Soot Generation for the Testing of Diesel Particulate Filters and Particle Control within the Nanometer Range

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Choice of the right test system

Depending on the particular measuring requirement of the tester, e.g.

- Comparison of filters or filter media according to standards
- Quality assurance in the production of filters and filter media
- Incoming components inspection of filter media
- Optimisation of filters and filter media
- New development of filter media and separators

it is convenient to use different test systems, particularly with regard to the economy.

Test of diesel soot filters

The operating test of a diesel particle filter (DPF) has to be carried out with an artificial soot test aerosol and with the suitable measuring technology.

Test of diesel soot filters

The **production control** of DPF is realised reliably and economically with a polydisperse droplet aerosol, generated with the aerosol generator PLG-2010, and with the optical aerosol spectrometer welas®.

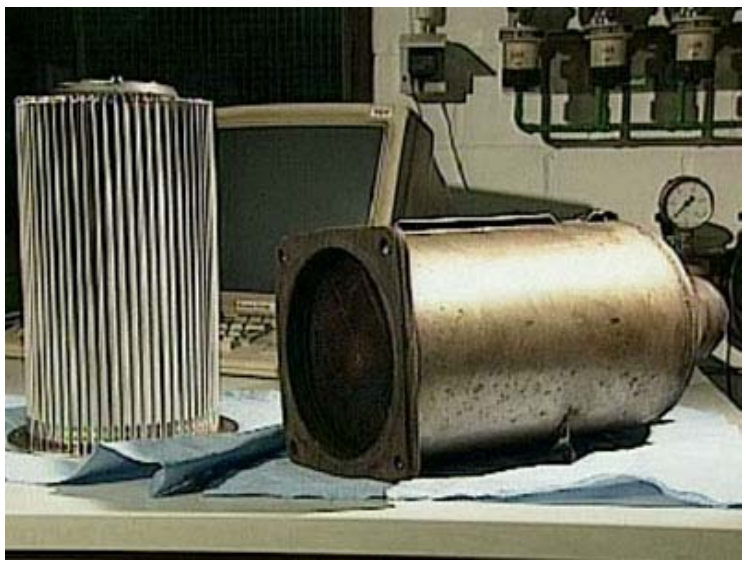
Aerosol Generator PLG

Aerosol spectrometer welas®

The **leak detection** of DPF during the production process is realised with a quasi monodisperse droplet aerosol, generated with a special PLG type, and with the optical aerosol spectrometer welas®.

Test of diesel soot filters

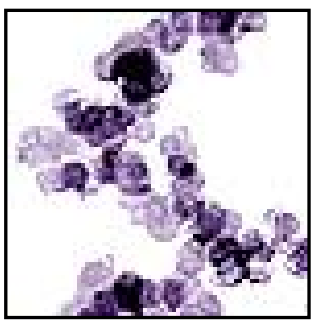
You see that this differentiated regard is necessary because not only the investment in the test system for these varying objectives but also the running costs are important.



Approach

In this presentation, I will go into

- the generation of artificial soot particles,
- the measuring of the particle number concentration from approx. 25 nm.



Soot particles - Example

A non-defined aerosol

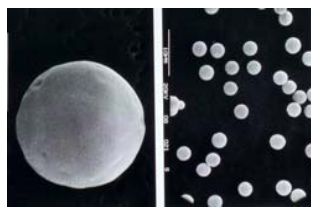
and an unstable aerosol

are not applicable for the characterisation of a DPF.

Generation of test aerosols

An aerosol generator which is used for the test of measuring devices and for the evaluation of filter media and diesel particle filters

- has to be **clearly characterised,**
- has to provide **defined, known and adjustable particle sizes and particle concentrations,**
- must be manufactured **reproducibly.**



Only under this circumstances the generator deserves the denomination **test aerosol generator**.

First overview

The different problems in testing of DPF require different test conditions in order to obtain quick, reliable and economic results.

- Leak tests and quality assurance are to be carried out with polydisperse droplets and the aerosol spectrometer welas®.
- Operative and development tests must be carried out with an artificial soot aerosol provided by a test aerosol generator.

In the next part of this paper I will introduce:

- the test aerosol generator GFG-1000 for artificial soot particles and small mass flows,
- the new test aerosol generator VSG-3000 for artificial soot particles and large mass flows,
- the new welas® CNC-module for determination of total number concentration down to 25 nm.

