

# Roll out of SCR on Filter.....



**VERT FORUM 2015**  
**EMPA Dübendorf**

20.03.2015

LMB  
Dr. Regis VONARB

**LIEBHERR**

# Agenda

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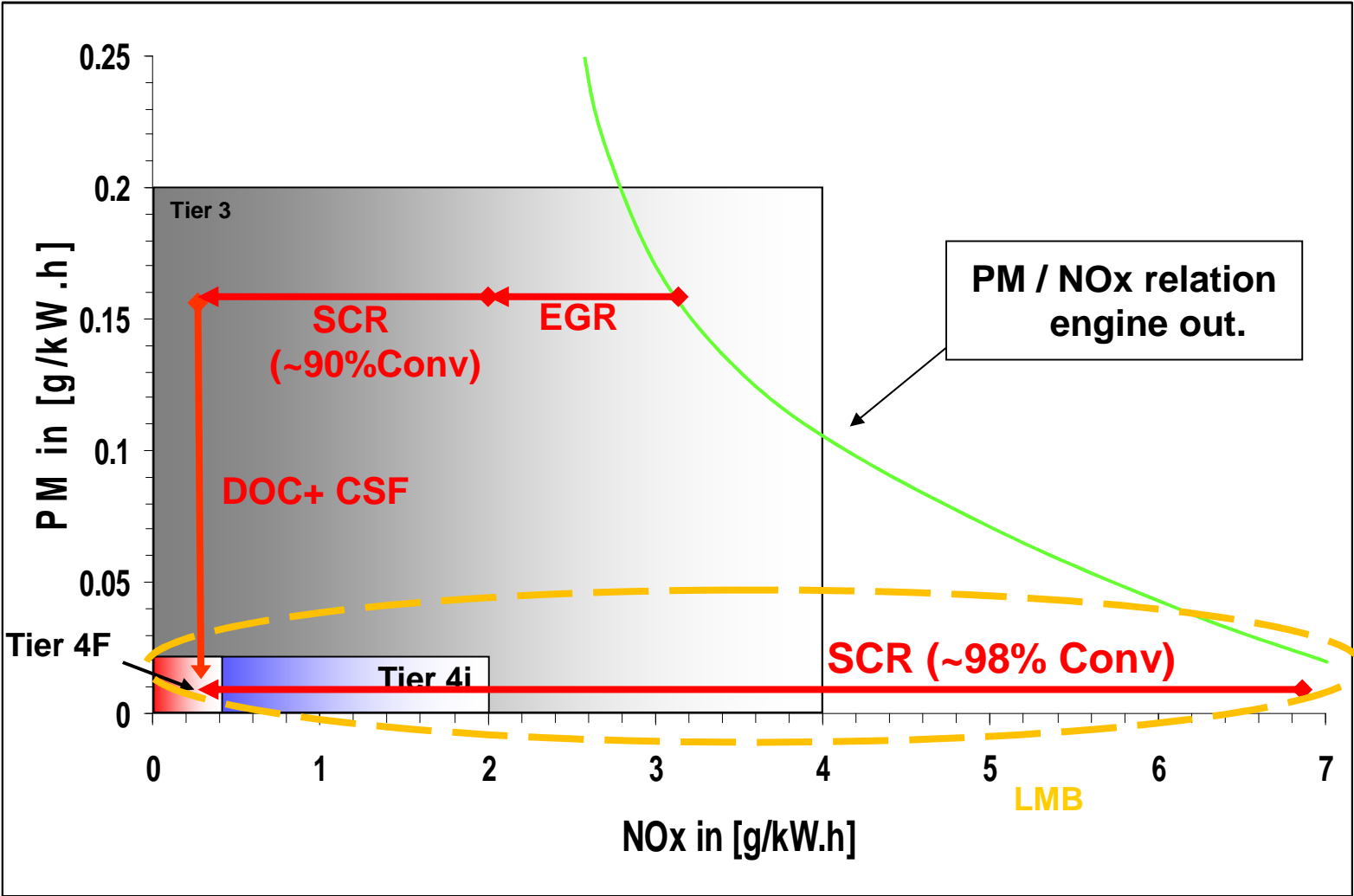
- **The Liebherr After treatment solutions for Stage IV**
- **Already the next generation : SCR on Filter (ALL IN ONE) by Liebherr**
- **Summary and conclusions**

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# Strategy LMB Stage IV/Tier4f



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# Stage IV/Tier 4 final – SCR-only for all Liebherr NRMM applications

