Impact of different fuels on engine-out-emissions and on the SCR-on-Filter system

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Overview

- General information
- INTERREG project
- Fuel impact on the engine out emissions
- Fuel impact on the soot reactivity
- B10R20H fuel impact on SCR on Filter performance
- Summary

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General information

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Liebherr – NRM Product Range

Earth Moving & Mining Equipment

Wheel loaders

Wheeled excavators

Telescopic handlers

Crawler tractors

Mining Trucks

Crawler excavators

(Earthmoving & mining)

Articulated Trucks

Cranes

Mobile cranes

Crawler cranes

Port Equipments & maritime cranes

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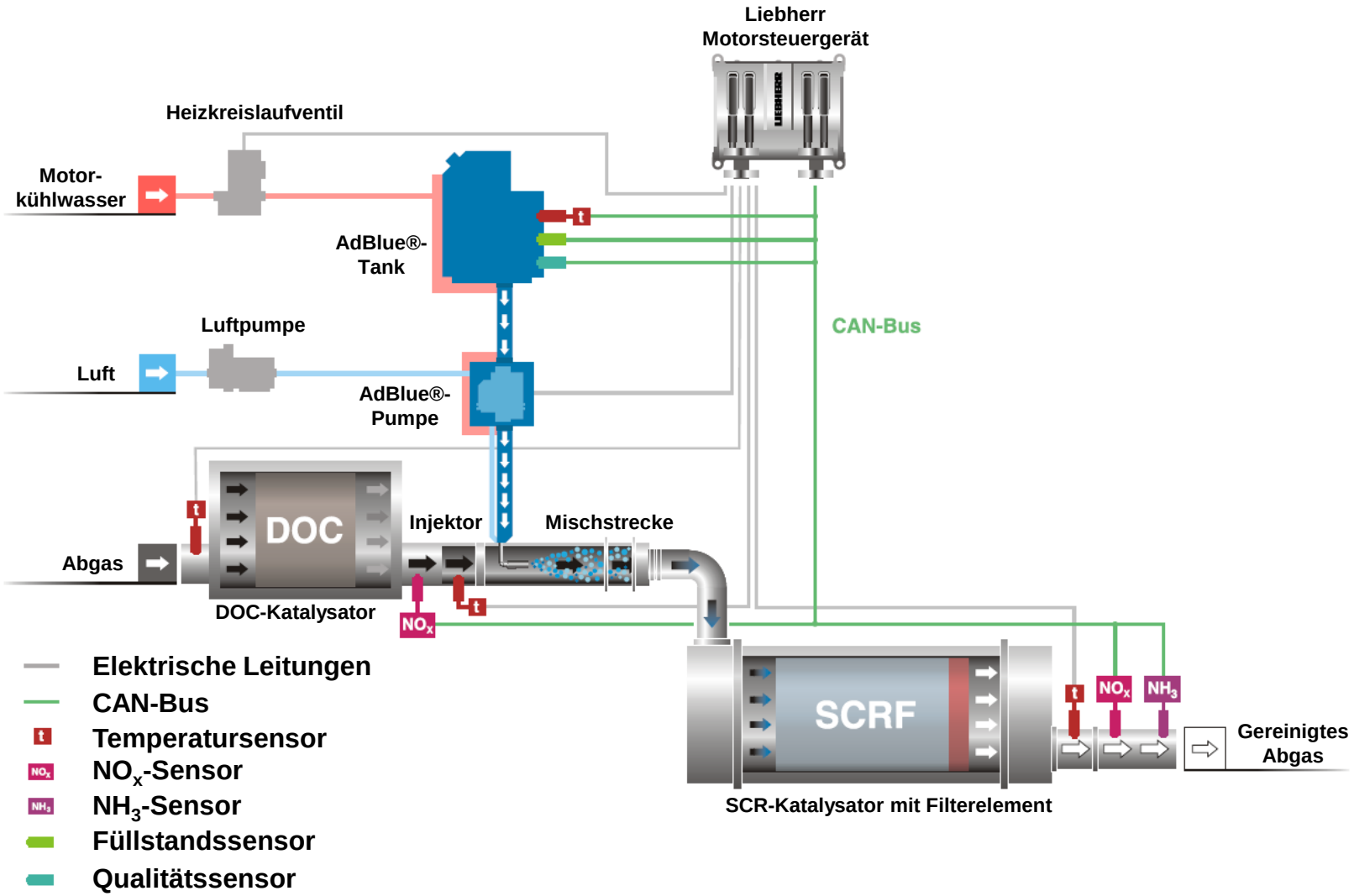
SCR on Filter (SCRoF) system