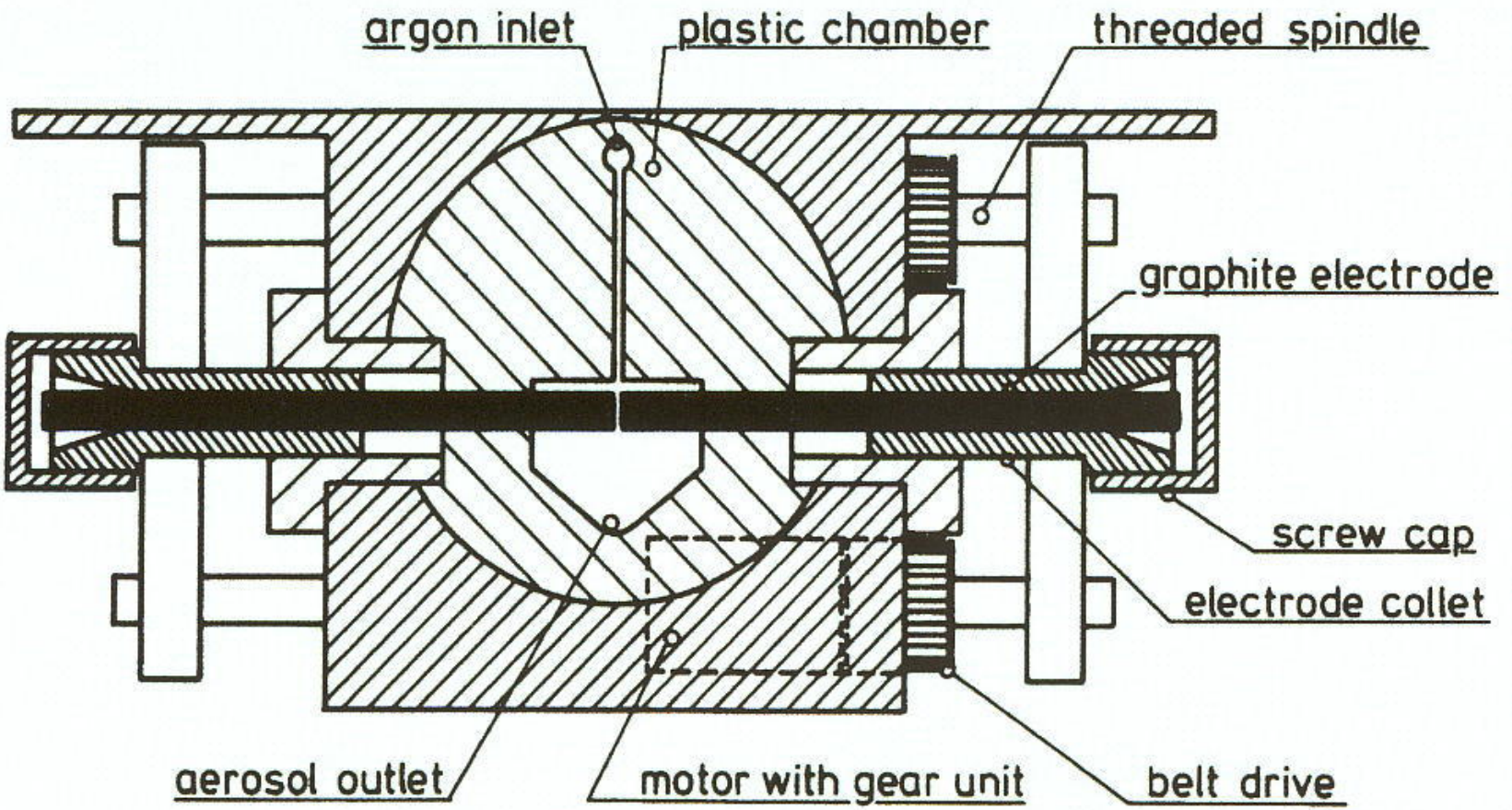
Generation of artificial soot particles in small mass flows

