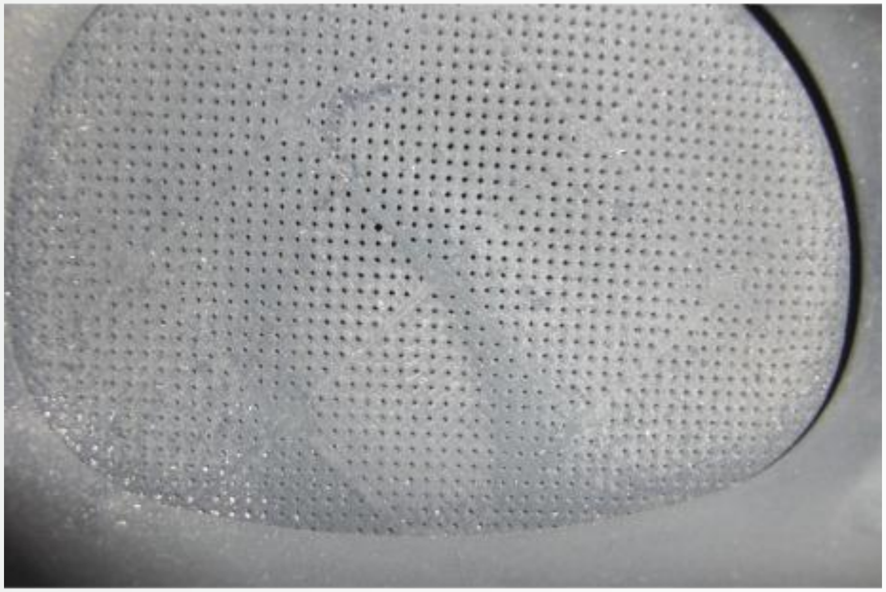
Chemical cleaning of Diesel Particle Filters

CONTENT

BACKGROUND - PROBLEM



Blocked DPF

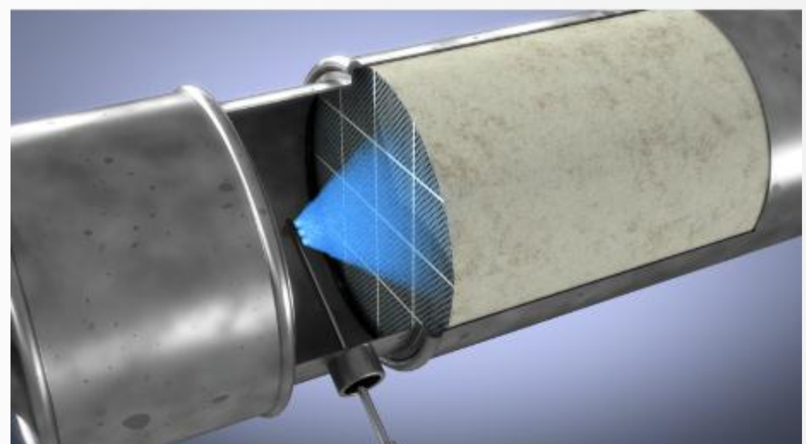
Reasons

- Soot / dirty injectors
- Deposits in EGR System
- Fluctuating fuel quality
- Unfavorable driving profile: The vehicle is only used for short trips

BACKGROUND - SOLUTION

- Mechanical-chemical cleaning
- Easy application
- The particle filter does not need to be removed.

- Pressure cup spray gun with a special probe
- Cleaner + flushing concentrate



PRODUCTS

Features

- Non flammable
- Free of ash
- Metal-free
- Proved material compatibility

FIELD TEST

Result + extra info		
Before		
% saturation DPF iddle	90%	=very high
% saturation DPF 3000 rpm	90%	=very high
difference Pressure DPF (with atmosphere) at iddle	11.2kPa	
difference Pressure DPF 3000 rpm	43.5kPa	
After Cleaning; no testdrive		
% saturation DPF iddle	90%	=very high
% saturation DPF 3000 rpm	90%	=very high
difference Pressure DPF iddle	5.4kPa	=improvem
difference Pressure DPF 3000 rpm	33.5kPa	=improvem
After Cleaning + testdrive (15km)		
% saturation DPF iddle	10%	= good
% saturation DPF 3000 rpm	10%	= good
difference Pressure DPF iddle	0kPa	
difference Pressure DPF 3000 rpm	3.8kPa	

EXTRA INFO

During Testdrive we noticed a regained full power; during testdrive also a dynamic RG occured: temp bis 670°; no enforced static RG was done after testdrive because saturation of DPF was normal again

In a field test carried out by GM Europe, >80% of filters which would have been replaced normally were successful cleaned.

