Next Generation PN Instruments for Quality Control of DPF Kerbside

Luis Cachón, Testo AG

VERT-Forum 2016, Dübendorf 18.03.2016

Contents

- EU current legislation / PN Instrumentation
- EU oncoming legislation / PN Instrumentation
- Focus of Swiss legislation on PN for construction machinery
- Application examples out of type approval

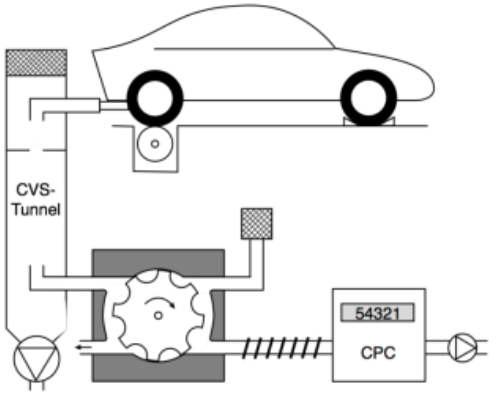
EU current legislation

Wir messen es. testo

➢ Current legislation on particle number emissions

- UNECE R83 → Euro 6 for LDV
  (Diesel since 2011, GDI from 2017)
- UNECE R49 → Euro VI HDV

Type Approval



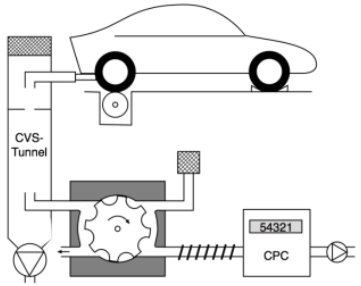
➢ testo ViPR + CPC: PMP compliant measurement technology for chassis dyno

- Type approval UNECE R83 and R49
- R&D of Diesel and Gasoline engines
- R&D of Diesel Particle Filter (DPF)
- Particle counting at chassis dyno and/or test bed

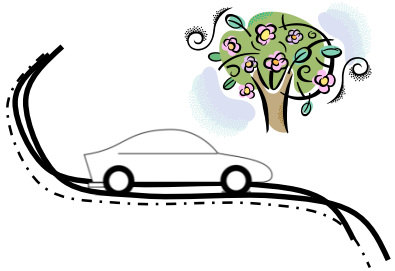
EU oncoming legislation

Wir messen es. testo

- **Oncoming legislation on particle number emissions**
  - RDE for LDV according to regulation 459/2012
  - In-Service Conformity HDV according to regulation 64/2012
  - Stage V Regulation for NRMM according to COM(2014) 581



Type Approval



- **testo NanoMet3: PEMS-PN compliant technology for on-board measurements**
  - Type approval RDE
  - In-Service Conformity HDV
  - R&D of Diesel and Gasoline engines
  - R&D of Diesel Particle Filter (DPF)

Swiss legislation on PN for construction machinery

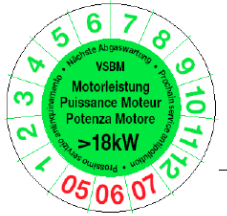
Wir messen es. testo

Type Approval

- The Swiss Ordinance on Air Pollution Control (OAPC) requires a limit value for particle number emission (1×10^{12} particles/kWh) for non-road mobile machinery (NRMM) used on construction sites.
  → this limit can only be met with diesel particulate filters (DPF).

Periodic Technical Inspection

- Periodic control of the machine every second year, done by the owner (Construction Guideline Air) .