Spark generator **GFG-1000** according to VDI 3491 p. 16

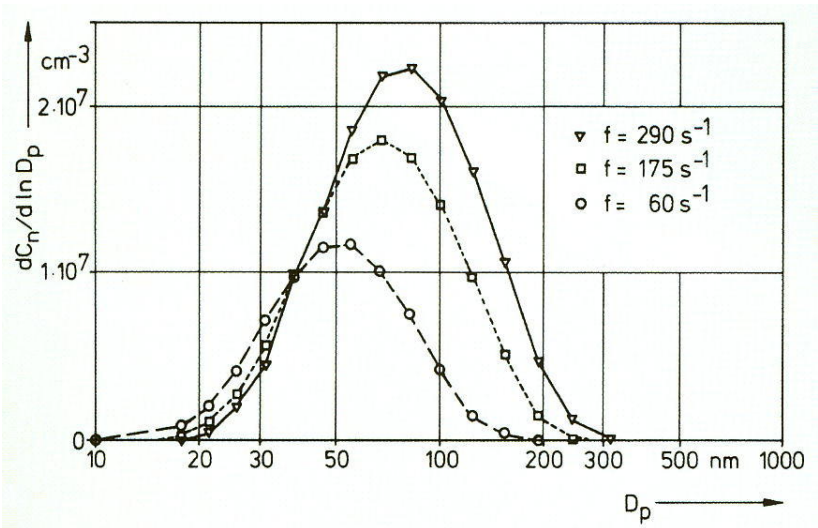
successfully established in practical use since nearly 20 years.

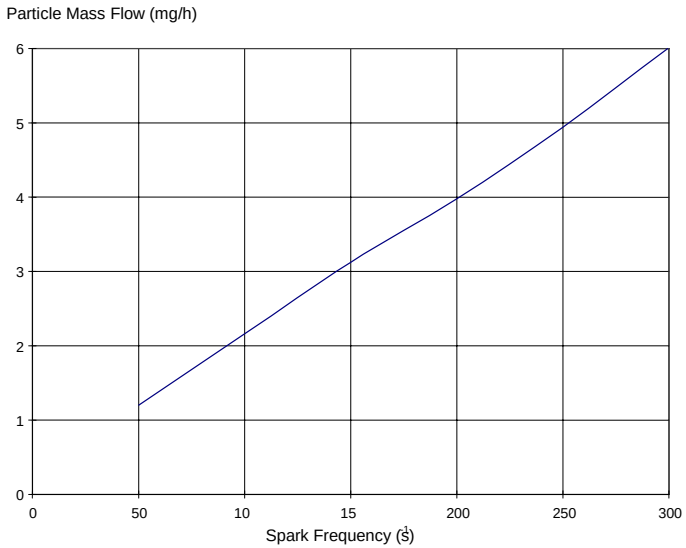
- **High number concentration**
- **High stability of particle sizes and concentrations**
- **For low mass flows (max. mass flow rate: 7 mg/h)**
- **Electrically adjustable mass concentration**
- **Controlled agglomerate formation**
- **All electroconductive particle materials: soot particles / metal particles**

GFG-1000 - Operating Principle



GFG-1000 - Particle Size Distribution





mean particle size: 20 nm - 150 nm

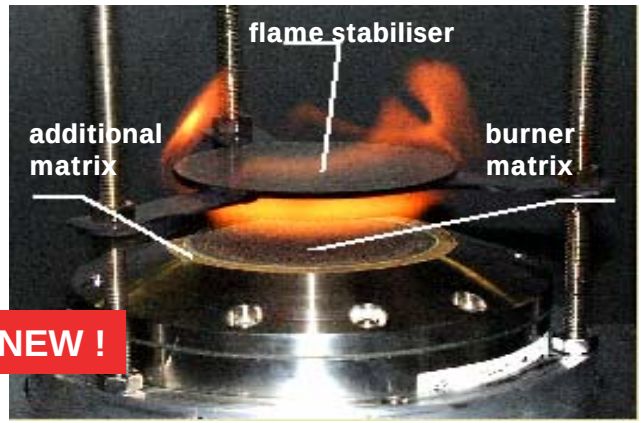
depending on operation conditions

adjustable mass flow:

relation of spark frequency to mass output

Variable Soot Generator VSG-3000

... for real combustion aerosols!



NEW !