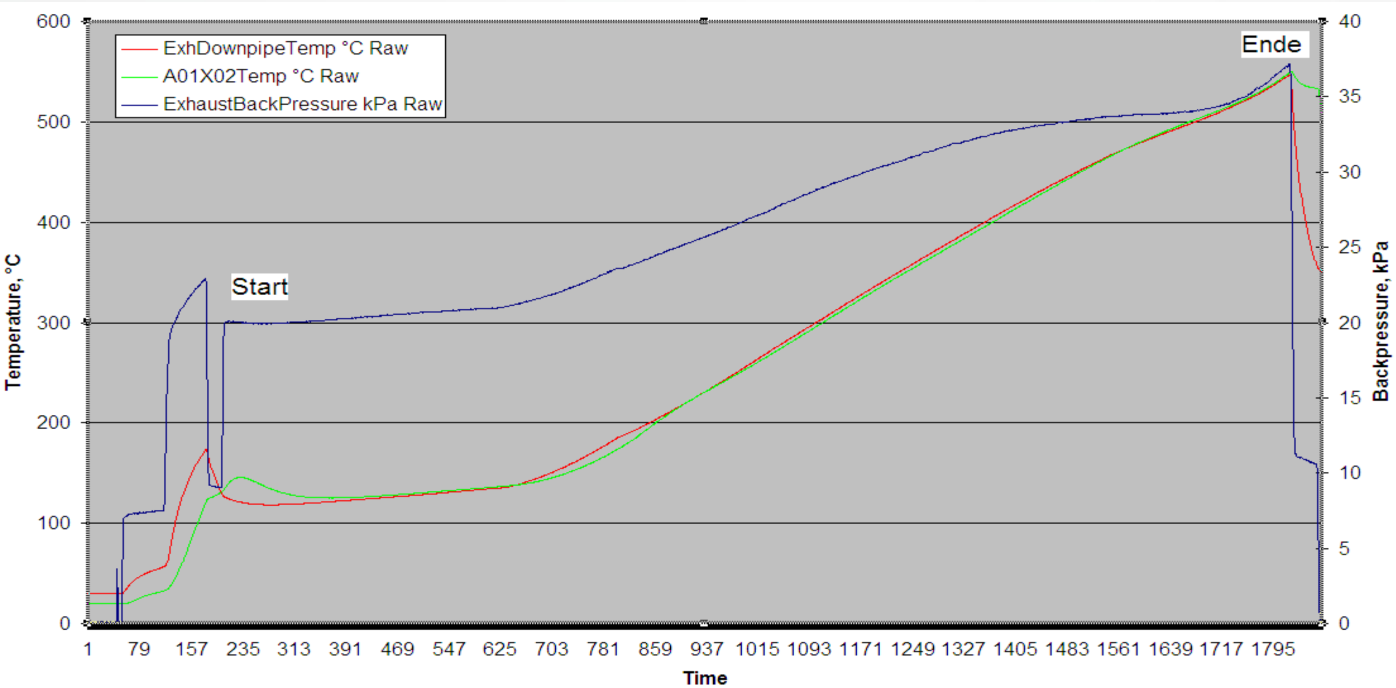
BENCH TESTS – EFFICIENCY + TEMPERATURE MONITORING

Engine: VM R425 2,5 l 100 kW

Particle Filter: DINEX X25 Siliciumcarbid ø5,66” x 8”

