

Paper/Poster-Abstract Form

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Title: EMISSION TESTING AT PERIODICAL TECHNICAL INSPECTION ON DIESEL PASSENGER CARS EXPERIENCE AND FURTHER DEVELOPMENTS IN GERMANY

Abstract: (min. 300 – max. 500 words)

Coming from the EU wide regulation for harmonized periodical technical inspection (PTI) last updated version 2010/48/EU emission tailpipe testing is mandatory; also for diesel powered vehicles. Since the vehicle technology is developing faster and faster following the demanding Euro 4, 5 and 6 standards the existing PTI – measures are object of discussion concerning the effectiveness and over all benefit for the environment and the society.

The biggest PTI – organization worldwide has done different studies and measures to evaluate the existing and develop future new measures for PTI – tail pipe testing in future.

The most important part at emission testing is PM – measurement on diesel engines. The existing regulation defines opacity measurement using opacimeter. Objective of the finished studies was the evaluation of the existing thresholds mandatory in Germany compared with the actually vehicle fleet emission behaviour under appropriate conditions as well as to test new measurement devices in practice which are capable to measure mg/m³ instead of k- values like it is defined at the existing EU – regulation defined.

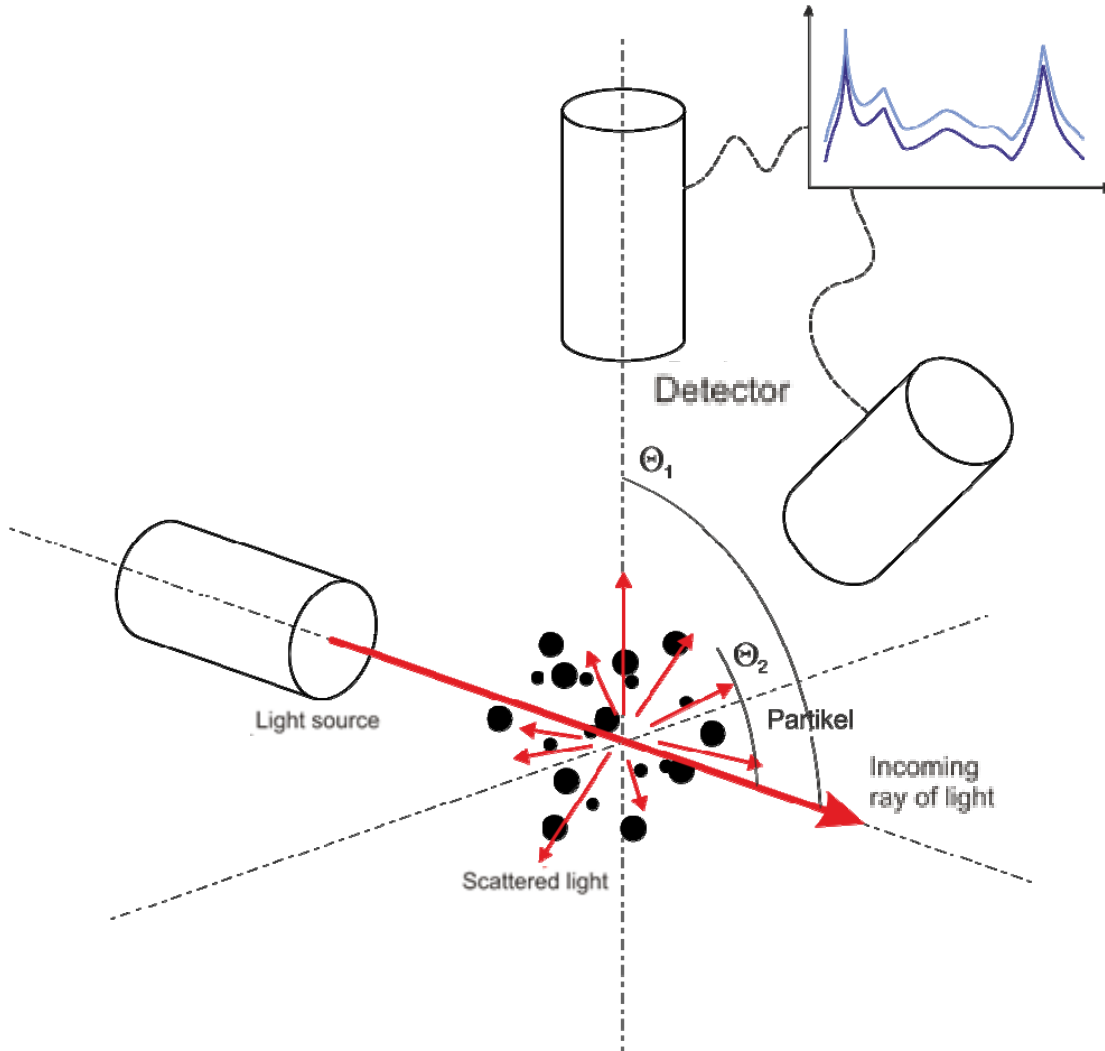
After processing more than 500 test results and a sample of 5 in depth measurements on dedicated vehicles we have found promising results for an updated emission testing on modern vehicles by using new and appropriate thresholds and new measurement devices. We have also considered a cost – benefit calculation for the economic impact of such an updated process. Also this calculation is very promising and will underline the need and benefit for a new PTI – test procedure using free acceleration method and OBD - scanning and measurement devices measuring mg/m³. The overall accuracy of these new devices is much better than the old opacimeter systems and in good correlation with them for having a phase in period of time for the introduction of the new devices. Even Euro 6 engines are emitting extremely high mass of PM if there is a failure at the emission after treatment system, were the existing OBD – system is not capable to detect exceeding emission of PM. For the further work we think about measurement of NO_x or other components which are seen important as indicator for malfunctioning system / components or in general terms worthwhile to be limited in the light of environment protection.