3

testo ViPR + CPC

testo PEPA

Wir messen es. testo

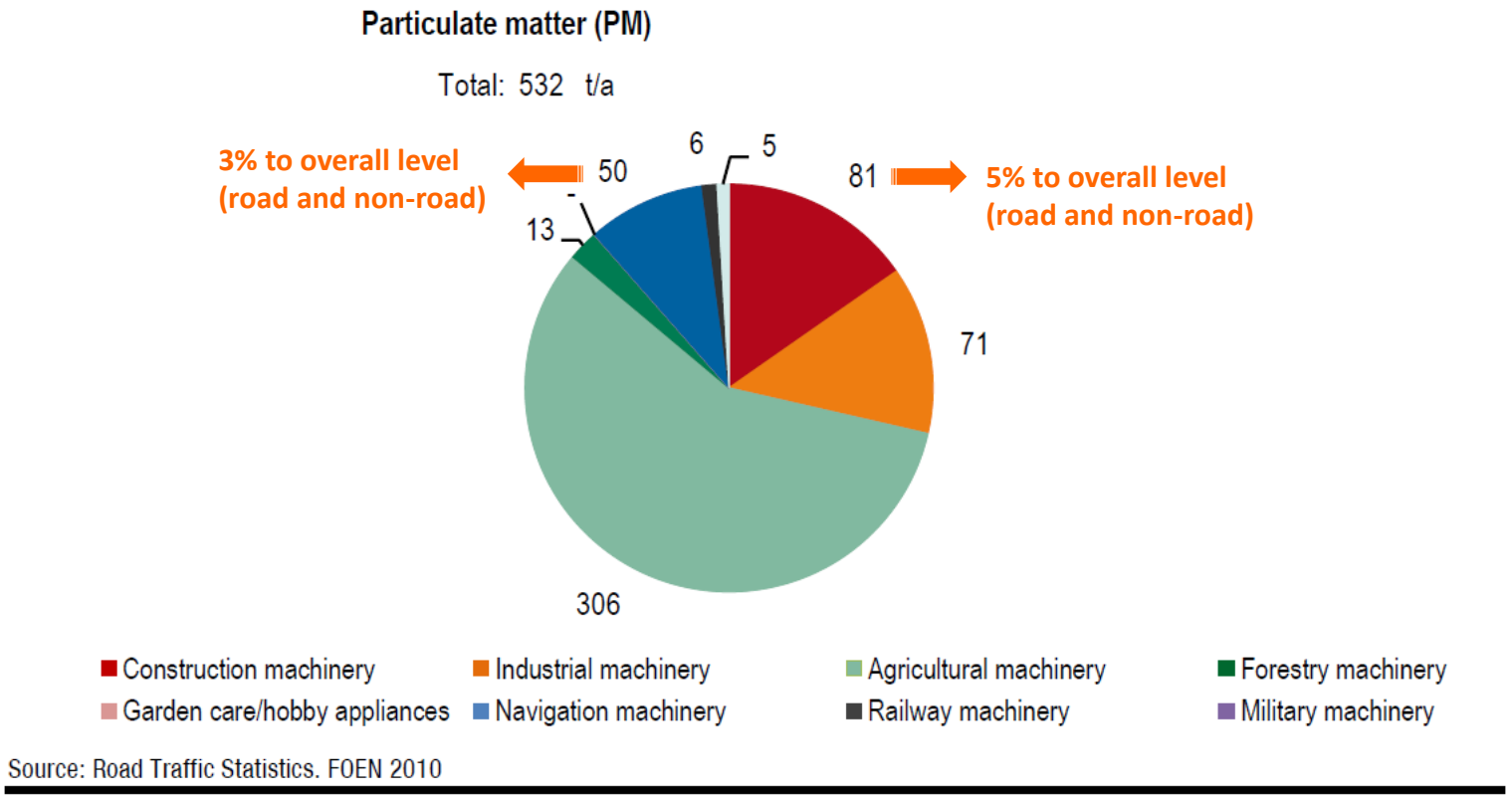
Comparison between the non-road sector and road traffic (2010)

	Non-road sector [tonnes p.a.]	Road traffic [tonnes p.a.]	Proportion of non-road sector to overall level (road + non-road)
Energy consumption			
Diesel	348,700	1,726,600	17 %
Petrol	44,900	2,807,100	2 %
Energy	18 PJ	193 PJ	9 %
Emissions			
Carbon monoxide (CO)	39,200	124,200	24 %
Hydrocarbons (HC)	4,370	17,100	20 %
Nitrogen oxides (NO_x)	10,400	39,300	21 %
Particulate matter (PM)	532	1,135	32 %
Carbon dioxide (CO_2)	1,254,000	14,373,100	8 %

