VERT-Workshop within AQM2016-Conference Tehran Jan.2016

Quality Control of Emission Control Systems

Certification, IUC-Inspection and Maintenance

Andreas C.R.Mayer

The VERT Scientific Committee

What is VERT ?

1. **VERT** =
   Verification of Emission Reduction Technologies

2. **VERT** is a **Diesel Particle Filter Testing**, **Certification and Quality Control System**

3. **VERT** is a Trade Mark
   for Particle Filters of Best Available Technology

4. **VERT** is a non-profit Association (based in CH) of Filter Manufacturers, Engine Builders and Associates – 24 members

Concept of VERT-Testing

- In Depth Testing of Exhaust Gas Filter Structures for Nanoscale Filtration (**Physical Properties**)
- In Depth Testing **Chemical Phenomena** in Exhaust Gas Filter Structures
- Testing a **complete DPF system**
- Type Approval of **one filter per filter family**
- **Endurance Testing** on Typical Vehicle Application
- **Testing is Worst Case oriented**
- Best Available Technology is the moving Target

→ Testing of each Combination Filter + Engine not required

DOC

Reduction CO, HC

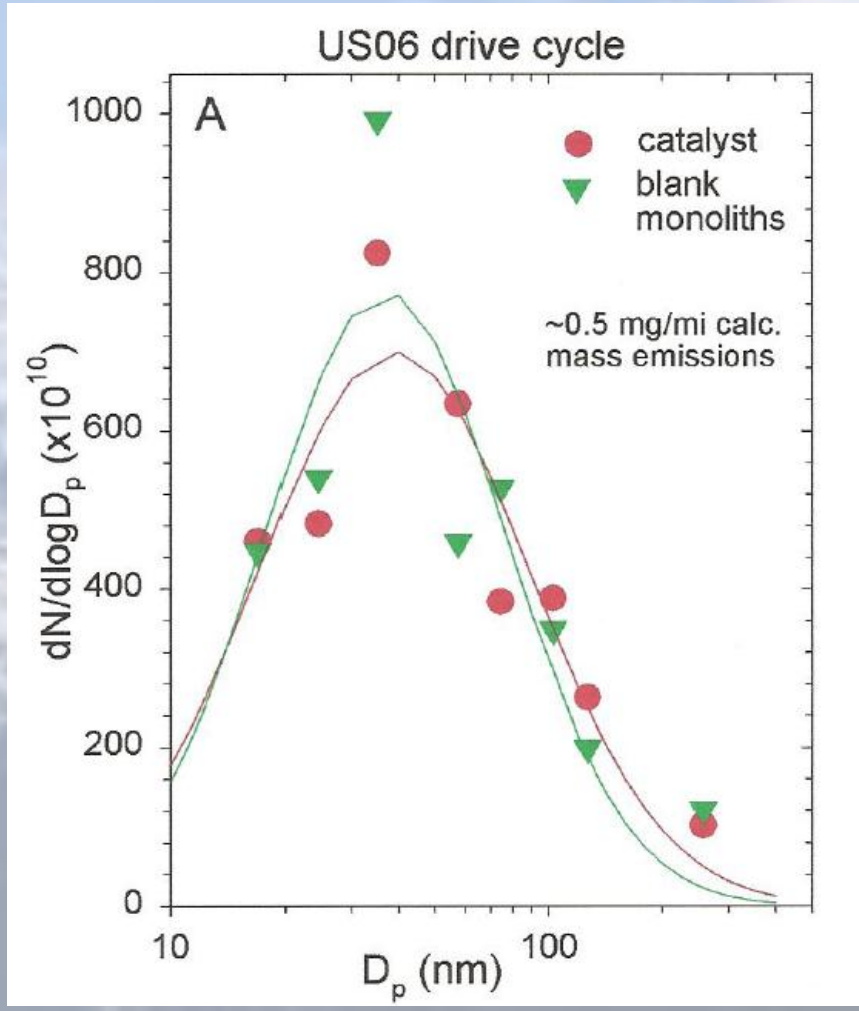
Production

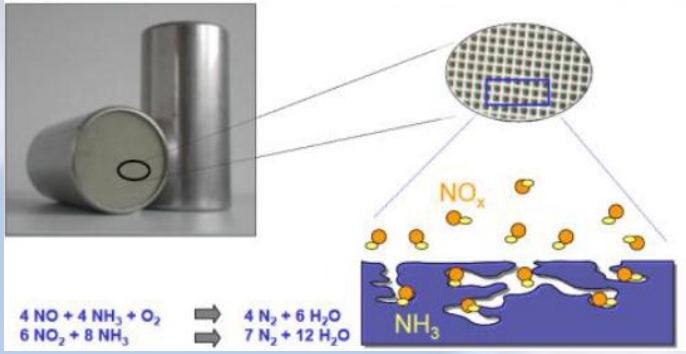
$NO \rightarrow NO_2$

$SO_2 \rightarrow O_3$

No Effect on Particles

(M.Maricq)





SCR

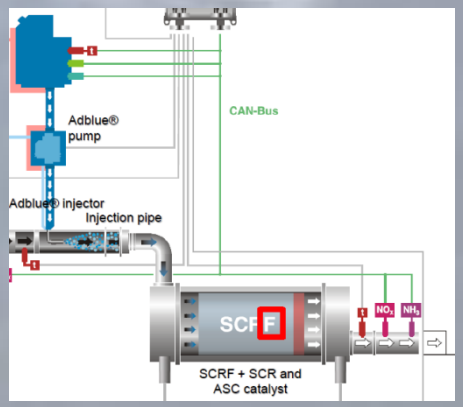
reduces NO and NO_2

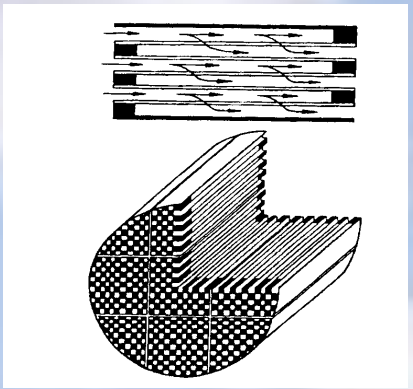
but no effect on particles

nor CO, HC, PAH

and needs elevated exhaust temperature

→ SCRT coming





DPF

reduces PM, PN

and if catalysed CO, HC, PAH

operated with FBC also NO2

and with SCR-coating even NO2

but can also be a Chemical Reactor ?

with extremely long residence time

VERT® Quality System

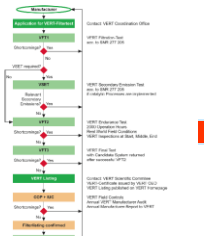
In Use Compliance + Review
Inspection and Maintenance

VERT Certification

Installation
Acceptance Test

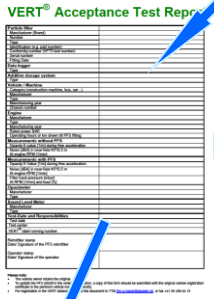
Data-Base

Reporting
COP



VERT® Filter List
VERT certified ®
Particle Filter Systems
for Combustion Engines
October 2010

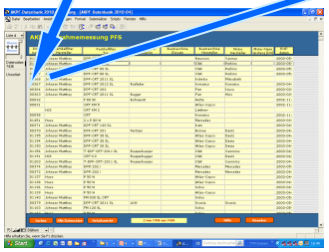
Public Awareness



Road Permit

VERT certified for Health and Climate
J F M A M J J A S O N D 10 11 12

Public Awareness



Clients Reference

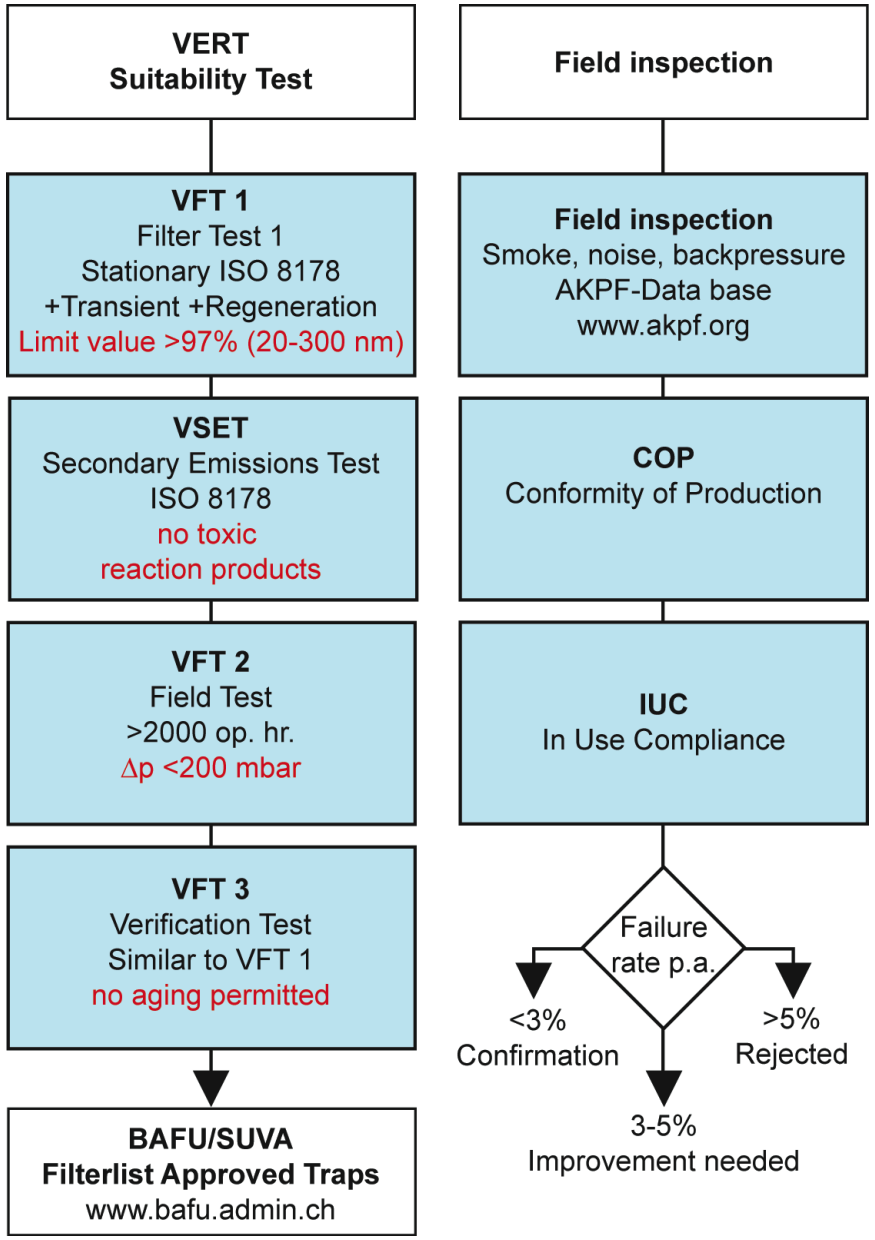
Public Reference

Public Awareness

VERT Overall Sales Failures

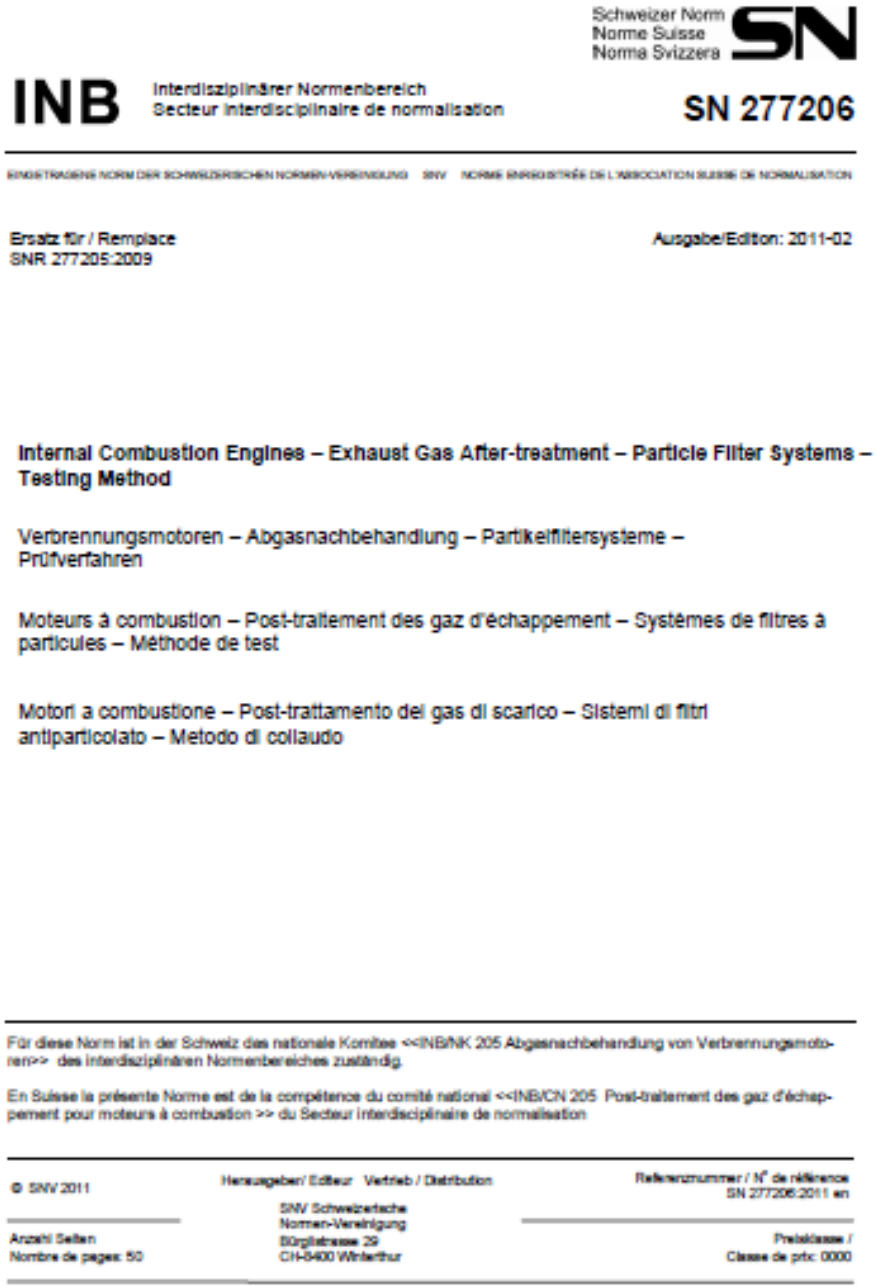
VERT-Homepage
www.VERT-certification.eu

Step 1
VERT Certification
= Type Approval



Swiss Standard (Techn.Norm)

How to measure and characterize Nanoparticle Filtration systems for Combustion Engines



Schweizer Norm
Norme Suisse
Norma Svizzera
SN

INB Interdisziplinärer Normenbereich
Secteur interdisciplinaire de normalisation

SN 277206

EINGETRAGENE NORM DER SCHWEIZERISCHEN NORMEN-VEREINIGUNG SNV NORME ENREGISTRÉE DE L'ASSOCIATION SUISSE DE NORMALISATION

Ersatz für / Remplace
SNR 277205:2009

Ausgabe/Edition: 2011-02

Internal Combustion Engines – Exhaust Gas After-treatment – Particle Filter Systems – Testing Method

Verbrennungsmotoren – Abgasnachbehandlung – Partikelfiltersysteme – Prüfverfahren

Moteurs à combustion – Post-traitement des gaz d'échappement – Systèmes de filtres à particules – Méthode de test

Motori a combustione – Post-trattamento dei gas di scarico – Sistemi di filtri antiparticolato – Metodo di collaudo

Für diese Norm ist in der Schweiz das nationale Komitee <<INB/NK 205 Abgasnachbehandlung von Verbrennungsmotoren>> des interdisziplinären Normenbereiches zuständig.

En Suisse la présente Norme est de la compétence du comité national <<INB/CN 205 Post-traitement des gaz d'échappement pour moteurs à combustion >> du Secteur interdisciplinaire de normalisation

Herausgeber/ Editeur Vertrieb / Distribution
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Bürglistrasse 29
CH-8400 Winterthur

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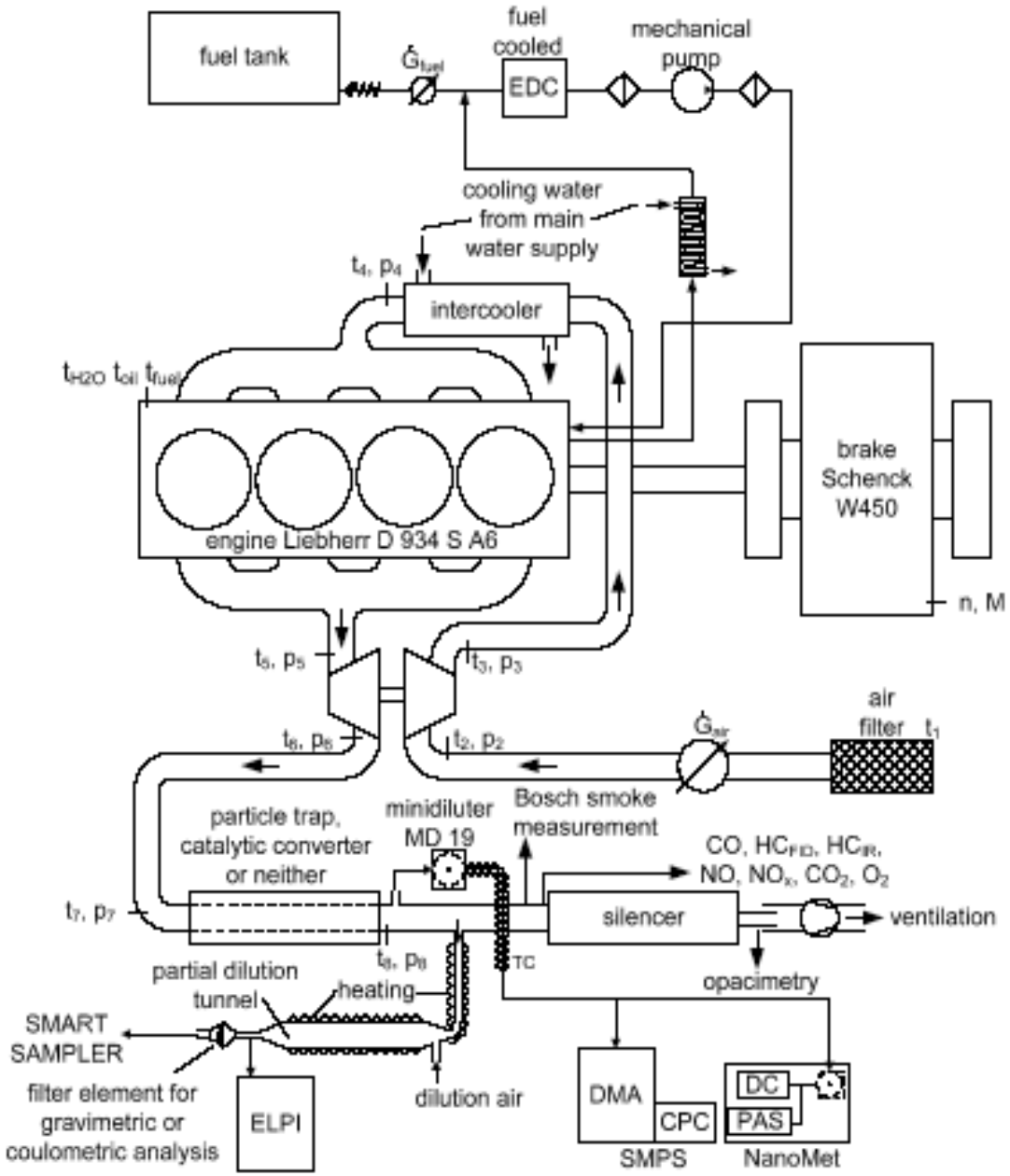
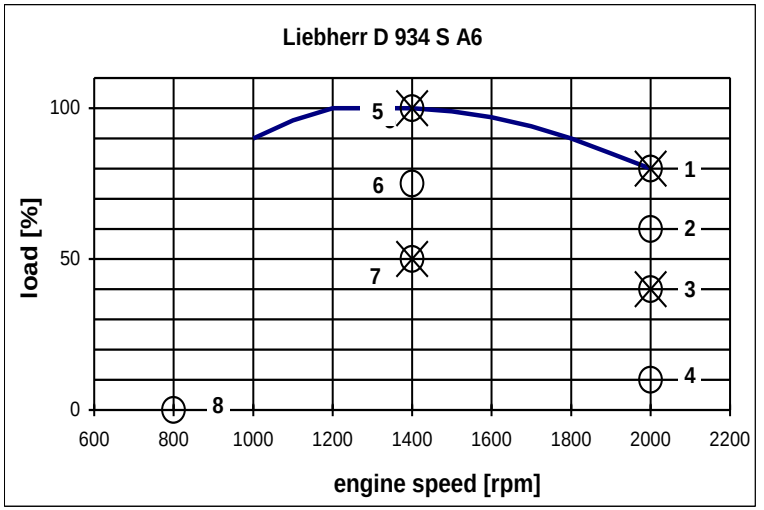
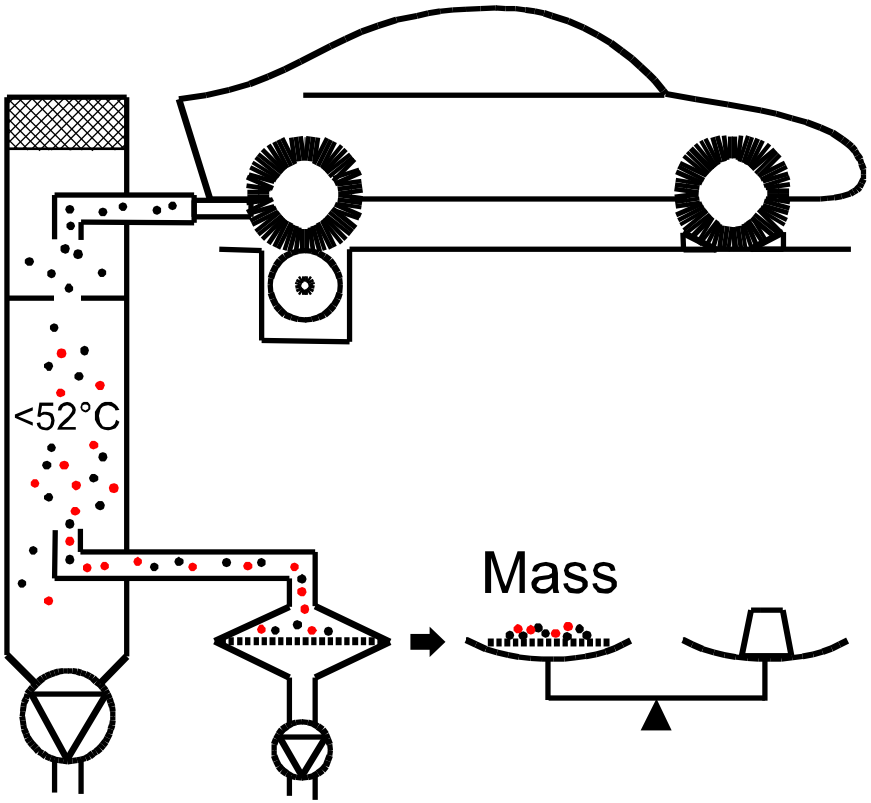
Test Setup