Technical Data:

soot particle diameter: variably adjustable from 5 nm up to >200 nm

burner: Coflow Matrix burner

fuel: premixed ethene (C_2H_4) / air

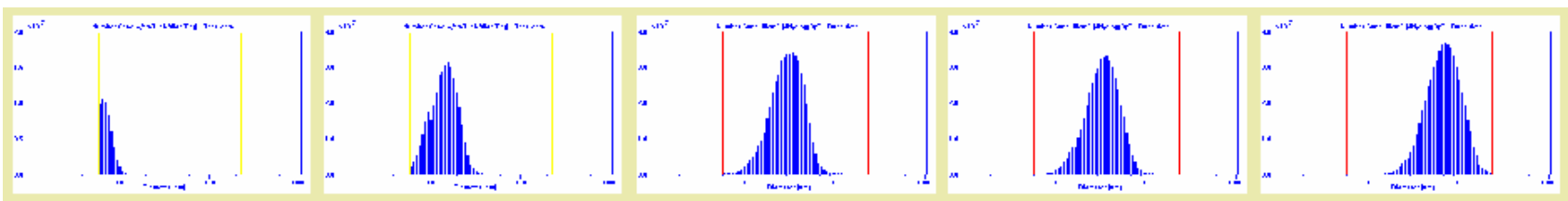
admixture: nitrogen

pressure: outside air pressure

mass flow: variably adjustable

Applications

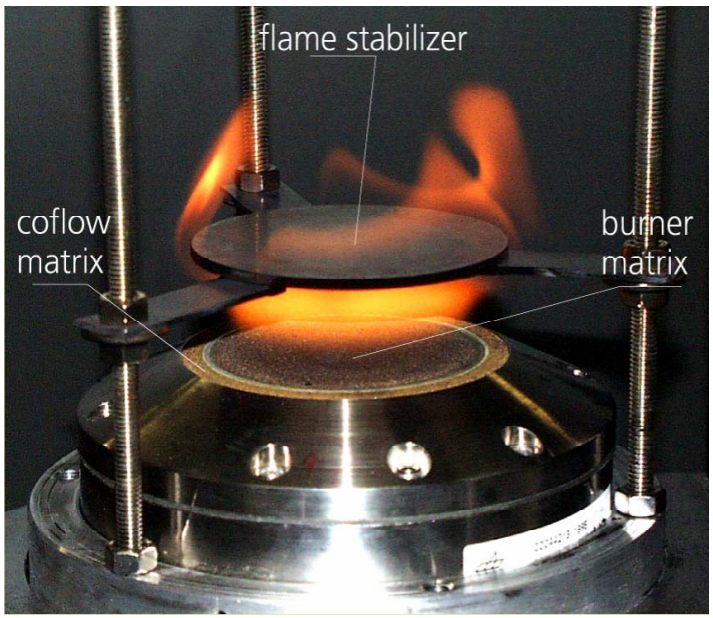
- calibration of particle measuring devices
- inhalation tests
- test of diesel soot filters
- atmospheric research
- test of fire detectors

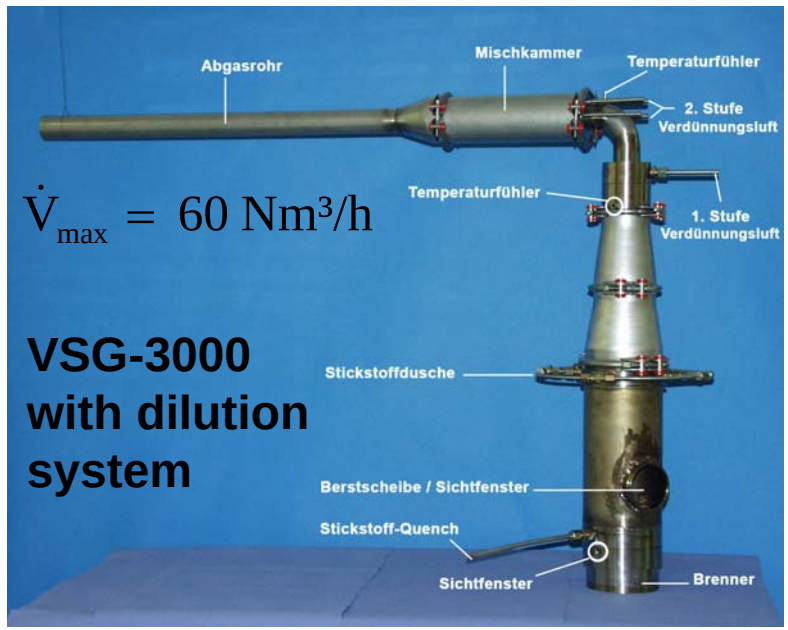


diameter d = 7,5 nm | **diameter d = 15,2 nm** | **diameter d = 32,8 nm** | **diameter d = 36,7 nm** | **diameter d = 76,3 nm**