Source: Road Traffic Statistics. FOEN 2010

Wir messen es. testo

Emissions of regulated pollutants in the non-road sector in 2010



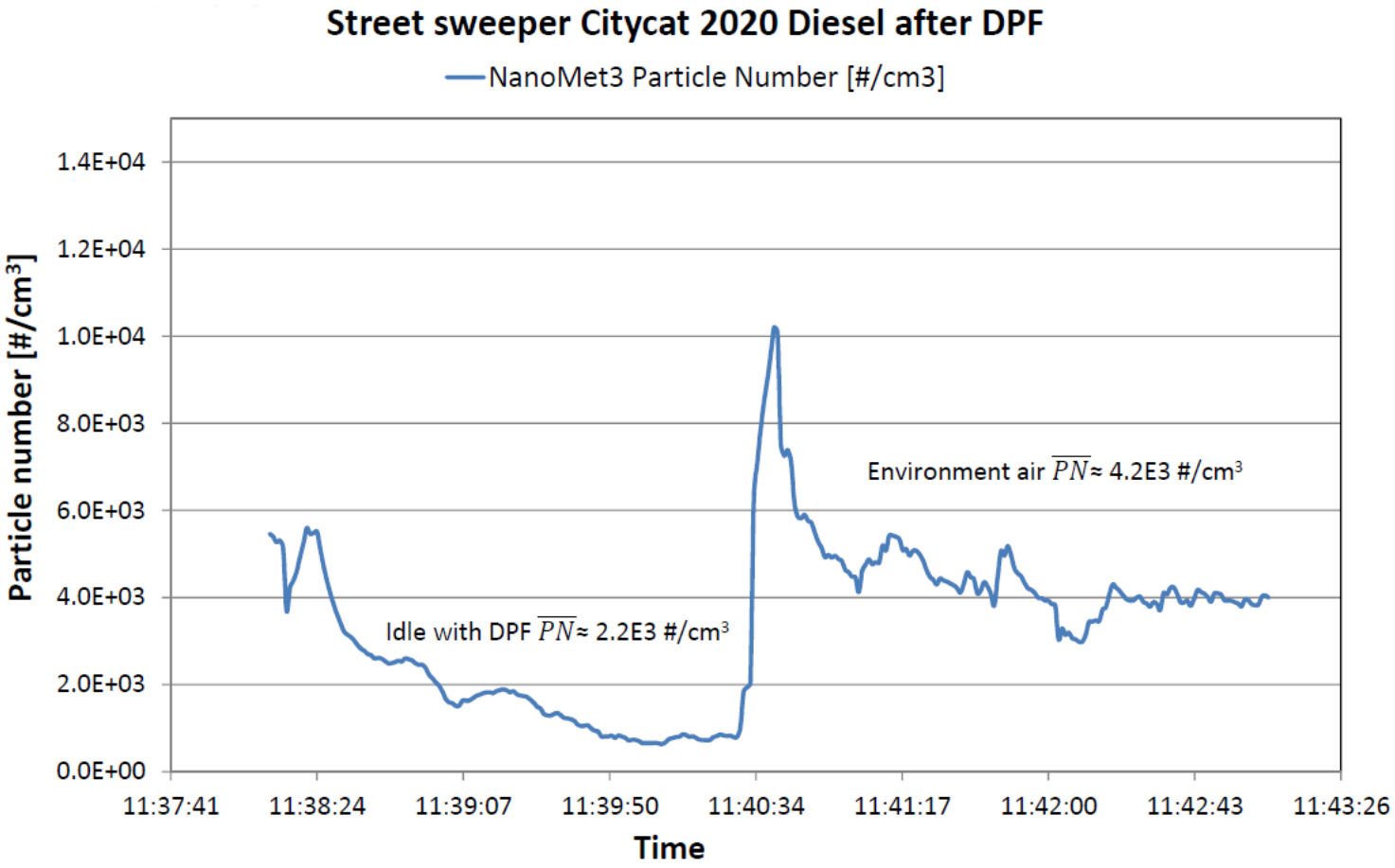
Source: Road Traffic Statistics. FOEN 2010

Is the Swiss legislation on PN for construction machinery an exaggeration? Is there an unnecessary over-engineering regarding exhaust aftertreatment and inspection?

- Particulate matter are local emissions. As soon as they are **reduced**, we improve our air quality.
- The safest way to **control** the particle emissions is through periodic technical inspection