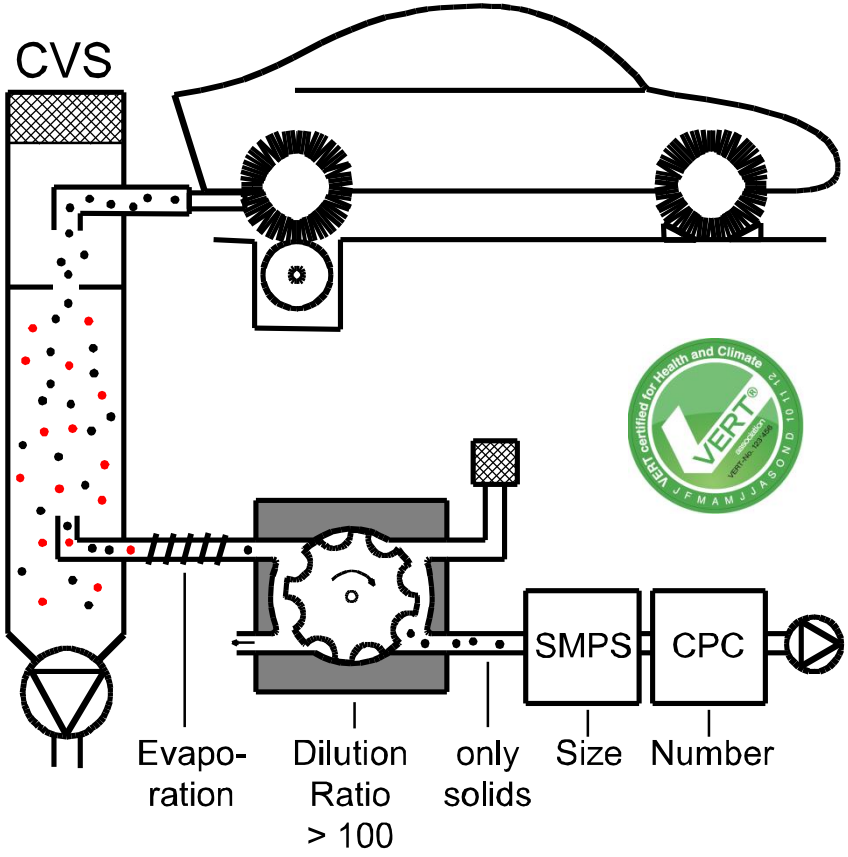

fuel tank
$\dot{G}_{fuel}$
fuel cooled
EDC
mechanical pump
cooling water from main water supply
t_4, p_4
intercooler
t_{H2O} t_{oil} t_{fuel}
engine Liebherr D 934 S A6
brake Schenck W450
n, M
t_5, p_5
t_3, p_3
t_6, p_6
t_2, p_2
$\dot{G}_{air}$
air filter t_1
particle trap, catalytic converter or neither
minidiluter MD 19
Bosch smoke measurement
CO, HC_{FID}, HC_{IR}, NO, NO_x, CO_2, O_2
t_7, p_7
silencer
ventilation
t_8, p_8
TC
opacimetry
partial dilution tunnel
heating
SMART SAMPLER
filter element for gravimetric or coulometric analysis
ELPI
dilution air
DMA
CPC
SMPS
DC
PAS
NanoMet

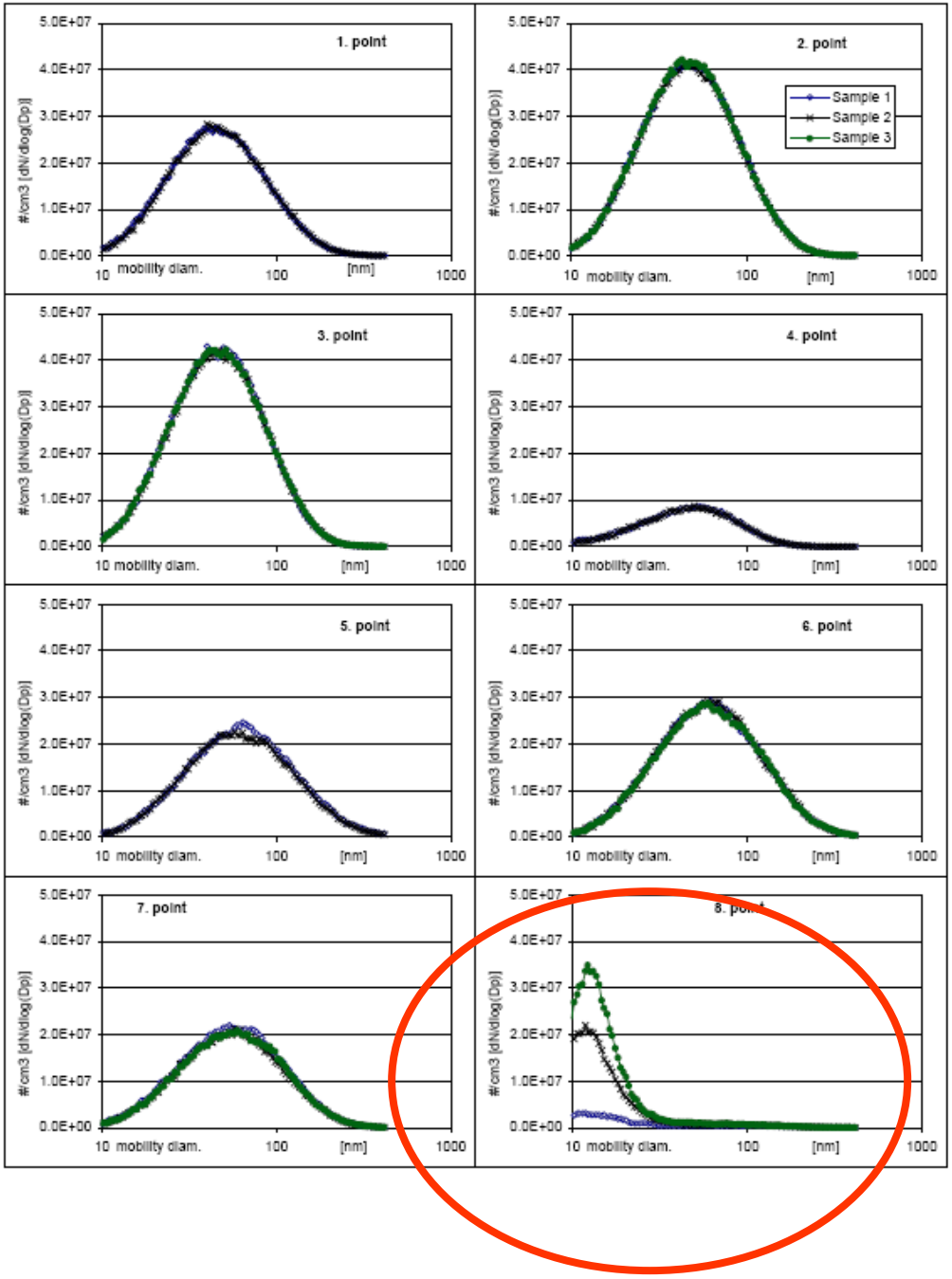

Liebherr D 934 S A6
load [%]
100
50
0
600
800
1000
1200
1400
1600
1800
2000
2200
engine speed [rpm]
1
2
3
4
5
6
7
8

Change from unspecified PM to solid Particle number PN and size

In Switzerland 10 years before EU-PMP





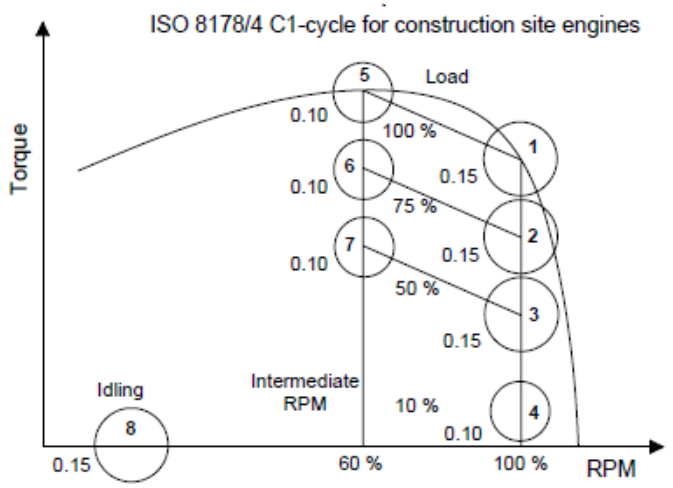


Size distributions

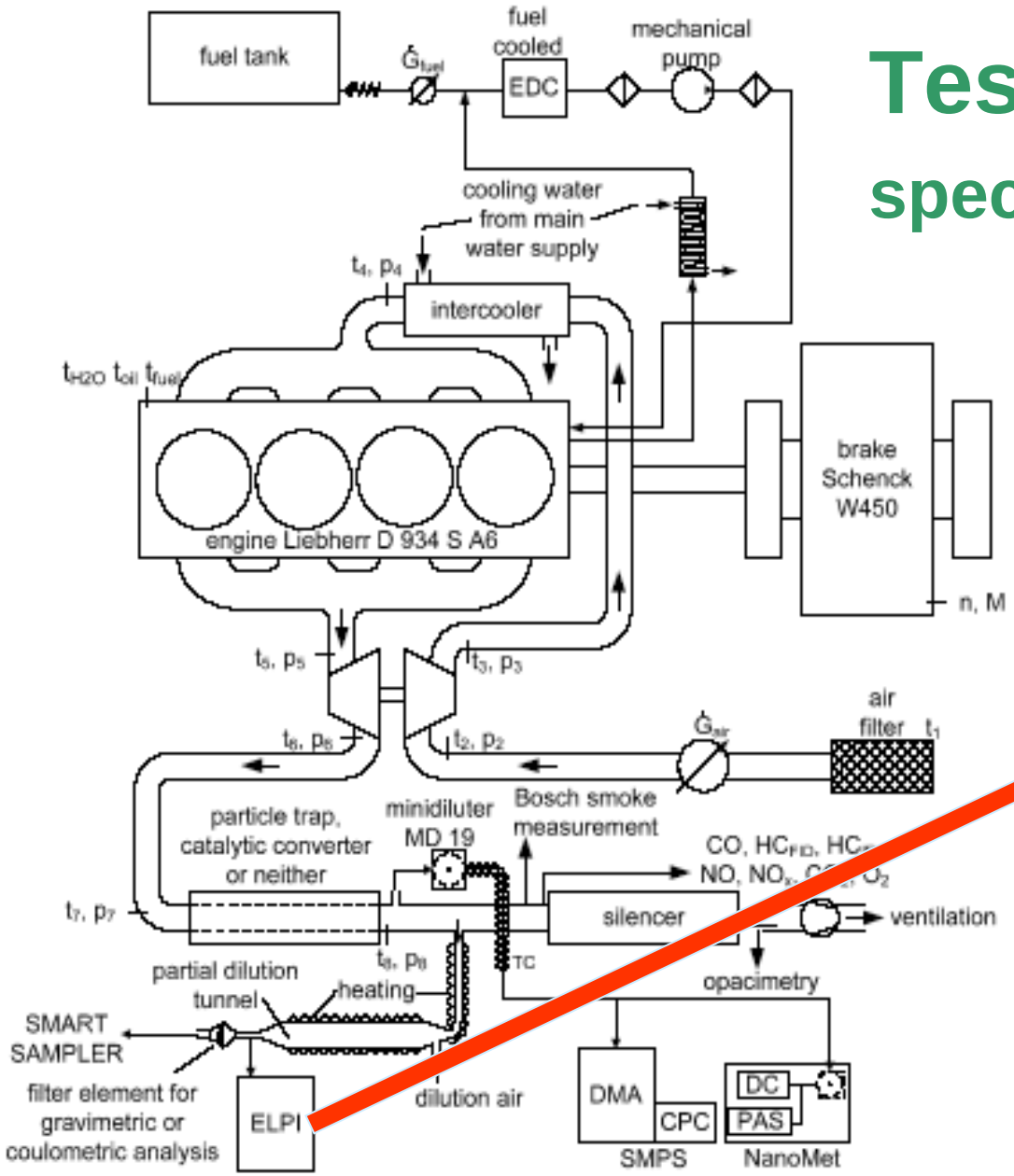
Liebherr Diesel

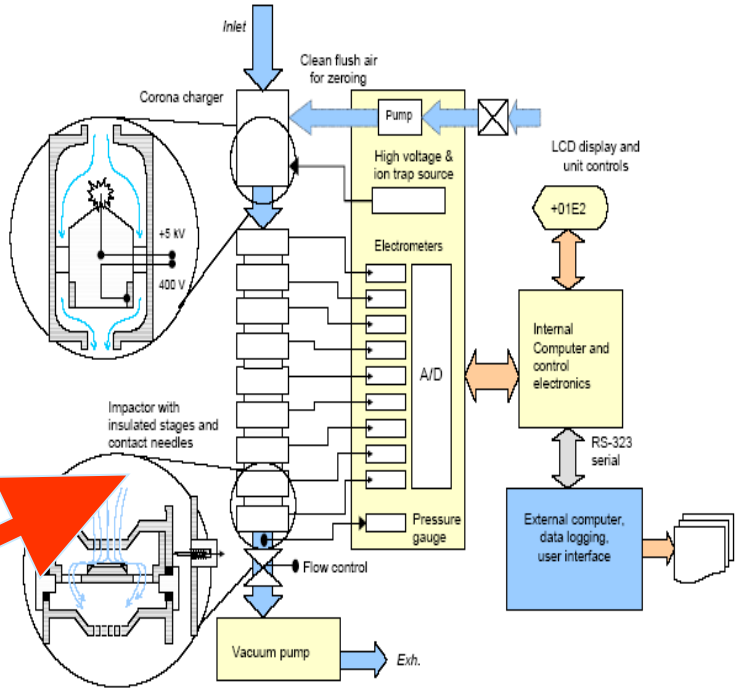
110 kW

8 operation points of
ISO 8178/4 C1 test cycle
OP 8 = idle
Sampling: 300°C,
Dilution Ratio DR=100