Coating: Platinum

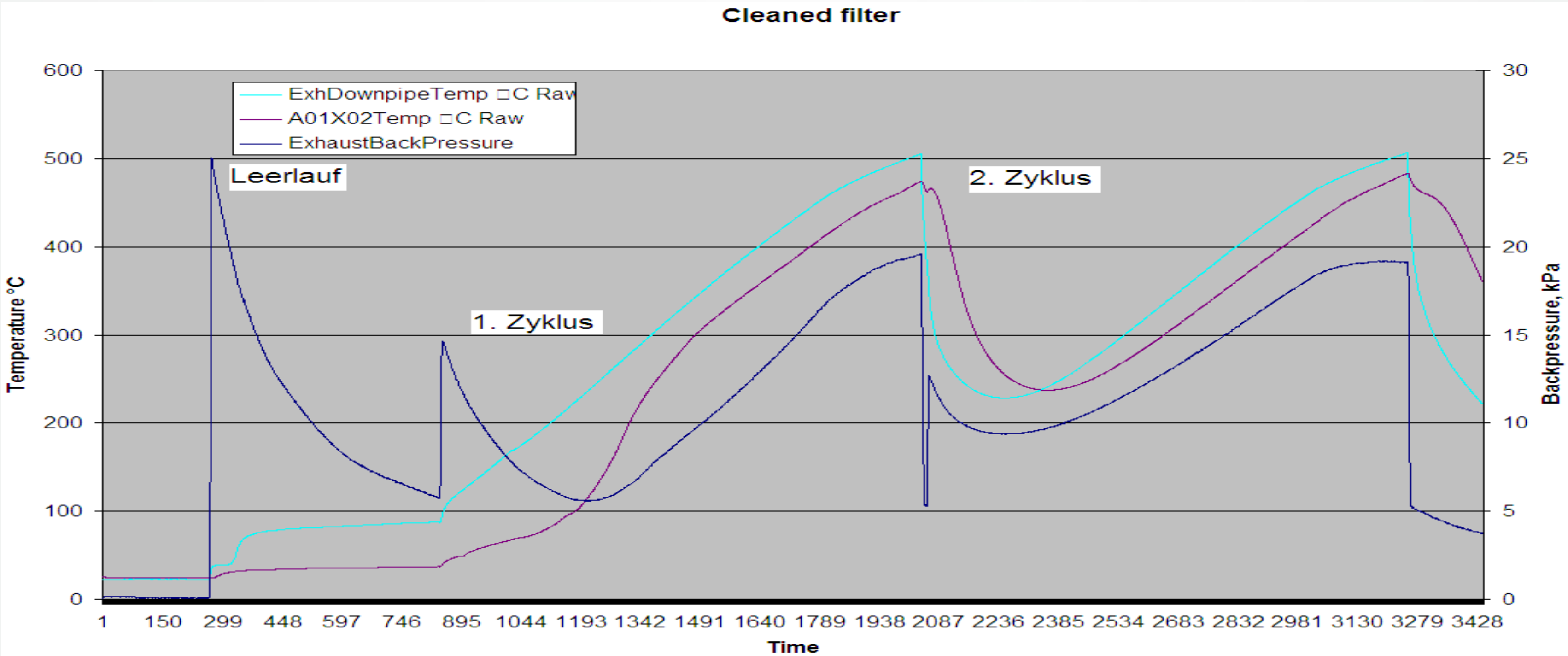
BENCH TESTS – EFFICIENCY + TEMPERATURE MONITORING



Regeneration untreated filter

BP at start:	20,0 kPa	Due to exothermic reaction the temperature after filter surpasses th temperature before the filter quickly	
BP at maximum load:	37,2kPa	Maximum temperature after filter:	547°C
BP at end of test:	10,6 kPa	Maximum temperature before filter:	549°C
BP fresh filter:	3,9 kPa		

BENCH TESTS – EFFICIENCY + TEMPERATURE MONITORING



Regeneration treated filter

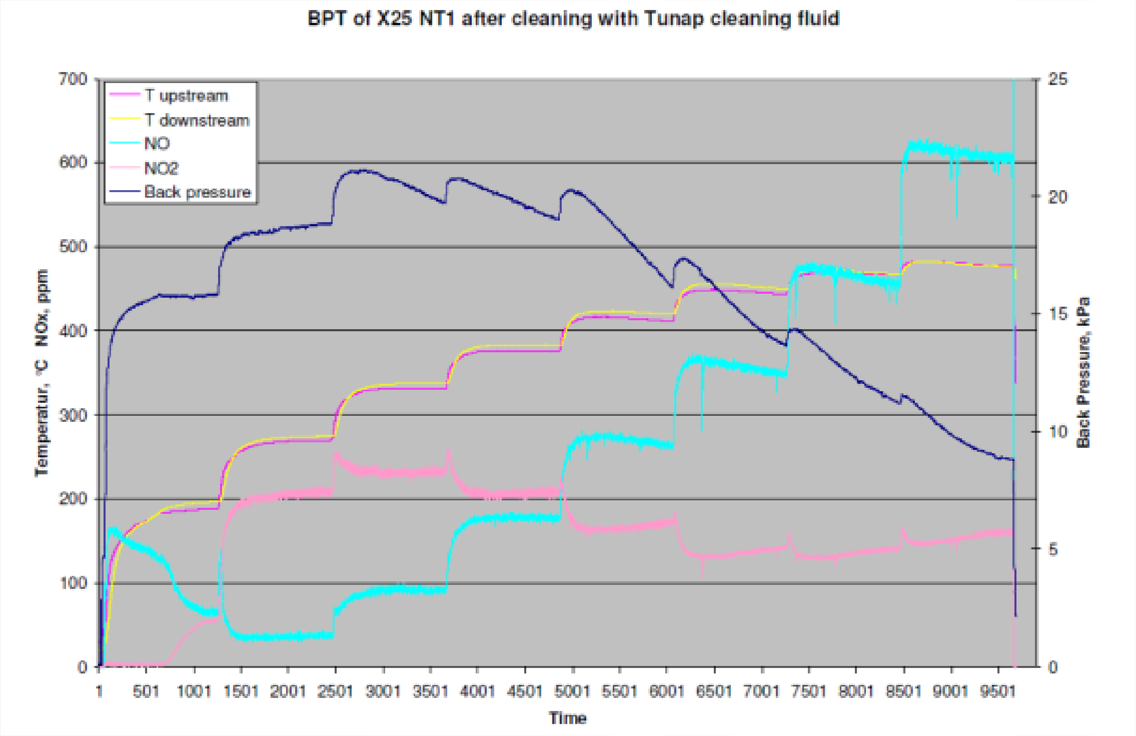
BP at start ideling:	25,0 kPa
BP after ideling:	5,7 kPa (20,0 kPa)
BP at maximum load:	19,5 kPa (37,2 kPa)
BP at end of test:	4,0 kPa (10,6 kPa)
BP fresh filter:	3,9 kPa