Technological Outlook:

LLSP – Laser Light Scattering Photometry

- size range 40 to 1000 nm
- 0.01 – 700.00 mg/m³ PM concentration
- m⁻¹ (Opacity) by correlation
- #/m³ number concentration
- nm (mode) particle at logarithmical normal size distribution
- non road PM emitters

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Short CV:

Antonio Multari is the Director Project Management for MAHA Maschinenbau Haldenwang GmbH & Co. KG in Haldenwang, Germany. Over the past 12 years, he has worked in several international emission programmes. Antonio has worked in several working groups, to realize emission projects. currently he worked in the German project "Emission Check 2010", UBA Study (German EPA), European emission study "TEDDIE" and in the Californian pilot program with CARB, SCAQMD and FCCC.

He is member of CITA Working Group Environmental Protection Systems and member of the German Equipment Manufacturer Association ASA.

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Wir im Allgäu



„Emission Testing at Periodical Technical Inspection on Diesel Passenger Cars“

Antonio Multari, MAHA, Germany

@16th ETH Conference on Combustion Generated Particles
June 24th – 27th 2012, Zurich, Switzerland





Emission Test for Modern Vehicles Need an Update Due to:

- **Report of the WHO (World Health Organisation)**
- **Air Quality Directives**
- **Results from Emission Check 2010**
- **Results from UBA Study**
- **Results from TEDDIE Study**
- **Certification Project with German Metreology (PTB)**
- **Technological Outlook**



Diesel engine exhaust carcinogenic



WHO/PAHO

12 June 2012 – After a week-long meeting of international experts, the International Agency for Research on Cancer (IARC), which is part of the World Health Organization, today classified diesel engine exhaust as carcinogenic to humans (Group 1), based on sufficient evidence that exposure is associated with an increased risk for lung cancer.

[Read the press release from IARC on diesel engine exhaust](#)



World Health Organization Report, September 2005:

“Health damage in the EU countries attributed to particulate matter (PM)”

Premature death from long-term exposure	288.000
Cases of chronic bronchitis	138.000
Cases of infant mortality	600
Total economic cost	150 billion Euros



Every Year!

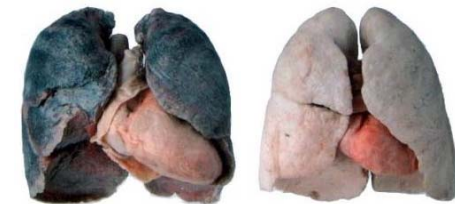




Table 2.1 Air quality limit and target values for PM₁₀ and PM_{2.5} as given in the Air Quality Directive

Size fraction	Averaging period	Value	Comments
PM ₁₀ , limit value	One day	50 µg/m ³	Not to be exceeded on more than 35 days per year. To be met by 1 January 2005
PM ₁₀ , limit value	Calendar year	40 µg/m ³	To be met by 1 January 2005
PM _{2.5} , target value	Calendar year	25 µg/m ³	To be met by 1 January 2010
PM _{2.5} , limit value	Calendar year	25 µg/m ³	To be met by 1 January 2015
PM _{2.5} , limit value ^(a)	Calendar year	20 µg/m ³	To be met by 1 January 2020
PM _{2.5} , exposure concentration obligation ^(b)		20 µg/m ³	2015
PM _{2.5} , exposure reduction target ^(b)	0–20 % reduction in exposure (depending on the average exposure indicator in the reference year) to be met by 2020		

Note: ^(a) Indicative limit value (Stage 2) to be reviewed by the Commission in 2013 in the light of further information on health and environmental effects, technical feasibility and experience of the target value in Member States.

^(b) Based on a three-year average.

Source: EU, 2008c.





Table 4.1 Limit and threshold values for NO₂ and NO_x as set out in the 2008 Air Quality Directive

Objective	Averaging period	Limit or threshold value	Number of allowed exceedances
Human health	One hour	200 µg/m ³	18 hours per year
Human health	Calendar year	40 µg/m ³	
Alert ^(a)	One hour	400 µg/m ³	
Vegetation ^(b)	Calendar year	30 µg/m ³	

Note: ^(a) To be measured over three consecutive hours at locations representative of air quality over at least 100 km² or an entire zone or agglomeration, whichever is smaller.