Test Setup for size-specific particle analysis



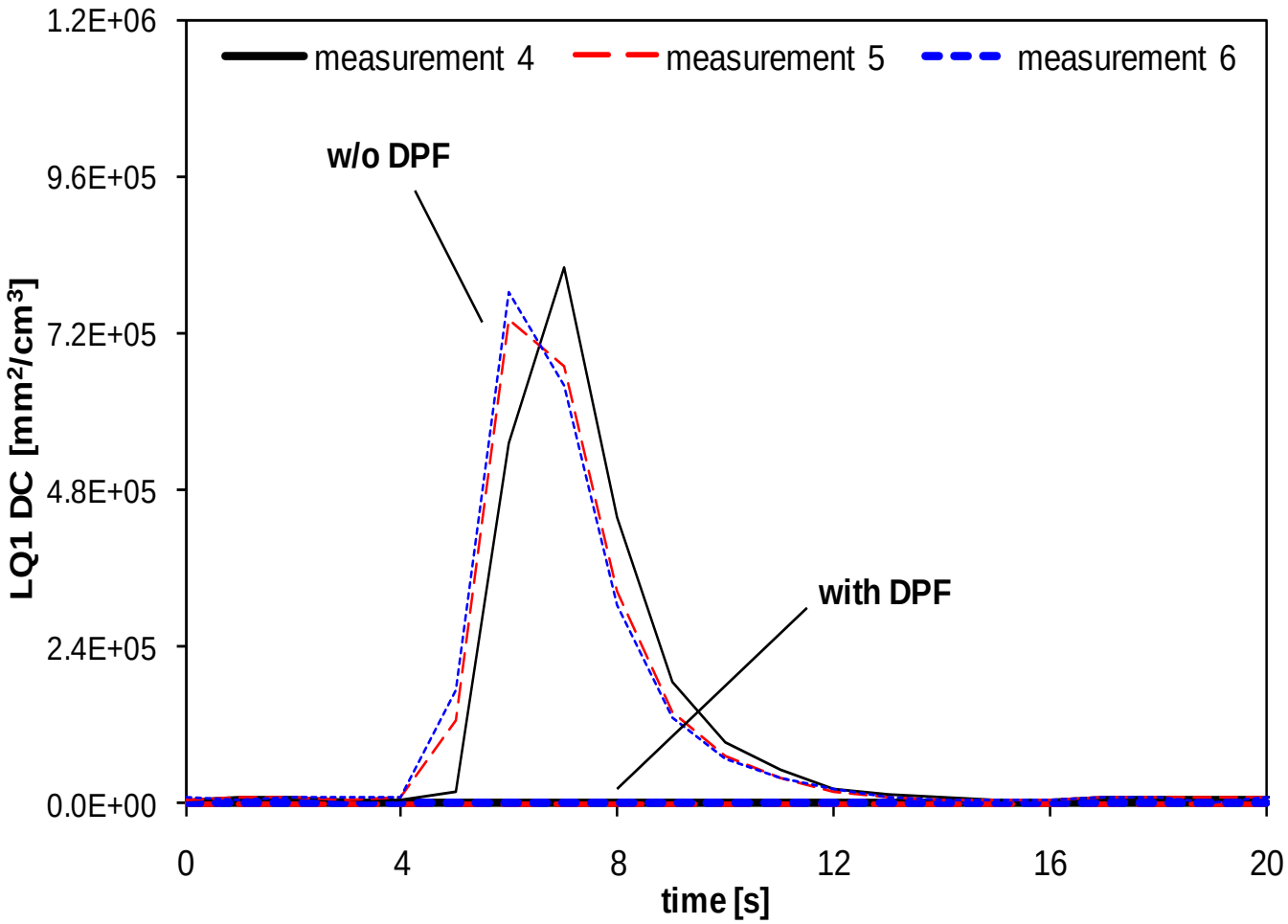


ELPI – Impactor

13 size classes

30 nm – 10 µm

Extreme Transients « free acceleration » with DC-signal, with / without DPF

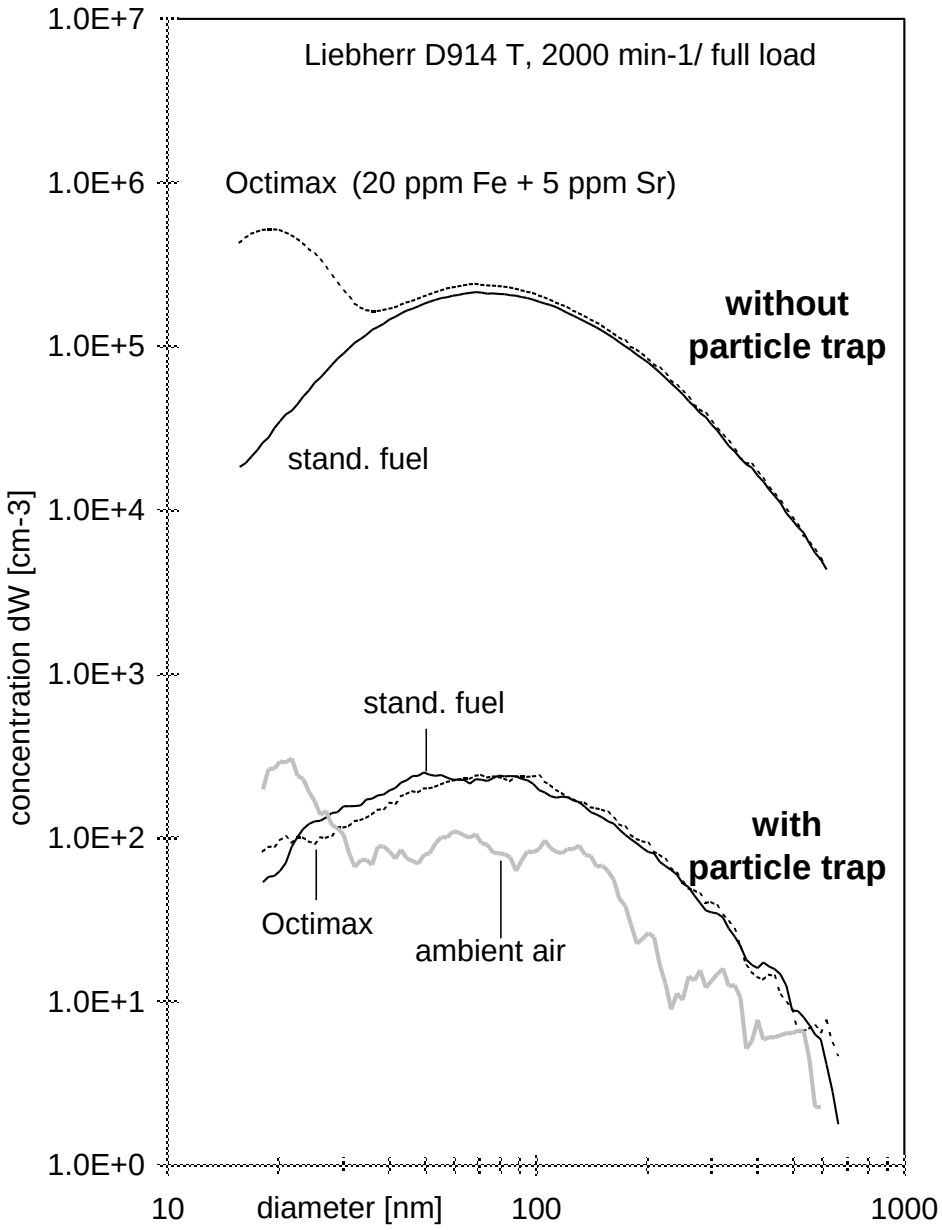


Main requirements of VERT filter test

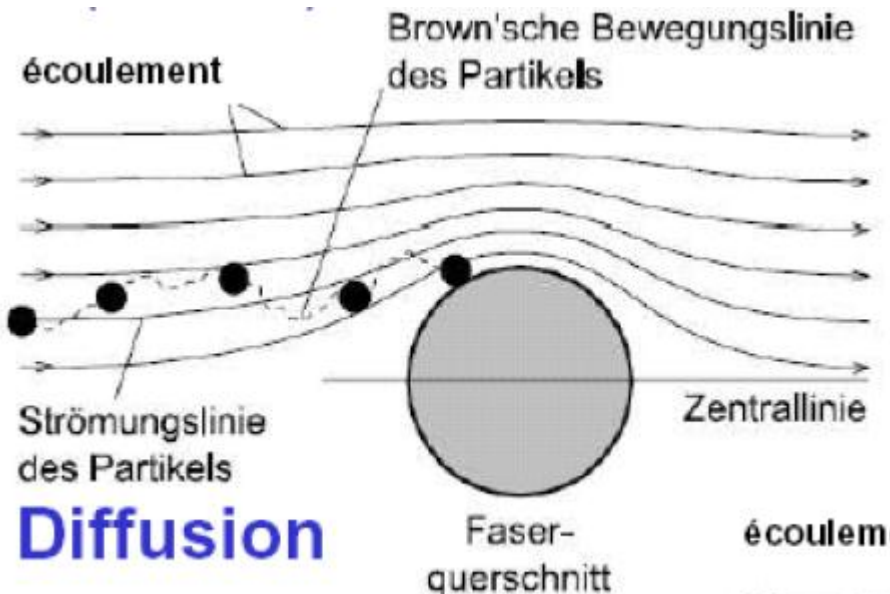
- **High filter efficiency 97 %:**
  highest space velocity,
  highest temperature,
  clean,loaded,regenerated and during regeneration
  new and aged,
  all particle sizes 20-500 nm
- **No secondary emissions**
- **Durability of filter quality**
- **Regeneration of the filter**

Measurement must be by Number and Size

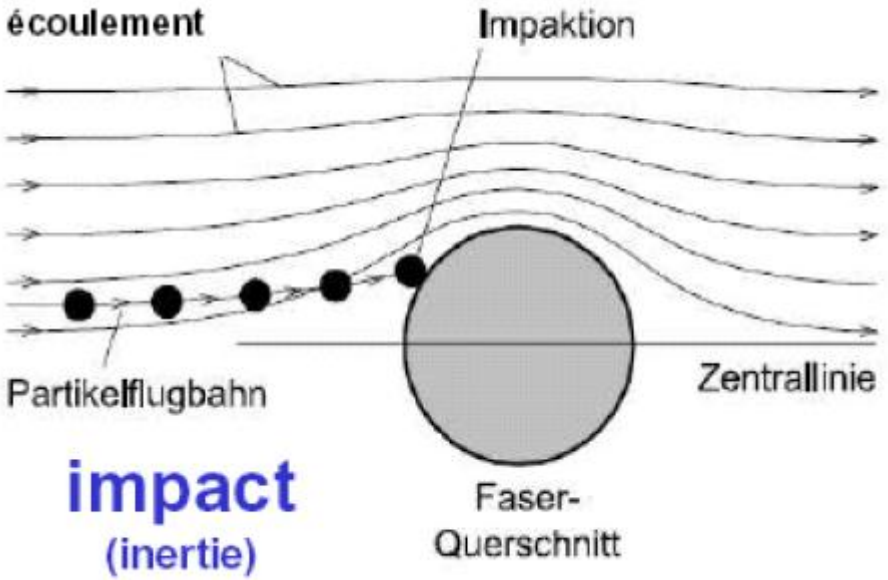
to show that Filtration Effectiveness is > 99 %



Filtration Mechanisms

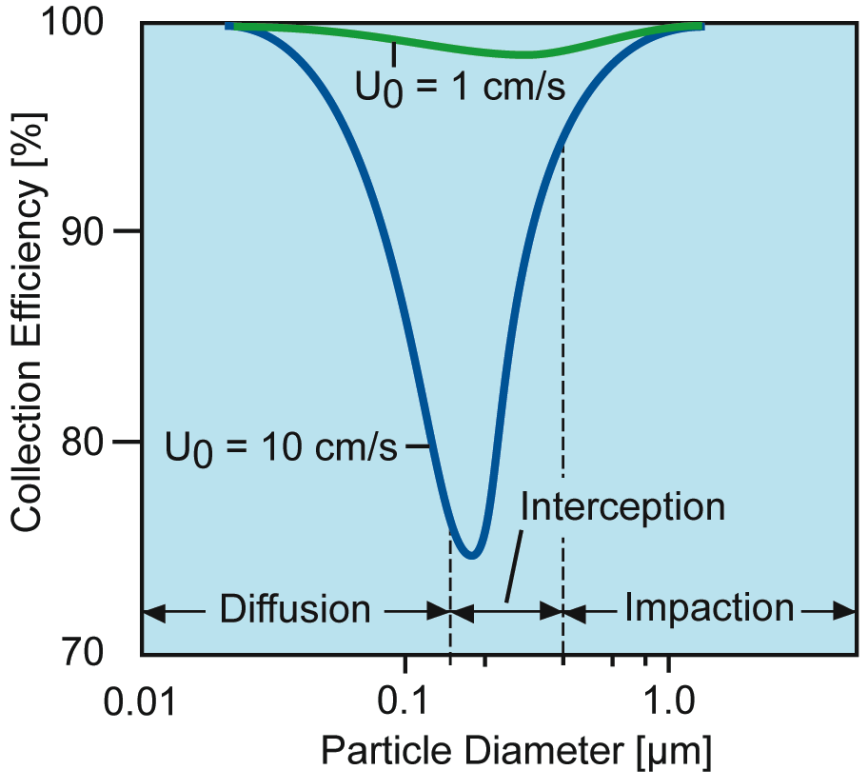


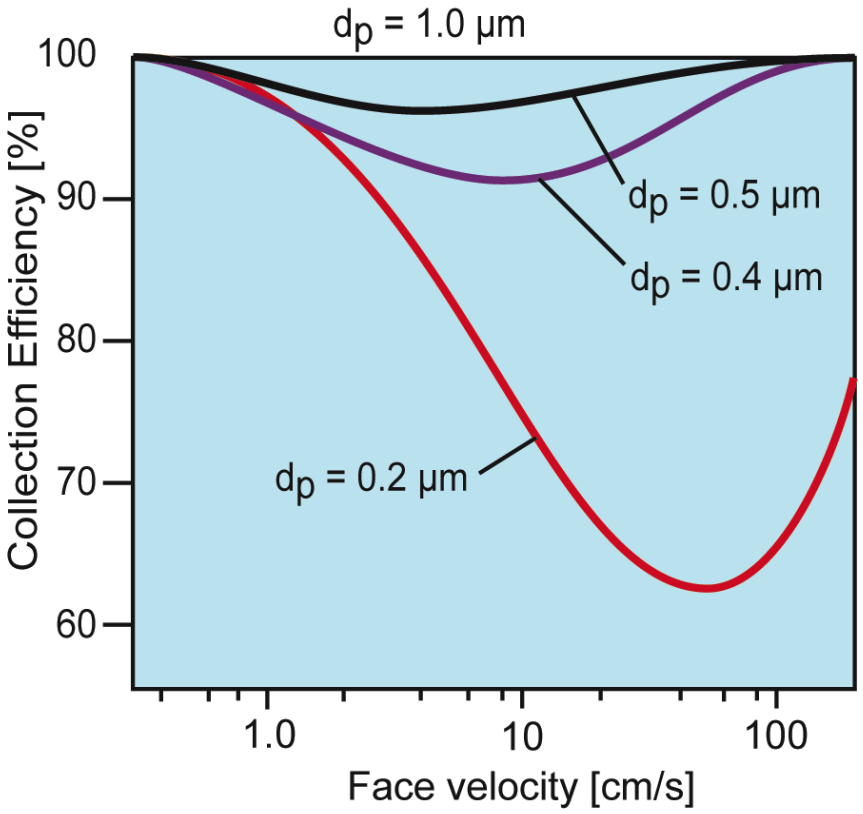
Diffusion

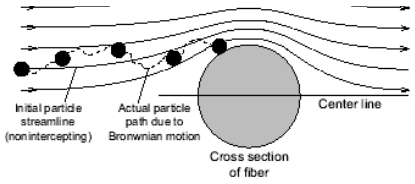


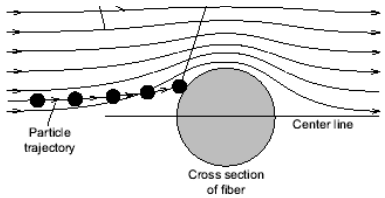
impact
(inertie)

Filtration Risk in the Middle Size Range

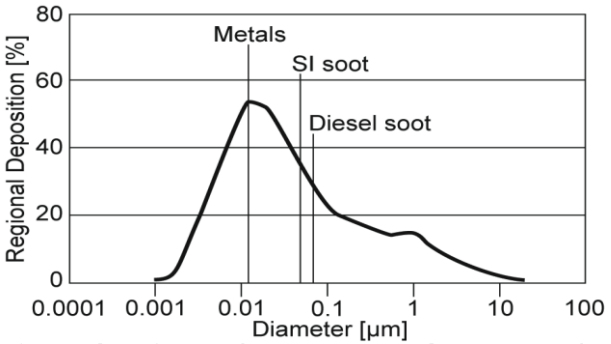


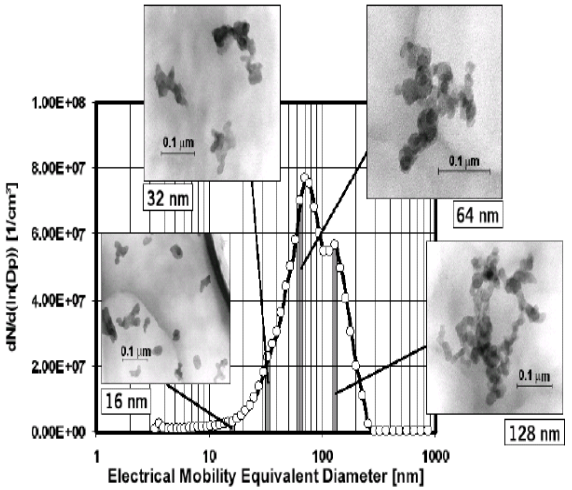




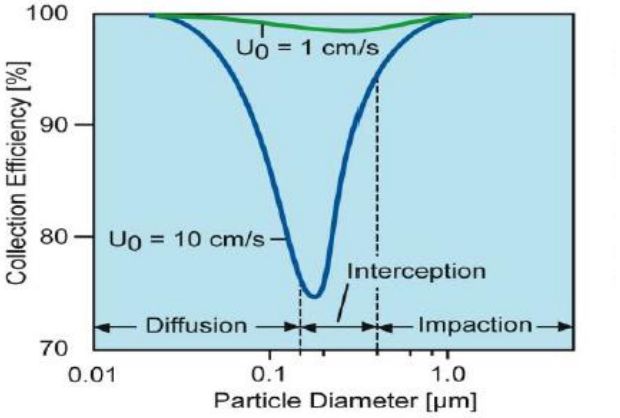


The most sensitive size range of the Lungs is the most intensive emission range of the Engines and the weakest size range of Filtration





The Lung is an open door for engine emitted ultrafine particles in this size range



Particle Emission of ICE

Diesel

Sootpeak: 80 nm; 10^6

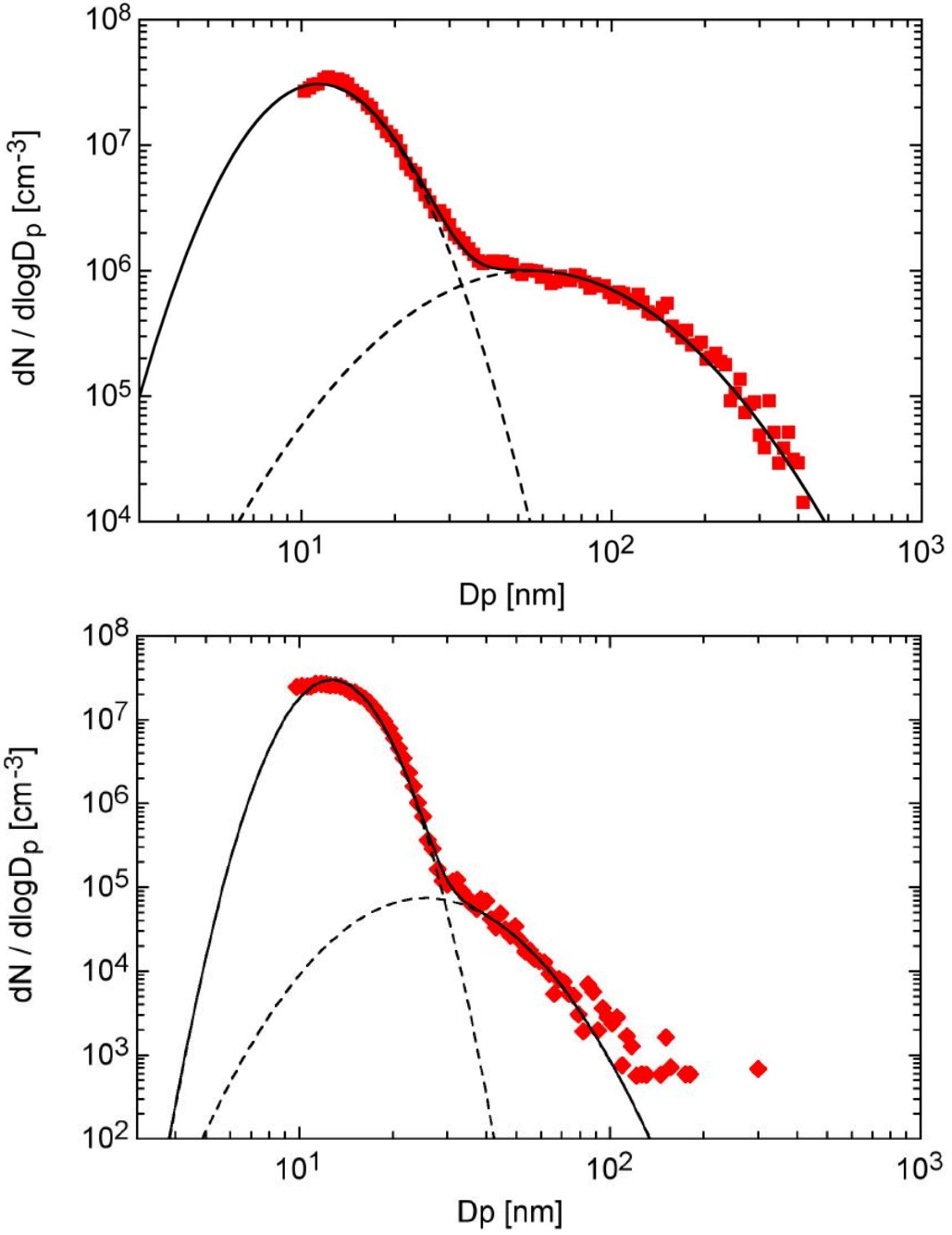
Ashpeak: 10 nm; 10^7

Petrol

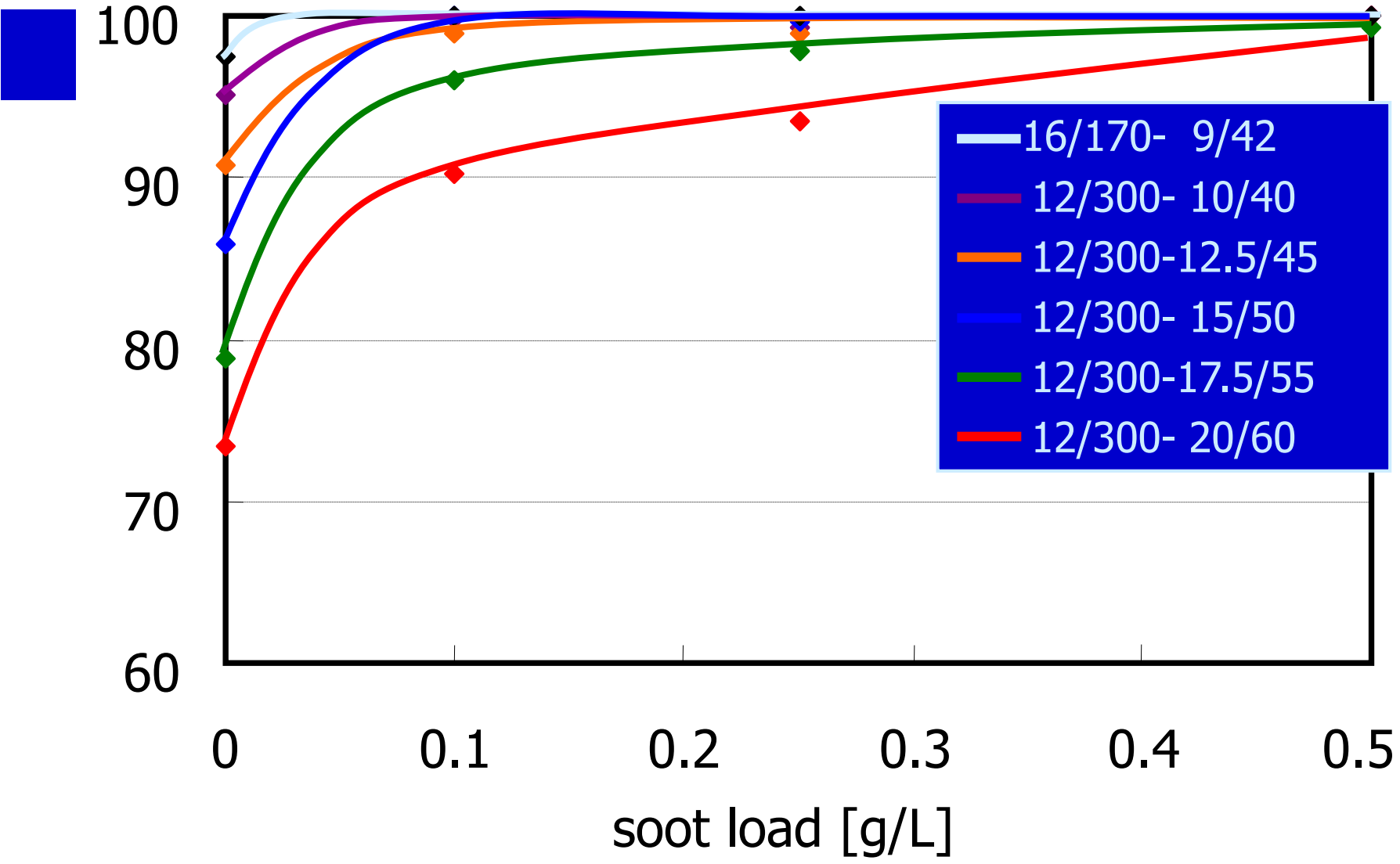
Sootpeak: 40 nm; 10^5

Ashpeak: 10 nm; 10^7

Soot and Ash Peaks



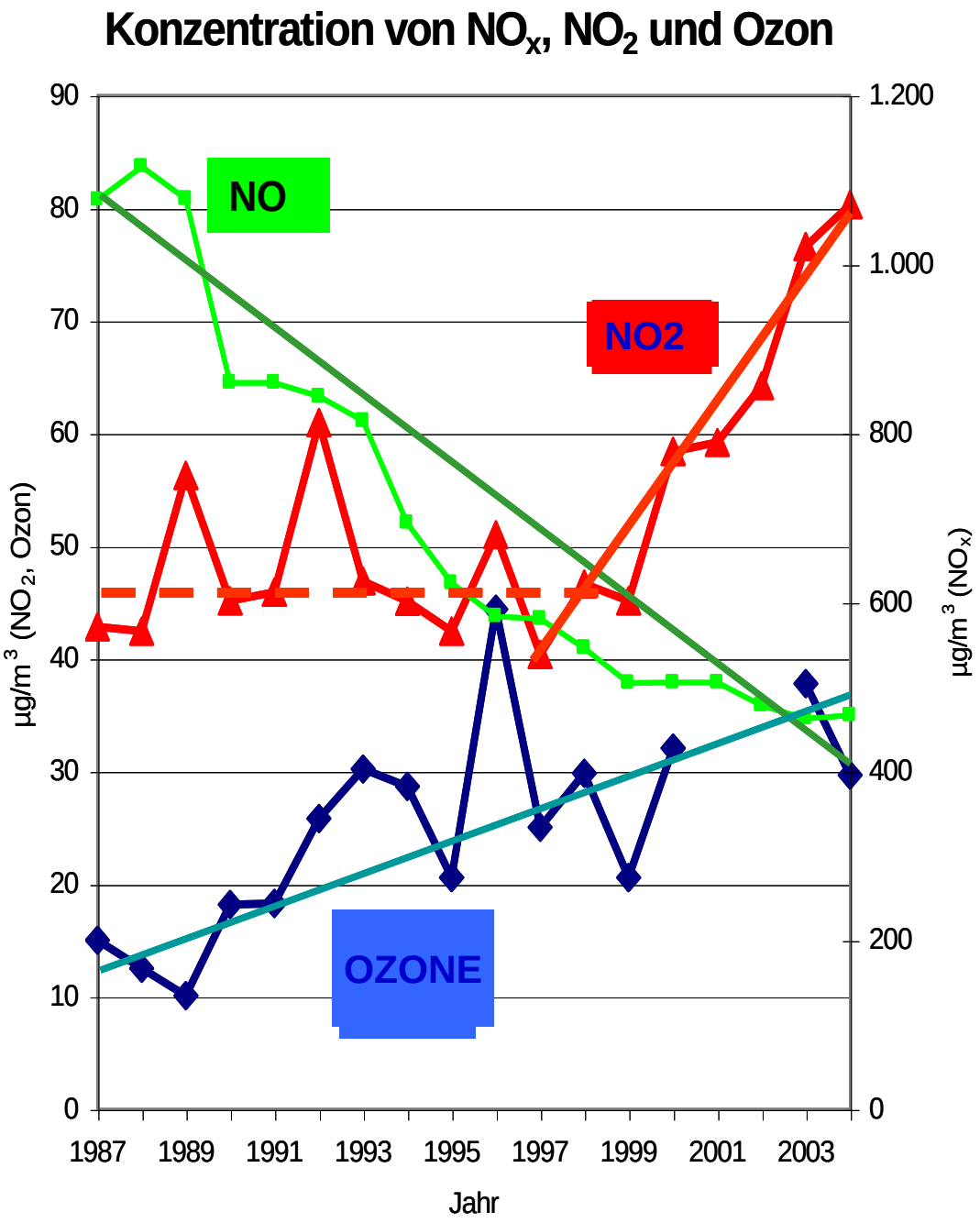
Filtration [%] = f (Time, Soot-Loading)



Secondary Emissions

Toxics generated in the Filter/Catalyst system

- VERT approved DPF systems do not release secondary emissions in relevant amounts, e.g.
- NO_2, Dioxins/Furans, PAH, Nitro-PAH etc.
- Sulfuric acid aerosols
- Metal oxide (Ash) particles, mineral fibers etc.