Temperature after filter distinctive lower than before filter

Maximum temperature after filter:	475°C (547°C)
Maximum temperature before filter :	504°C (549°C)

Werte in Klammern sind Werte vor Reinigung.

BENCH TESTS – EFFICIENCY + TEMPERATURE MONITORING



Determination of the balance point

The balance point temperature of the treated filter is 320°C, which is within normal for Dinex X25 coated filters.

The balance point is the point where sampled particles are as much as the oxidized particles. This is the point with the highest backpressure before the backpressure curve drops down.

BENCH TESTS – EFFICIENCY „ASH "

Sample material:

Silicon carbide filters from Volvo V50 after 145278 km. FBC has been used on the vehicle
Silicon carbide filter from Toyota Corolla after 104270 km. No use of FBC

Test Equipment:

VM Motori R4 R425-1, 2,5 l 100 kW
T250 Horiba engine test bench with standard data collection system, especially difference pressure upstream of filter and temperatures upstream and downstream
MEXA FTIR gas measurement system
EECPC particle counter, TSI
EEPS particle sizer, TSI
Thermo Dilution system, Matter Engineering

BENCH TESTS – EFFICIENCY „ASH “

Results

		After drying	After furnace	After test	After furnace 2	After cleaning
Volvo V50	From car running FBC	8059	8045	8038	8035	8032
Toyota Corolla	No FBC	7129	7093	7063	7065	7065

		Soot 1	Ash 1	Soot 2	Ash 2
Volvo V50	From car running FBC	14	7	3	3
Toyota Corolla	No FBC	36	30	-2	0

*all figures in g

New Questions and new Answers since 2015

- EURO 6 engines with SCR catalyst: Is there any problem with material stability especially with NOx sensor?
- How does the cleaning procedure work for older particle filters without active regeneration.
- Understanding the mechanism of cleaning

EURO 6: BENCH TESTS – NOx Sensors

- Test performed under supervision of TÜV Thüringen at University Magdeburg
- Tested sensors: Continental + Bosch

Engine Mercedes Benz OM 646.963
2150ccm 110KW
Common Rail
Oxidation catalytic system 220CDI

BENCH TESTS – MATERIAL STABILITY

Results

- Test performed in cooperation with TÜV Thüringen at University Magdeburg
- No changes in the electronic readings of the sensors before and after cleaning were observed
- No changes in the ceramic surface of the sensor were observed
- There were neither any irregularities or failures of the sensors

VERT Retrofit „Project Megacities“

- Particle Filter Cleaning was thoroughly tested and successful used in practice for many years for electronic controlled particle filter systems

- For the VERT Retrofit Project „Megacities“ the effectiveness of the procedure for unregulated retrofit filters had to be tested.