^(b) As oxides of nitrogen (NO_x), expressed as µg NO₂/m³.

Source: EU, 2008c.



Exceeding PM₁₀ limits in Europe



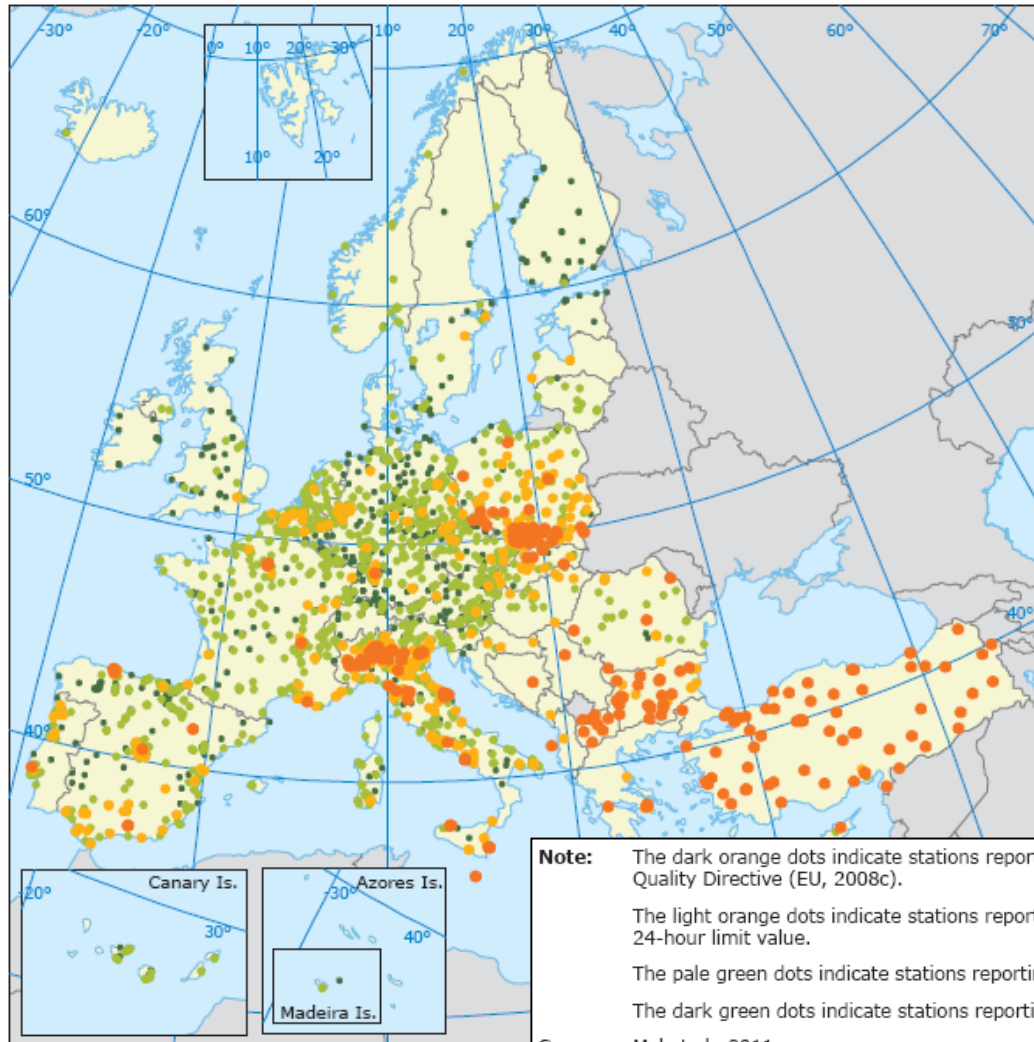
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Slide 7

25.06.2012



Annual mean, particulate matter (PM₁₀), 2009, based on daily averages with percentage of valid measurements 75 % in $\mu\text{g}/\text{m}^3$

- ≤ 20
- 20-31
- 31-40
- ≥ 40
- Outside data coverage

European Environment Agency



Note: The dark orange dots indicate stations reporting exceedances of the 2005 annual limit value ($40 \mu\text{g}/\text{m}^3$), as set out in the Air Quality Directive (EU, 2008c).
The light orange dots indicate stations reporting exceedances of a statistically derived level ($31 \mu\text{g}/\text{m}^3$) corresponding to the 24-hour limit value.
The pale green dots indicate stations reporting exceedances of the WHO air quality guideline for PM₁₀ of less than $20 \mu\text{g}/\text{m}^3$.
The dark green dots indicate stations reporting concentrations below the WHO air quality guideline for PM₁₀.

Source: Mol et al., 2011.