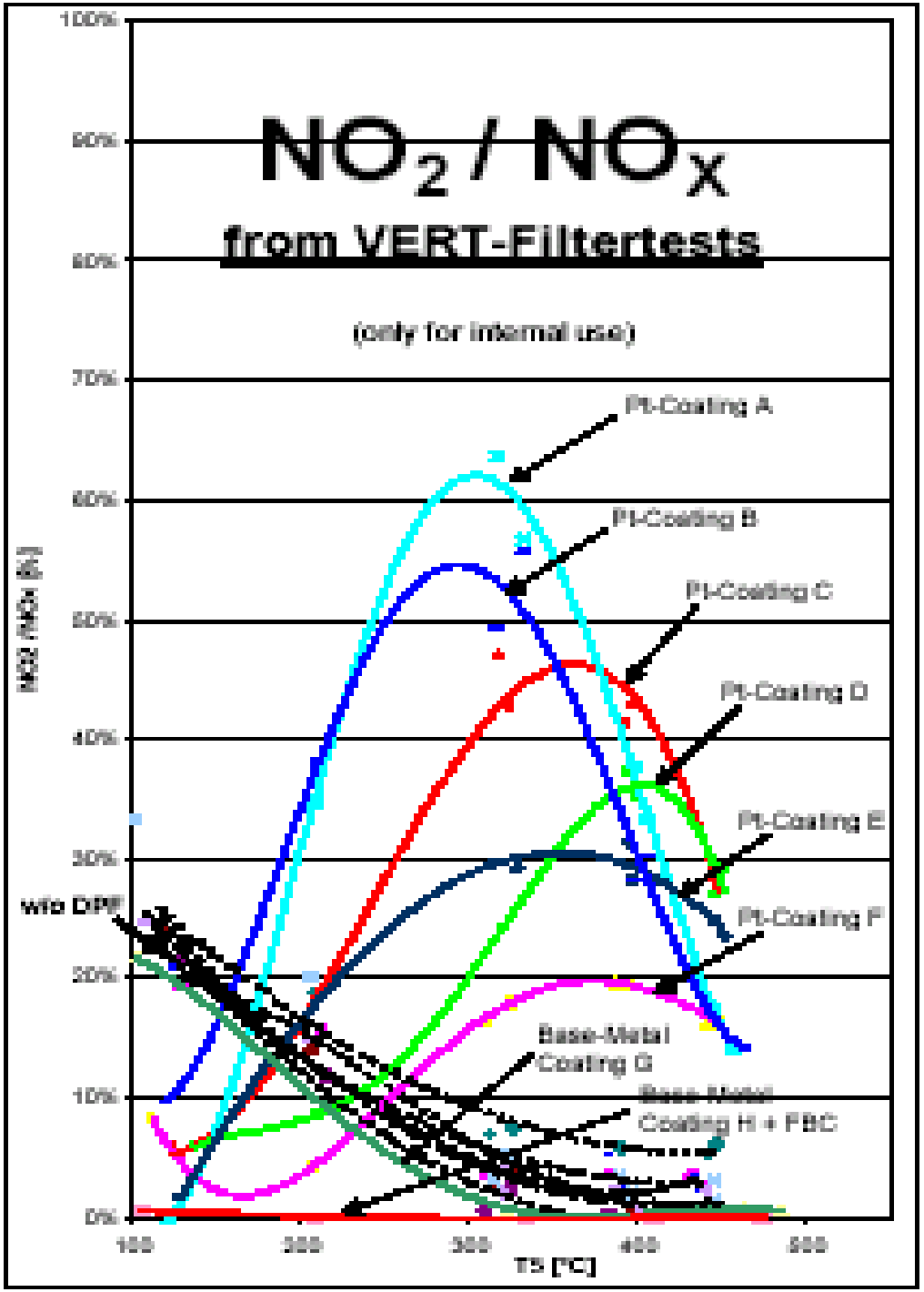
Monitoring a German Highway

1987-2004

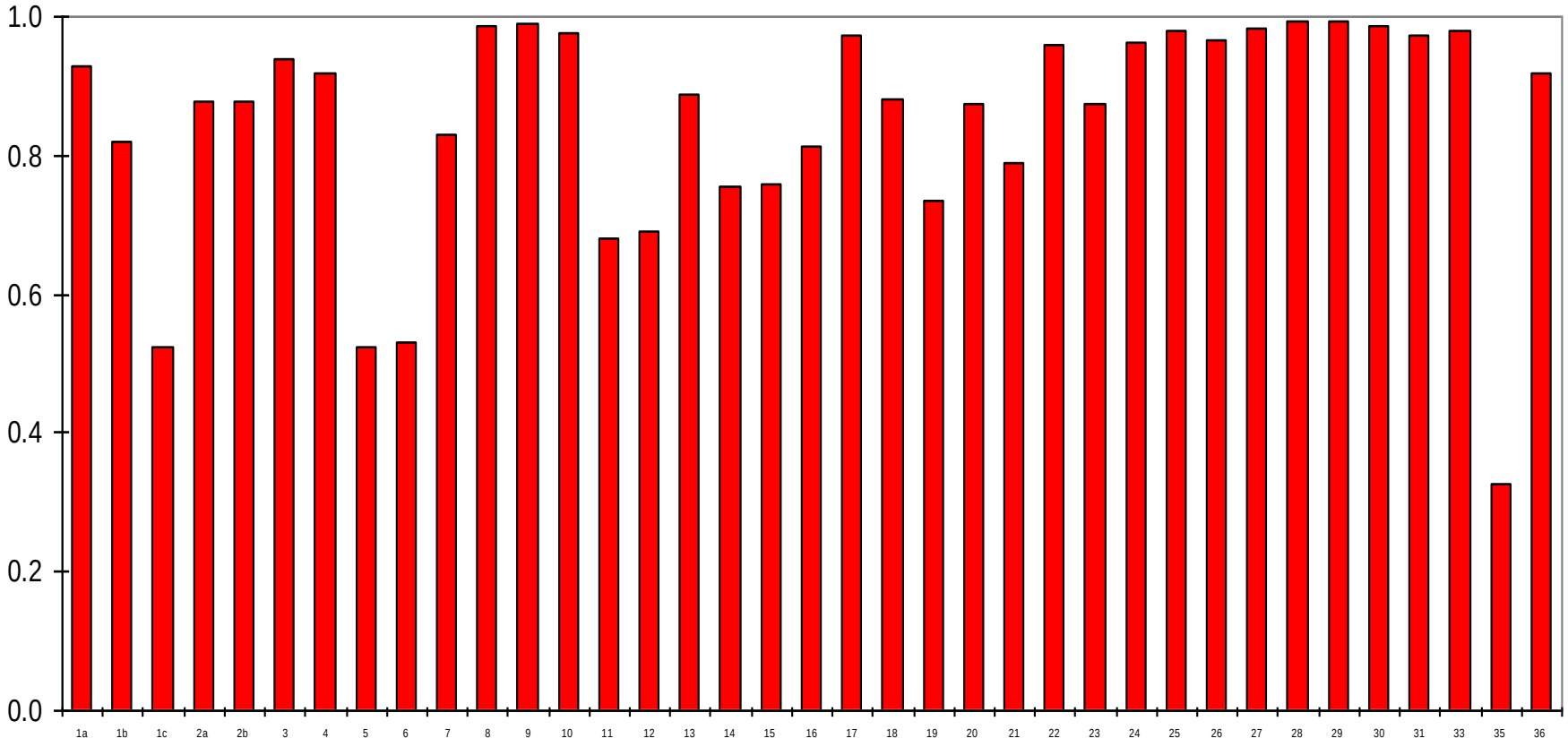
Source: UBA, Umwelt Bundesamt

NO→NO_2 Conversion due to PMG Catalysis

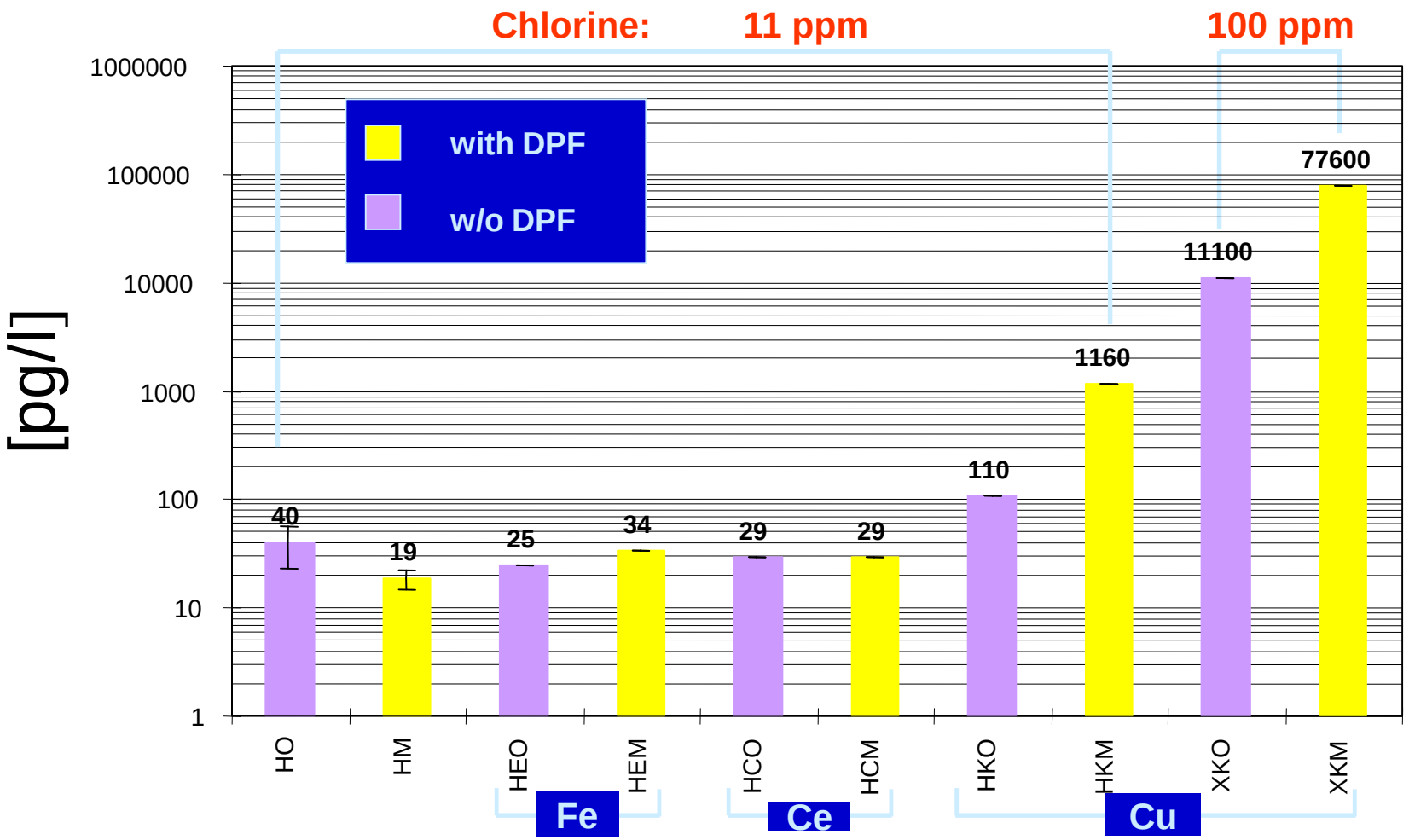
but non-PMG-catalysts and FBC can avoid this



PAH Emission Reduction for many VERT-certifications



Formation of Dioxins in a Filter System using Cu-FBC



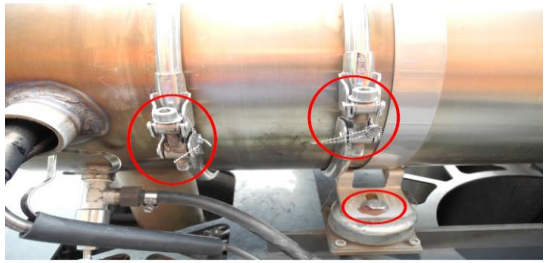
Durability Test (Field test) 2000 hrs

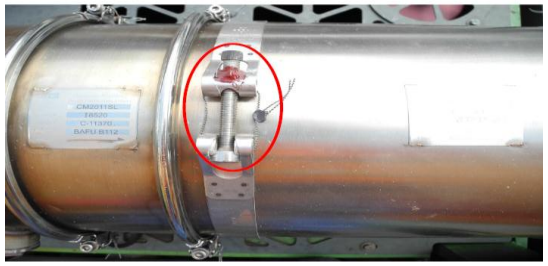
VERT approved DPF systems must undergo a field test of **at least 2000 operating hours**

Do be done in a typical application of the specific DPF system (i.e. stationary or mobile application resp.)

With periodic tests of filter performance, back pressure, regeneration, control and alert systems, mechanical construction etc.

Followed by a full filter test on bench VFT3 **no aging or deterioration permitted**



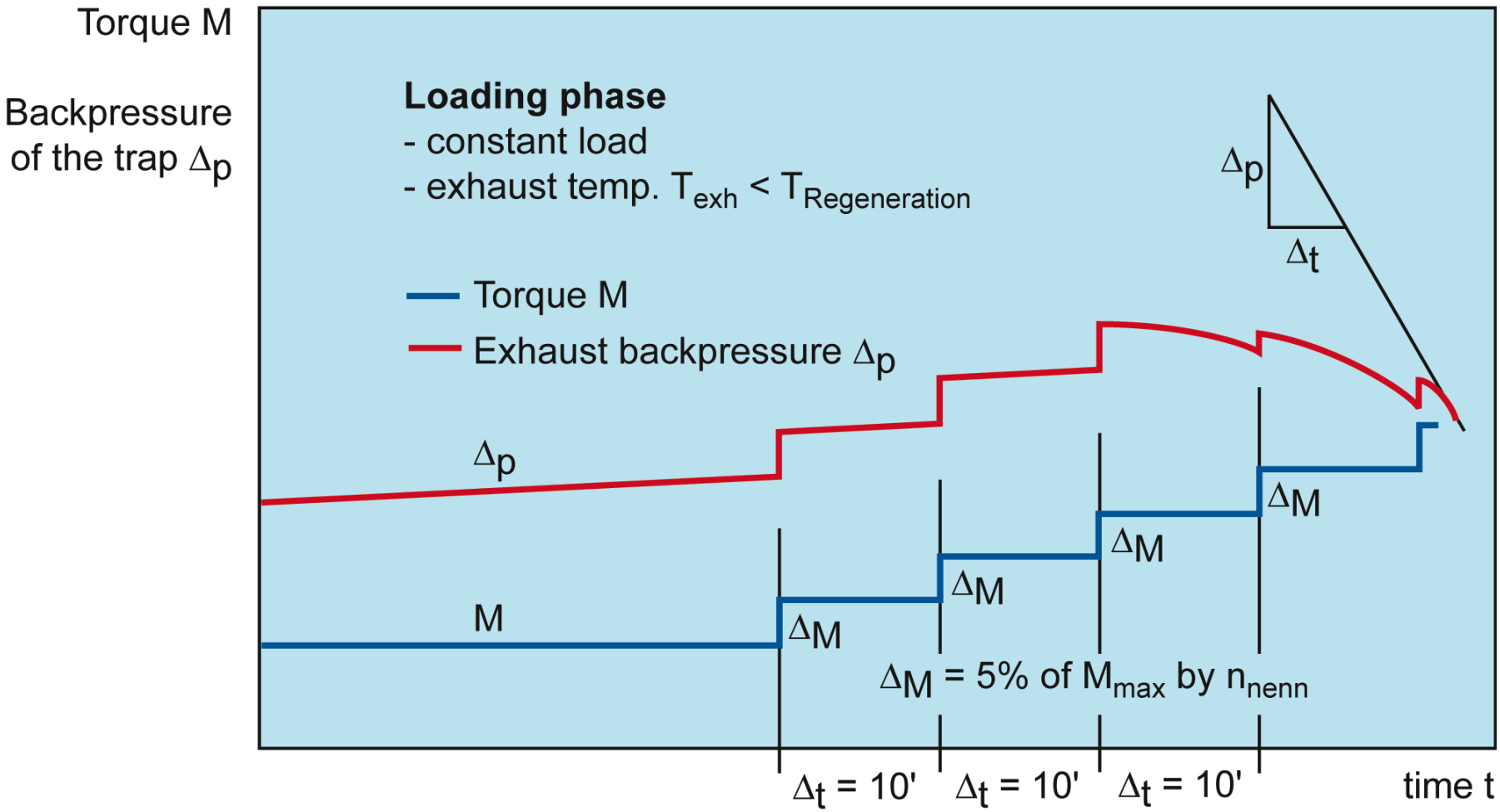


Filter Regeneration

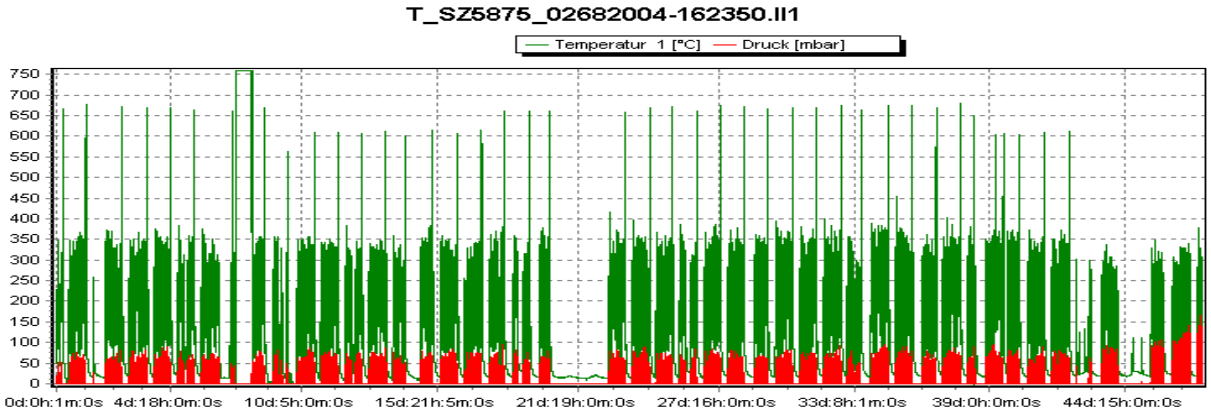
- During filter operation, the filter fills with filtered soot which must be removed
- Soot is carbon, i.e. can be burnt in the filter
- This so called „regeneration" of the filter is very important for a good functioning
- Filter regeneration is carefully tested in the VERT filter test
- Emission during Regeneration is measured online and limited

