

**Test rig for characterisation of oil separators-
Reproducible, reliable and quick
measurements and thus economic**

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1. Introduction

Special requirements on oil separator tests in the „Blow-by“-application

- The development of continuously improved separators at internal combustion engines demands a high-resolution measurement technology.
- Blow-by gases are **hot up to 120°C** and not constant as they depend on the engine temperature and type of oil.
- Particle concentrations with up to **10⁷ 1/cm³** and sizes up to approx. 5-8 micron must be determined quickly and exactly.
- Oil separators have to be characterised unambiguously at different temperatures, i.e. at different particle size and particle concentration as well as different volume flows with reference to their effect of efficiency.
- Changes depending on time, caused by the volume flow have to be characterised unambiguously by reliable online measurements.

Definition

Fractional Efficiency FAG

$$T(x) = 1 - \frac{C_{\text{down}}(x)}{C_{\text{up}}(x)}$$

with:

$T(x)$ = fractional efficiency

$C_{\text{up}}(x)$ = upstream concentration

$C_{\text{down}}(x)$ = downstream concentration

x = particle diameter

The more accurate and reliable the particle size x and the correspondent particle concentration C upstream and downstream are measured, the more exactly and reliably the separation curve can be determined.

A reliable determination of the particle size x can only be realised by a high size resolution and a good size classification accuracy.

The accurate determination of the particle concentration $C_{\text{up}}(x)$ is necessary!

NEW: ISO 21501-1 for optical aerosol spectrometers defines calibration of size accuracy and counting efficiency

2. Filter testing with the heatable modular test rig HMT 1000

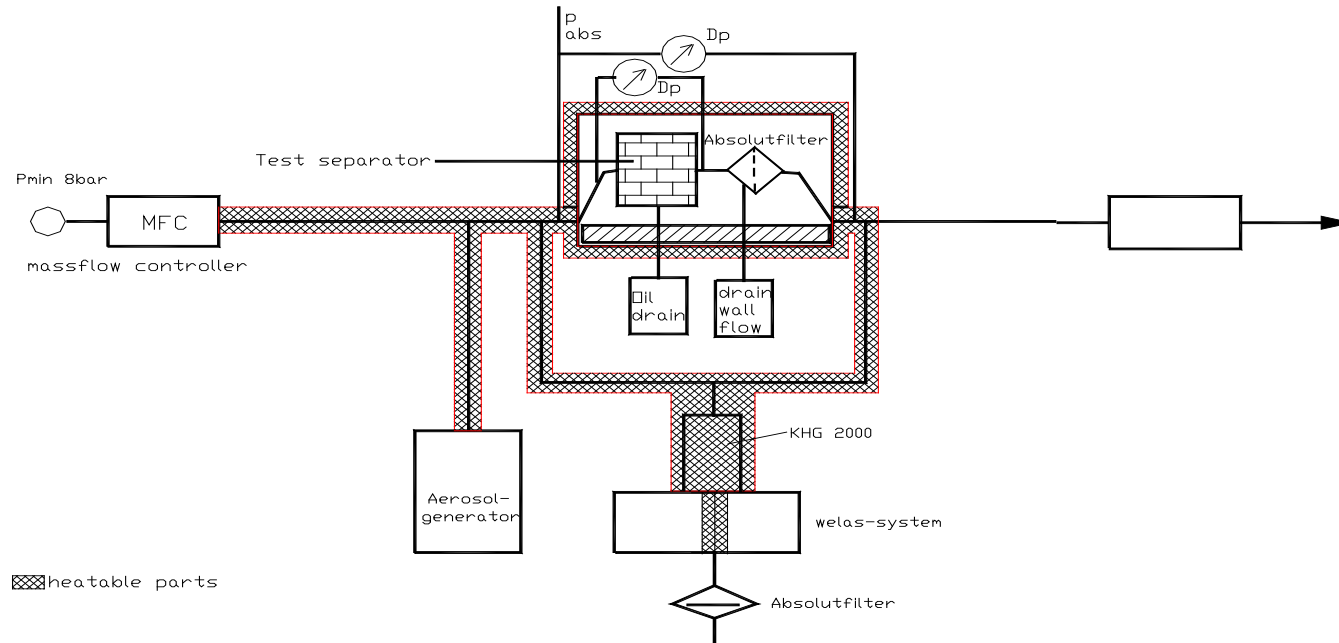
Single components of the Palas® test system HMT 1000 for oil separators

