



Schweizerische Eidgenossenschaft
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Swiss Confederation

Swiss Federal Office of Metrology METAS

Portable Combustion Particle Counter for On-site Control of Diesel Engines

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Outline

- Current CH-Legislation**

- Need for a new generation of instruments**

- “Nanoparticle measuring instrument” – NPM**

- Instruments?**

- Outlook**



Current CH-Legislation – type approval

Swiss Ordinance on Air Pollution Control (OAPC) Emissions requirements on construction machines

1. Emissions from construction machines must meet the relevant requirements of Directive 97/68/EC.
2. In addition, exhaust emissions from construction machines may not exceed the particle count of **1×10^{12} 1/kWh** for solid particles (on NRTC and NRSC test cycles according to PMP Protocol)

The particle count limit value cannot be verified on the construction machine in real operation

=> The value of 1×10^{12} 1/kWh is only valid for type-approval at engine test bench

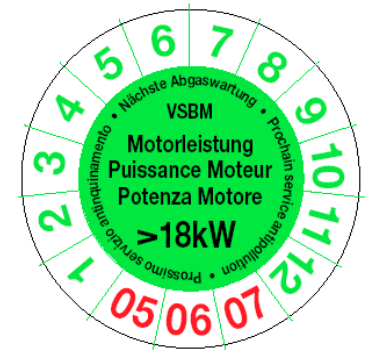
=> For in-use conformity and maintenance purposes a corresponding particle number limit concentration in $[1/\text{cm}^3]$ is needed



Current CH-Legislation – in use control

In-use exhaust measurement (tail pipe)

- Opacimeters according (with periodic verification) to VAMV (Verordnung über Abgasmessgeräte für Verbrennungsmotoren)
- Free acceleration test
- Limit to pass test:
Extinction coefficient $k < 0,15 \text{ m}^{-1}$