Generation of artificial soot particles in high mass flows

Variable Soot Generator VSG-3000 in licence DLR Stuttgart





- **mass flow adjustable up to 2,2 g/h**
- **high stability of particle sizes and concentrations**
- **soot particle diameter variably adjustable from 5 nm up to approx. 200 nm**
- **insensitive against external temperature alteration and air pressure alteration**
- **simple and robust set-up**

VSG-3000 - Adjustable mass flow

Example of mass flow with burner diameter 50-65 mm and different mixture rates φ

Mass flow [mg/h]	Geometrical mean diameter* [nm]	Geometrical standard deviation
94,7	49,47	1,86
107,4	75,76	1,72
292,4	99,2	1,75
462,3	120	1,76
889,6	152	1,71
1348,7	171	1,71
2206,4	184	1,66

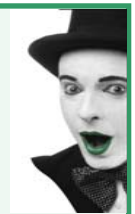
* measured with SMPS

Particle Measurement: welas® SYSTEM

Aerosoltechnologie

For measurements in particle size ranges down to 180 nm

The welas® SYSTEM Features



Due to the patented T-aperture-technology:

- **High resolution** and **good classification precision**
- Clear **calibration curve** due to **white-light source** and **90° scattered-light-detection**
- Measures **without border-zone error**
- **Coincidence detection**
- Measurements are possible in **over- and under-pressure**
- Measurements in atmospheres **down to -90°C** (welas® 2000 / 3000)
- Heatable **up to 120°C** (optional)

Palas® offers a further development of the welas® SYSTEM system for particle measurements in the nanoscale size range down to approx. 25 nm.