completely heatable up to 130 °C



- Heatable aerosol generator PLG 2100
- Heatable dilution system KHG10 with dilution factor 10
- Heatable aerosol spectrometer welas® digital 1000 or welas® digital 3000
- Test channel with integrated heating of test housing and mixing air
- Automatic switch to change place of measurement
- Main control unit and temperature control
- HEPA-filter and oil run-off

Example for Test set-up according to the standard for oil separators



Please note:

You can perform measurements of fractional efficiency of your separator

or

evaluate the efficiency of your separator in accordance to the new standard as shown above.

Die Welt der Palas® Aerosolgeneratoren zum Vernebeln von Flüssigkeiten

The World of the Palas® Aerosol Generators for the Nebulization of Liquids



AGF 2.0
 $dp_{max} \approx 2 \mu m$
 $\dot{m}_{max} \approx 4 g/h$

AGF 2.0 iP
 $dp_{max} \approx 2 \mu m$
 $\dot{m}_{max} \approx 2 g/h$



AGF 10.0
 $dp_{max} \approx 10 \mu m$
 $\dot{m}_{max} \approx 20 g/h$



AGF 2.0 D
 $p \leq 10 \text{ bar}$
 $dp_{max} \approx 2 \mu m$
 $\dot{m}_{max} \approx 4 g/h$

AGF 10.0 D
 $p \leq 10 \text{ bar}$
 $dp_{max} \approx 10 \mu m$
 $\dot{m}_{max} \approx 20 g/h$



UGF 2000
 $dp_{max} \approx 1.5 \mu m$
 $\dot{m}_{max} \approx 1.5 g/h$



**Expertise in
 Aerosol Generators for
 The Nebulization of Liquids**



MAG 3000
 monodisperse
 $dp_{max} \approx 0.2 - 8 \mu m$



PLG 2300
 - with heating
 $dp_{max} \approx 10 \mu m$
 $\dot{m}_{max} \approx 300 g/h$

PLG 2300 S
 - with heating and automatic refill

**Liquid, e. g. DEHS/ DOP
 EN 779, ISO CD 20564**



PLG 2100 - with heating
 $dp_{max} \approx 10 \mu m$
 $\dot{m}_{max} \approx 100 g/h$

PLG 2100 S
 with heating and automatic refill



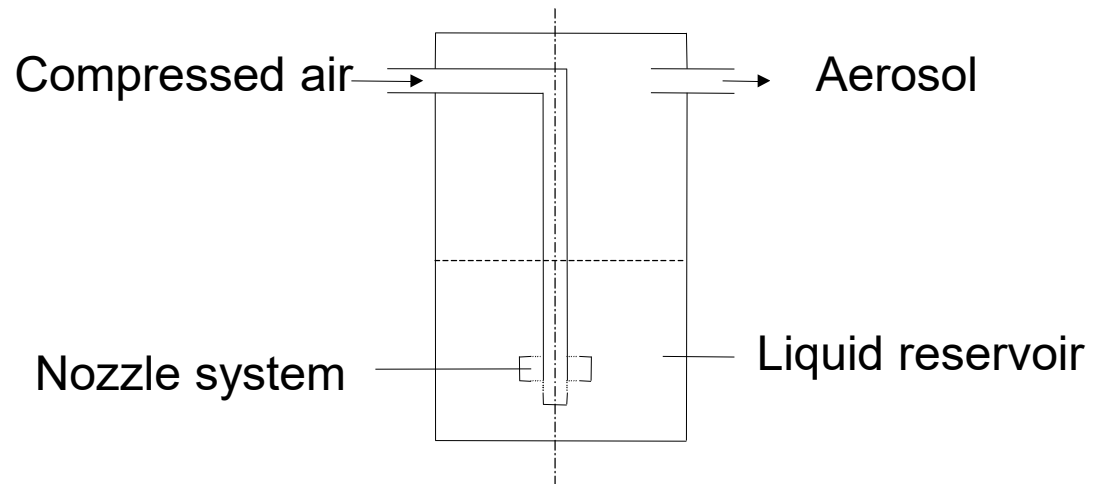
PLG 2000
PLG 2010 - with heating
PLG 2010 S with heating and automatic refill
 $dp_{max} \approx 5 \mu m$
 $\dot{m}_{max} \approx 20 g/h$