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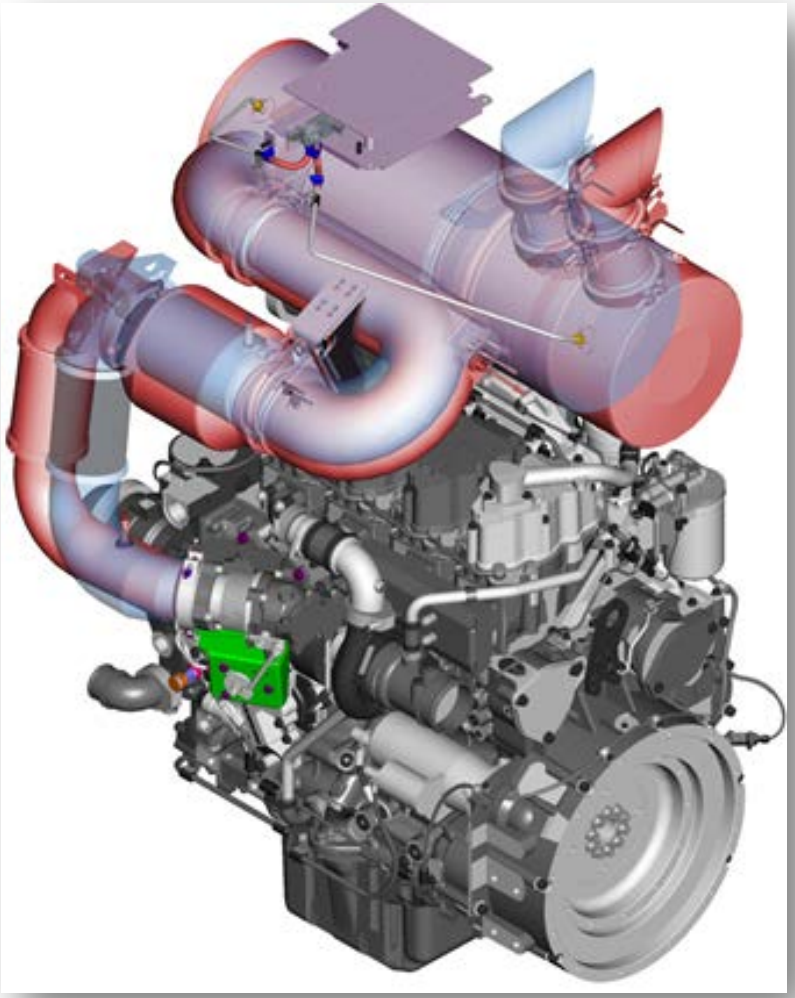
Packaging adavantage

SCR on Filter vs. SCR-only



- Installation comparison between the SCR-only (purple) and SCR on Filter solution (red)
- The component installation is the same for SCR-only and SCR on Filter solution for:
  - The exhaust gas aftertreatment system fixation
  - The sensors
  - The urea supply system
- Only the piping between turbine outlet and SCR on Filter inlet has to be changed
- With this installation, the machine could be sold to the end customer with the SCR-only or with the SCR on Filter solution.
- From the outside of the machine, no differences is visible if SCR-only or SCR on Filter is installed

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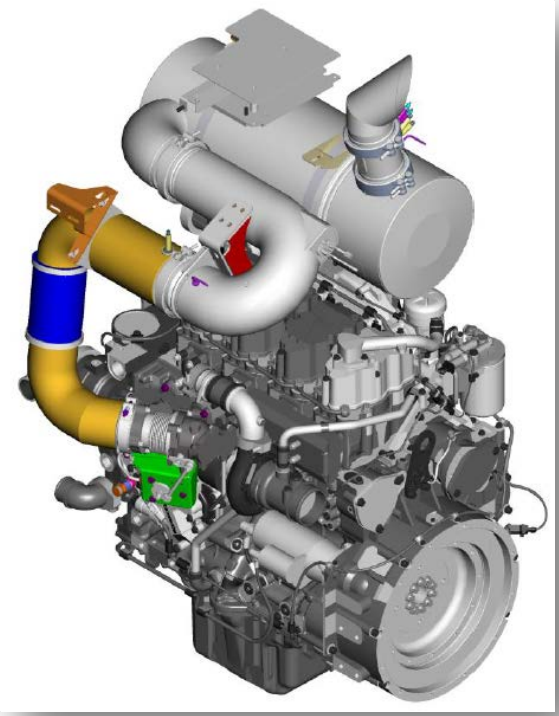
NOx conversion & PN filtration efficiency