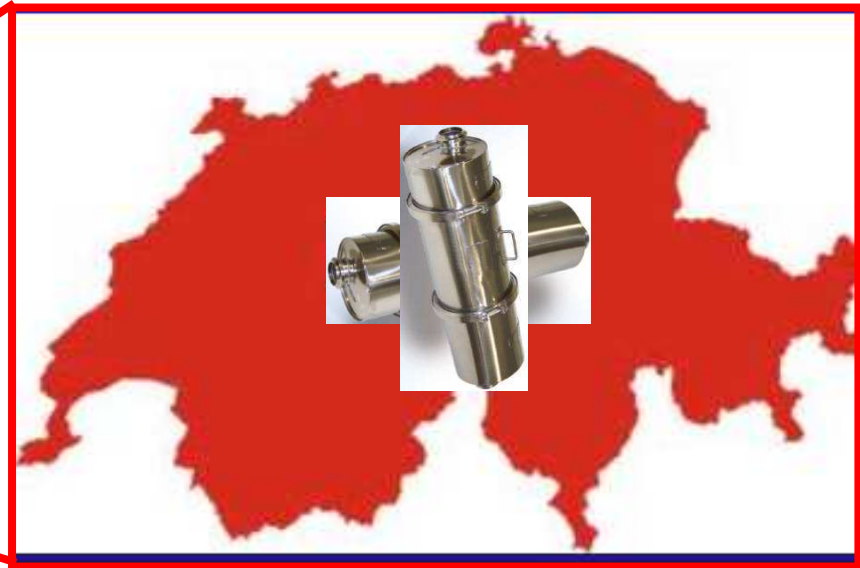
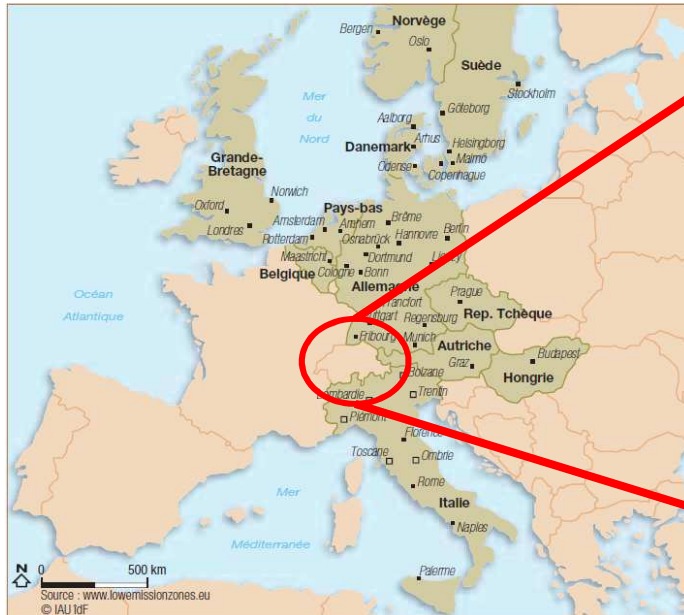