Aerosol Generator PLG Series

The liquid nebulizing system PLG 2000 to PLG 2300 has proved itself especially for the standard EN 779 and the test of **oil mist separators** as well as for production control of diesel soot filters.



Picture: PLG 2000 H special with precision pressure minimiser and integrated heating

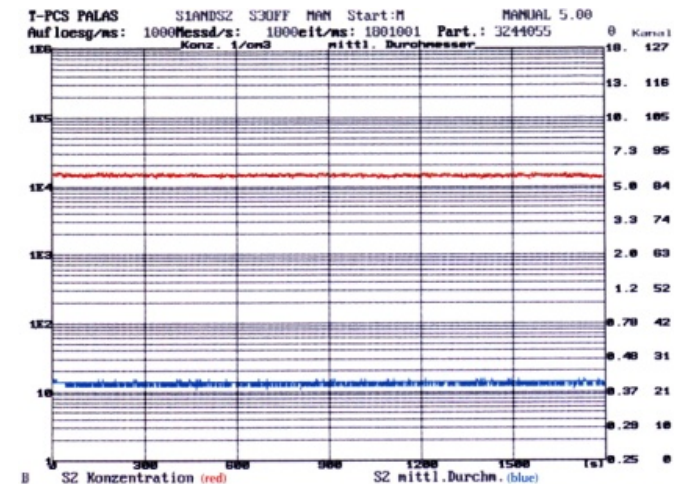


$$\dot{m} = 1 - 100 \text{ g / h}$$

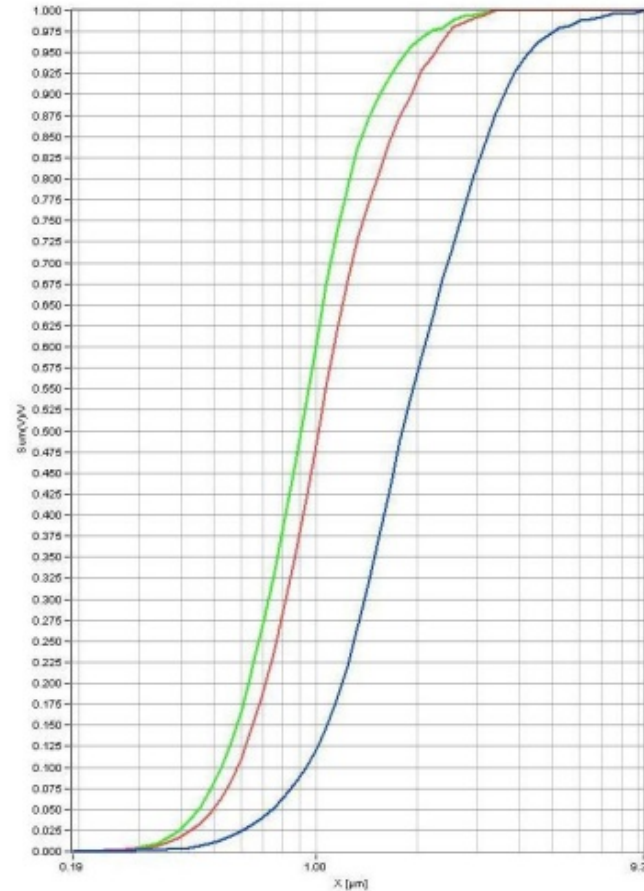
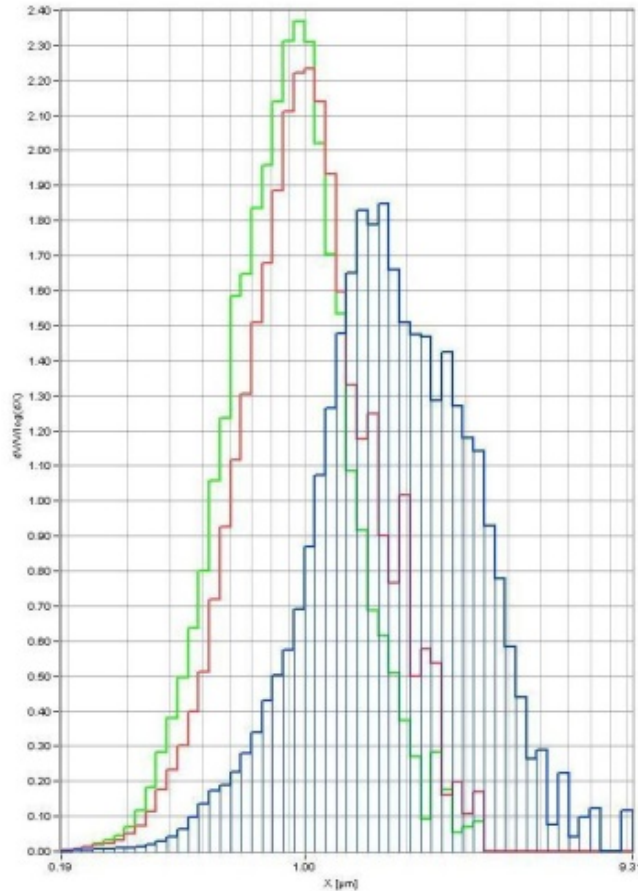
The series PLG fulfils the requirements of EN779 standard.