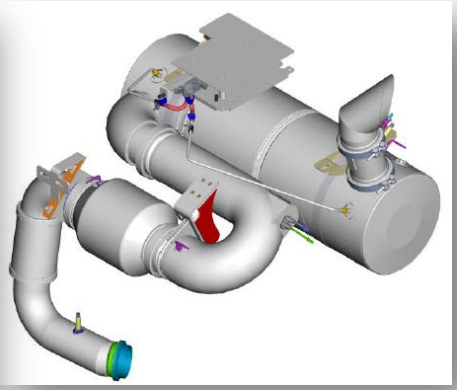
SCRonly - Tier4F

		CO	HC	NOx	PM
		g/kWh	g/kWh	g/kWh	g/kWh
230kW	NRTC	0.4899	0.0225	0.3376	0.02
	RMC	0.1778	0.0106	0.3182	0.0128
200kW	NRTC	0.4338	0.0213	0.3275	0.0172
	RMC	0.1639	0.0089	0.3338	0.0066

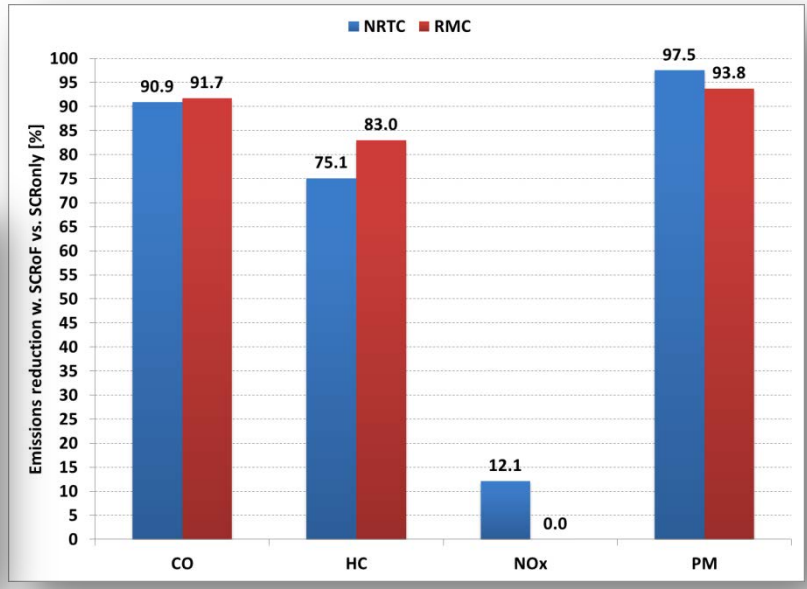


SCRoF - Tier4F + LRV

CO	HC	NOx	PM	PN
g/kWh	g/kWh	g/kWh	g/kWh	#/kWh
0.0445	0.0056	0.2967	0.0005	6.97E+10
0.0147	0.0018	0.3197	0.0008	1.87E+11
0.0513	0.0058	0.2774	0.0007	5.04E+10
0.0144	0.0017	0.2016	0.0006	9.03E+11



SCRoF vs. SCRonly



- Compared to the SCRonly,
  - the SCRoF is able to reduce the CO of about 90%, the HC of about 75% and the PM of about 95%.
  - the SCRoF length is about 20% longer

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INTERREG project

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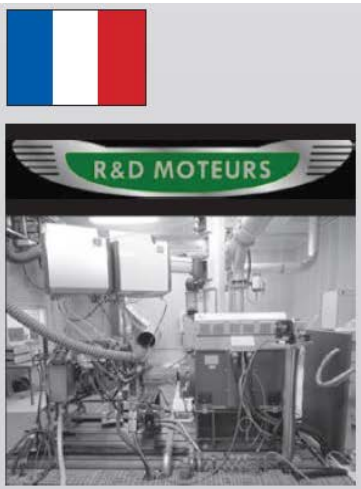
Project organization