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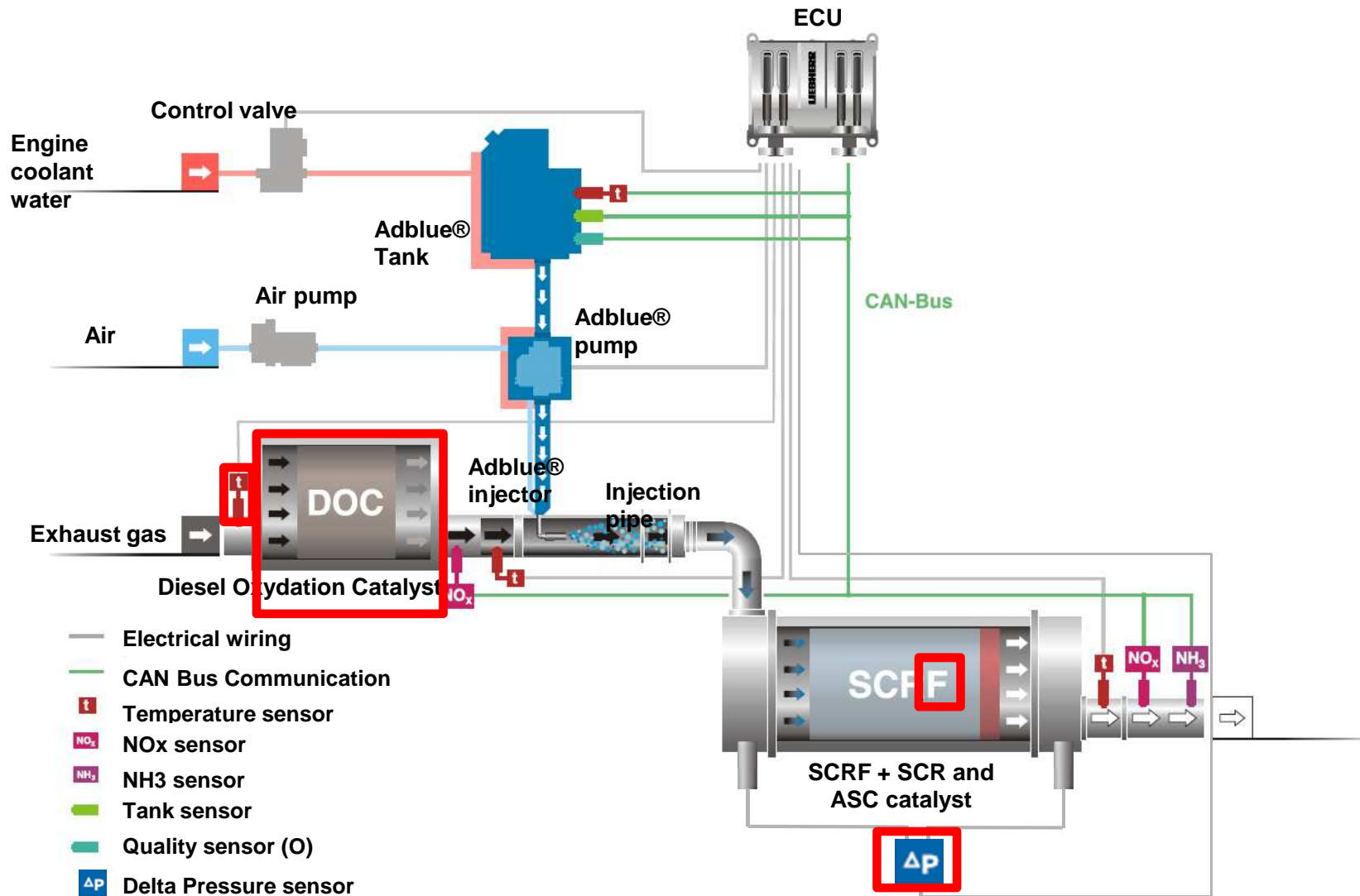
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# Swiss Market (OAPC –Tunneling), Germany & Austria (SUVA, TRGS, AUVA)



- Since January 2000, Wall flow DPF are mandatory at Swiss underground sites.
- Since 2009 a PN limit was introduced (OAPC) use closed DPF for new construction machine.
- As for EURO VI, the PN limit will come for the next EU-NRMM emissions stage V  
-> Incentives for Liebherr to develop a robust and cost effective solution for those specific markets and toward the new EU stage V (~ 2019)

# LMB SCR on Filter System (SCRoF)



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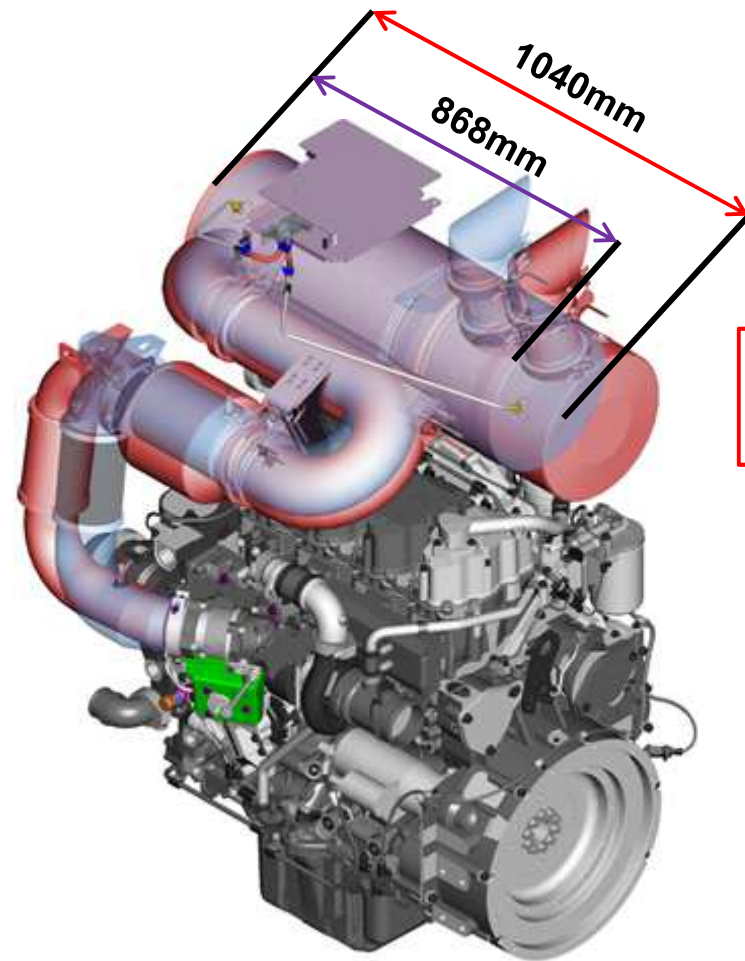