Aerosol generation with PLG 2100

- This highly-constant aerosol generator nebulises liquids by a special Laskin nozzle.
- The generated particle size as well as the concentration depend substantially on the type of liquid and on the chosen working conditions.
- All conditions can be chosen separately.
- At constant conditions (temperature of liquid and air volume flow) this generator operates with absolute constancy concerning the particle concentration and the particle size.
- Mass flow up to 80 g/h (10W40).



Aerosol generation with PLG-series

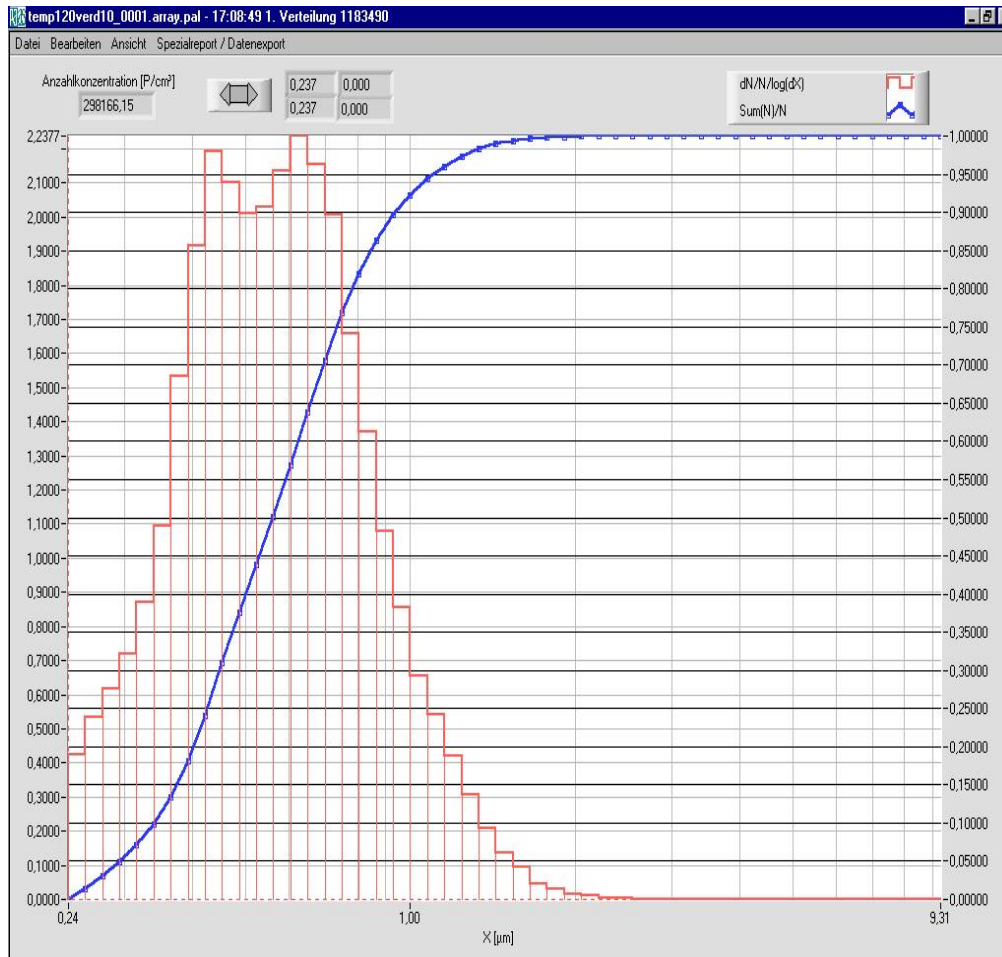


In order to test the function of the oil aerosol separators at different temperatures, an aerosol with the appropriate temperature is required. With the heatable aerosol generators of the PLG series, the particle size distribution and the mass flow can be reproducibly adjusted at different temperatures.

Particle size distribution of 10W40 motor oil at 40 °C, 80 °C and of 15W40 at 80 °C

- Blue = 15W40 at 80 °C
- Green = 10W40 at 80 °C
- Red = 10W40 at 40 °C

PLG 2100 number concentration 10W40 at 120°C



Measuring device:

welas[®] digital 1100

Aerosol generator:

PLG 2100:

- T=120°C
- initial pressure = 2 bar

Volume flow test channel 10%

Dilution system KHG 10:

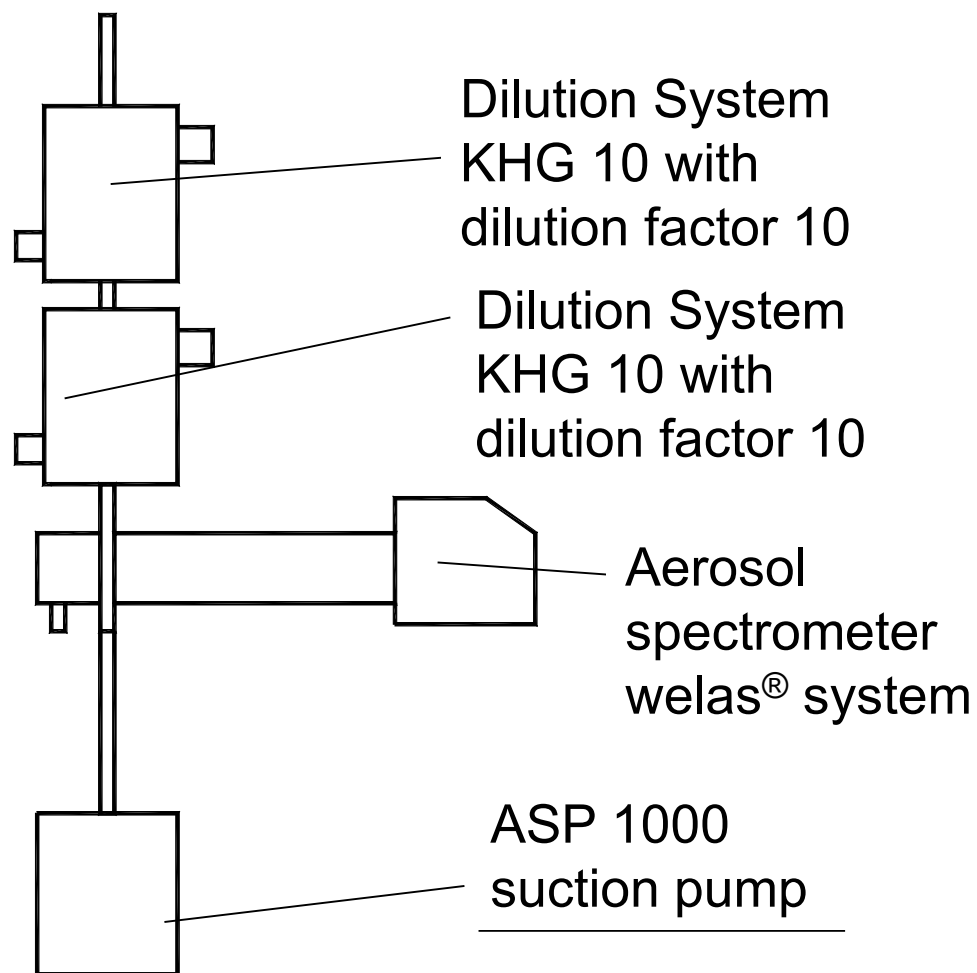
- factor 10
- initial pressure = 2 bar

Principle test set-up for Blow-by measurements