- FR project carrier
- Test bed capacities
- Testing different fuels
- Test performing/analysing

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Interreg
FRANCE-SUISSE

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- CH project carrier
- HW supplier
- Testprogramm definition

UHA UNIVERSITE DE HAUTE-ALSACE Mulhouse-Colmar

GRE

- V SCR catalyst sublimation study (EPA)
- Soot reactivity measurements

UNION EUROPÉENNE

Berner Fachhochschule

- PN Measurements (according to SN 277 206)

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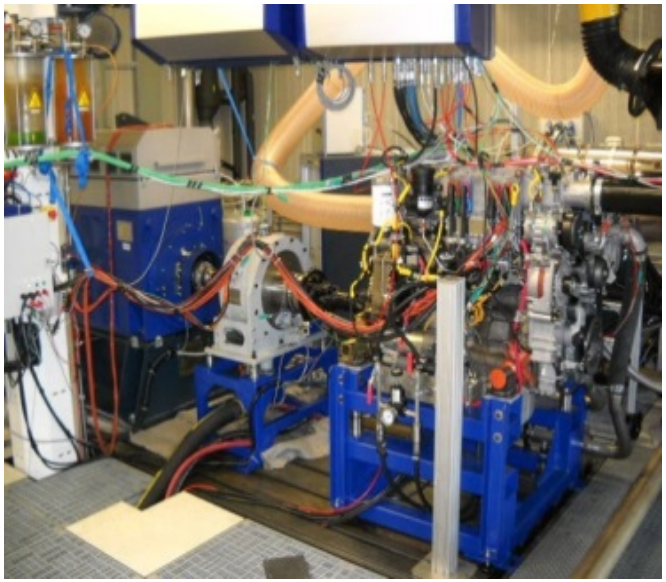
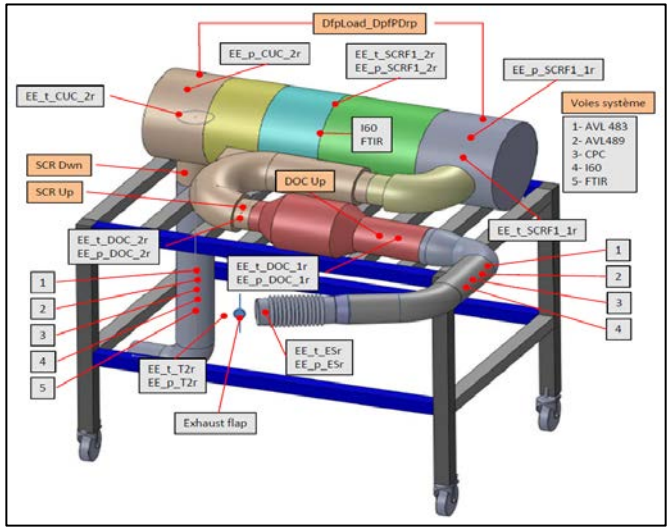
Test equipment





3 different fuels were considered

- EN590
  - Sulfure content < 10ppm
  - Oxidation stability «Rancimat» > 40
- US-Fuel
  - Sulfure content < 15ppm
  - Oxidation stability «Rancimat» > 40
- B10RME20H
  - Sulfure content < 10ppm
  - Oxidation stability «Rancimat» > 22.2

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Fuel impact on the engine out emissions

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Engine out emissions

Trend of difference between EN-590 and B10, US-Fuel		
Engine Map	B10	US-Fuel
GA_qm_CO_raw	→	↗
GA_qm_CO2_raw	→	→
GA_qm_HC_raw	→	→
GA_qm_NOX_raw	→	→
GA_qm_PM	→	↗
EE_GEXHW (kg)	→	→
FU_qm_M	→	→

Trend of difference between EN-590 and B10, US-Fuel		
NRSC	B10	US-Fuel
GA_qm_CO_raw	→	↗
GA_qm_CO2_raw	→	→
GA_qm_HC_raw	→	→
GA_qm_NOX_raw	→	→
GA_qm_PM	→	↗
EE_GEXHW (kg)	→	→
FU_qm_M	→	→

Trend of difference between EN-590 and B10, US-Fuel		
Full Load	B10	US-Fuel
GA_qm_CO_raw	→	→
GA_qm_CO2_raw	→	→
GA_qm_HC_raw	→	→
GA_qm_NOX_raw	→	→
GA_qm_PM	→	↗
EE_GEXHW (kg)	→	→
FU_qm_M	→	→

