis dyno)



T_7 before DPF

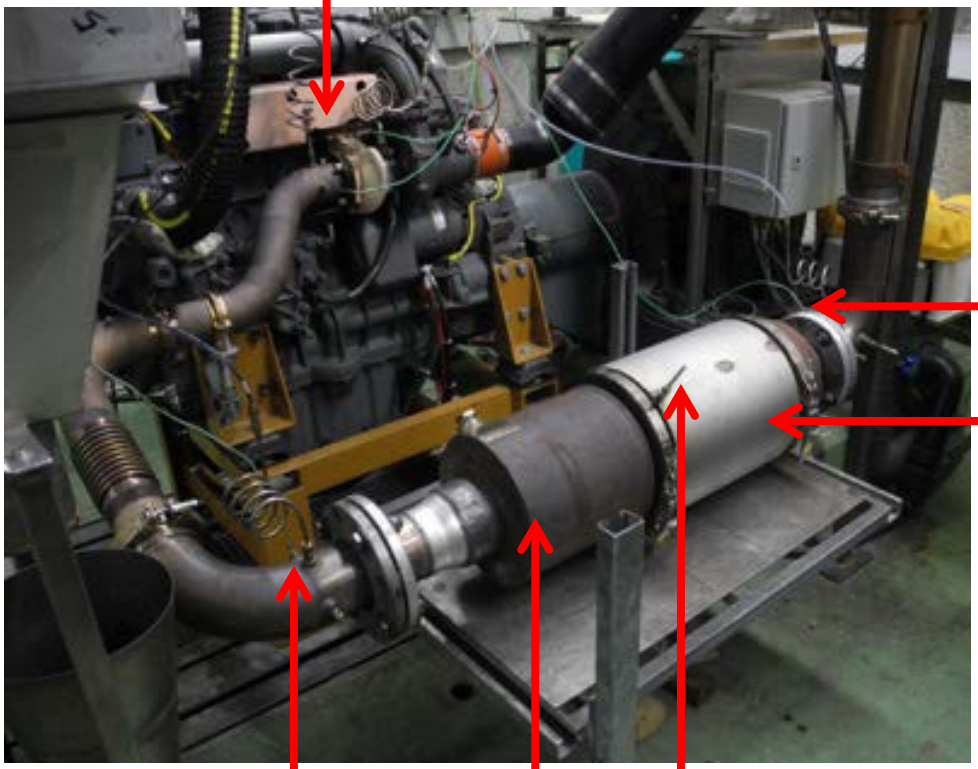
Time to light-off (50% conversion): 26 s



SCR Load Step

(needs chassis dyno)

DOC Light-off Testing



VERT-investigations on a Liebherr D934 Engine, Okt. 2015

Test facility:

Berne University of Applied Sciencies
Biel-Bienne, Switzerland
IC-Engines and Exhaust Gas Control

Source: BFH

Chassis Dynamometer for Trucks

Source: MAHA

Load Step Test Procedures – Intermediary Results

- The positive load jump (with heat-up) or the negative load jump (with cool down) are the best tools to check the quality, the conversion efficiency and the aging of catalytic aftertreatment devices or systems.

- Portable equipment for measuring gaseous components (CO, NOx, NH_3) was successfully tested.

Thank you for your attention