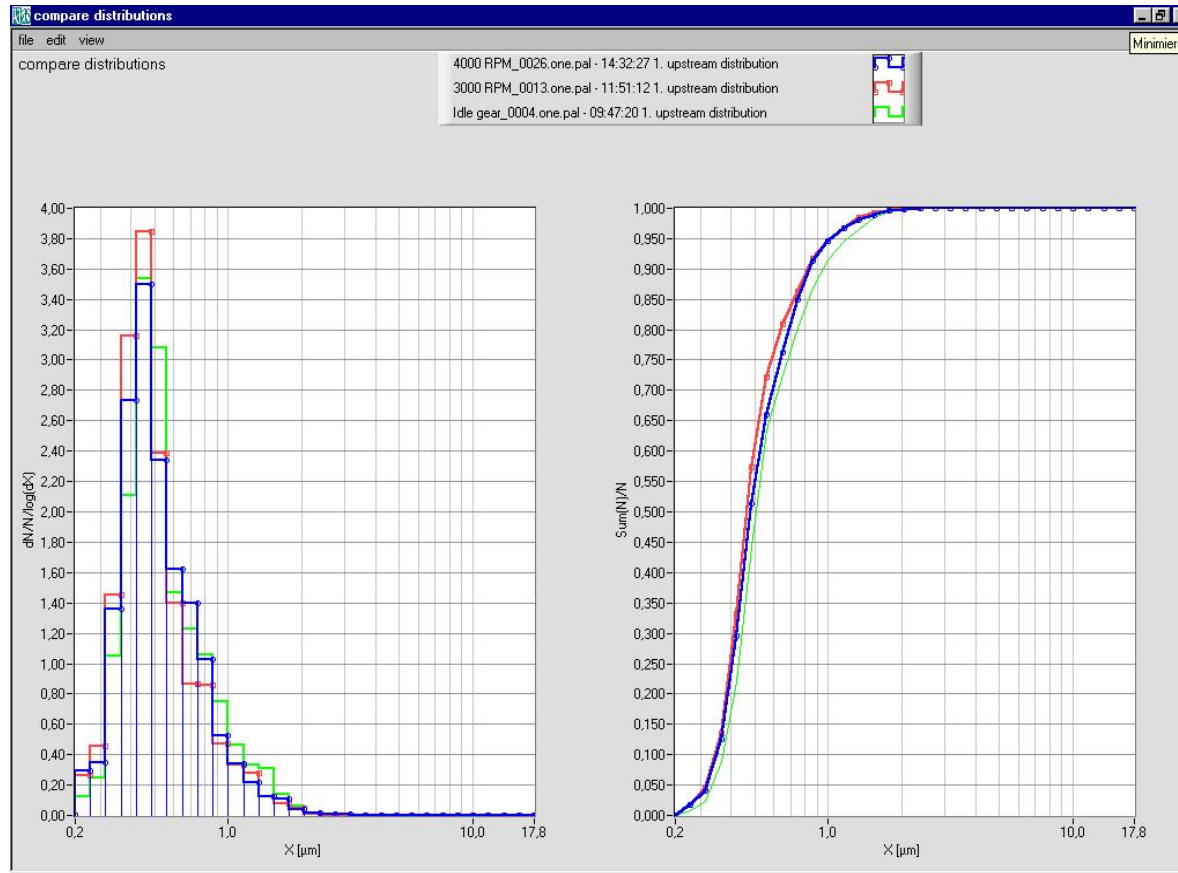
- To avoid condensation effects the whole aerosol sampling including the aerosol spectrometer must be temperature-controlled.