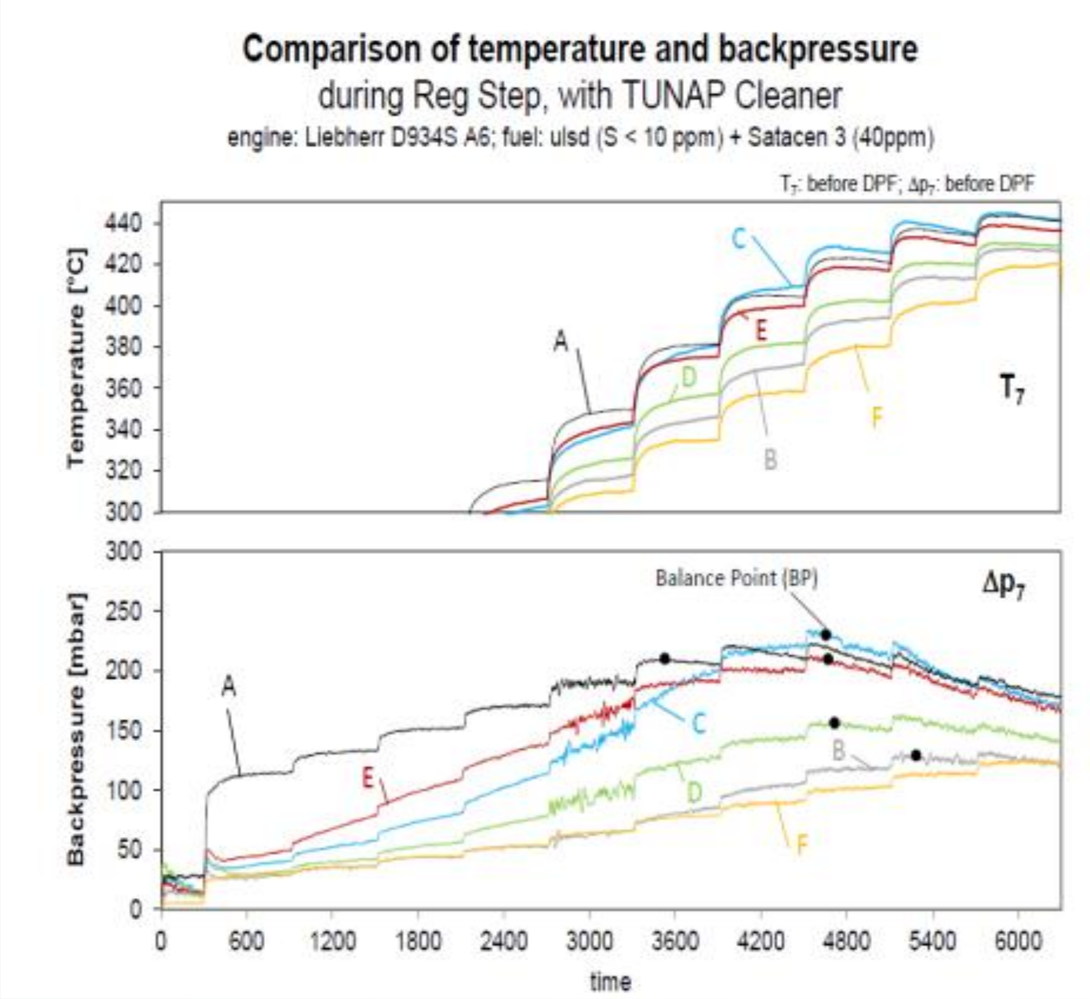
- In cooperation with VERT and Innospec tests were carried out by the team of Prof. Czerwinski at the Laboratory for Exhaust Emission Control of the University of Applied Sciences Biel.

- In addition, further tests were carried out to understand the mechanism of the cleaning procedure

First VERT Test

- Tests were done on a Liebherr engine, equipped with an uncoated DPF and with FBC added to the fuel.
- Measurements and evaluations, are performed according to the VERT DPF quality testing procedures.
- Besides the usual engine operating parameters particulates number, volatile pollution and filter mass was measured.
- The analysis was performed by running standard regeneration Step Tests, post to the injection of the cleaner. The Step Test is a well-known regeneration procedure used in all VERT/LRV DPF certifications.