# Targets to be achieved with the SCR on Filter-system

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- **Target 1 - Packaging**
  - Installation has to use the «same» space as the SCR-only (Stage IV solution)
- **Target 2 – Compliance with the exhaust gas regulation**
  - Stage IV final emissions compliance ( $\text{NO}_x \leq 0.4 \text{ g/kWh}$ )
  - VERT / LRV (Swiss market) compliance ( $\text{PN} \leq 1 \times 10^{12} \text{ \#/kWh}$ )
- **Target 3 - Passive Regeneration**
  - The system has to be certified as passive system (Balance Point has to be achieved on NRTC)
  - The balance point has to be reached on specific customer cycles
- **Target 4 - Durability**
  - Ash impact on the DeNO<sub>x</sub>, on the filtration efficiency and on the backpressure
  - Emissions compliance: 8'000 hours
  - Liebherr durability target: 15'000 hours

# Target 1 : System installation on a Excavator



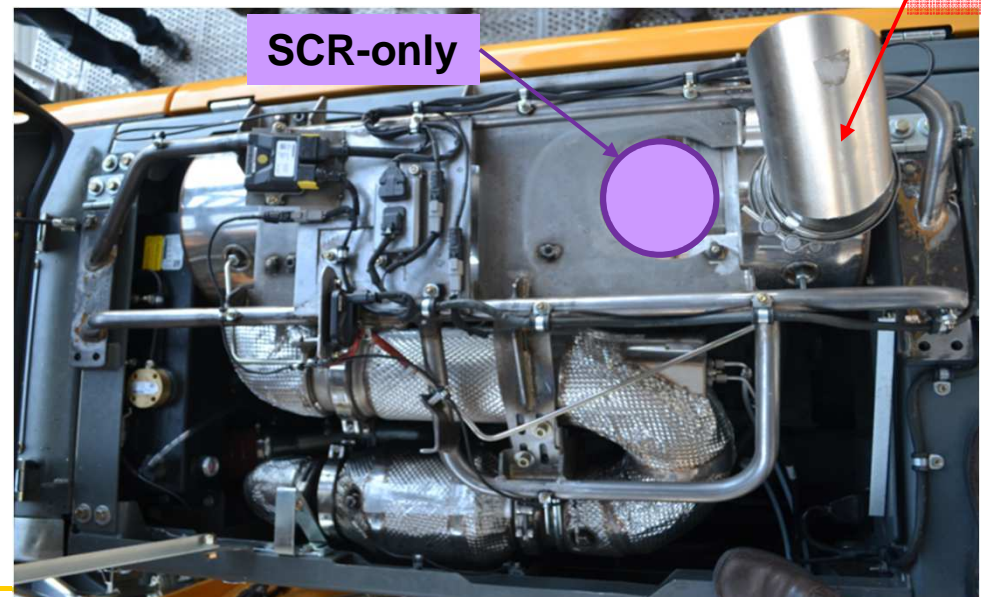
Red → SCRoF (1040mm)

Purple → SCR-only (868mm)