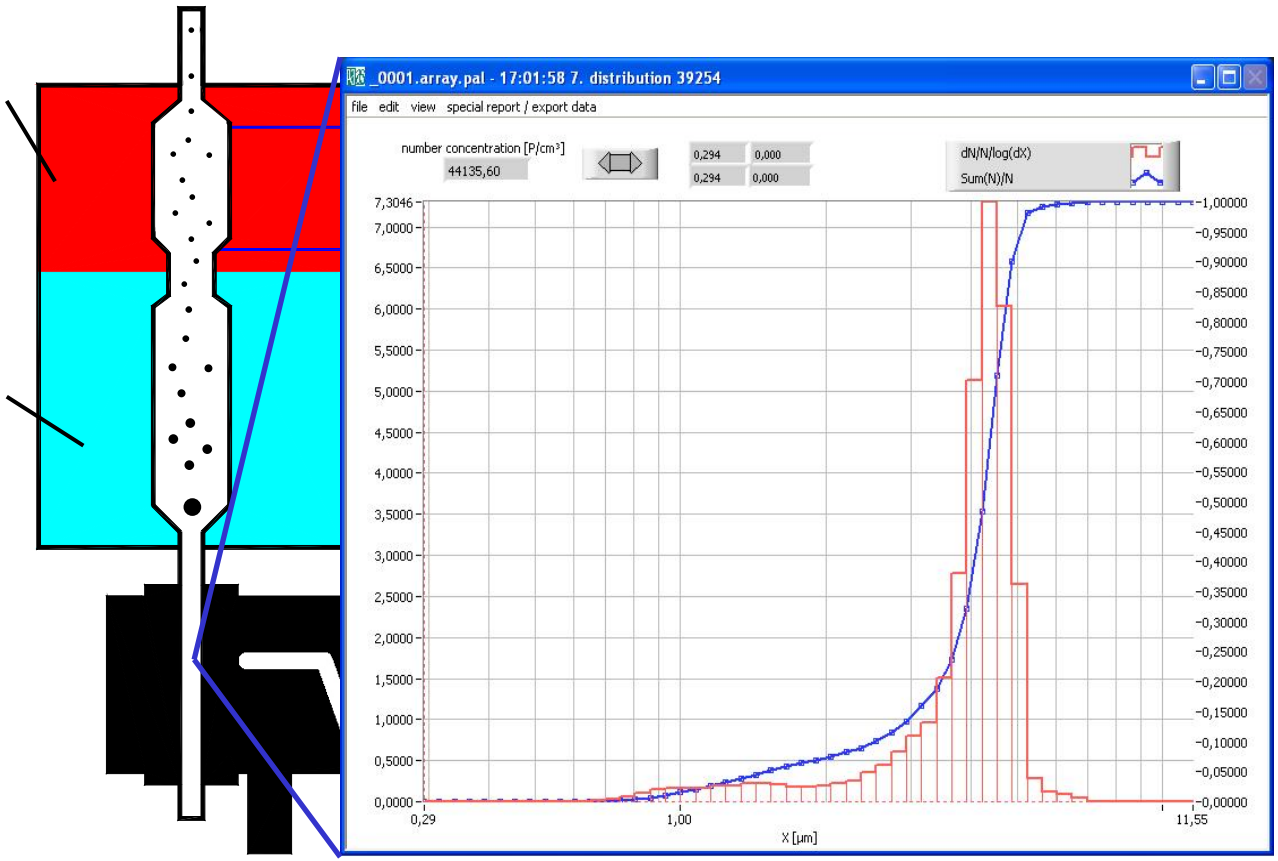
welas® + CNC-module

- **Particle counting from approx. 25 nm**
- **Concentrations up to 100.000 P/cm³ in real counts - no photometer mode**
- **Coincidence (particle overload) detection**
- **Online monitoring of number concentration**