First VERT Test



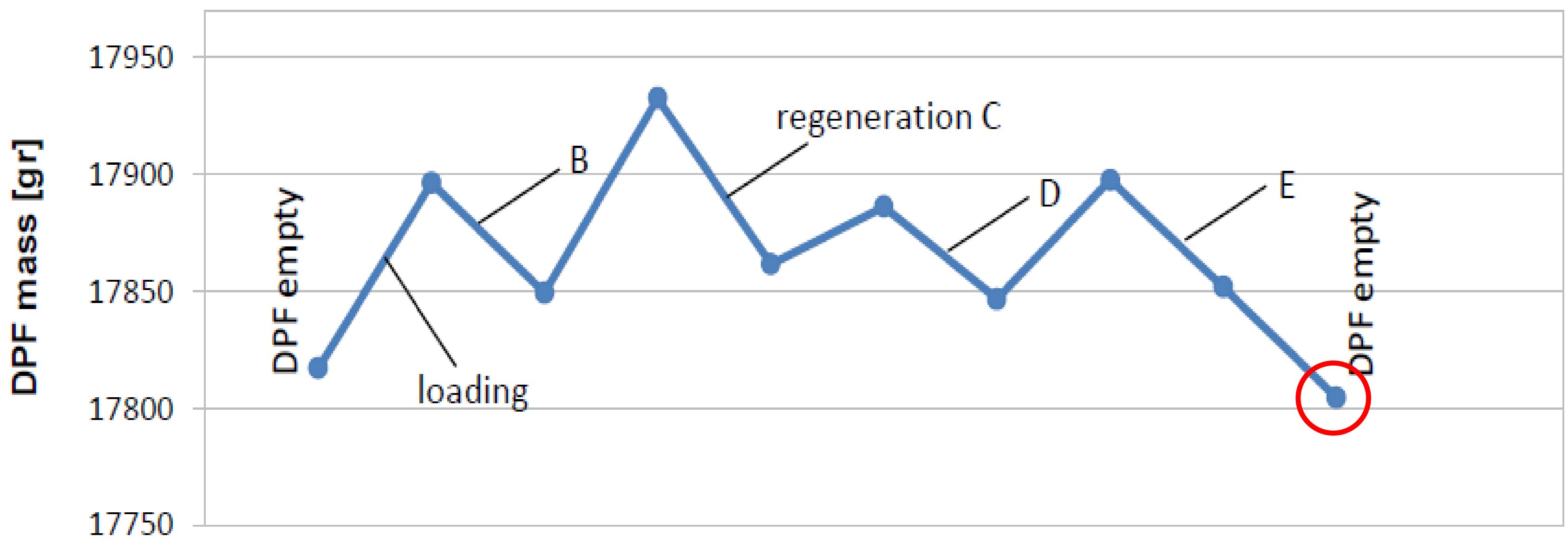
A-E: DPF loaded, regeneration
A: without Cleaner Injection
B/C: Cleaner Injection 1 side
D/E: Cleaner Injection 2 sides
F: DPF empty, no Cleaner

First VERT Test

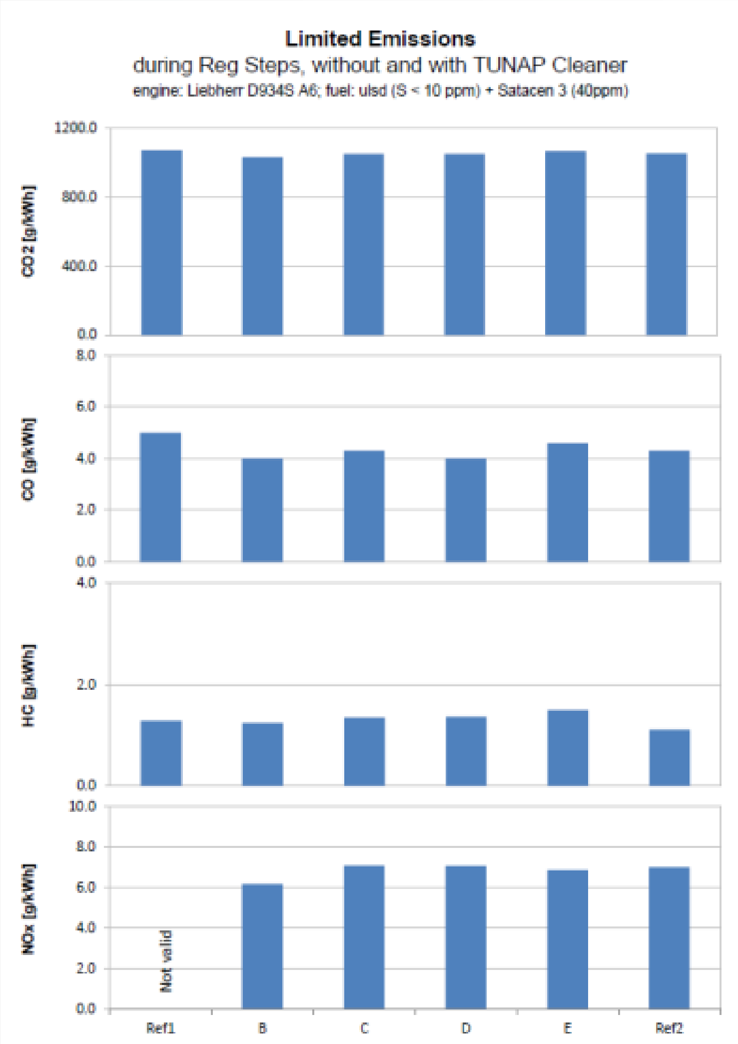
DPF mass evolution

during Soot Loadings and Reg Steps, with TUNAP Cleaner

engine: Liebherr D934S A6; fuel: ulsd (S < 10 ppm) + Satacen 3 (40ppm)