Source: Air Quality in Europe – 2011 Report from European Environment Agency

Exceeding NO₂ (Nitrogen Dioxide) limits in Europe

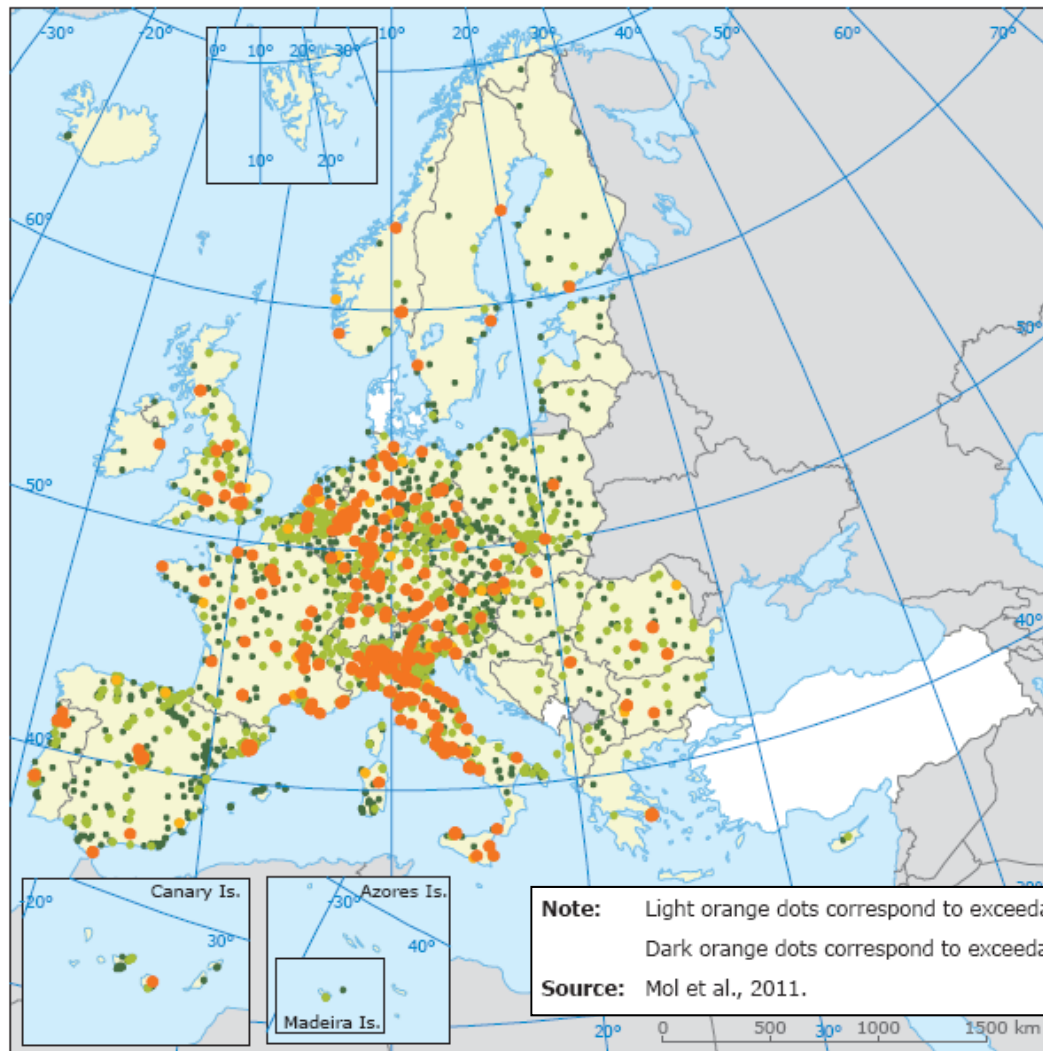


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Slide 8

25.06.2012



Annual mean, nitrogen dioxide, 2009, based on daily averages with percentage of valid measurements 75 % in µg/m³

- ≤ 20
- 20–40
- 40–42
- ≥ 42

□ No data
 □ Outside data coverage




Note: Light orange dots correspond to exceedances of the annual limit value (40 µg/m³).
 Dark orange dots correspond to exceedance of the annual limit value + margin of tolerance in 2009 (42 µg/m³).
Source: Mol et al., 2011.