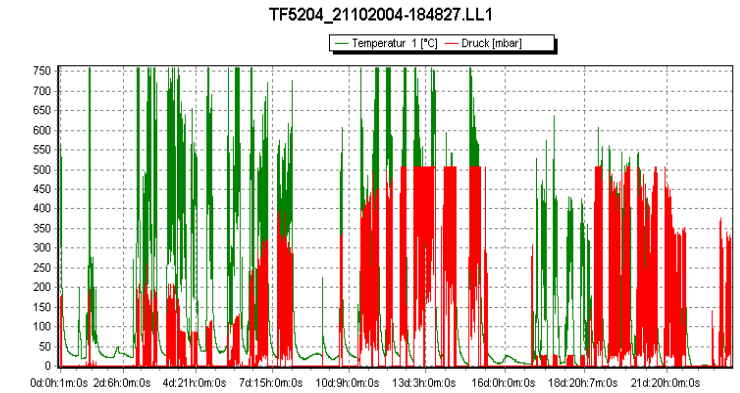
Regeneration Test

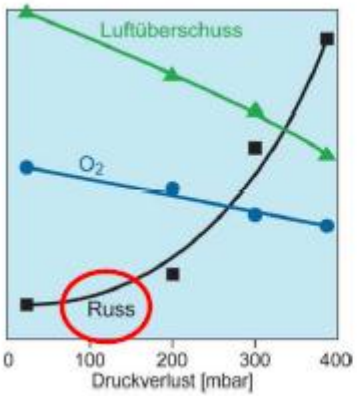
Find Balance Point and Regeneration Gradient

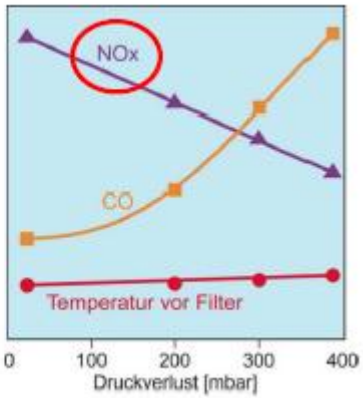


Electronic Control of the Filter-System must be certified also



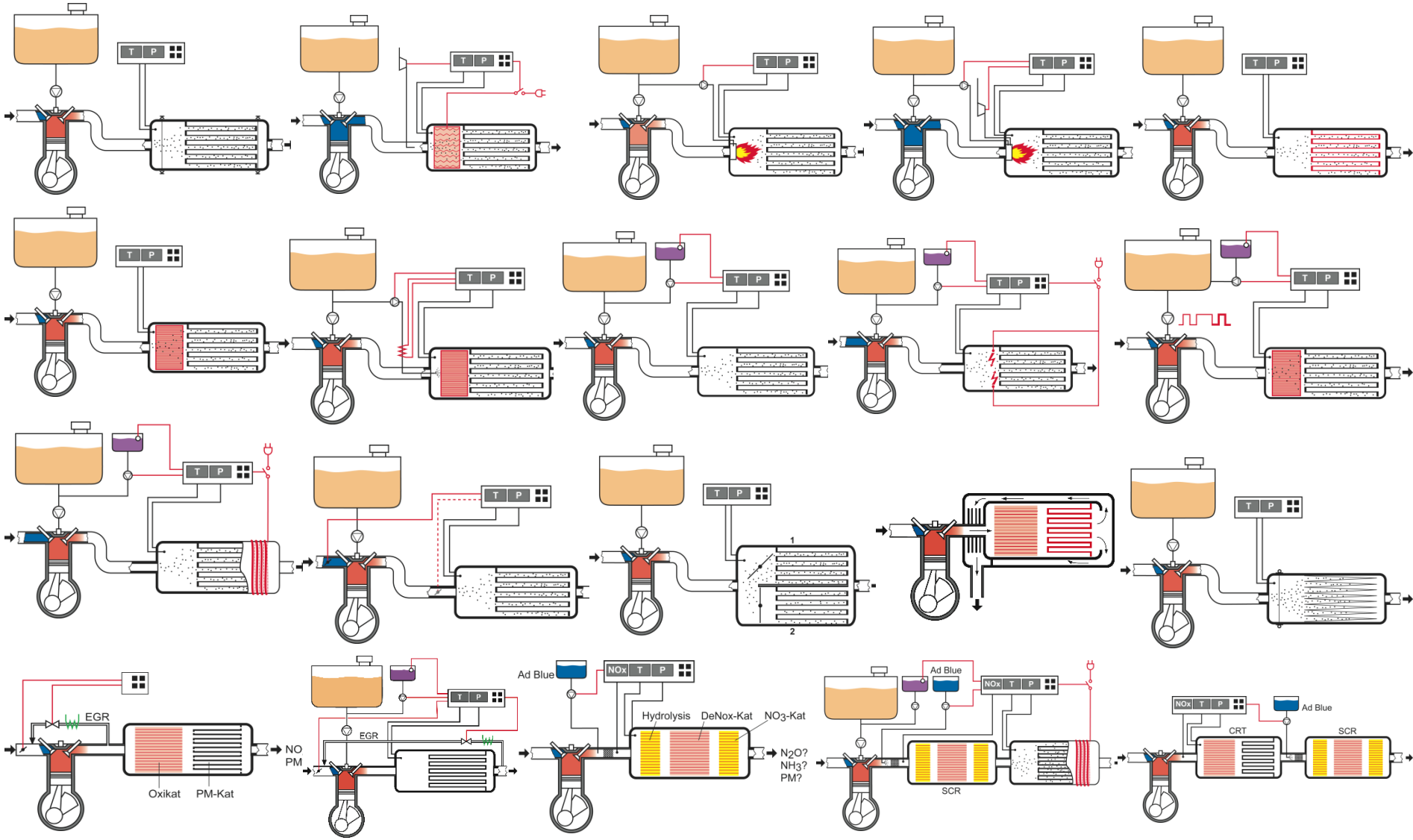






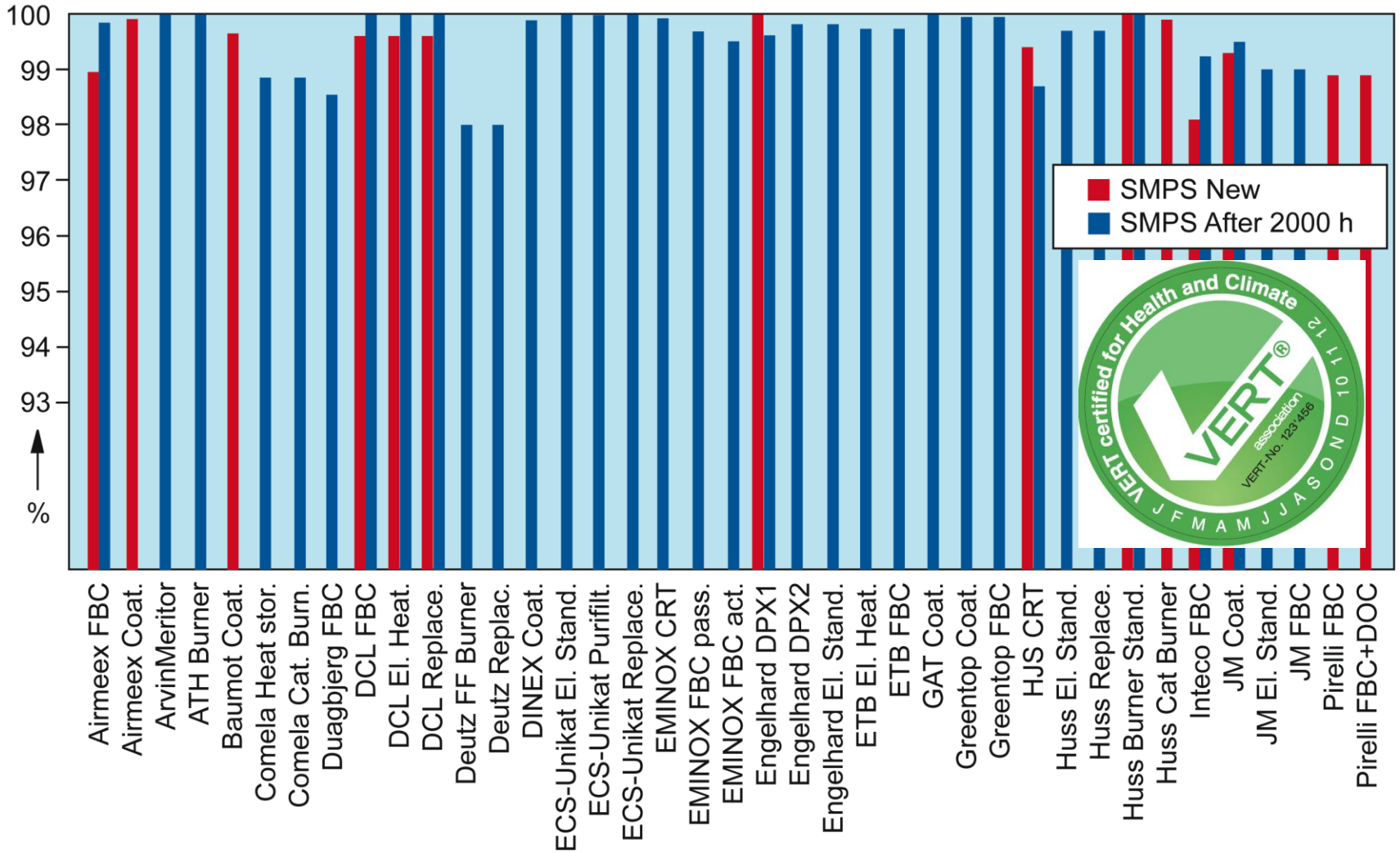
VERT–certified DPF Systems

for different targets and applications



Filtration - 65 DPF VERT-tested

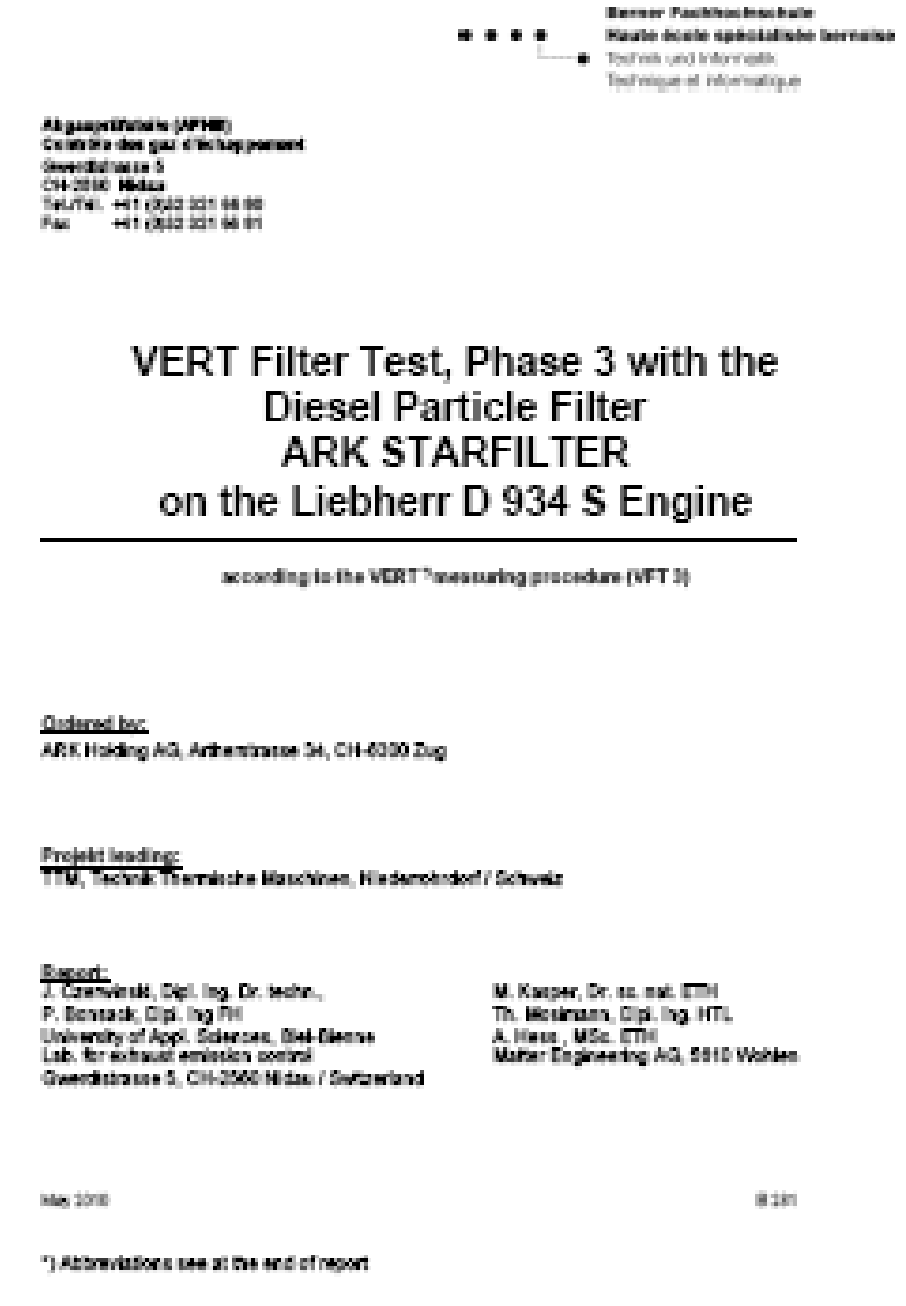
average 98.4 %; 25 % > 99.8 %



VERT– Reports for DPF Systems

are confidential

By now 443 reports



Berner Fachhochschule
Haute école spécialisée bernoise
Technik und Informatik
Technique et informatique

Abgasprüfstelle (APHB)
Centre de gaz d'échappement
Quellgasse 21
CH-2501 Biel
Tel./Tél. +41 (0)32 321 66 66
Fax +41 (0)32 321 66 61

VERT Filter Test, Phase 3 with the
Diesel Particle Filter
ARK STARFILTER
on the Liebherr D 934 S Engine

according to the VERT*) measuring procedure (VFT 3)

Ordered by:
ARK Holding AG, Artherstrasse 34, CH-6330 Zug

Project leading:
TTM, Technik Thermische Maschinen, Hindelbankdorf / Schweiz

Report:
J. Czerwinski, Dipl. Ing. Dr. techn.,
P. Bonsack, Dipl. Ing FH
University of Appl. Sciences, Biel-Bienne
Lab. for exhaust emission control
Quellgasse 21, CH-2501 Biel / Switzerland

M. Kasper, Dr. sc. nat. ETH
Th. Mosimann, Dipl. Ing. HTL
A. Hess , MSc. ETH
Müller Engineering AG, 5610 Wohlen

May 2008 B 281

*) Abbreviations see at the end of report

VERT
Filter List

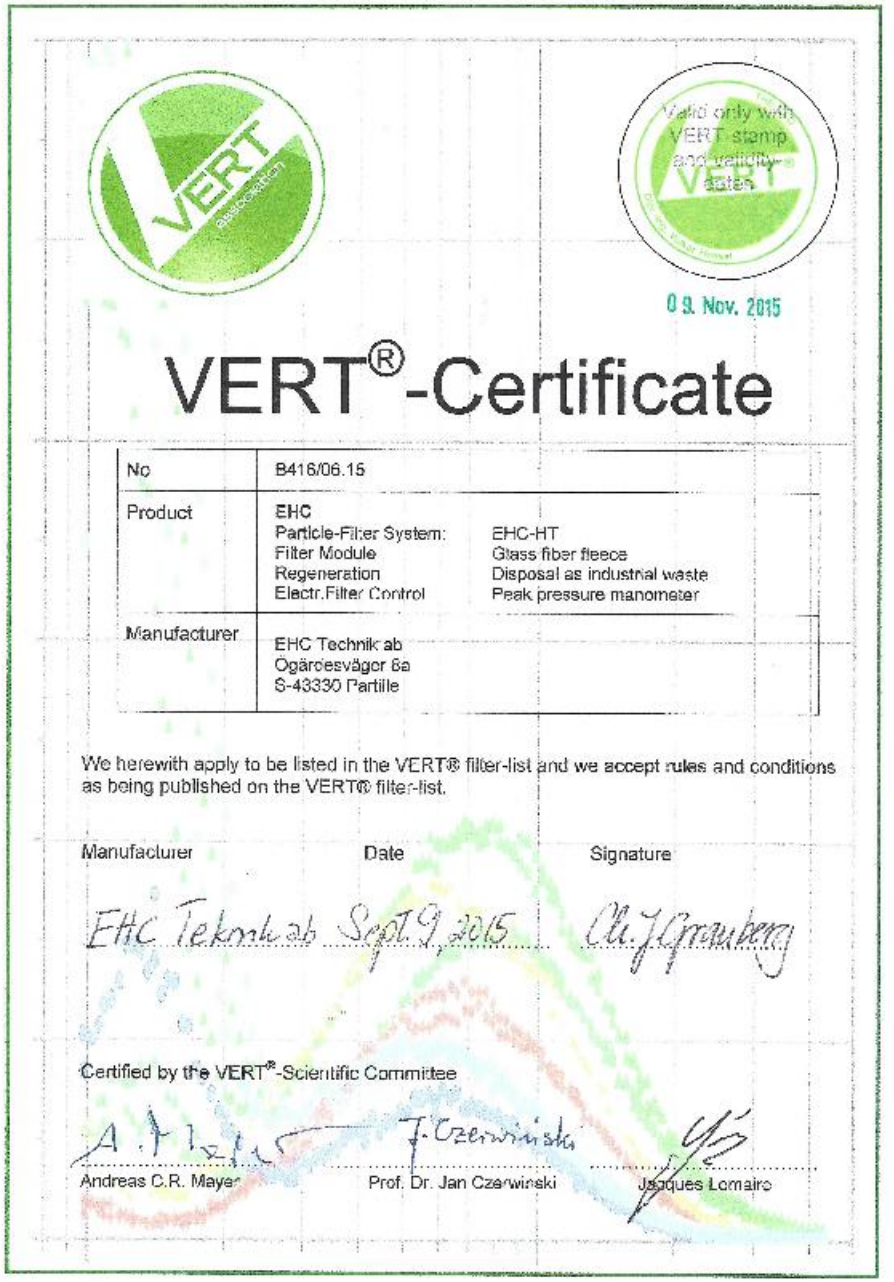
65 Certifications
First Publication 1998
Published on VERT-homepage
www.VERT-certified.eu
Updated whenever modified
Responsible:
VERT-Scientific Committee
Language: English only

VERT is recognized worldwide by

- BAFU, SUVA, ASTRA, BAV - Switzerland
- AUVA, Wien, Tirol - Austria
- BG Bau, UBA, TRGS 554 –Germany
- CARB, MSHA, NY City – USA
- VROM – Netherlands
- Alto Adige – Italy
- Santiago de Chile
- Columbia-Bogotá
- DEEP – Canada
- London LEZ – UK
- Denmark LEZ
- Tehran – IRAN
- Australia
- Mexico
- China

VERT-Certificate

1. VERT-testing successfully completed
2. Application per System duly signed - directed to VERT coordination office
3. Examination by VERT Scientific Committee - ananimity required
4. Stamp “Valid” VERT-CEO
5. Filter listed
6. Certificate to manufacturer



09. Nov. 2015

VERT®-Certificate

No	B416/06.15	
Product	EHC Particle-Filter System: Filter Module Regeneration Electr.Filter Control	 EHC-HT Glass fiber fleece Disposal as industrial waste Peak pressure manometer
Manufacturer	EHC Technik ab Ögärdesväger 8a S-43330 Partille	

We herewith apply to be listed in the VERT® filter-list and we accept rules and conditions as being published on the VERT® filter-list.