SCRoF length +20%  
vs. SCR-only length



SCRoF



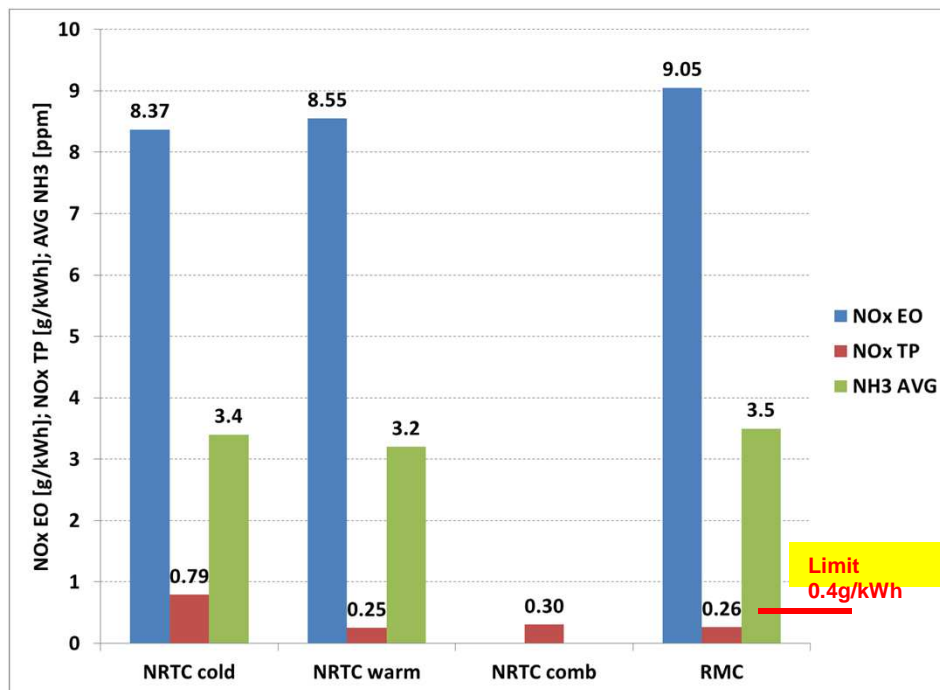
SCR-only

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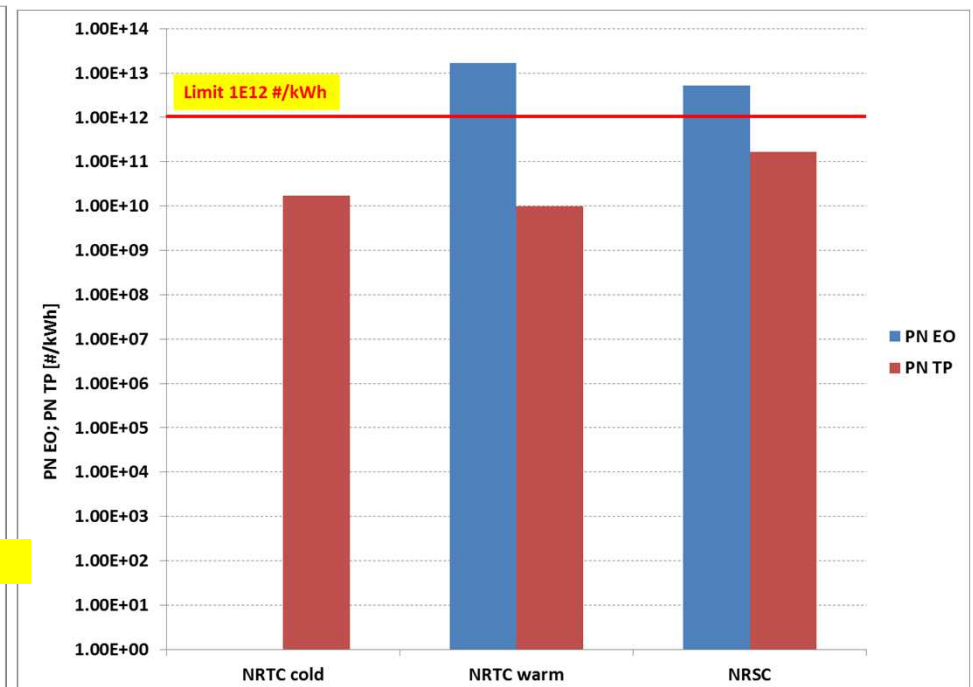
# Target 2 : Compliance with the exhaust gas regulation

- D944/D946 and D934 engines + SCR on Filter has been certified by the TÜV Stage IV & LRV

Ex. NOx conv. eff.



Ex. PN filtration eff.