- The 3 different fuels were tested with the same engine calibration
- Engine Out emissions with EN590 and B10R20H are more or less the same
- Same tendencies measured on NRSC as on NRTC → only the NRSC results are presented
- On NRSC and NRTC as well as in the engine map, the CO and PM emissions increase significantly with the US-Fuel compared to EN590 or B10R20H

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Fuel impact on the soot reactivity

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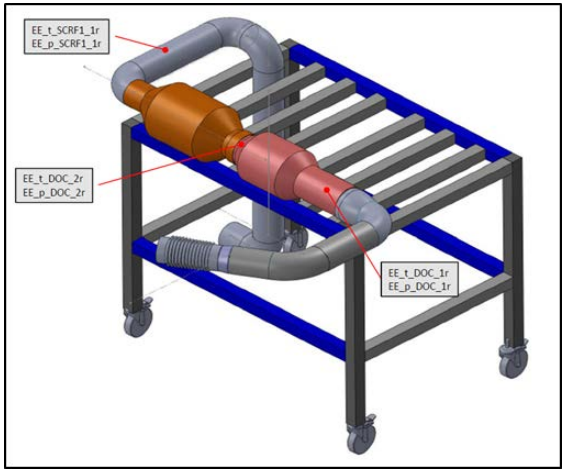
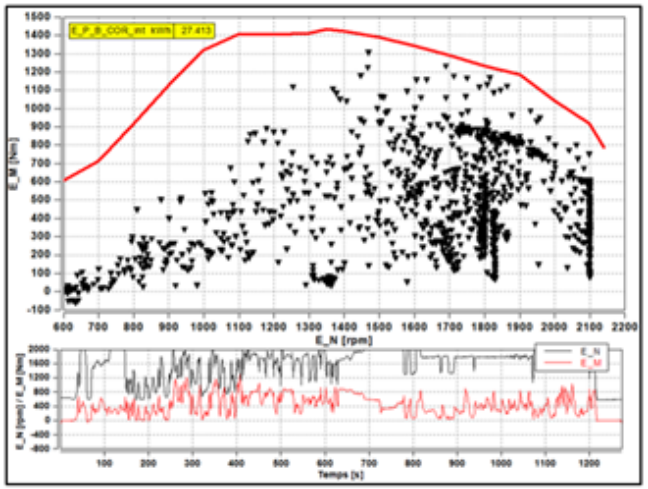
Soot collection

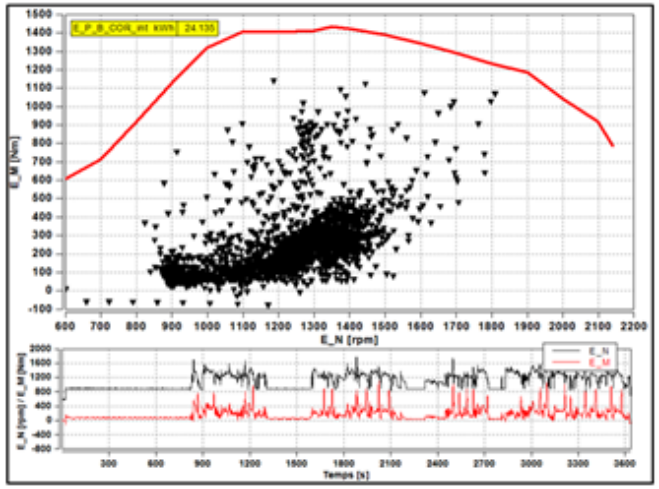


- Uncoated DPF substrates were used, in order to collect soot with different cycles and with different fuels
- L566 and NRTC cycles were used with and without DOC
- The tests were performed with EN590, B10R20H and US-Fuel
- After the test, the soot was removed from DPF and analyzed in the laboratory

NRTC cycle



L566 cycle (Wheel Loader)