First VERT Test

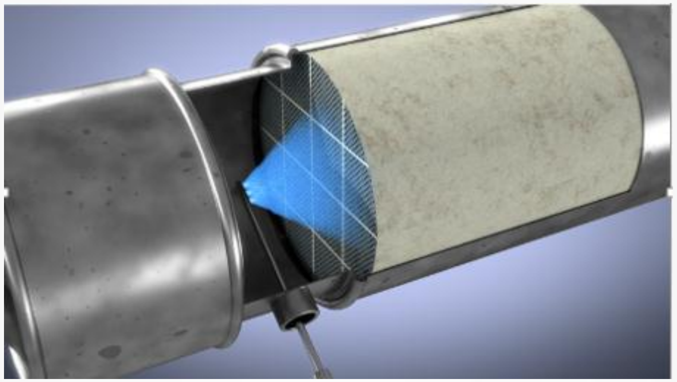


- Emission values for test curves B-E compared to the reference values A and F
- The result of the measurement shows that the filter cleaning has no negative effect regarding emission values.

Second VERT Test

Analysis of wash-out effects

163 g soot load

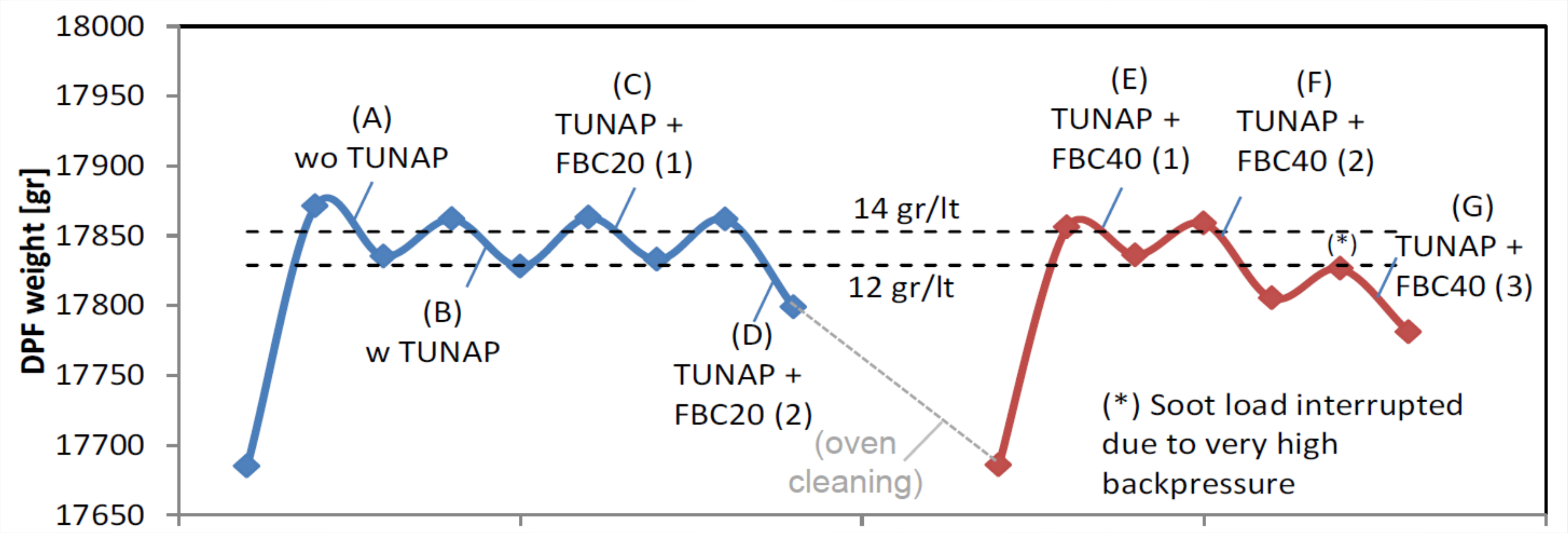


Engine at standstill: 1 g before DPF, „zero“ after DPF
Engine at idling: 1,1 g before DPF, 0,25 g after DPF