# Target 3 : Passive Regeneration (1/2)

To evaluate the passive regeneration (CRT™) behavior of the system, some customer cycles were selected

LTM\_OW



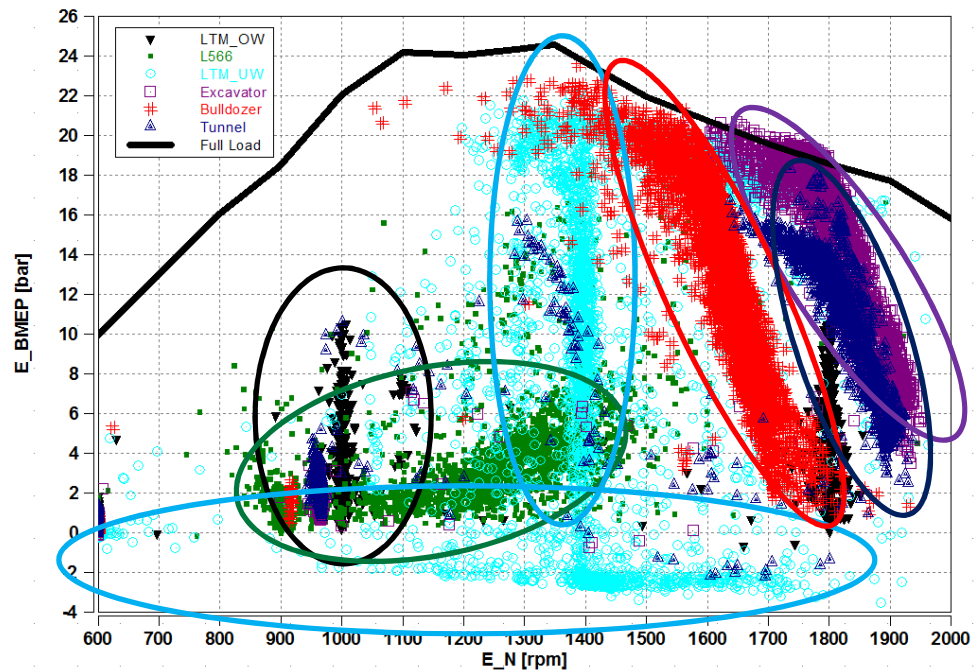
L566



LTM\_UW



Engine Load



Excavator



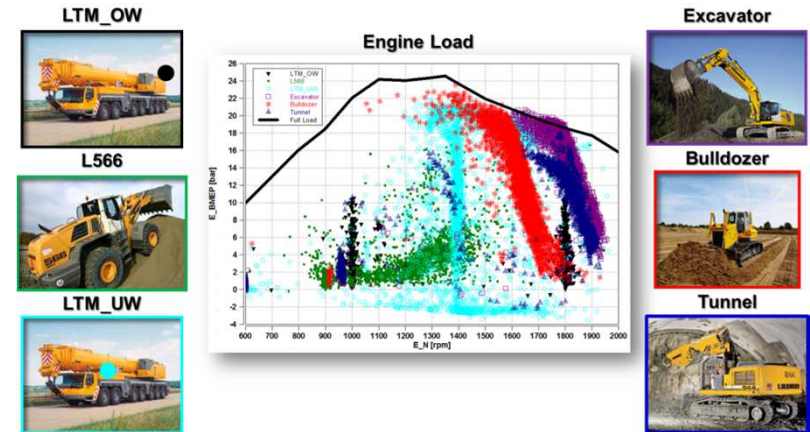
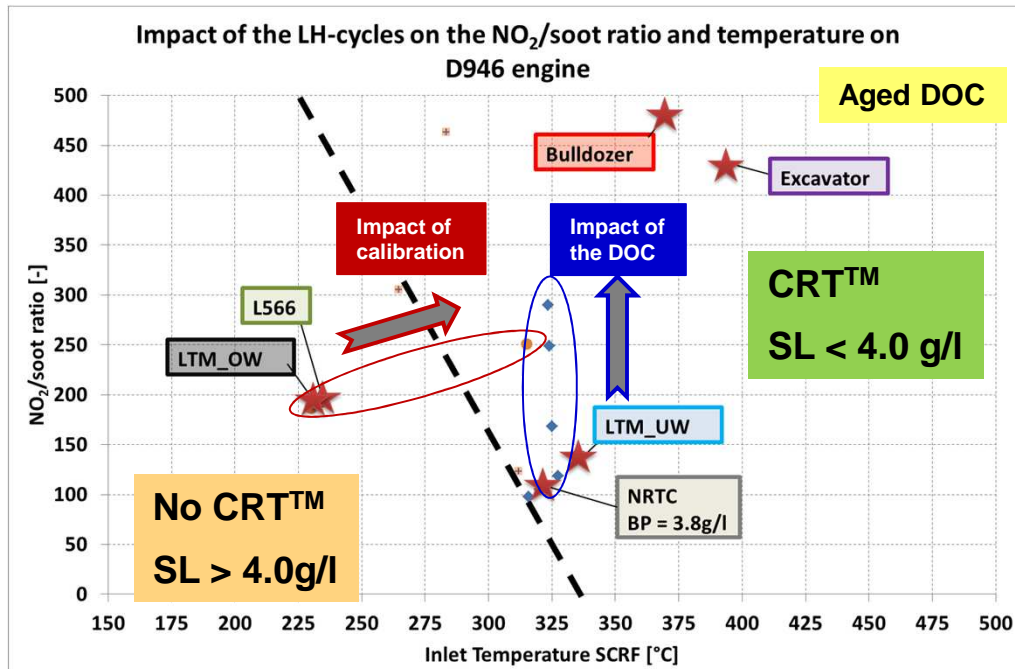
Bulldozer