Source: Air Quality in Europe – 2011 Report from European Environment Agency



German Project Emission Check 2010 (2009-2010):

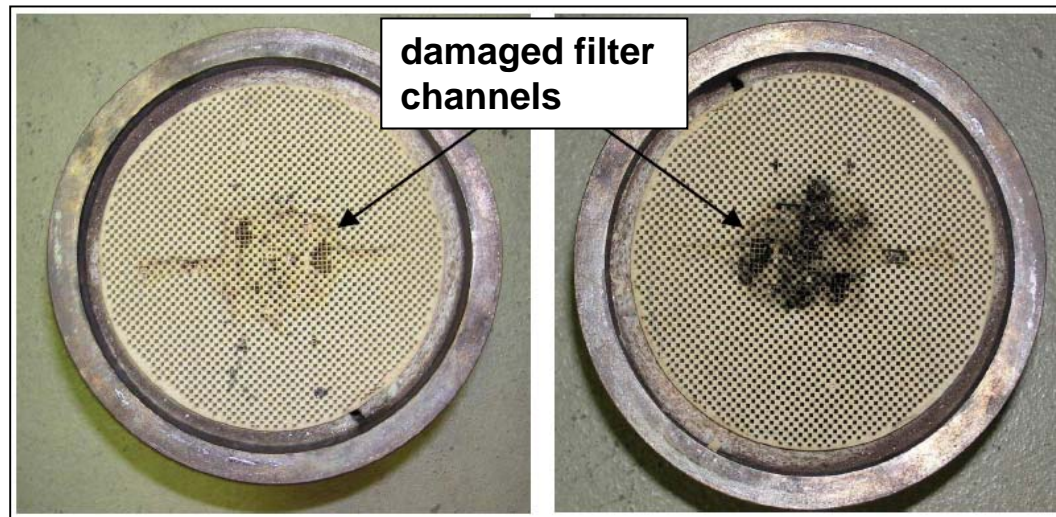
- OBD is not covering all emission aspects
- Reference values used during PTI are too high
- New instruments working on scattered light are much more sensitive and precise

Deterioration / Defect status	Particular Mass PM			Partikel numbers n	Particular-Masse (max. Peak) Streulicht (MPM4) mg/m ³	DTC - trouble codes	 MIL
	mg/km	% v. Typ approval value	% of OBD-threshold value				
Ok - Condition	1,070	21,4	2,14	7,031*10 ⁸	8,01	0	off
Step 1 (1 hole)	8,570	175	17,5	2,521*10 ¹³	45,25	0	off
Step 2 (4holes)	15,059	301	30,1	3,660*10 ¹³	90,25	0	off
Step 3 (29 holes)	51,300	1026	102,6	-	400,6	0	off



German Project UBA (2010-2011) (German Environmental Protection Agency):

- OBD is not covering all emission aspects
- Reference values used during PTI are too high
- Reference value for Diesel vehicles with after treatment systems should not be higher than $0,1 \text{ m}^{-1}$ (Opacity) !
- Petrol vehicles with direct injection produce significant particles – particle filters are necessary too





EU TEDDIE Study (2011-2012):

Founded by the European Commission in 2011

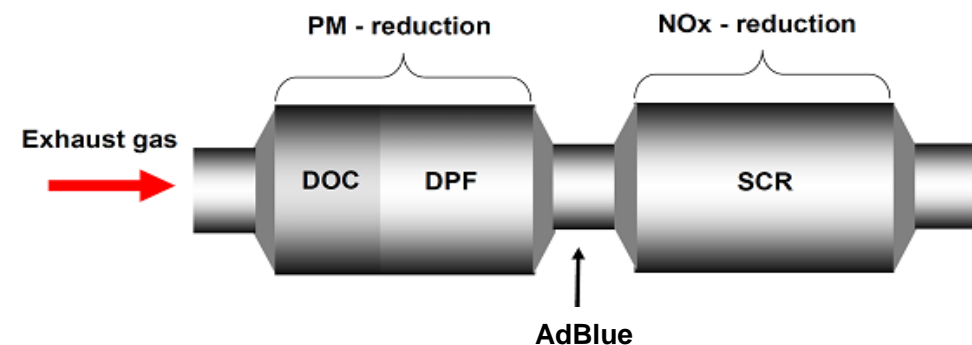
- to investigate **new measurement devices** for particle mass and NO/NO₂-ratio
- to evaluate if **OBD will identify increased particle emission** by activating MIL or storing DTCs

Limits: type approval = 5 mg/km in NEDC, OBD threshold = 50 mg/km

- to identify reliable **methods of emission testing**

Vehicles prepared with defects of the exhaust emission system:

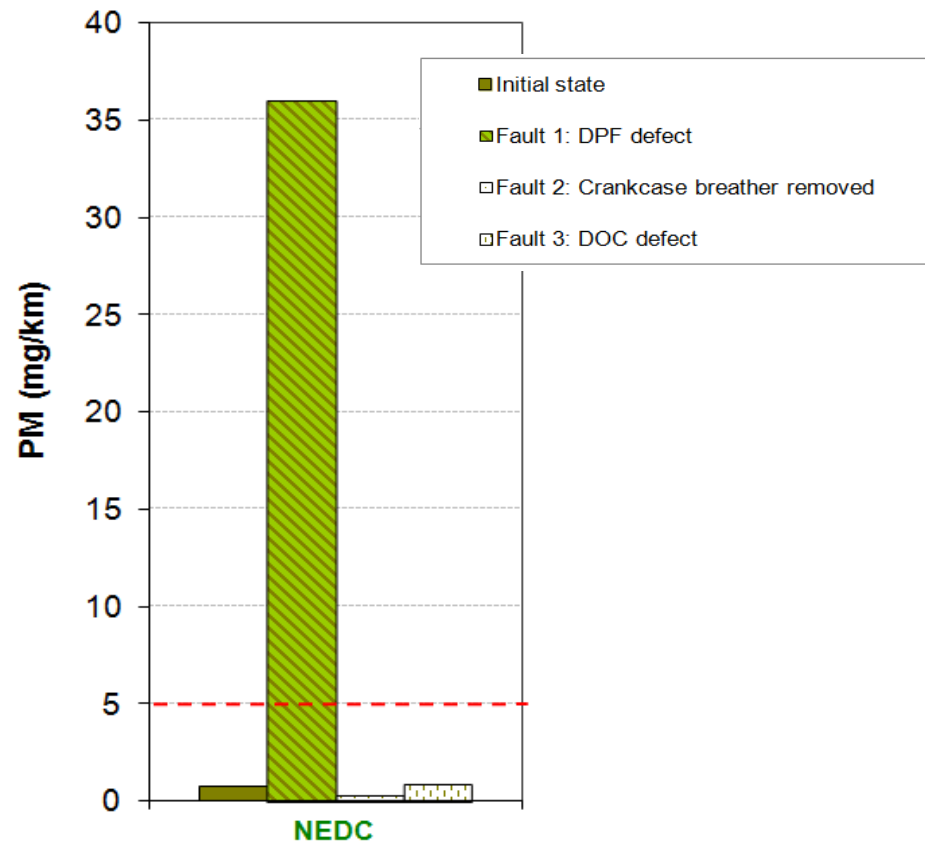
- defects of particle trap (DPF)
- defective/damaged/aged SCR
- manipulated crankcase breather
- defective air mass flow sensor



Source: DEKRA



EU TEDDIE: Deterioration of the Particle Trap (DPF)



Source: DEKRA



EU TEDDIE: Emission Test Results:

	max. particle emission	OBD-MIL	OBD-DTC
results:			
vehicle 1	5.1 mg/km	OFF	none
vehicle 2	36.0 mg/km	OFF	none
vehicle 3	8.9 mg/km	OFF	none
Emission Check 2010 result:			
vehicle	51.3 mg/km	OFF	none

→ Defects (e.g. defective particle traps) might cause **higher emissions** up to the OBD MIL threshold, **without MIL and DTC activation**.

Limits for emission testing (opacity is ranging from 3.0 m⁻¹ down to values below

0.5 m⁻¹) comes closer to the technical limitations of opacity measurement.

→ New measurement technology:
laser light scattering photometry (LLSP)

Source: DEKRA

TEDDIE Study Results



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Particle (PM) System	LLSP <small>(Laser light spectroscopy)</small>	Opazimeter
	Optical	Optical
Accuracy	**	***
Linearity		
Stability		
Repeatability		***
Dynamic		

= Calibration method actually under development and hopefully done soon

= Not given for measurements below 0,3 m⁻¹

Source: DEKRA



Use of OBD and Tailpipe Measurements

European studies show that a variety of serious defects of emission systems in diesel engines will not be identified by OBD.

Tailpipe emissions may increase by more than 50 times without being detected by OBD !

→ The new technologies for measuring tail pipe PM concentration are sufficiently sensitive to deliver valid results even with Euro 6 engines. It is not necessary to rely on OBD to identify faults in the emission system.

Source: DEKRA



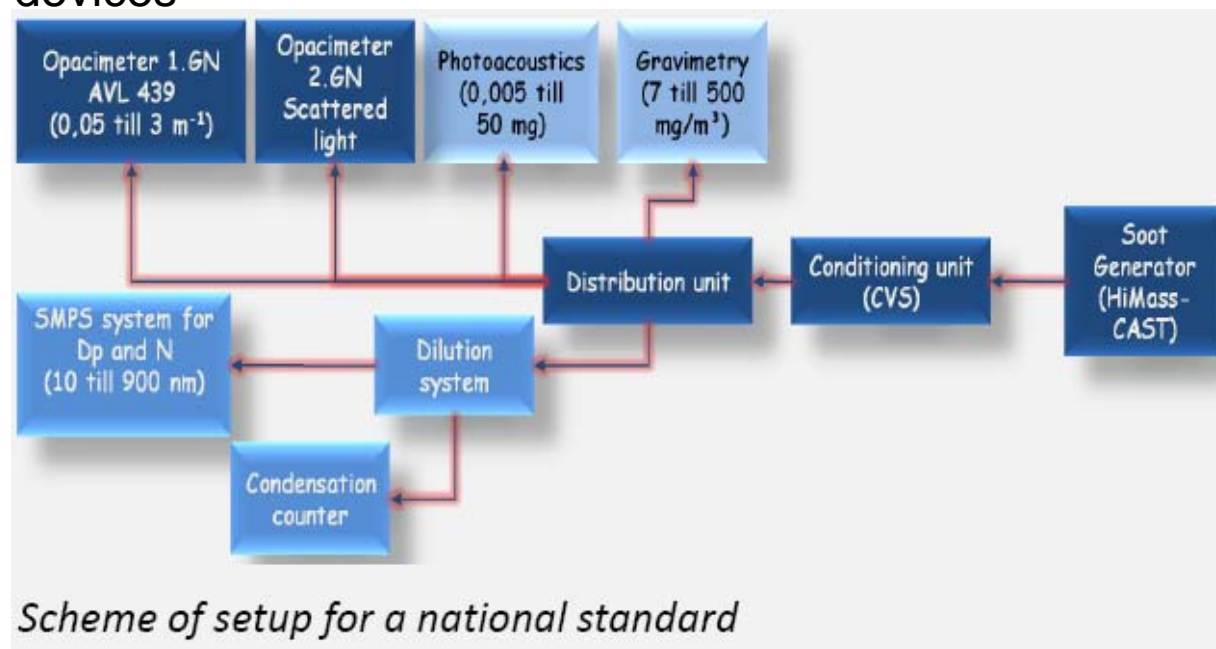
Limits for emission testing and measurement devices