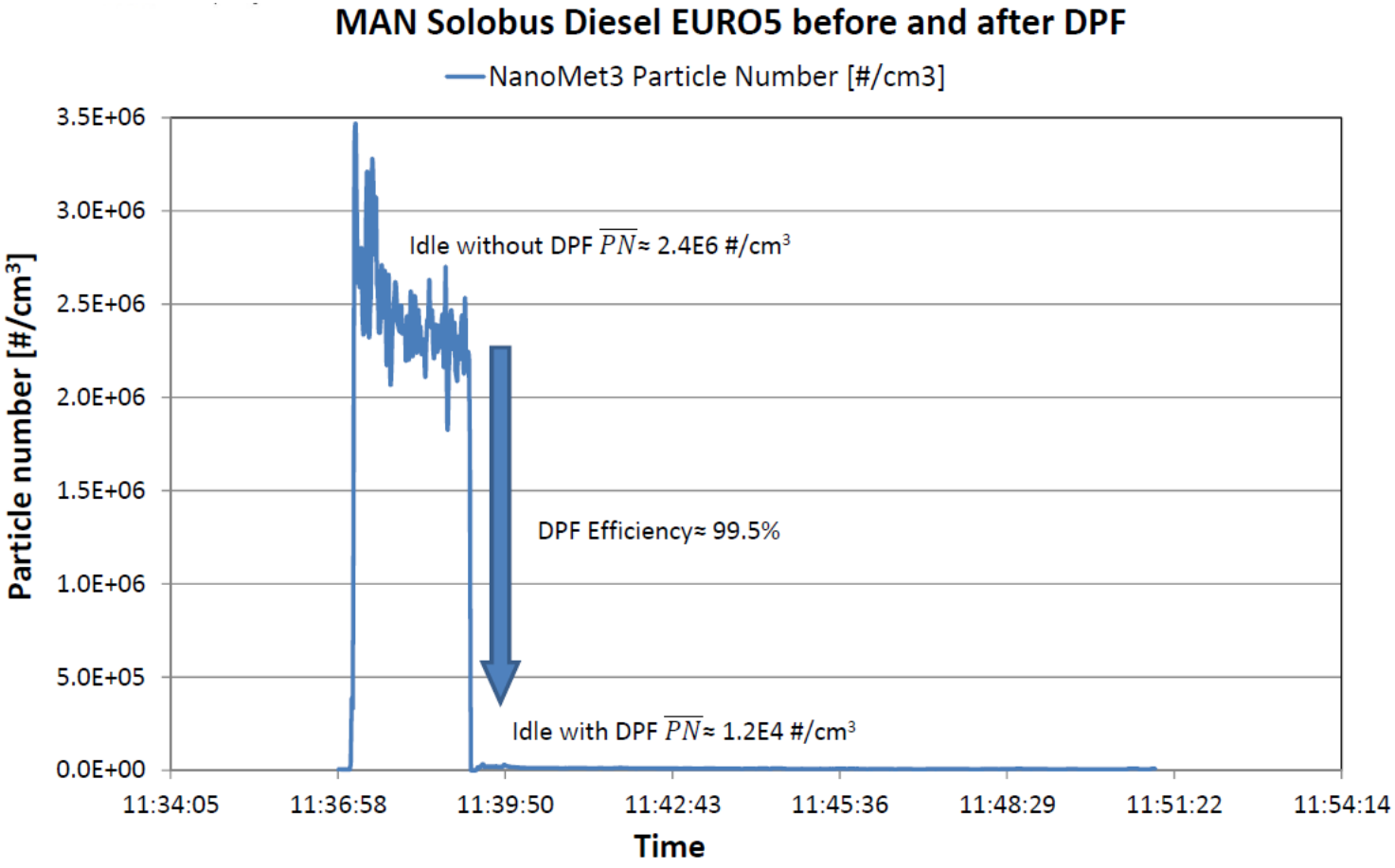
Wir messen es. testo

Periodic technical inspection in Switzerland



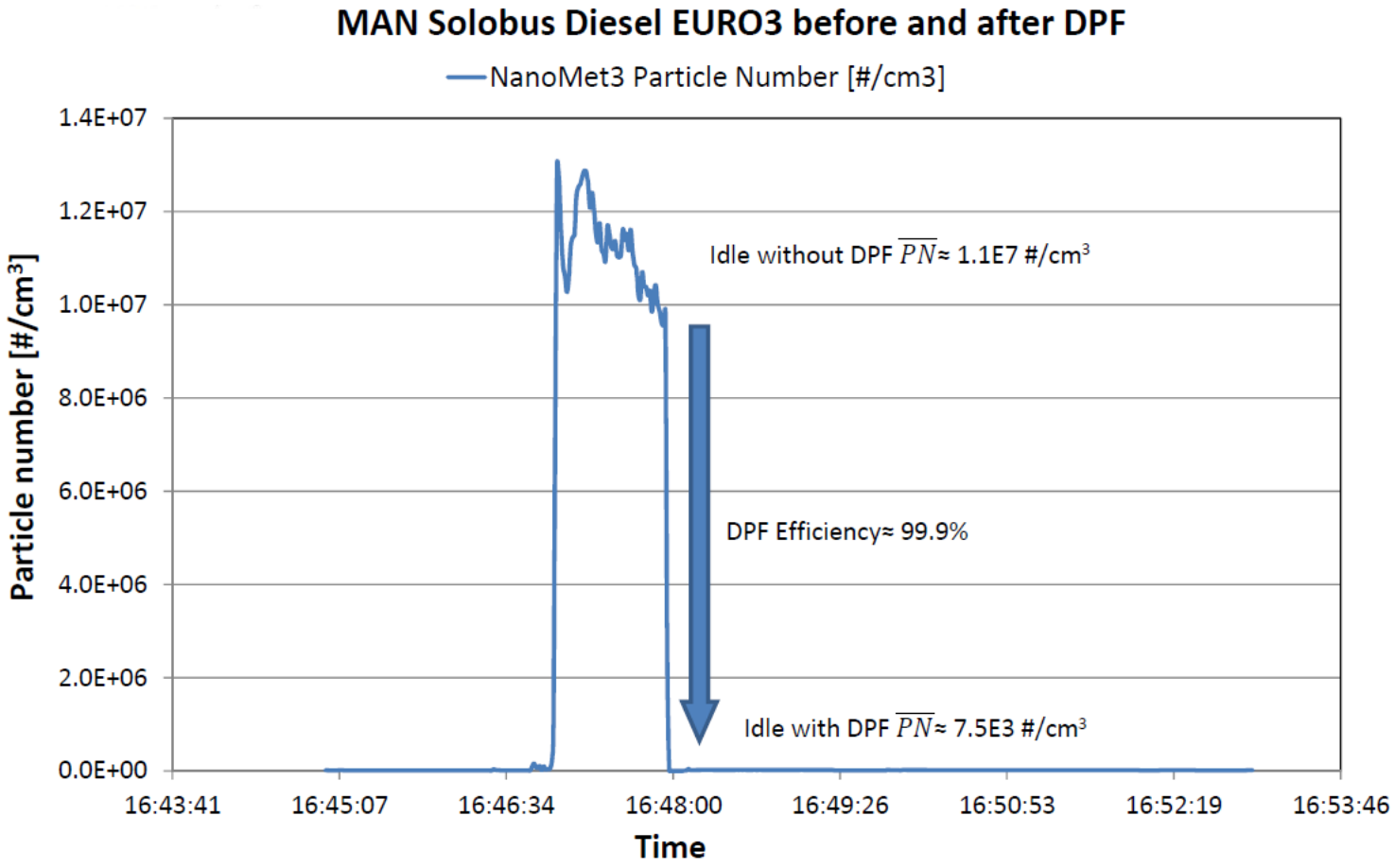
Wir messen es. testo

Retrofit projects in Switzerland



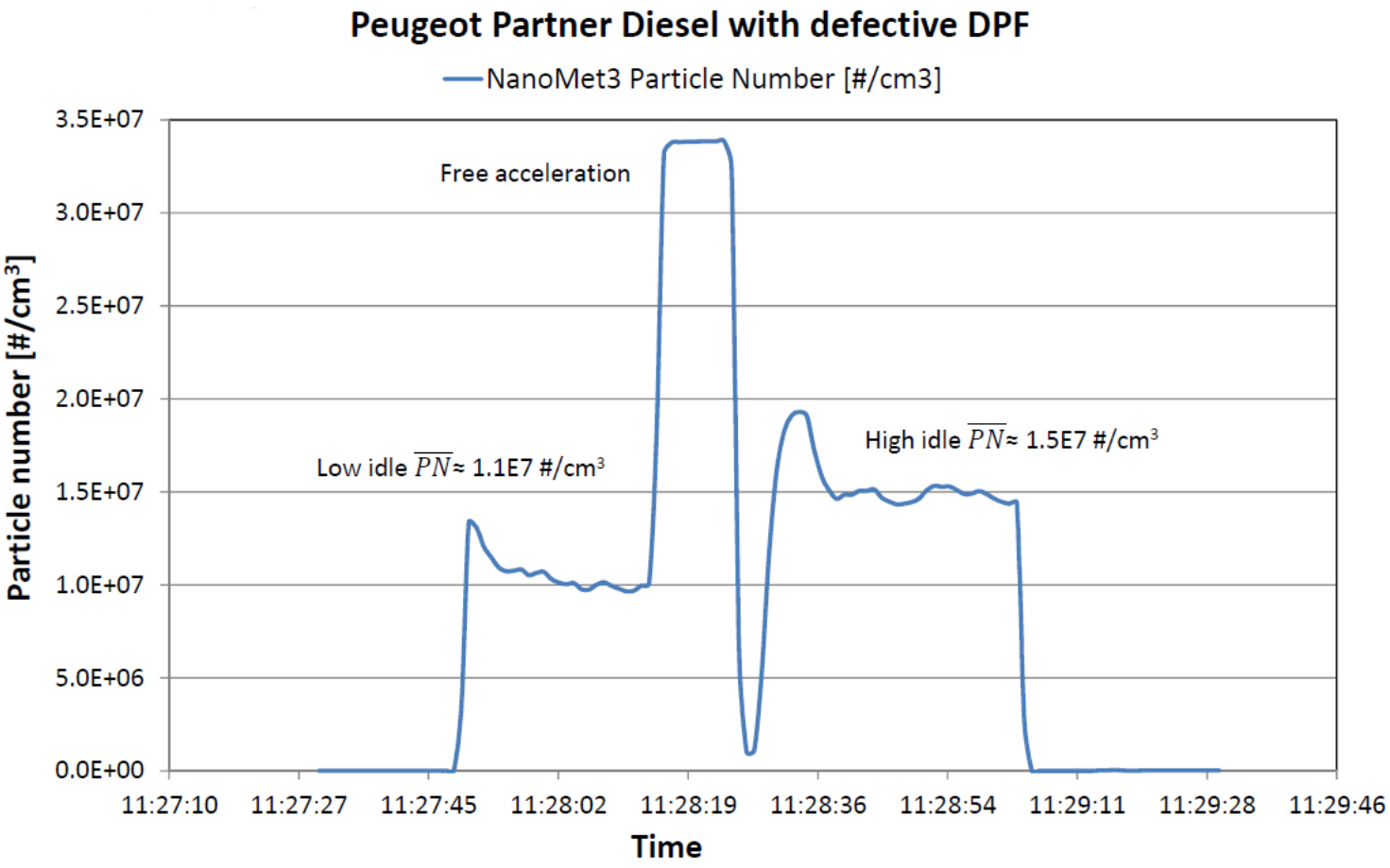
Wir messen es. testo

Retrofit projects in Colombia, Santiago de Chile, China, Iran, Israel, Mexico…



Wir messen es. testo

Detection defective DPF



After replacement of defective DPF in this vehicle the measured concentration at idle $\overline{PN} < 1E4\ \#/cm^3$

Wir messen es. testo

Monitoring Light Duty Vehicle fleet

Nanoparticle number concentrations [#/cm³] measured with testo PEPA					
	VW Touareg 3.0 TDi Euro 6	Mitsubishi ASX Diesel Euro 5	Ford Focus ST Euro5	Audi A6 3.2 TFSI Euro 5	VW Golf 1.2 TSI Euro 5