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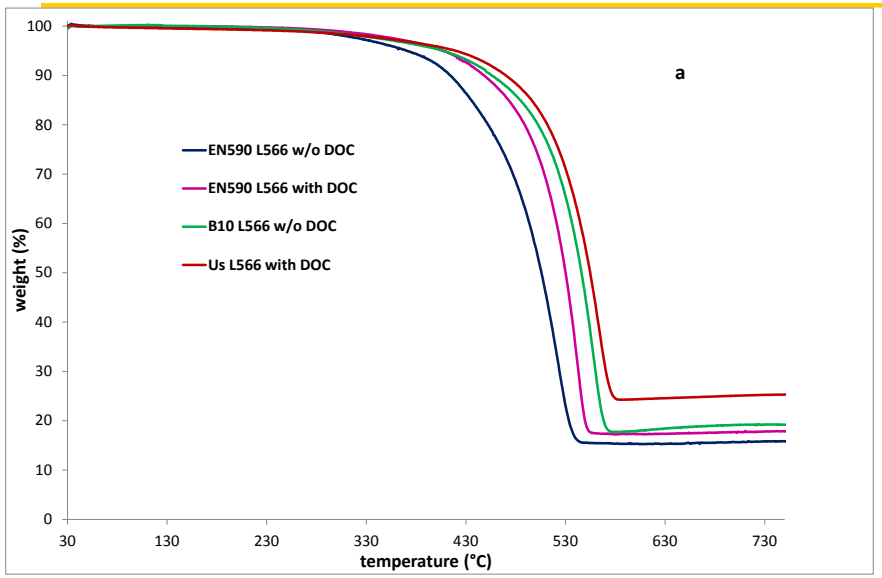
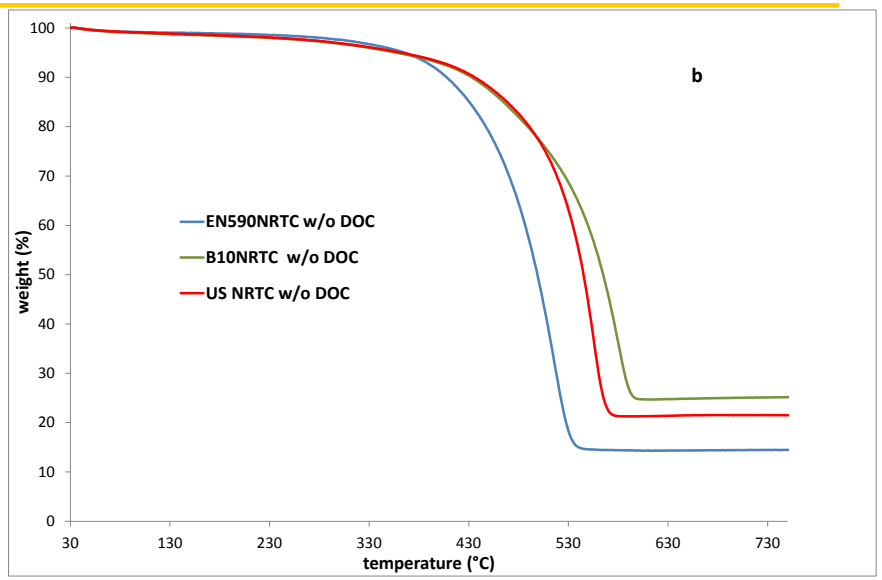
Thermogravimetric analysis





Thermogravimetric analyses (TGA) were conducted - TA Q600 microbalance.2 mg of soot is placed in an open ceramic crucible and is heated from room temperature to 900°C with a heating rate of 5°/min under an air atmosphere
(gas flow of 6 NL/h). The accuracy of the mass measurement is 0.1 µg. The accuracy of the oven regulation is 0.02°C/min.

- EN590 soot is more reactive than the other soot (B10 and US)
- Thermograms obtained from EN590 soot produced during the L566 engine cycle reveals that introduction of a DOC upstream the DPF reduce soot reactivity for active oxidation
- The rate of non-combustible materials, generally attributed to a rate of ash, is important, whatever the soot sample.
- This rate of non-combustible materials varies between 14%, for soot produced using the EN590, to 29% for B10 soot produced during the NRTC cycle.