Entrance surface of the DPF was clean after injection

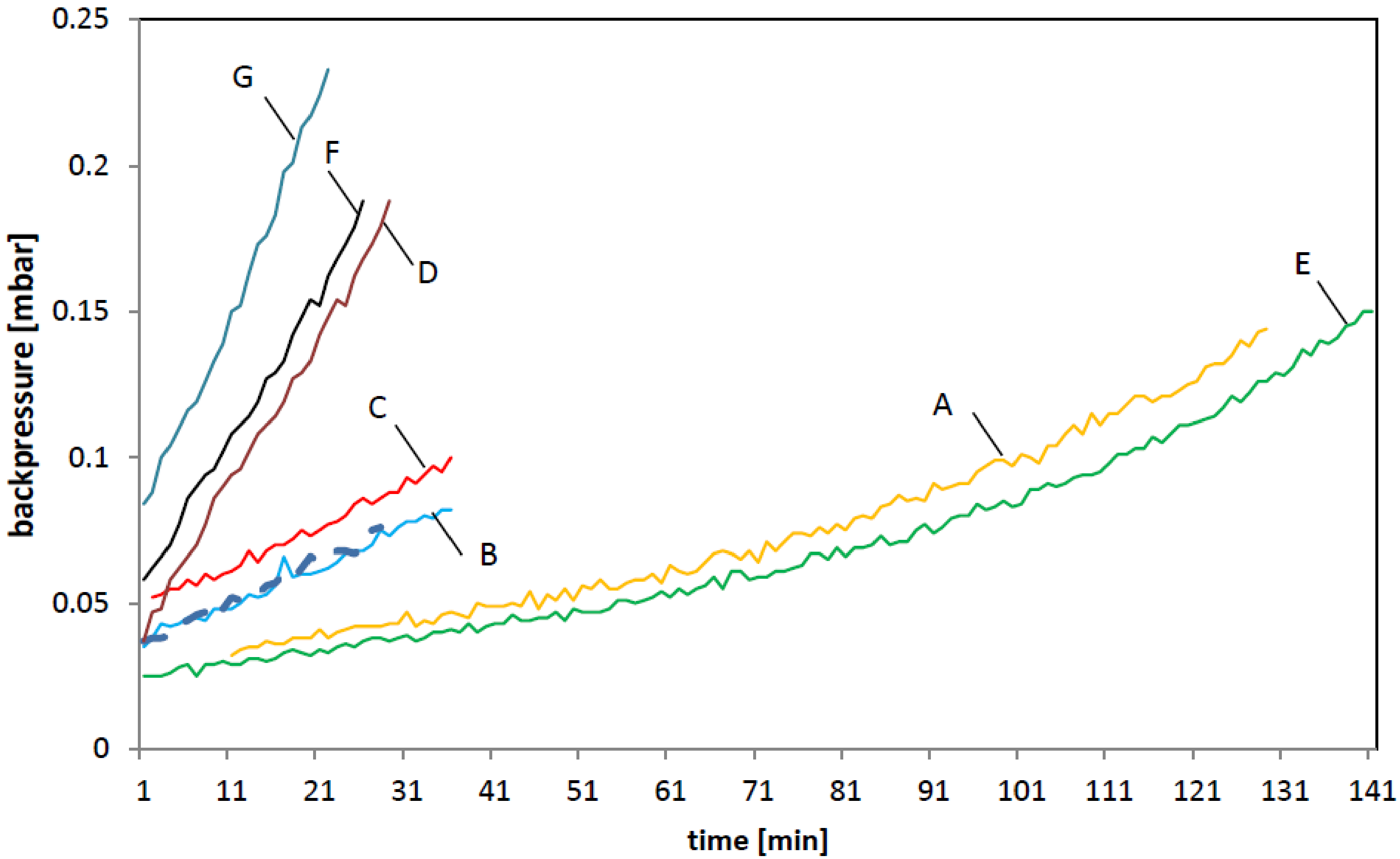
➔ Soot gets „mobilized“/changes structure but is not washed out

Second VERT Test



- A reduction in soot mass was found after using the cleaning method
- Addition of FBC showed positive effects
- Procedure was still not enough to accomplish a complete regeneration

Second VERT Test



Third VERT Test

Testing of different ways to improve the regeneration of particle filter:

- Addition of catalyst through the cleaner „cleaner borne catalyst“
- Addition of a defined amount of flammable/exothermic components
- Further investigations on the mechanism of filter cleaning

Will not be applied for the regular 931/932 Particle Filter cleaner!

Conclusion

- TUNAP cleaning method is well established and tested for electronic controlled particle filter systems
- Regeneration after cleaning is an important part of cleaning process
- Material stability including no harm against electronic components in the system was tested.
- No negative effect on exhaust gas during cleaning/regeneration
- For unregulated filters we still need to find a method to ensure a complete regeneration after the cleaning procedure

Thank you for your attention