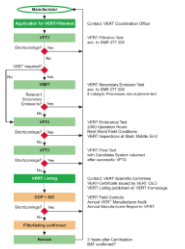
Manufacturer: EHC Teknik ab — Date: Sept 9, 2015 — Signature: Ch. J. Gruneberg

Certified by the VERT®-Scientific Committee

Andreas C.R. Mayer — Prof. Dr. Jan Czerwinski — Jacques Lemaire

Step 2 VERT® Acceptance Test

VERT Certification



VERT® Filter List

VERT certified ® Particle Filter Systems for Combustion Engines

October 2010

Public Awareess

After each Installation
Acceptance Test
required by EJPD regulation 8/1990

VERT® Acceptance Test Report for PFS

Particle filter	
Manufacturer (Brand)	
Number	
Type	
Identification (e.g. part number)	
Conformity number (VFT3 test number)	VERT Certification Numb B316/09.11
Serial number	
Fitting Date	
Data logger	
Type	
Additive dosage system	
Type	
Vehicle / Machine	
Category (construction machine, bus, car ..)	
Manufacturer	
Type	
Manufacturing year	
Chassis number	
Engine	
Manufacturer	
Type	
Manufacturing year	
Rated power [kW]	
Operating hours or km driven till PFS fitting	
Measurements without PFS	
Opacity K-value [1/m] during free acceleration	
Noise [dBA] in near-field 45°/0.5 m At engine RPM [1/min]	
Measurements with PFS	
Opacity K-Value [1/m] during free acceleration	
Noise [dBA] in near-field 45°/0.5 m At engine RPM [1/min]	
Filter back-pressure [mbar] At RPM [1/min] and load [%]	
Opacimeter	
Manufacturer	
Type	
Sound Level Meter	
Manufacturer	
Type	
Test-Date and Responsibilities	
Test date	
Test center	
VERT® label running number	VERT® Label Induviduel running number 22'351
Retrofitter stamp Date/ Signature of the PFS retrofitter	
Operator stamp Date/ Signature of the operator	Customer Data remain confidential → not on database

- Th… …ains the original.
- To update the PFS retrofit in the vehicle registration, a copy of this form should be submitted with the original vehicle registration certificate to the pertinent vehicle licensing authority.
- For registration in the VERT database, submit this document to TTM jim.a.mayer@bluewin.ch or fax +41 56 496 64 15

VERT-Certification Number

VERT-member Self Commitments

Filter Individual Running Number

Copy must go to VERT-Coordination Office

VERT

AcceptanceTest

Identical to BAFU/ASTRA (see Technische Anleitung except for the Individual VERT-Number to use with each retrofit, and send to VERT-coordination office for databank input

Customer Data remain confidential

VERT® Acceptance Test Report for PFS

Particle filter	
Manufacturer (Brand)	
Number	
Type	
Identification (e.g. part number)	
Conformity number (VFT3 test number)	
Serial number	
Fitting Date	
Data logger	
Type	
Additive dosage system	
Type	
Vehicle / Machine	
Category (construction machine, bus, car ..)	
Manufacturer	
Type	
Manufacturing year	
Chassis number	
Engine	
Manufacturer	
Type	
Manufacturing year	
Rated power [kW]	
Operating hours or km driven till PFS fitting	
Measurements without PFS	
Opacity K-value [1/m] during free acceleration	
Noise [dBA] in near-field 45°/0.5 m At engine RPM [1/min]	
Measurements with PFS	
Opacity K-Value [1/m] during free acceleration	
Noise [dBA] in near-field 45°/0.5 m [illegible] RPM [1/min]	
Filter [illegible]ssure [mbar] At RPM [1/min] [illegible]d [%]	
Opacimeter	
Manufacturer	
Type	
Sound Level Meter	
Manufacturer	
Type	
Test-Date and Responsibilities	
Test date	
Test center	
VERT® label running number	
Retrofitter stamp Date/ Signature of the PFS retrofitter	
Operator stamp Date/ Signatur[illegible] operator	

VERT Certification Number B316/09.11

VERT® Label Induviduel running number 22'351

Customer Data remain confidential → not on database

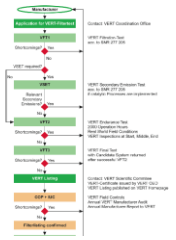
Please note:

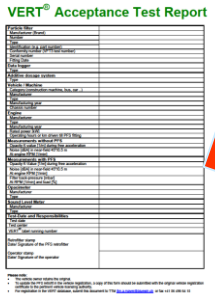
- The vehicle owner retains the original.
- To update the PFS retrofit in the vehicle registration, a copy of this form should be submitted with the original vehicle registration certificate to the pertinent vehicle licensing authority.
- For registration in the VERT database, submit this document to TTM [illegible] or fax +41 56 496 64 15

Road Permit with VERT® Quality

VERT Certification

Installation
Acceptance Test



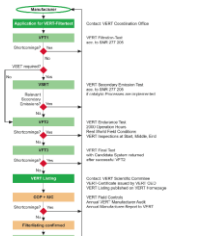


Road Permit by MFK
Official Entry in Vehicle Documents

Step 3: VERT® Label

VERT Certification

Installation
Acceptance Test

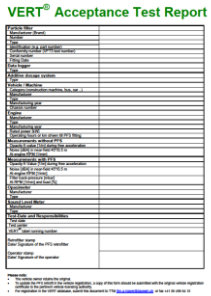


VERT® Filter List

VERT certified ®
Particle Filter Systems
for Combustion Engines

October 2010

Public Awareness



Road Permit

VERT-Label

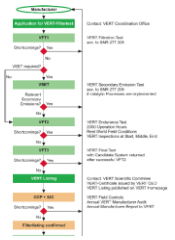
with individual running number
and retrofit date
should be used
in each single VERT Retrofit Case

Step 4: VERT® Data Base

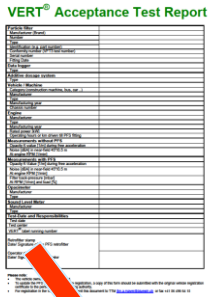
VERT Certification

Installation
Acceptance Test

Data-Base

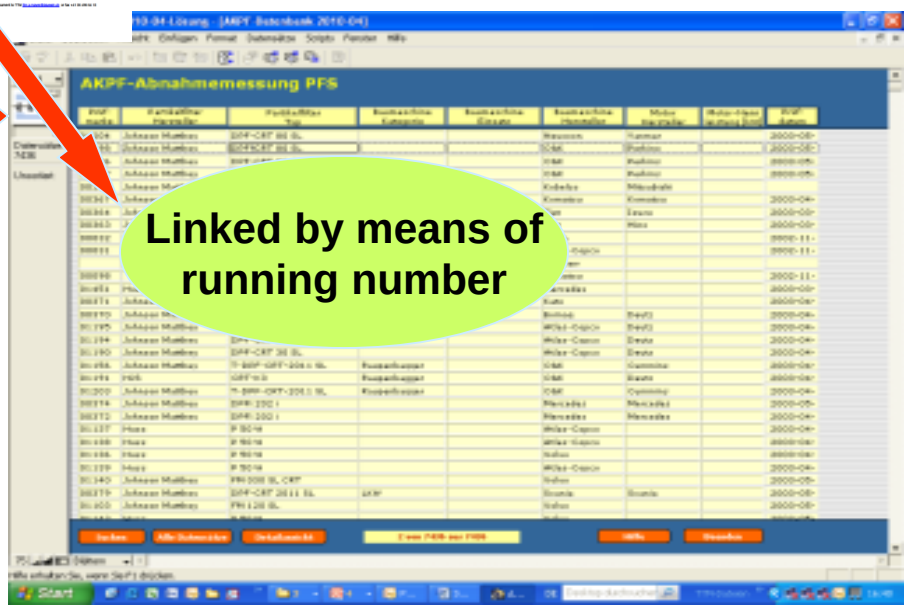


Public Awareness



Road Permit

Public Awareness



Linked by means of running number

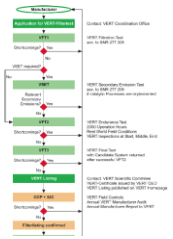
Step 5 VERT® Reporting

VERT Certification

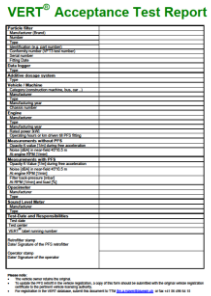
Installation
Acceptance Test

Data-Base

Reporting
Sales –Figueres
Problems & Failures

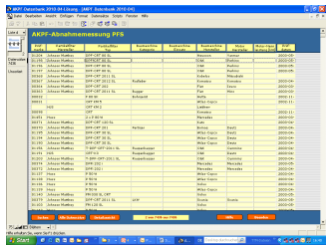


Public Awareness



Road Permit

Public Awareness



Clients Reference

Public Reference

Public Awareness

VERT annual
Overall Sales
Overall Quality

VERT-Homepage
www.VERT-certification.eu

Step 6 VERT® IUC-Review by I&M

In Use Compliance + Review
Inspection and Maintenance

VERT Certification

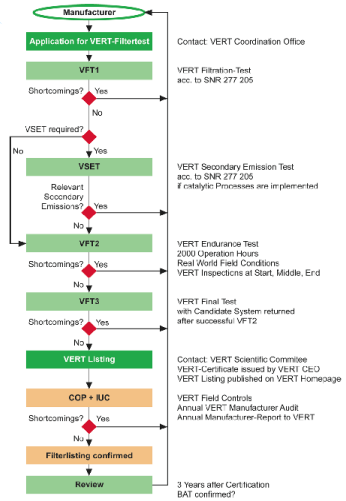
Installation
Acceptance Test

Data-Base

Reporting
Sales –Figueres
Problems & Failures
COP

Confirmation

De-Listing
Re-Verification



To check IUC In Use Compliance
requires measurement in-use
roadside, workshop, inspection
for all emission control functions
Filtration
Catalysis
Backpressure
Noise attenuation etc

Must be fast and at low cost
should immediately recommend
preventive maintenance

New Swiss Regulation for PN-Roadside Measurement Instruments

- Fast, handheld, accurate PN-measurement for
  - Fleet Maintenance and Control
  - Roadside Measurement
  - Official periodic emission check (TÜV)

- Verify filter efficiency after cleaning
- Find small defects to repair
- Establish criteria for filter exchange
- Detect engine malfunctions

New Swiss Ordinance for Field control 2012 defines rules for solid PN counting instruments

Ordinance of the FDJP
on Exhaust Gas Analysers
(VAMV)

Amendment of 22nd august 2012

The Federal Department of Justice and Police
hereby decrees:

B Measurement requirements

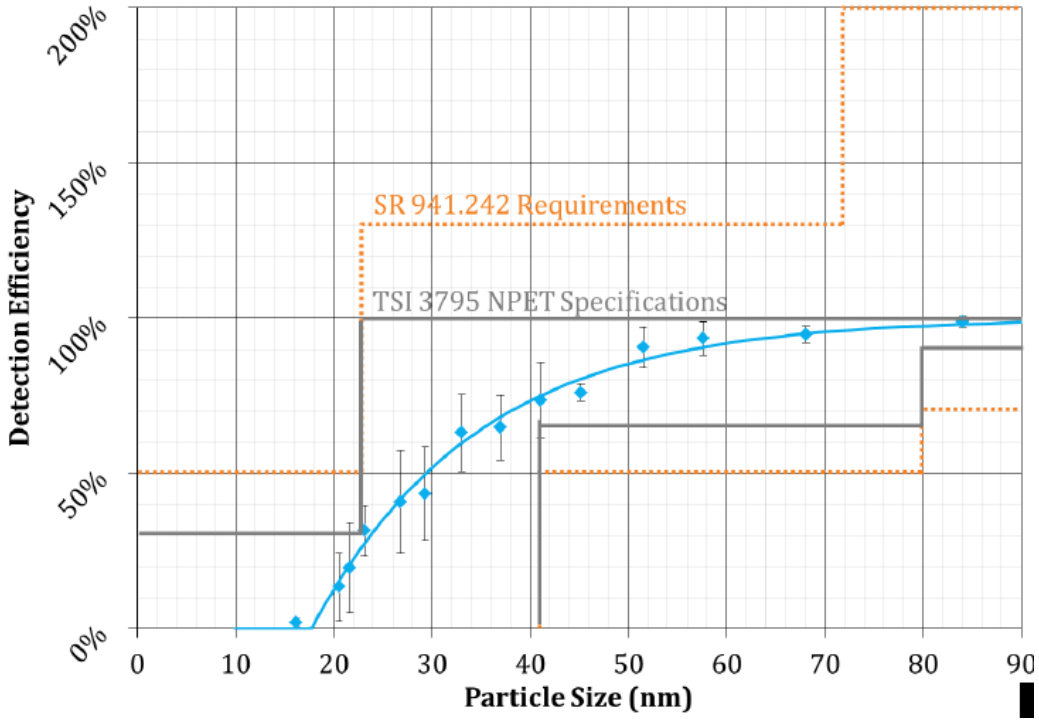
1 Measurement range

1.1 The measurement range for the nanoparticle number concentration is at least between 5 x 10^4 cm^{-3} and 5 x 10^6 cm^{-3}.

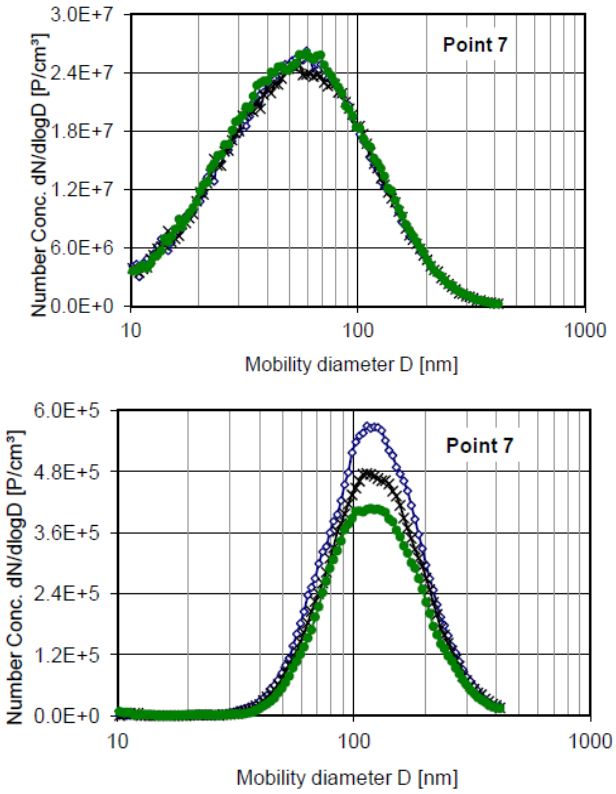
1.2 In case of measured values outside the measurement range, the measuring instrument must indicate whether the measured value lies below or above the measurement range. If no categorisation is possible, then no value should be displayed.

1.3 The particle number concentration of each measurement must be indicated at the ambient conditions.

Requirements of Swiss Ordinance
size cut-off and particle counting efficiency
METAS = Swiss office for measurment



Instrument characteristics acc.to Swiss METAS counting efficiency band

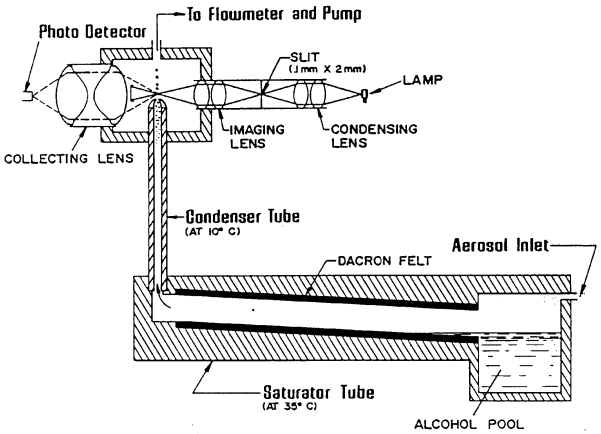


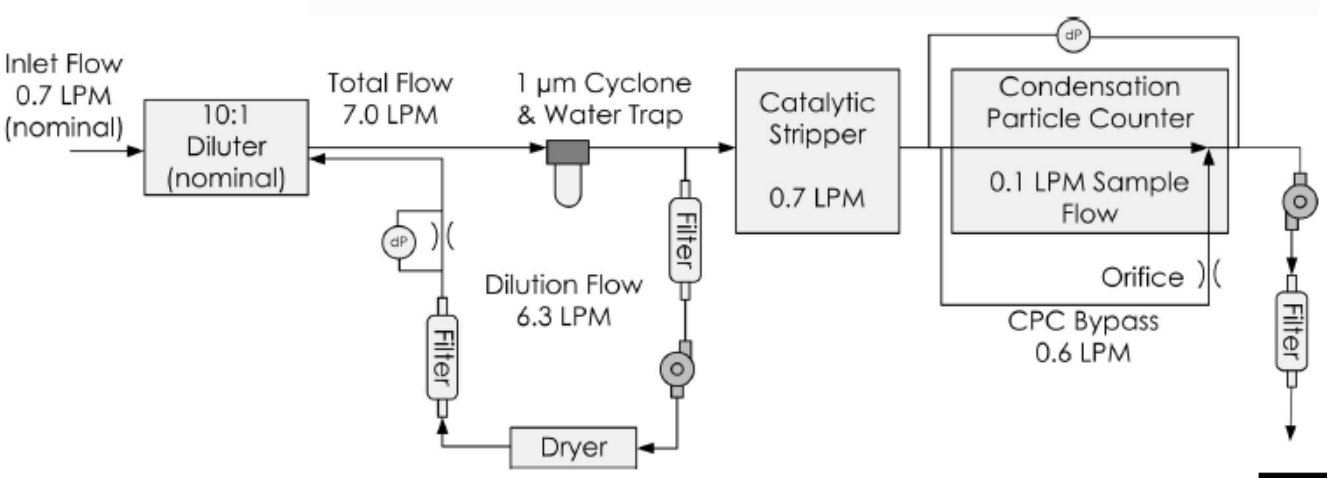
Size distribution without and with filter (VERT-VSET)

Instruments for roadside DPF control

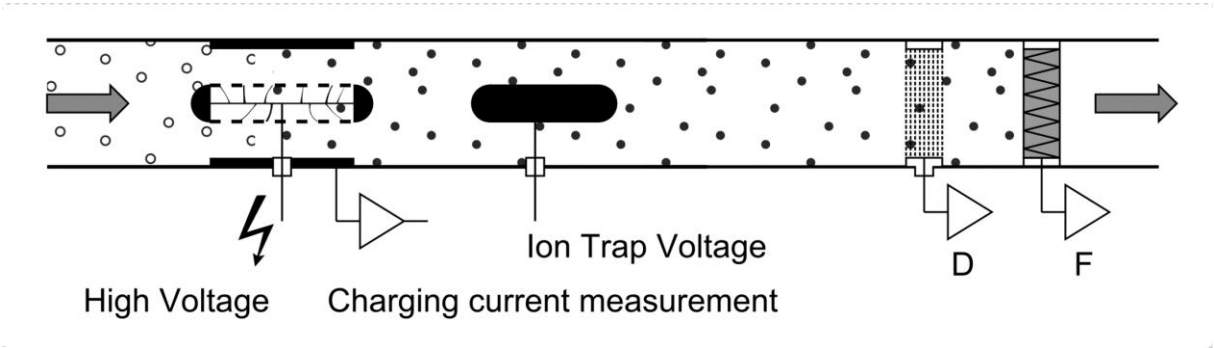
Target of measurement	Availability in the market	Dynamics	Measured parameters	Sensitivity Size range	Cross sensitivity by	Cost
Total Mass Mass in size classes	AVL MSS Impactor Dekati ELPI	no no	Mass EC Mass per size class	1 mg/kWh 0.1 mg/kWh > 60 nm	Volatiles Conden-sation	45’000 $ 60’000 $
Opacity	Many instruments 430 mm light length	yes	K [1/m] prop.mass	30 mg/kWh prop D^5	NO2	8000 $
Total number of particles	CPC TSI-NPET with PMP-VR	1Hz	PN Solid particle numbers	0.01 mg/kWh 10-2500 nm	-	20’000 $
Number and size of particles	Nanomet3 PEPA Testo with PMP-VR	10 Hz	PN number D size S surface M mass calc.	0.1 mg/kWh 10-1000 nm	-	20’000 $
Dispersion of laser light	AVL MAHA	10 Hz	no correlation with number, size, surface or mass	1 mg/kWh ? prop D^6	light	15’000 $?