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B10R20H fuel impact on SCR on Filter performance

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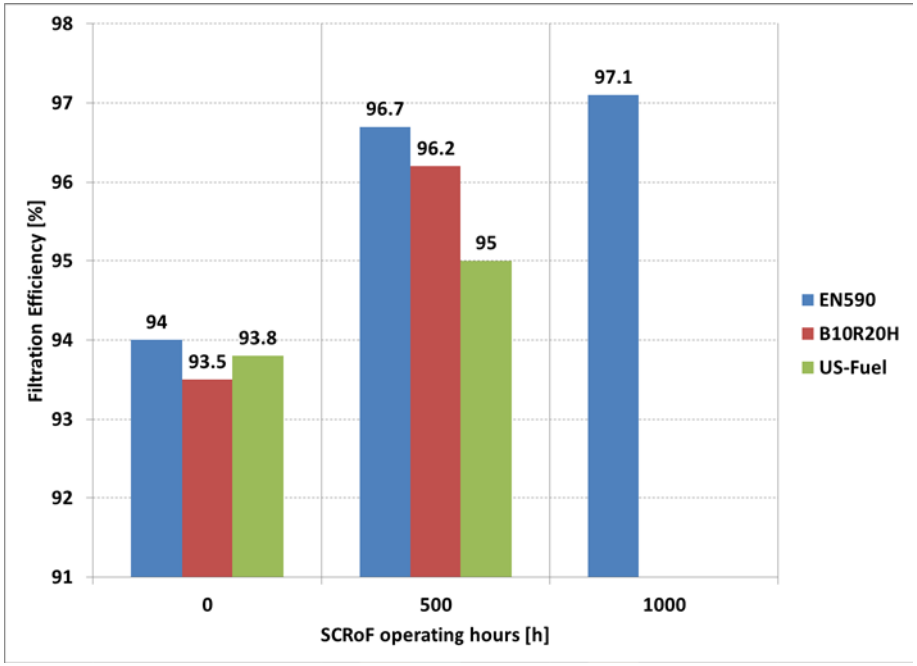
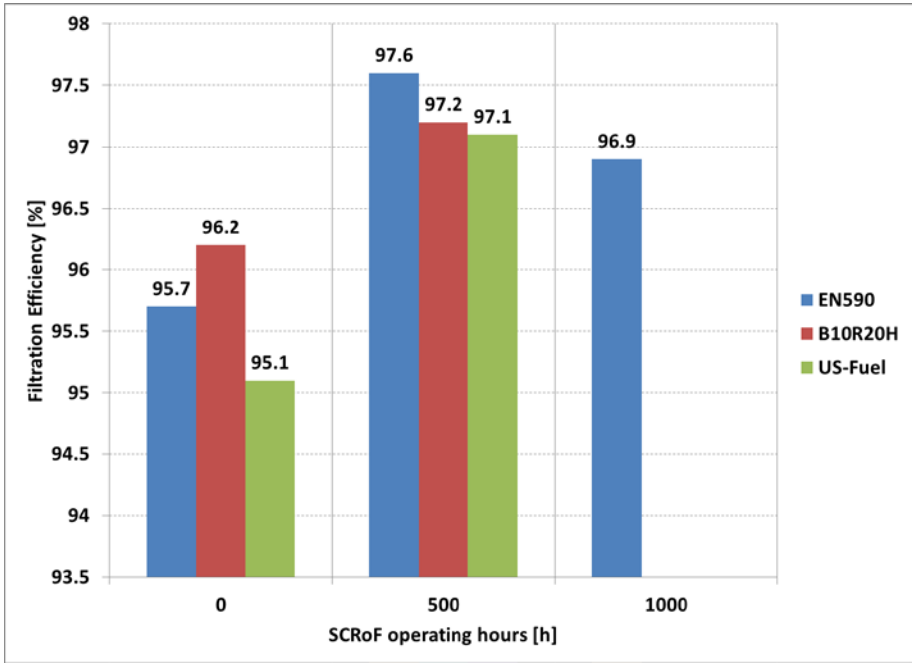
Particulate filtration

NRTC



NRSC



- The filtration efficiency of the SCRoF @ 0hrs is low because the measurement was done with a fresh coated substrate, wo. degreening
- After 500hrs due to the soot cake formation, the filtration efficiency increase up to 97%
- No significant filtration efficiency changes observed between the 3 different fuels