Idle	3.5E3	4.0E3	9.0E3	8.7E5	7.4E5
2.000 rpm	9.0E3	4.0E3	5.0E3	4.5E6	1.4E6

Wir messen es. testo

Periodic technical inspection LDV fleet

Stationair draaiende motor

Met filter	Zonder filter
Renault grijs	Renault zwart
1736	4491476
1913	4632870
9	4803802
1219	4.642.716

RDW

Roetmeettestdag 29-01-2016

HAN Automotive

Periodic technical inspection LDV fleet

Stationair draaiende motor

Met filter	Zonder filter
Ford zwart	**Ford grijs**
2.970.175	8.572.341
2.937.984	9.207.079
2.963.310	9.263.617
2.957.156	**9.014.345**

RDW

Roetmeettestdag 29-01-2016

HAN Automotive

Summary

- The current EU legislation is mainly focused on vehicle performance under laboratory conditions for type approval
- The oncoming EU legislation pretends to regulate also the performance under real driving conditions for type approval
- Swiss legislation on PN for construction machinery covers type approval requirements as well as periodic technical inspection
- Different examples on PEMS-PN applications demonstrate the necessity of periodic technical inspection

Acknowledgements

- BAFU and AFHB and AVESCO for measurement demonstration
- RDW and HAN Automotive for PTI pilot project
- Geosur for measurement campaign in Santiago de Chile
- Baudirektion Amt für Abfall, Wasser, Energie und Luft, Amt für Umwelt Kt. Solothurn, PURItech, Eberhard Bau AG, inNET Monitoring AG and Hug Engineering AG for valuable feedback

Visit us at
ETH Zurich NPC 2016

Wir messen es. testo

Thank you for your attention!

Luis Cachón, Testo AG

VERT-Forum 2016, Dübendorf 18.03.2016