This is a basis to obtain reliable measurement results.

- The number of dilution systems required is related to the number concentration of the aerosol in the blow-by air flow. To dilute an aerosol with the KHG 10 dry pressurised air, free of particles is required.



In-Situ measurements at the engine with the welas[®] digital



- Variation of particle distribution by different engine speeds

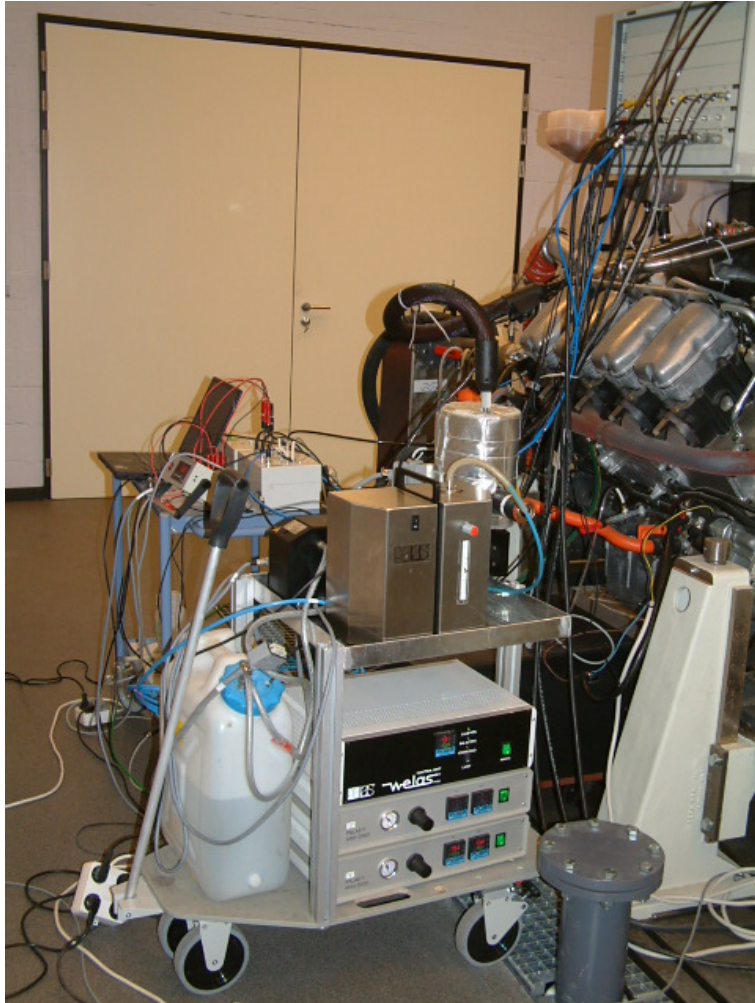
- Particle measuring device:

welas[®] system

- Dilution system:
2*KHG 10

- Dilution factor 100

In-Situ Measurement



Source:

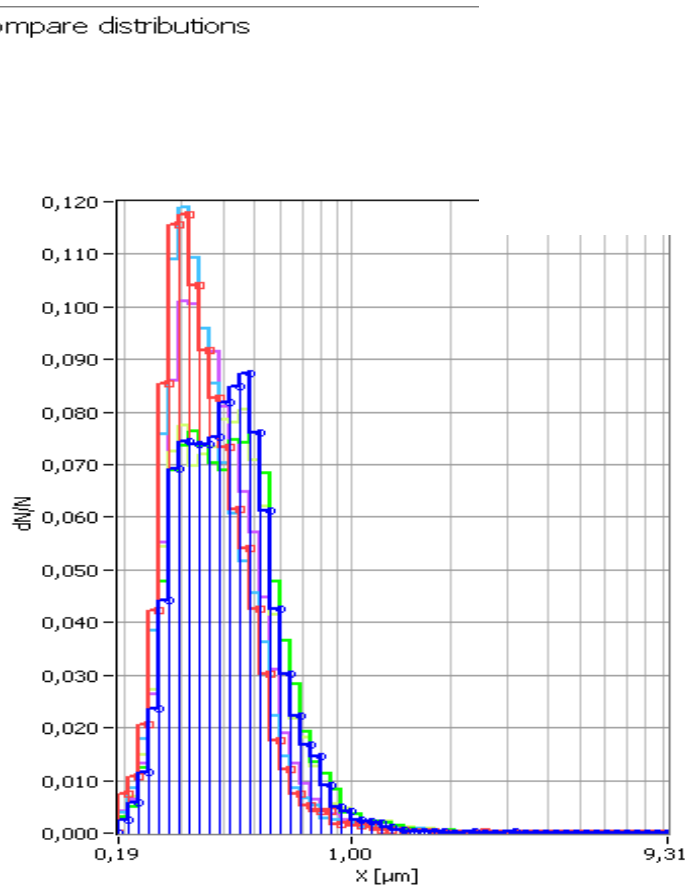
Customer of Palas GmbH for In-situ-Blow-By measurement

Used devices:

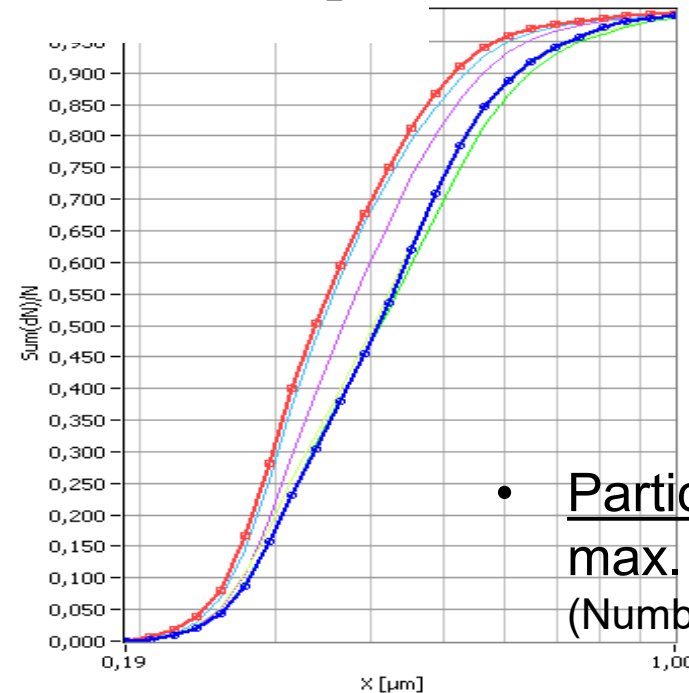
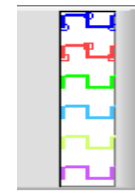
- Welas[®] digital 1000 H
- Aerosol sensor welas[®] 1100 H
- External suction pump ASP 1000
- 2 x KHG 10 (dilution systems)
- Heatable sampling line

In-Situ Measurements at engine with Welas[®] Aerosol spectrometer

compare distributions



Point3 1000_100%
Point3 2200_100%
Point2 1000_100%
Point2 2200_100%
Point1 1000_100%
Point1 2200_100%



- Particle size:
max. 2-3 μm
(Number concentration)

*Measurement at different locations and different motor speeds
1000RPM 100% and 2200 RPM 100%*