Condensation Nucleus Counter CNC by TSI NPET

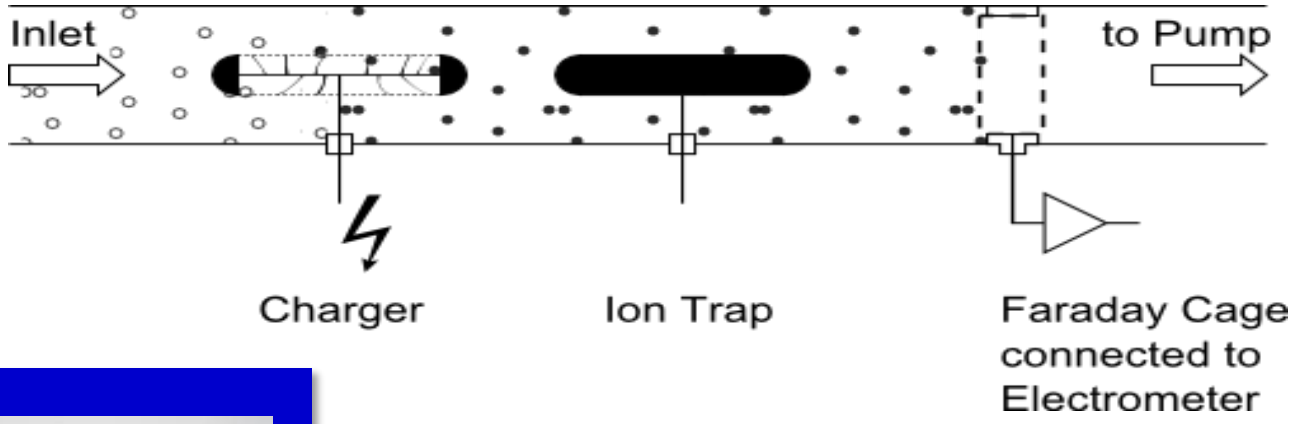




Diffusion Charging by TESTO NanoMet3 and PEPA

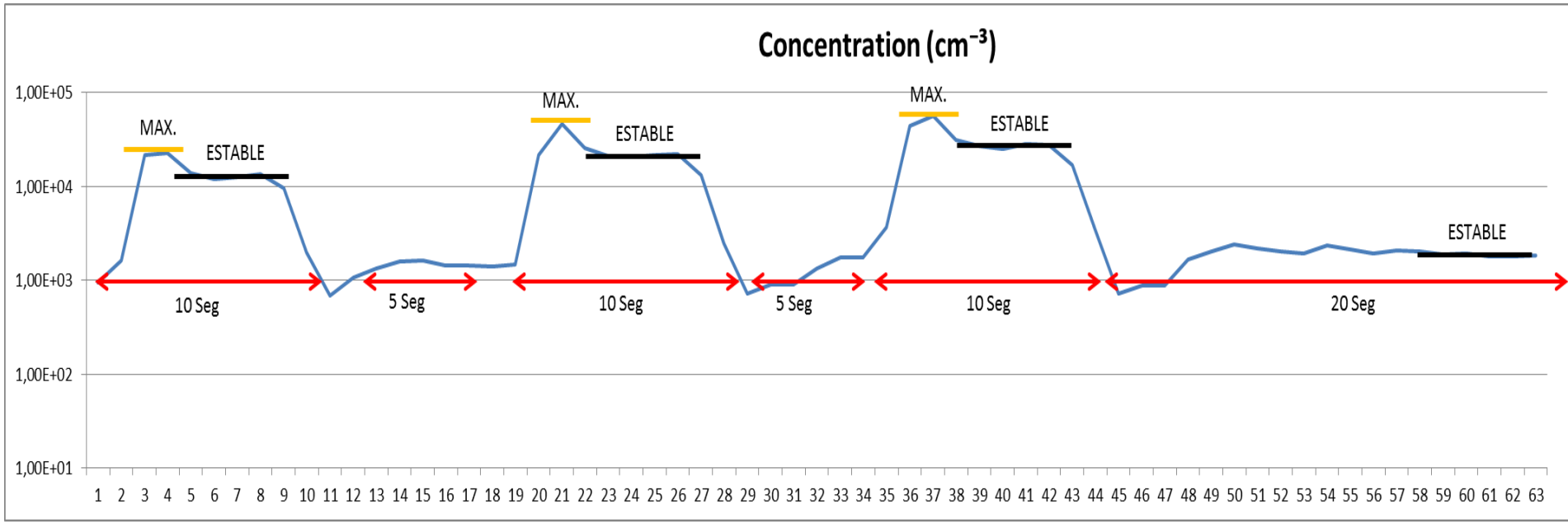


Diffusion Charging by NANEOS PARTECTOR



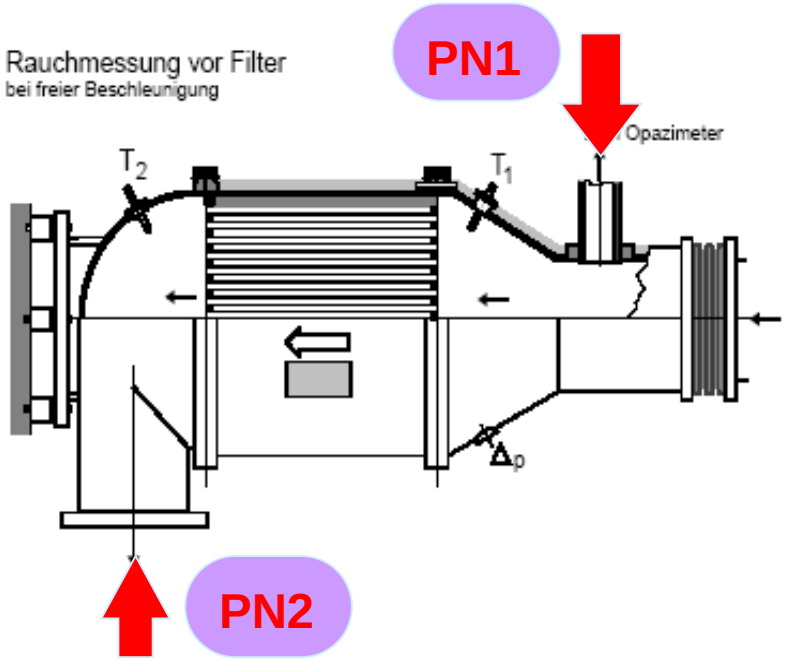
Partector

Measurement Protocol Roadside
Opacity and PN at exhaust exit
during free acceleration, high idle and low idle
all within 1 minute



Measurement PN up-and downstream DPF for filter efficiency and engine status

The filter masks the engine. Measurement upstream and downstream is needed to get information about engine raw emission and filter efficiency

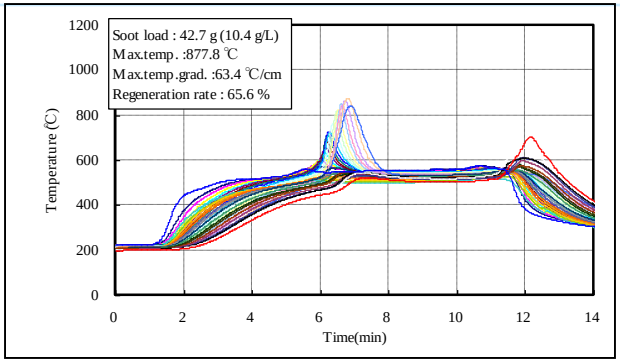
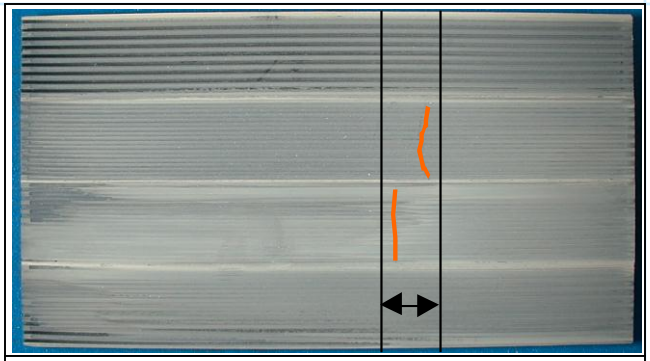
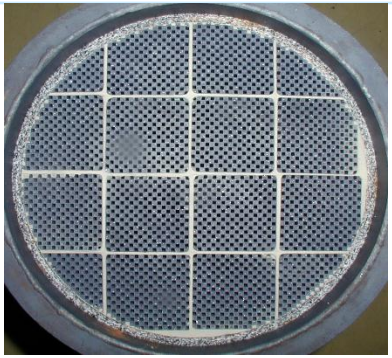
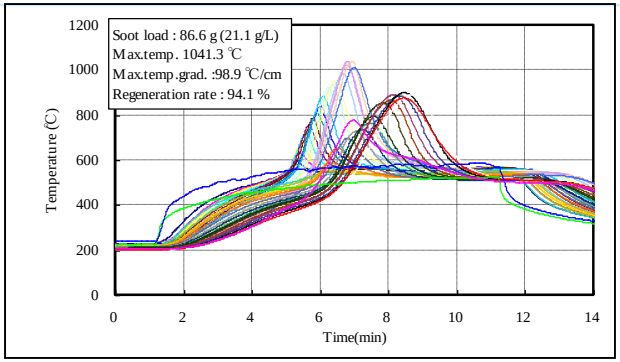
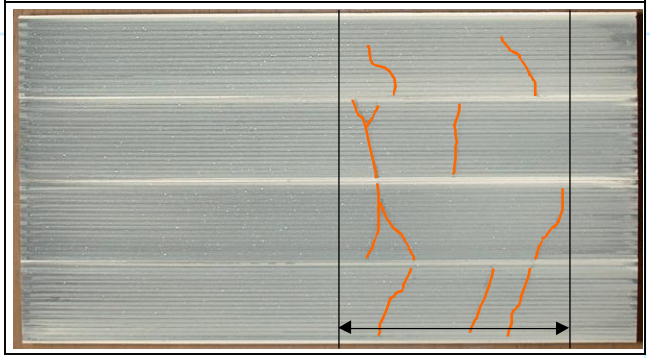
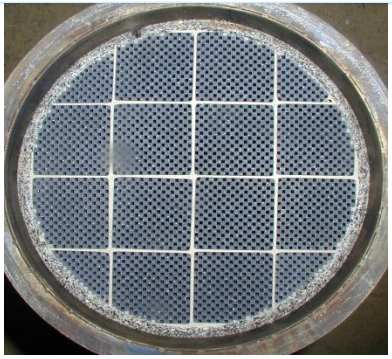
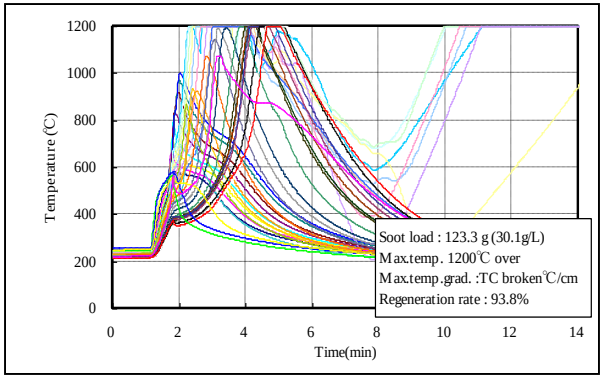
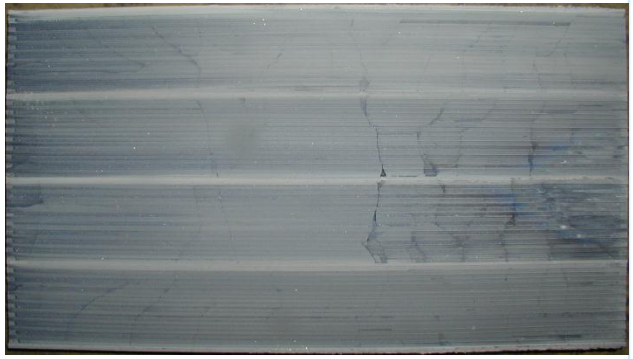
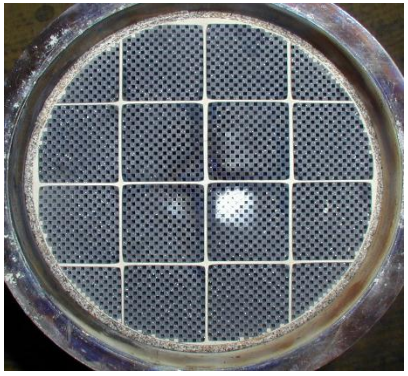


PN1 before the filter determines the emission status of the engine itself, eventual failures, leakages, deterioration,aging

PN2/PN1 determines la stability of the filtration very accurately

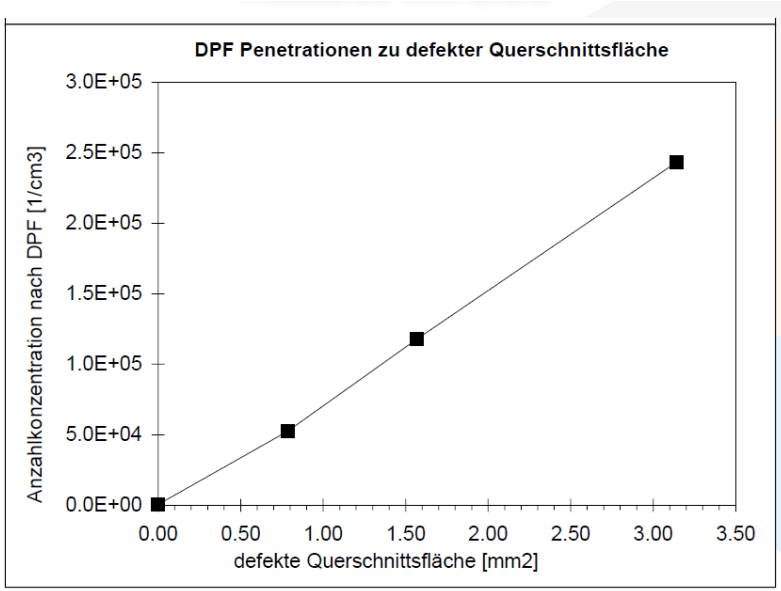
Filtration Efficiencies measured by PN of 9 buses of Transiantiago city bus fleet after 4-6 years of operation

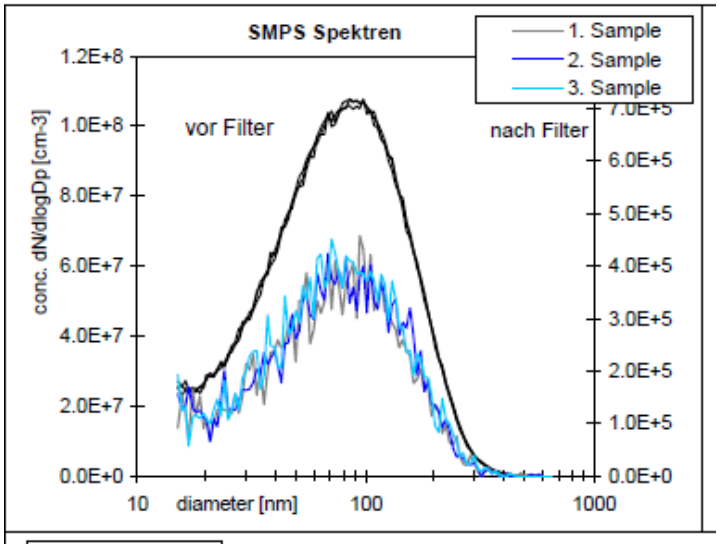
Modelo	Empresa	medicion 1	medicion 2	medicion 3	promedio fi	RESULTADO	RESULTADO	Prom. Max RPM
B7R	REDBUS	1,23E+06	1,61E+06	1,46E+06	1,33E+06	fallo	39,82%	
B7R	REDBUS	2,68E+06	2,55E+06	2,37E+06	2,21E+06	fallo		
LO915	REDBUS	7,52E+01	6,99E+01	5,60E+01	1,00E+03	paso	99,88%	1,00E+03
LO915	REDBUS	1,63E+06	1,55E+06	1,59E+06	8,20E+05	fallo		
O500U	REDBUS	8,67E+05	8,91E+05	9,10E+05	1,13E+06	fallo	73,02%	1,06E+06
O500U	REDBUS	4,51E+06	4,56E+06	4,36E+06	4,17E+06	fallo		
O500U	VULE	6,74E+04	6,62E+04	7,52E+04	7,49E+04	paso	98,04%	1,00E+03
O500U	VULE	3,94E+06	3,86E+06	3,72E+06	3,83E+06	fallo		
O500U	VULE	1,25E+04	1,22E+04	1,37E+04	1,46E+04	paso	99,29%	1,15E+05
O500U	VULE	2,31E+06	2,26E+06	2,25E+06	2,05E+06	fallo		
O500U	VULE	2,50E+03	3,19E+03	3,48E+03	4,55E+03	paso	99,83%	1,18E+05
O500U	VULE	2,58E+06	2,54E+06	2,39E+06	2,61E+06	fallo		
O500UA	METROPOLITANA	1,03E+05	1,08E+05	1,01E+05	1,07E+05	paso	97,52%	2,76E+03
O500UA	METROPOLITANA	3,91E+06	4,25E+06	4,25E+06	4,31E+06	fallo		
O500U	METROPOLITANA	5,73E+03	6,08E+03	5,71E+03	5,80E+03	paso	99,86%	4,40E+04
O500U	METROPOLITANA	4,30E+06	4,23E+06	4,32E+06	4,19E+06	fallo		
O500U	METROPOLITANA	6,28E+03	5,96E+03	6,28E+03	7,28E+03	paso	99,85%	4,40E+04
O500U	METROPOLITANA	4,97E+06	5,14E+06	5,06E+06	5,00E+06	fallo		

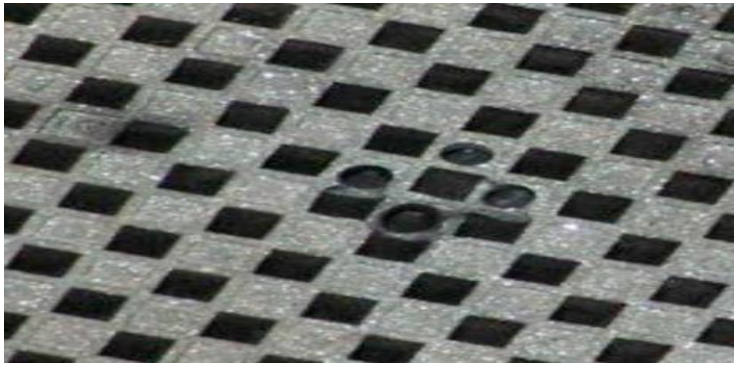
	Regeneration chart	Cross Section	Outlet Surface
10 g/L			
20 g/L			
30 g/L			

Detect Small Failures

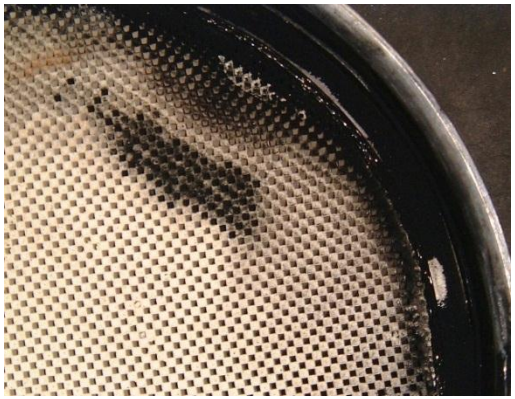
(Kasper **ETH 2008)**







Repair Small Failures by ceramic cement



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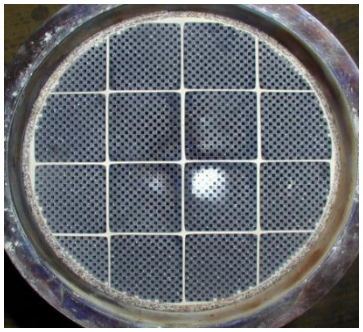
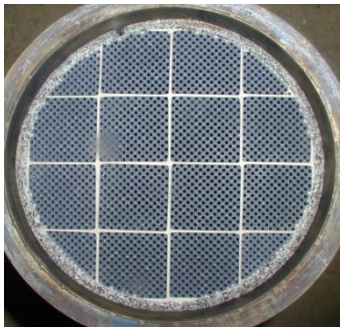




Conclusions for failure detection by PN-Measurement

- **PN emissions increase linearly with DPF damage ratio**
- **Opacity does not have enough sensitivity**
- **Laser Light Scattering LLSP has enough sensitivity to detect the emission of large particles but is very insensitive for ultrafine particles**
- PN measurement at low idle can detect even small DPF damage, which can be repaired

Conclusions on PN-Measurement for I&M

- **Very accurate tool**
- **Easy to apply and handle even at low idle**
- **Measurement time < 1 minute**
- **Useful for maintenance and periodic control**
- **Equally useful for DPF and Engine failure detection**
- **Will replace opacity measurement and light scattering**

Can we also check Catalysis in-use

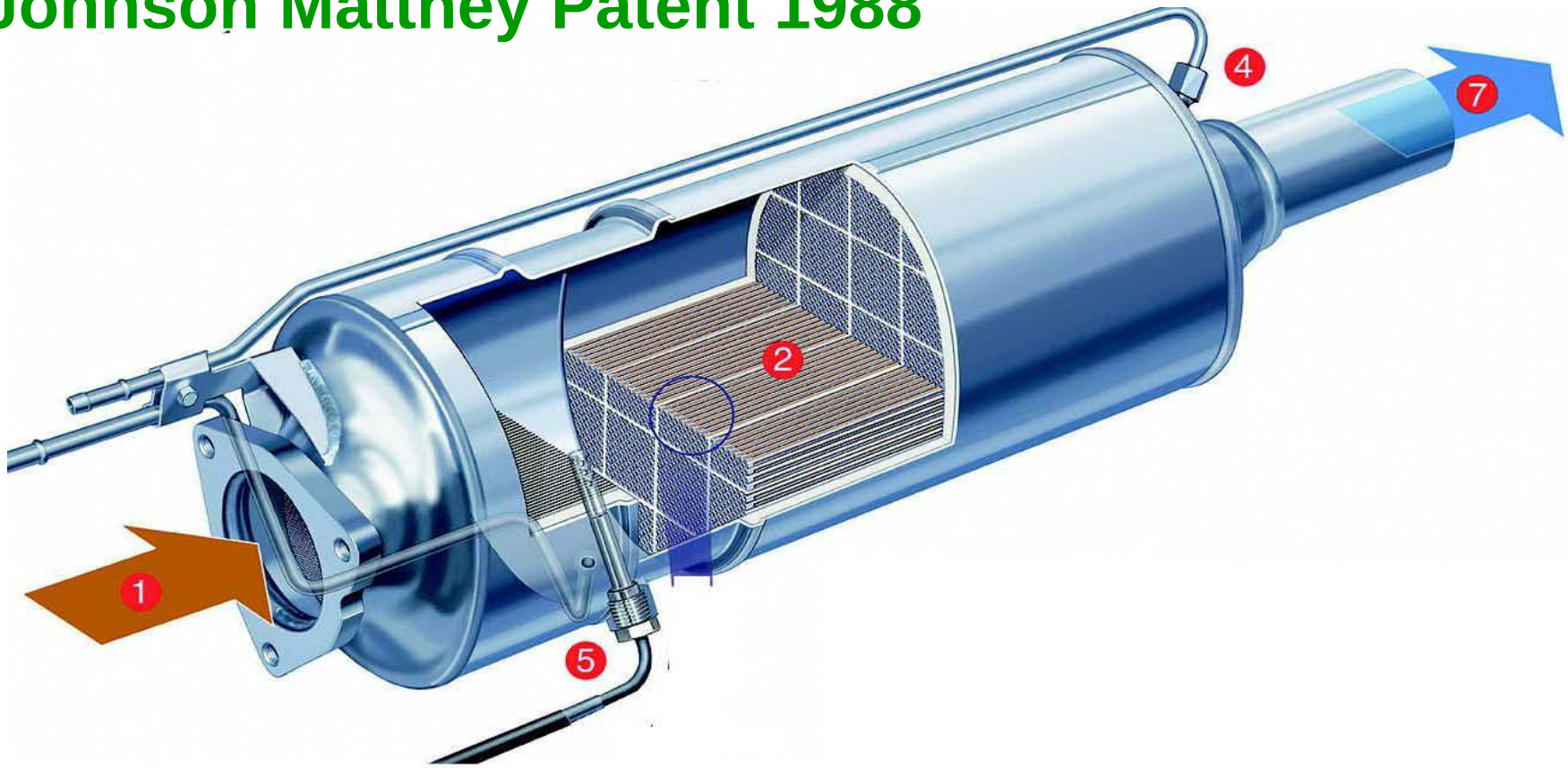
DOC
SCT
?