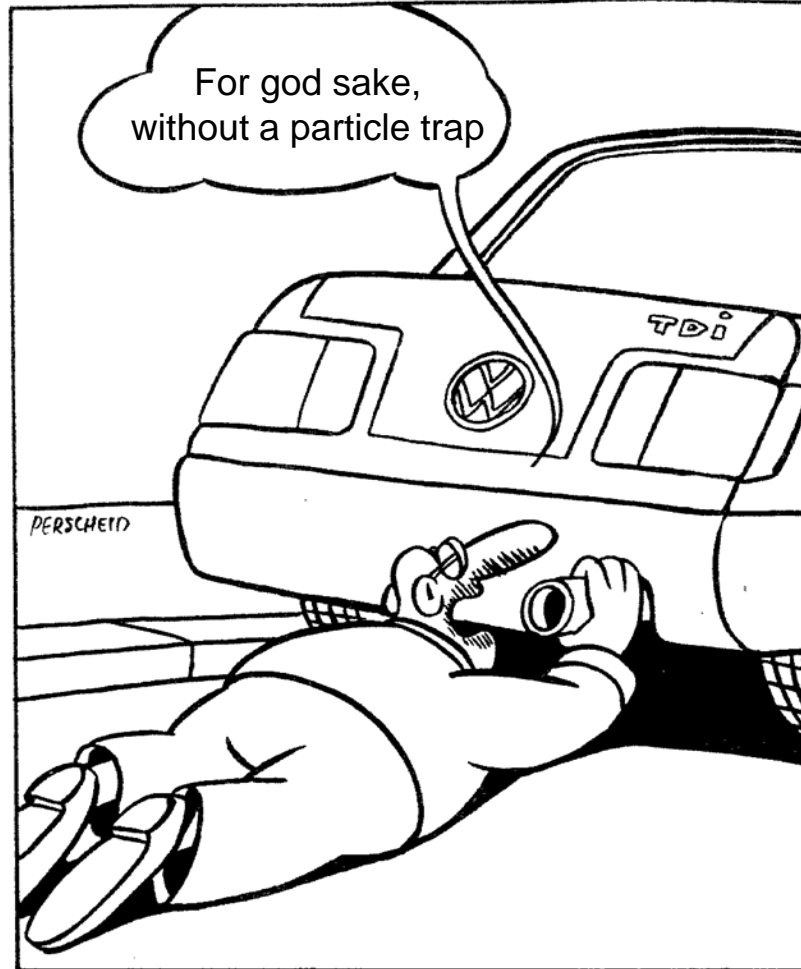


Limitations for Opacimeters

- Lack of sensitivity at low concentrations (EURO III and later)
- Free acceleration test often not applicable on construction machines
- Mandatory revolution measurement often not applicable
- Instrument not suitable for use on construction sites



New Generation of Instruments



Martin quickly found an alternative to harmful cigarettes smoke



Nanoparticle metrics

Selection of the metrics

- **Number Concentration Measurement** (particles / cm³)
 - + motivated by ECE R83
 - + high sensitivity for particles < 100 nm
 - high response time
- **High sensible opacimetry** (m⁻¹)
 - + motivated by current regulation (road and machines)
 - physical limitation for particles < 100 nm
- **Scattering light intensity** (μm / m³)
 - + fast
 - influence of chemical composition – calibration procedure
 - physical limitation for particles < 100 nm



Nanoparticle measuring instrument

Key requirements for NPM

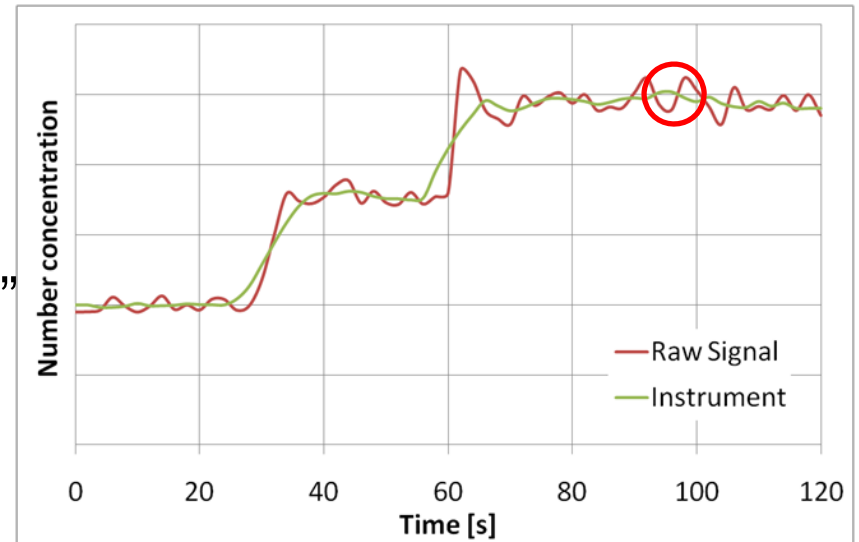
- Number concentration measurement -> in use control
(Difference to number per km or kW -> engine homologation)
- Size Cut-off defined by efficiency curve
(motivated by ECE R83)
- Nucleation particles shall be removed
(motivated by ECE R83)
- Dedicated for outdoor use



Nanoparticle measuring instrument

Measuring procedure for in-use control

- 3-step quasi stationary procedure:
 - 30 s “low idle”
 - 30 s “high idle”
 - 60 to 120 s “defined load”
- Result: Maximal particle concentration



- Print result for documentation
- Limit of number concentration to be defined in the OAPC
- No revolution or temperature measurement



Nanoparticle measuring instrument

Number concentration measurement

The measuring range shall be from 10^3 cm^{-3} to 10^7 cm^{-3} .

Values below measuring range shall be indicated as „below 10^3 cm^{-3} “, values above as „above 10^7 cm^{-3} “.

The result shall be referred to actual ambient conditions.