Tunnel



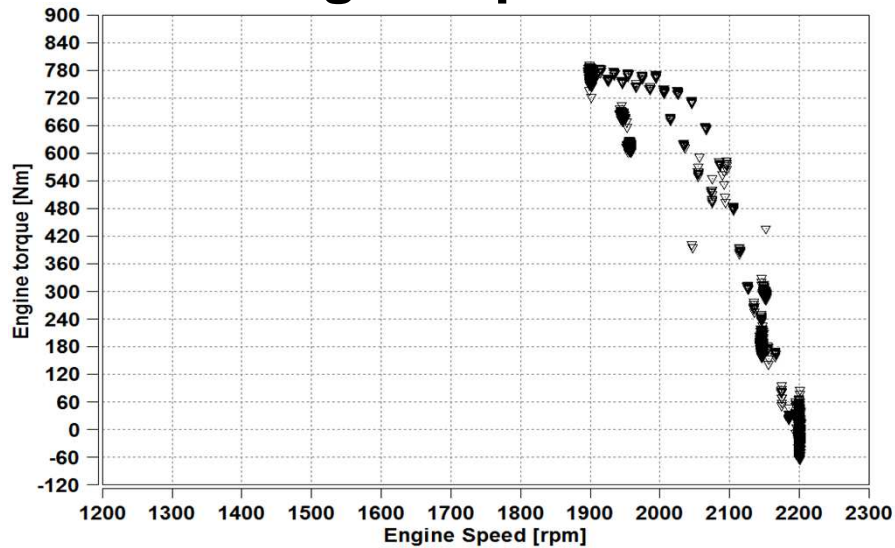
# Target 3 : Passive regeneration (2/2)



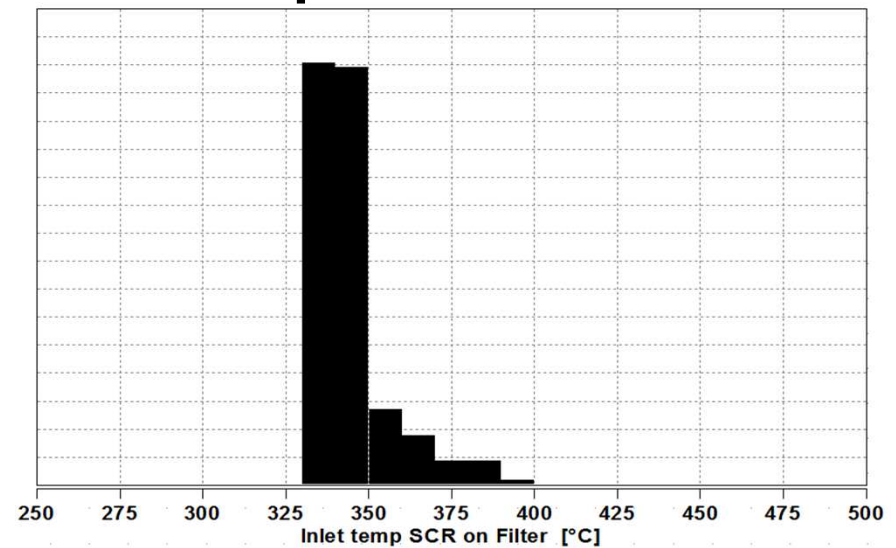
- Using the same calibration and the same Hardware, the NO<sub>2</sub>/soot ratio depends on the application cycles
- Using the same calibration, and changing the DOC, it is possible to improve the NO<sub>2</sub>/soot ratio (test done on NRTC cycle)
- It is possible to influence positively the NO<sub>2</sub>/soot ratio with the engine calibration (test done on L566 cycle)