The pass-fail criteria for PTI test should be set to reflect the certification standard of the vehicle being tested. It should allow for some reasonable deterioration during the service life of the vehicle.

- But the limit should not allow excessive deterioration to occur before repair- maintenance is required

PTB and ASA (German Equipment Manufactures) Cooperation Project

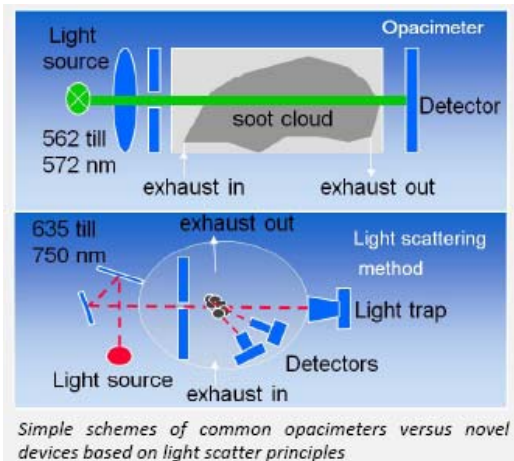
- Setup a metrological infrastructure for developing scientific fundamentals of the second generation opacimeter (scattered light principle)
- Determination of missing correlations between soot mass concentration (m) and transmission coefficient (k)
- Transfer of scientific results in the type approval procedures for the new devices



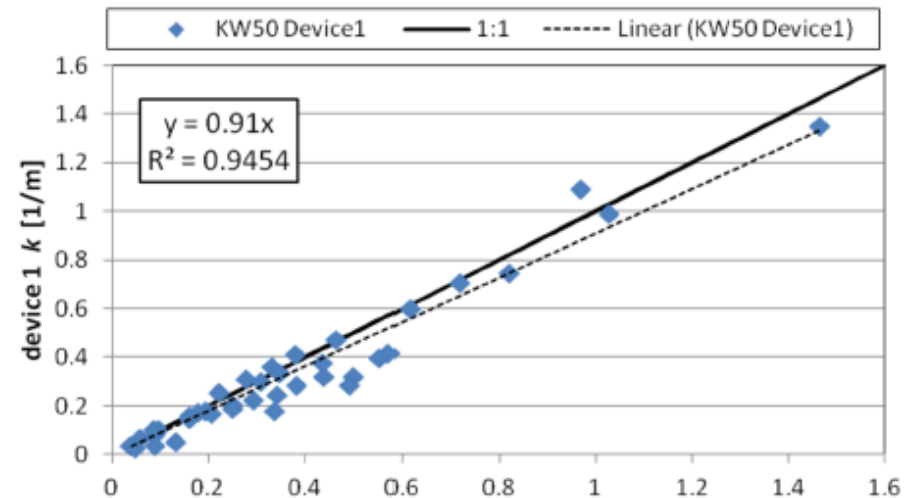
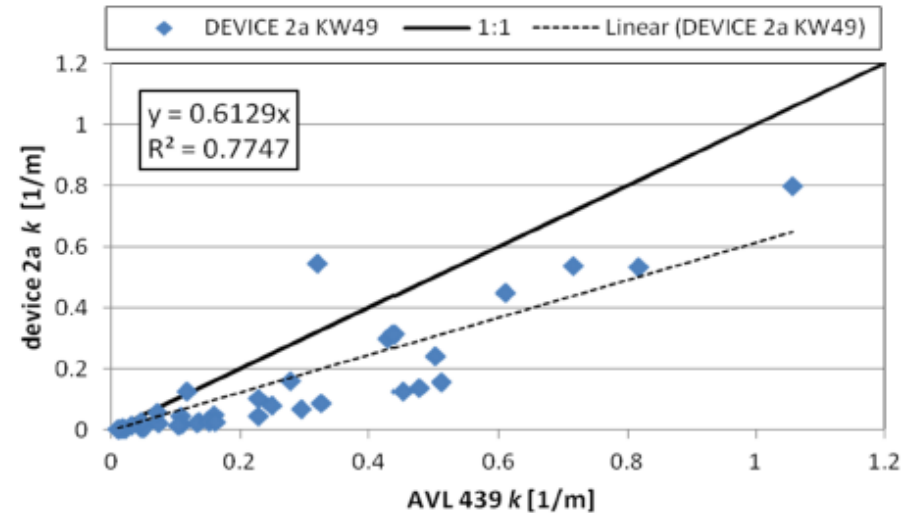
Source: PTB – Dr. Nowak