Nanoparticle measuring instrument

Error limits for number concentration measurement

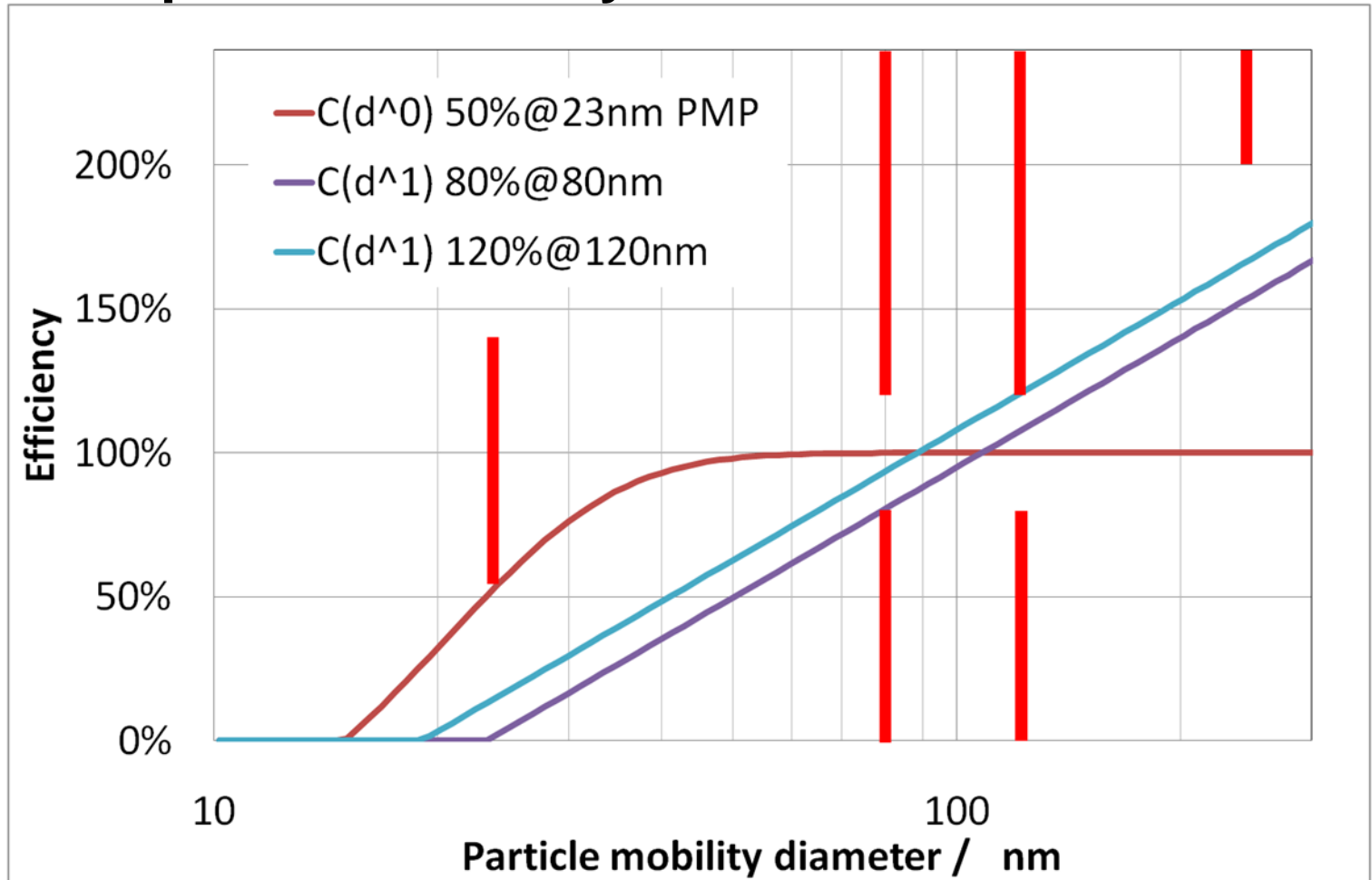
As a function of particle size and particle composition the counting efficiency E shall be within following limits:

Particle (mobility) diameter	Permitted range for E
23 nm solid particle	$E < 50 \%$
80 nm solid particle	$80 < E < 120 \%$
120 nm solid particle	$80 < E < 120 \%$
250 nm solid particle	$E < 200 \%$
30 nm tetracontane droplets	$E < 5 \%$



Nanoparticle measuring instrument

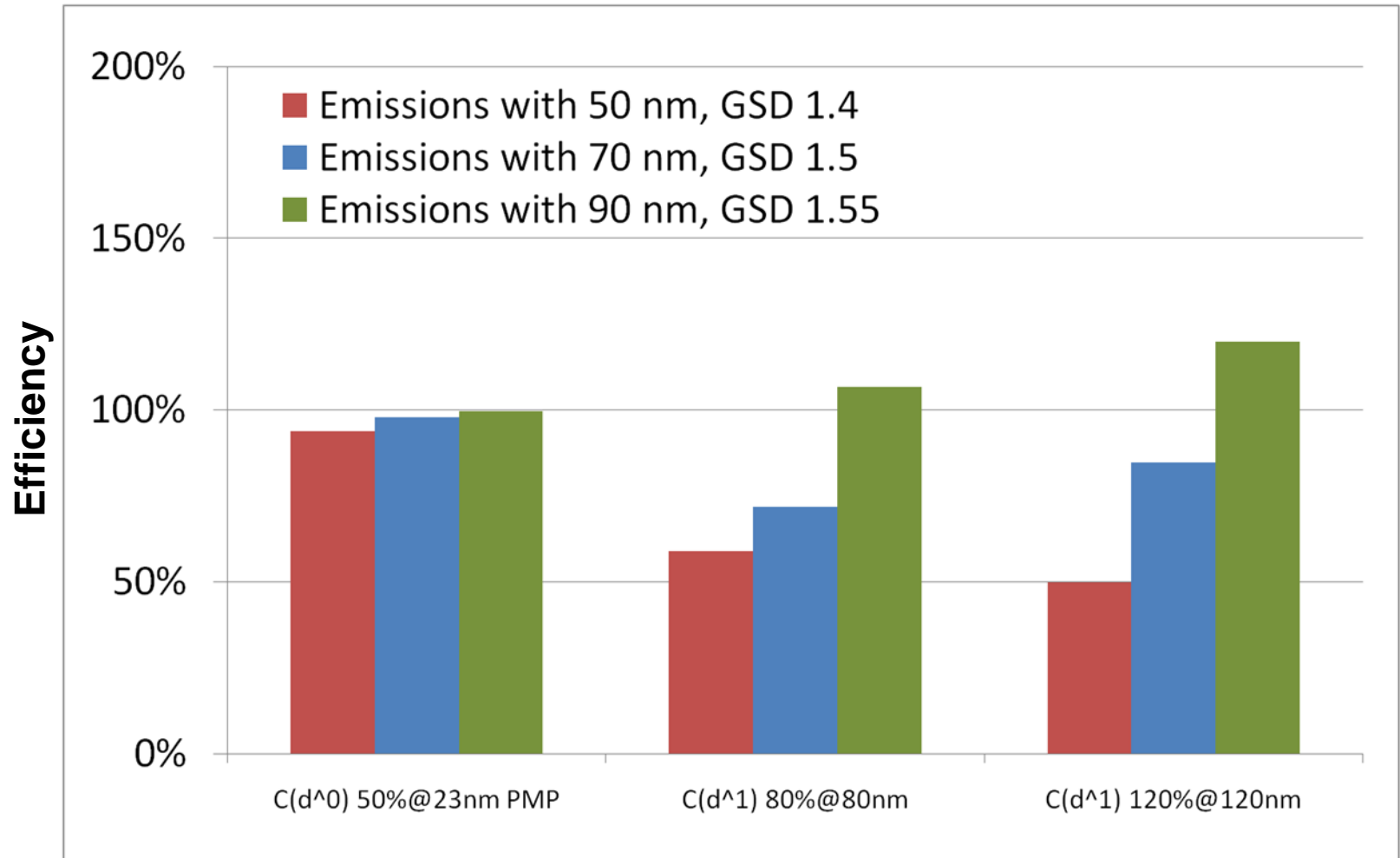
Examples of efficiency curves





Nanoparticle measuring instrument

Expected efficiency at various particle distributions



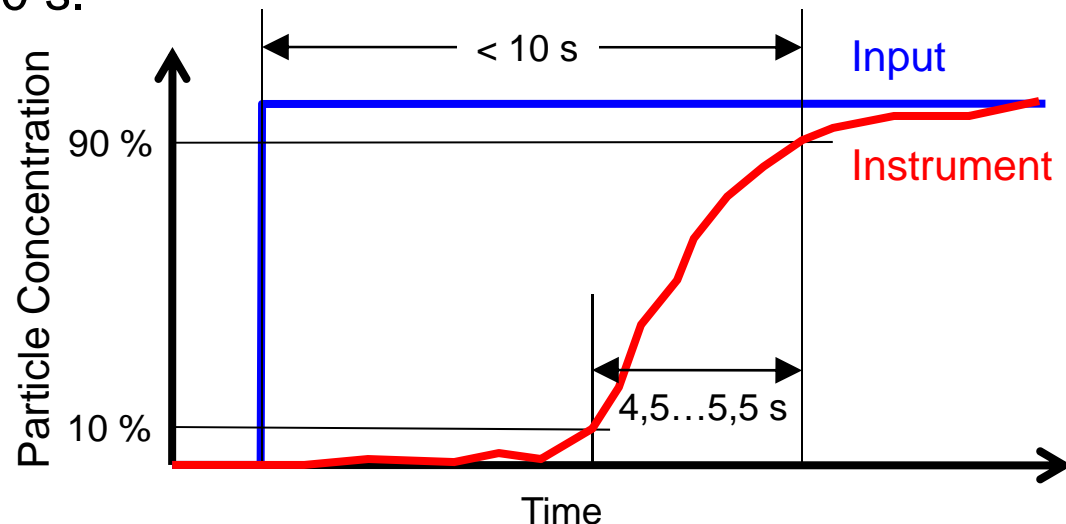


Nanoparticle measuring instrument

Requirements for time constants

Response Time: During the official measurement the instruments response from 10 % to 90 % of an instantaneous change of the particle number concentration (upward and downwards) shall last between 4,5 s and 5,5 s.

Delay Time: The duration between the entry of aerosol at the sampling line and the 90 % indication of the number concentration shall be below 10 s.





Schedule

Revision of VAMV (METAS)

“nanoparticle measuring instrument” regulation in VAMV

- 04/2010: Presentation of draft requirements
- 10/2010: Revision of requirements
- Early 2011: Adopt revised VAMV by FDJP
- 2011/2012: instrument type approval at METAS
- From 2012: Instruments available on market

Revision of OAPC (FOEN)

Replace opacity coefficient by a number concentration limit

- 2012/13: NPM complement Opacimetry
- 2014: Opacimetry is replaced by NPM



Outlook

- ❑ Particle number concentration is the metrics for future emission measurements
- ❑ Instrument technology will be ready shortly
- ❑ Legislation for “nanoparticle measuring instrument NPM” is in preparation and will come latest 2011
- ❑ Further applications for the “nanoparticle measuring instrument NPM” is evaluated
- ❑ Further research is needed to optimize the requirements for reliable measurement



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Thank you

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