welas® + CNC-module

VAPORATION
heating element with variable temperature control

CONDENSATION
cooling element with variable temperature control

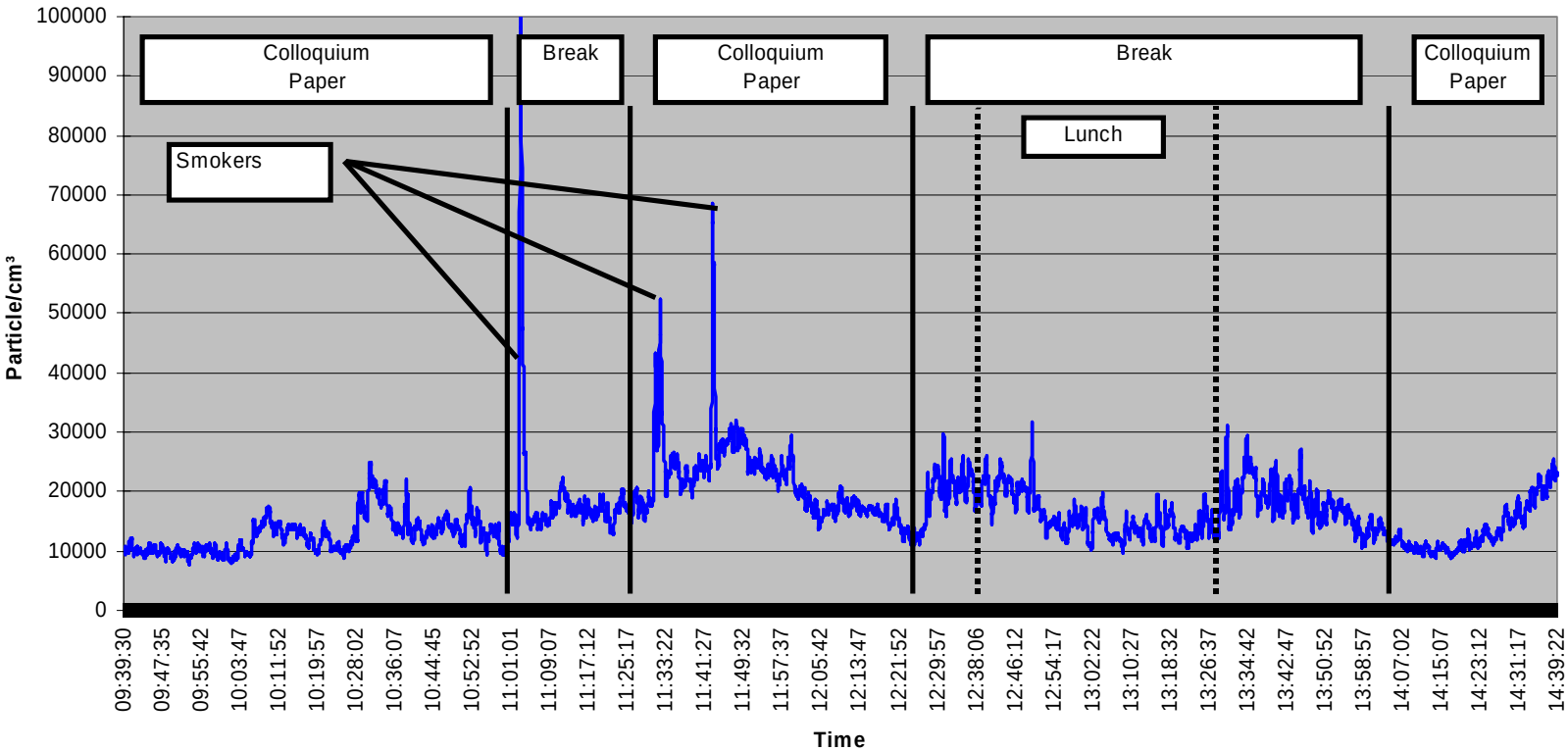


The total particle number concentration up to 100.000 P/cm³ down to approx. 25 nm is counted online by the welas® aerosol spectrometer.

welas® + CNC-module
Online monitoring of the total number concentration

Aerosoltechnologie

Total number concentration welas with CNC-module
Colloquium Schwäbisch Gmünd, Germany
08.06.2005



Summary

Since more than 20 years Palas® has been offering internationally new solutions in the field of aerosol generation, aerosol measurement and filter testing to the full convenience of our customers.

The reliable and well characterised Palas® instruments together with a robust and user-friendly design are the basis of this success.

The different applications in testing of DPF require different solutions in order to provide reliable, quick and therefor economic measurements.

With our new technology

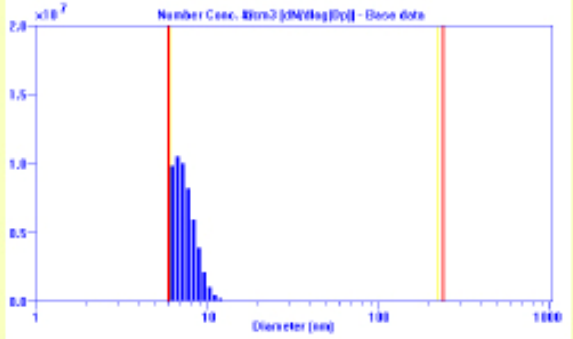
- the artificial soot generator VSG-3000 and
- the CNC-module with the welas® aerosol spectrometer

in combination with our already established equipment, we are able to offer new solutions according to the customers request as well in the field of testing DPF under conditions close to reality.

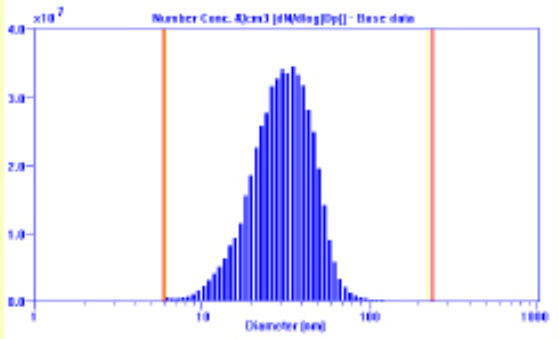
VSG-3000 - Particle Size Distributions

Examples

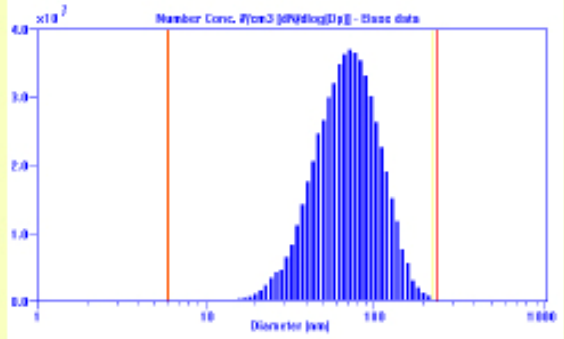
Phi = 1,85 mean diameter = 7,5 nm



Phi = 1,95 mean diameter = 32,8 nm



Phi = 2,10 mean diameter = 76,3 nm



mass volume flow: 107 mg/h

The particle size and quantity depends on the mixing ratio φ of the fuel gases and the diameter of the burner.