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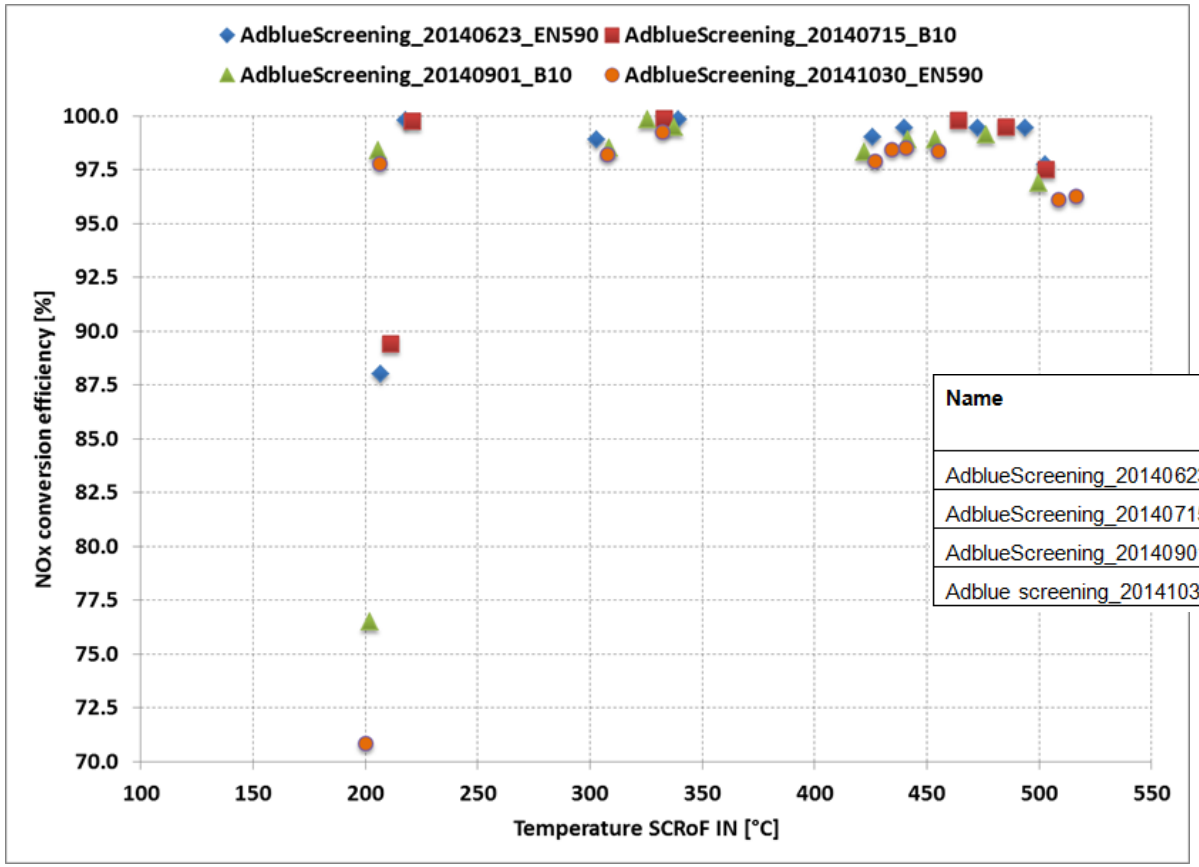
NOx conversion efficiency



Name	Fuel	SCRoF operating hours (tot / endurance)
AdblueScreening_20140623_EN-590	EN-590	40 hrs / 0hrs
AdblueScreening_20140715_B10	B10R20H	293 hrs / 207hrs
AdblueScreening_20140901_B10	B10R20H	919 hrs / 750hrs
Adblue screening_20141030_EN590	EN-590	1200 hrs / 943.6

- 4x urea screening were run during the endurance (at different times) in order to characterize the NOx conversion efficiency of the system
- No significant reduction of the NOx conversion efficiency was observed after 1'000 hrs endurance test with B10R20H fuel

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Summary

Engine Out emissions

- Between the fuel EN590 and B10R20H, no significant impact on the engine out emission.
- With the US-Fuel the particle mass as well as the CO increase compared to EN590 resp. B10R20H

Soot reactivity

- EN590 soot is more reactive than the other soot (B10 and US)
- NRTC cycle leads to quite more reactive soot than L566 cycle
- Introduction of a DOC upstream the DPF reduce soot reactivity for active oxidation

B10R20H impact on the SCR on Filter performance

- After 1’000hrs of endurance test, filtration efficiency stay at the same level
- No significant reduction of the NOx conversion efficiency was observed after 1’000 hrs endurance test with B10R20H fuel

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Aknowledgment

R&D Moteur - Bruno Courtalon, Lucien Germanese

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UHA-Mulhouse - Prof. Jean Francois BRILHAC, Valérie Tschamber

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THANK YOU !!

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