Yes, we can

Why Check DOC Conversion ability?

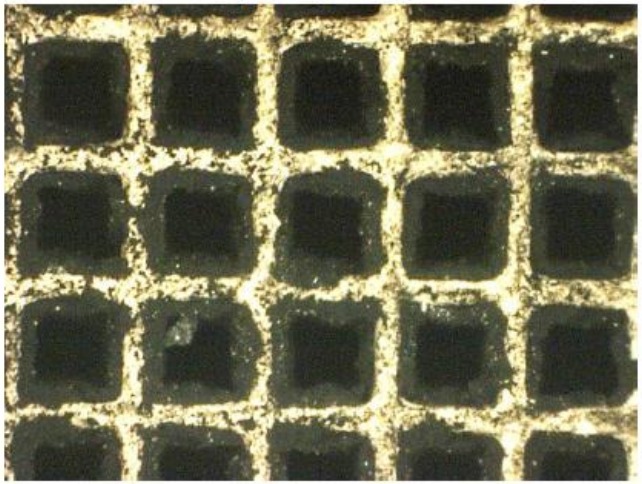
CRT-Filter System

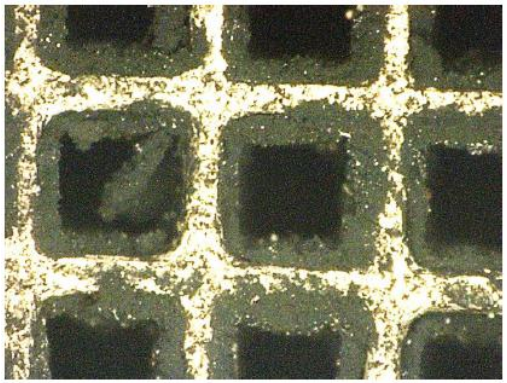
Johnson Matthey Patent 1988



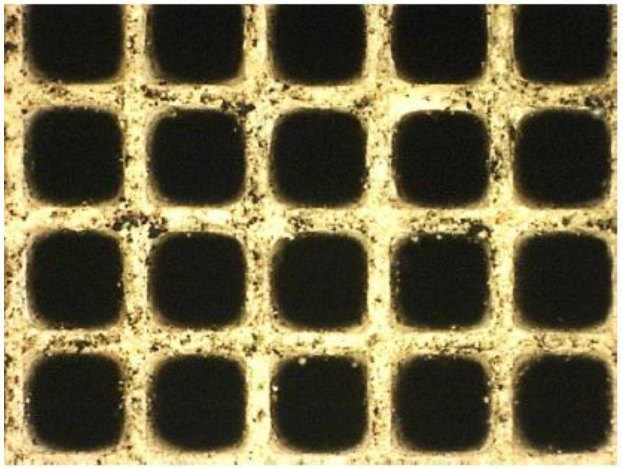
DOC might be covered by soot

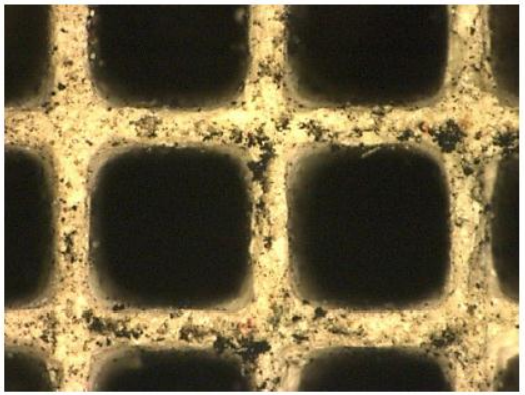
Inlet





Outlet



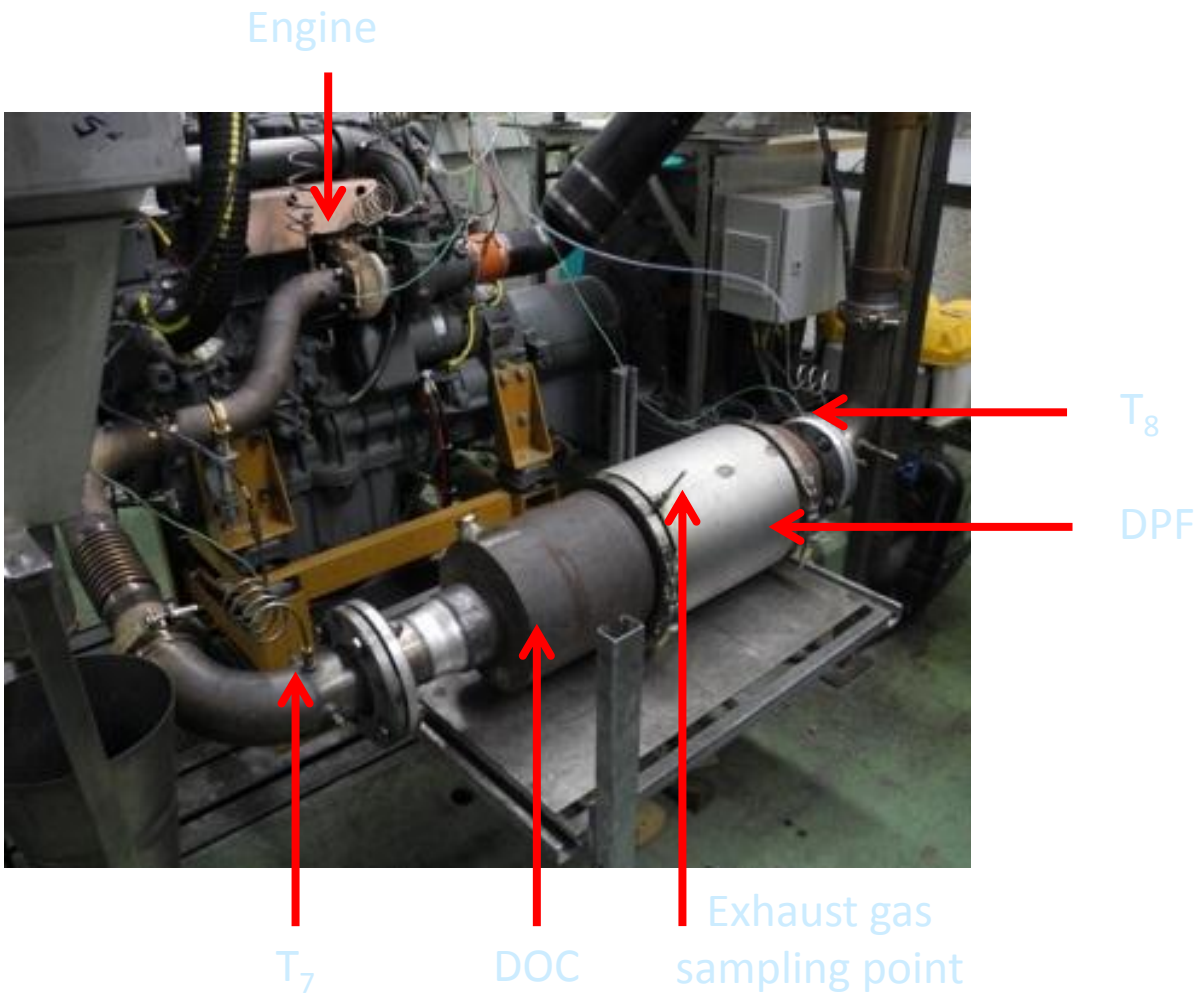


If a DPF is not properly regenerating, the reason might be DOC aging, pollution or poisoning

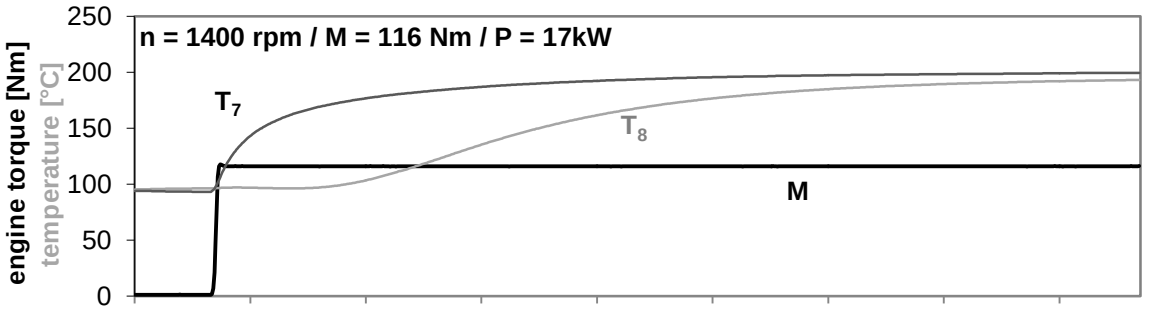
How to detect malfunction of the DOC during maintenance ?

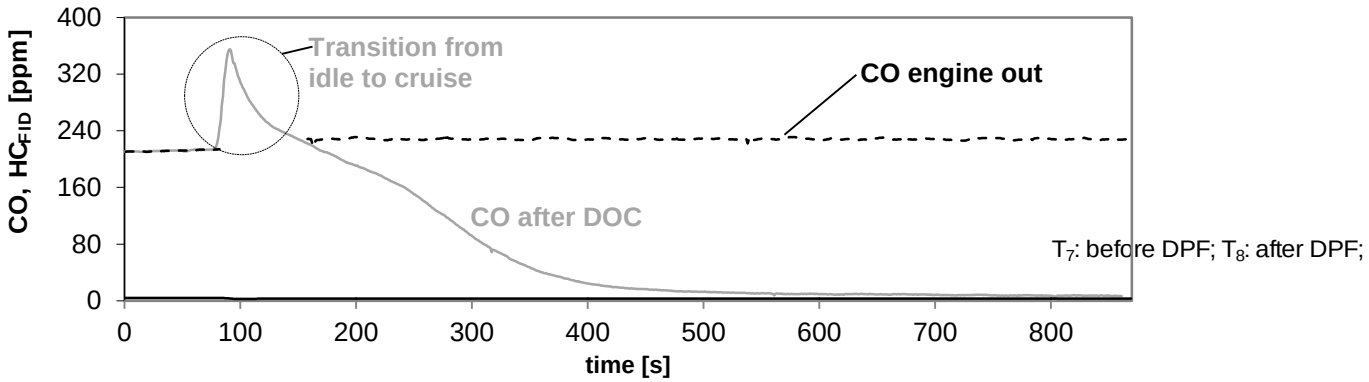
→ Check catalytic conversion efficiency
→ use CO-conversion
→ during engine temperature ramp

DOC Light Off test set-up

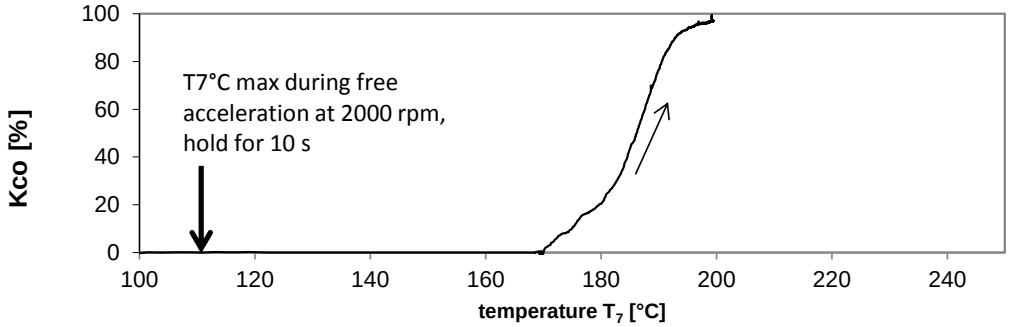


DOC Light off test during load step



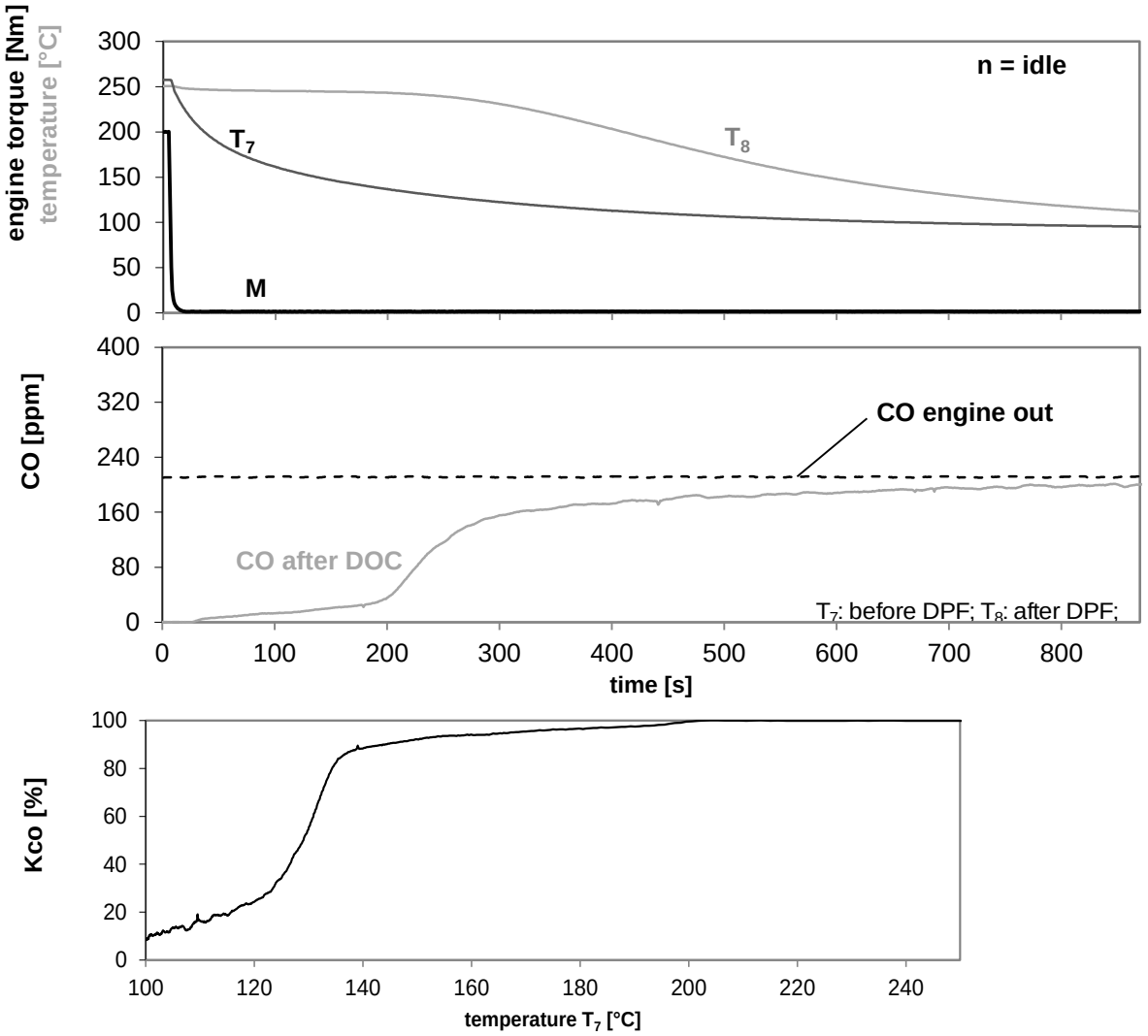


T_7: before DPF; T_8: after DPF;

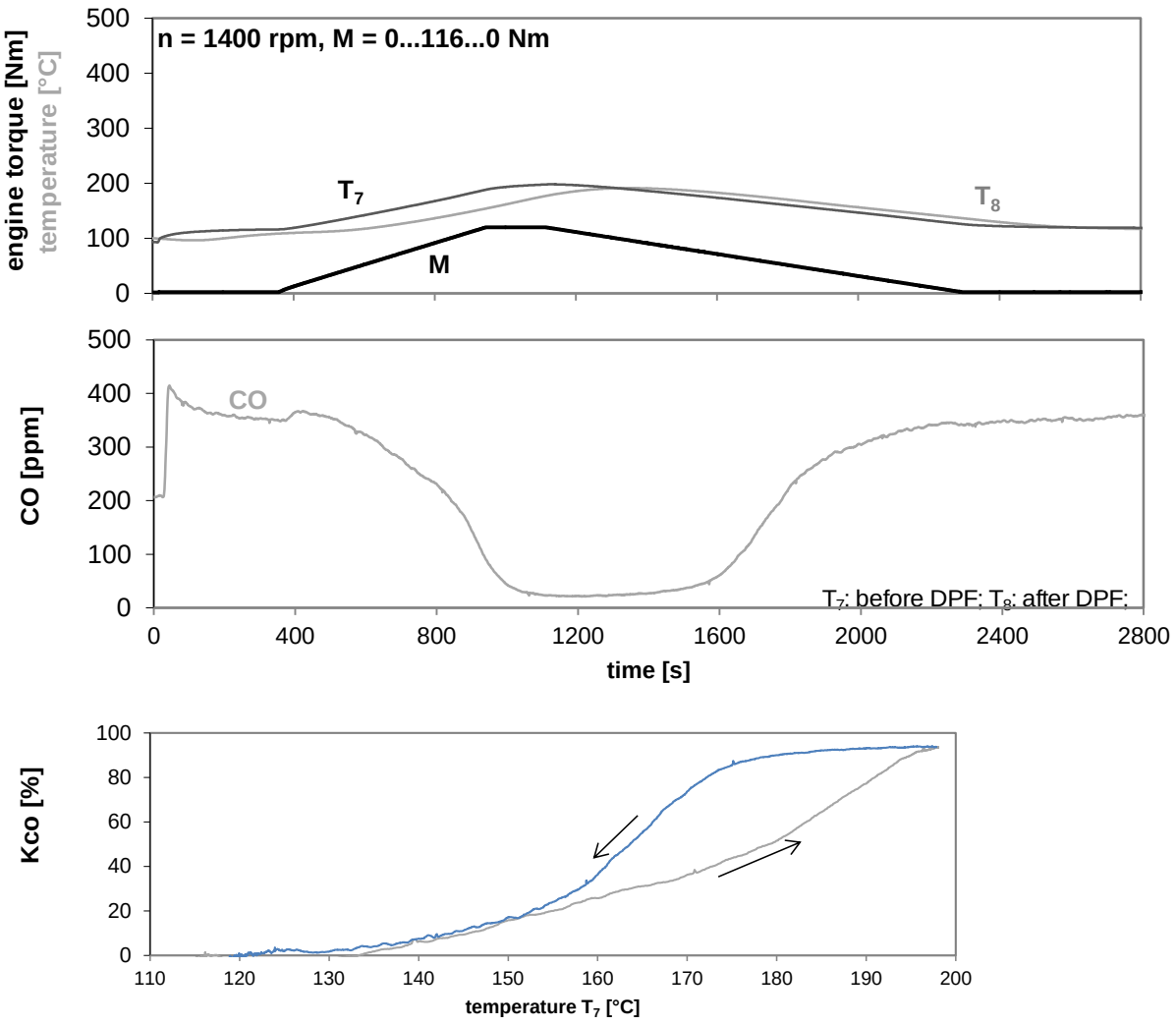


needs chassis dynamometer

DOC Light off test during cooling at idle



Ramp Test shows hysteresis due to thermal inertia



Summary and Conclusion

CO-conversion test during engine cooling at idle after road operation

→ is easy to perform and fast

→ confirms proper function of DOC

→ detects malfunctions

→ Supplies quantitative data to either clean or replace the CRT-DOC

→ Similar loadstep (ramp-) test for SCR to check proper Adblue injection and catalyst conversion stability

Inspection & Maintenance becomes very important for DPF (+SCR) retrofit and first fit

- Instruments are ready
  - PN-Measurement at idle for **DPF <u>and E</u>ngine** control
  * Fleet Monitor with remote control
  * DOC-conversion activity control
- Regulations are needed
- Periodic independent control is needed
- Documentation is needed (onboard emission passport)

The scientific network

1997 first international ETH-NP-workshop - 40 participants

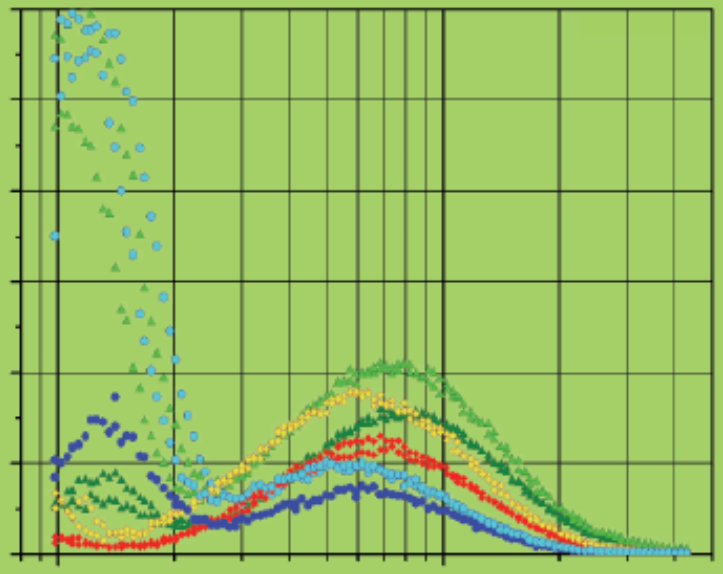
Today ETH-NPC is the annual event of UFP experts from science to technology > 400

20th conference June 2016
13th to 16th – no participation fee

Invitation and call for papers to the

19th ETH-Conference on Combustion Generated Nanoparticles

Focus Event:
Air Quality in Megacities



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Exhaust End Pipe stays clean !

onroad > 85‘000 km offroad > 1000 h