Conclusions

- First studies were preformed for k-values between 0,01 m⁻¹ (1 mg/m³) and 1,5 m⁻¹ (250 mg/m³).
- Good correlation for k-values between common reference opacimeter and the novel instruments could be found.
- For stabilizing the concentration the HiMass-CAST were modified.

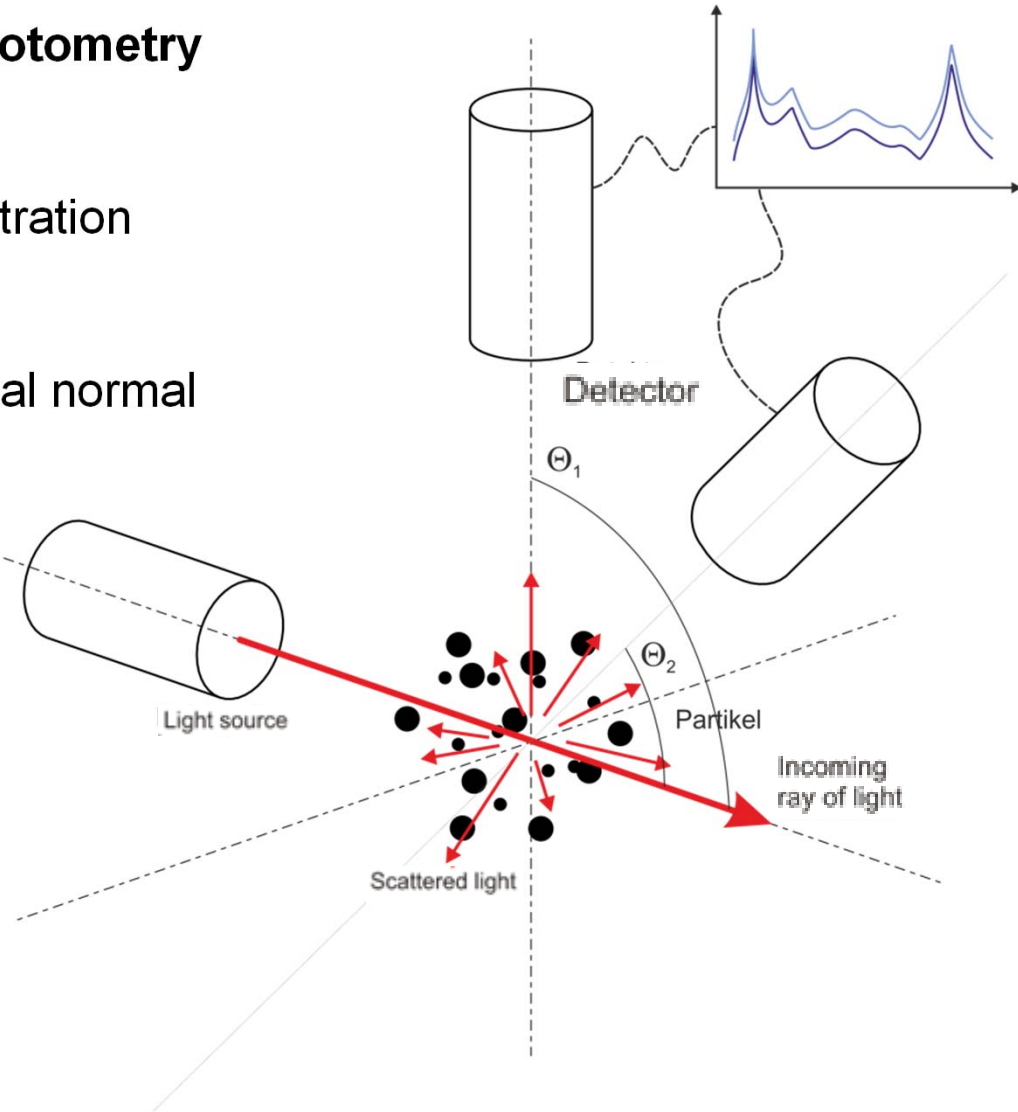


Source: PTB – Dr. Nowak



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- non road PM emitters
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Thank you for your attention!



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Thank you to all supporting
companies of this presentation:

PTB, DEKRA, PM-Tech, ASA