# Target 4 : Durability (1/2)

## Engine operation

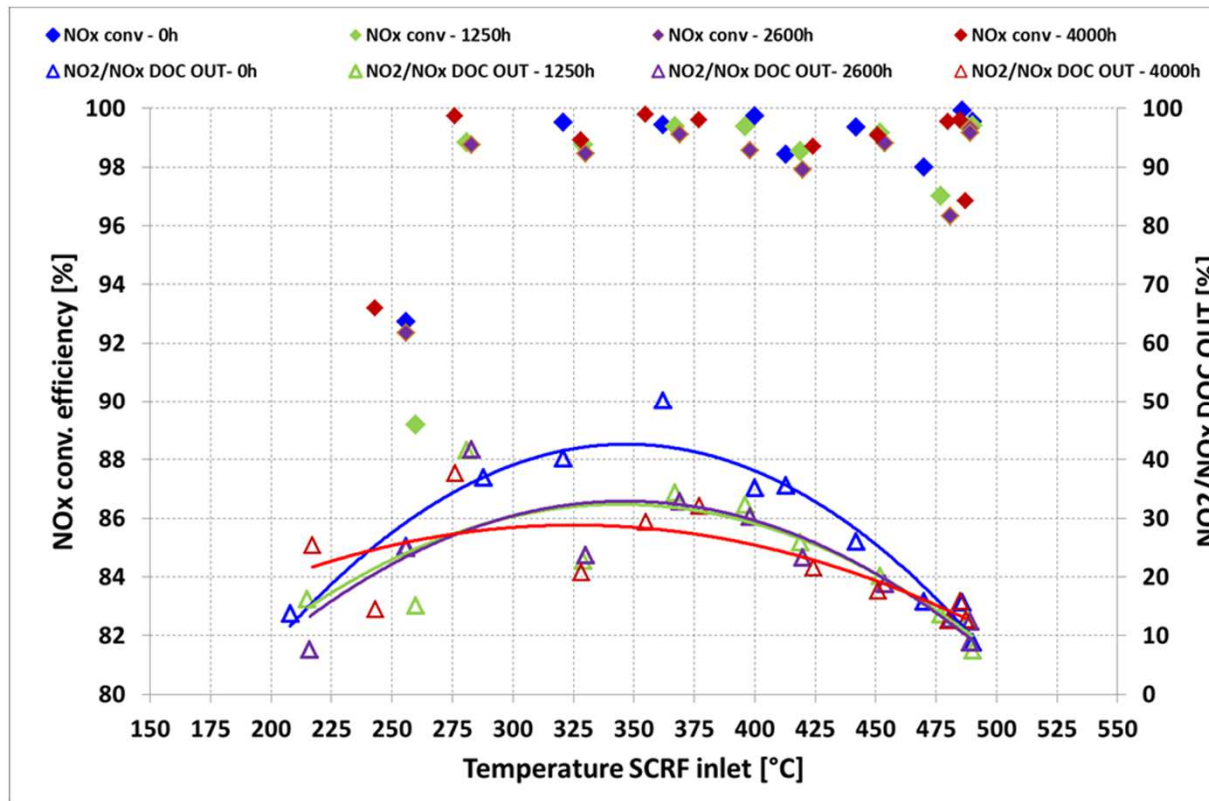


## Temp. SCR on Filter



- The “Grenzlast” cycle was run during 4000 hours (EN 590, E6 oil)
- During the endurance, all the performance of the EAS components were characterized 4 times

## Target 4 : Durability (2/2)



- @ 4000 hrs -> no decrease on the NOx conversion efficiency.
- DOC aging impact was observed after the 1<sup>st</sup> check (1250hrs) but after, the DOC performance was stable
- Limited impact of the ashes on the DeNOx was observed

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## Summary and Conclusions

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- For the same NOx conversion efficiency,  
 $V_{\text{SCR on Filter}} = 1.2x V_{\text{SCR-only}}$
- Substrate and coating definitions are keys to achieving the PN limit
- It is possible to achieve the Stage IV (NOx) and the LRV (PN) certification (potential Stage V) with a SCR on Filter  $V_2O_5$  based with passive regeneration
- Durability tests showed that the ashes have very limited no impact on the NOx conversion efficiency

