

NANOPARTICLE MEASUREMENT SYSTEMS

Reliable determination of particle size and number
in the nanoscale range from 4 nm to 1,400 nm



APPLICATIONS

- Research and development, environmental measurements
- Quality control and process optimisation
- Health and safety at work



NANO MEASUREMENT SYSTEMS

PALAS® OFFERS SOPHISTICATED AND RELIABLE SYSTEMS FOR DETERMINING PARTICLE SIZE AND NUMBER IN THE NANOSCALE RANGE FROM 4 NM TO 1,400 NM.



THE EXPERIENCE

To illustrate the dimension: A nanometre to a metre is like the diameter of a hazelnut to that of the globe. As far as their size is concerned, ultrafine nanoparticles border on molecules and have only since the invention of the scanning electron microscope been rendered visible.



1 nm to 1 m is like the diameter of a hazelnut to that of the globe

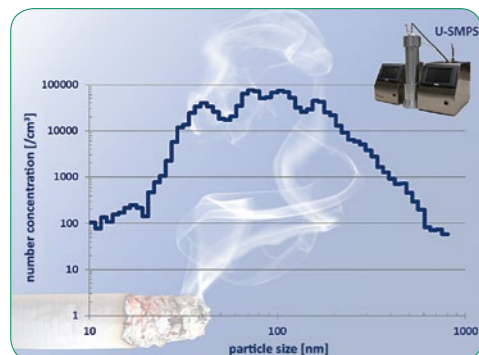
Today there is hardly an industry that manages without them: They are used in the chemical industry, the automobile industry, as well as in energy and environmental technologies. Nanoparticles are used in crèmes, sprays, medicines, paints and even in the textile industry.

Reliable determination of nanoparticles

Measurement systems are required in research and development, in industrial processes, as well as in environmental and climatic studies where size distribution and number concentration of nanoparticles is reliably determined.

Additional areas of use include measurements at the workplace and in enclosed spaces to ensure health and safety at work.

Palas® offers sophisticated and dependable systems for various measurement tasks in research and industry for determining particle size and number in the nanoscale range from 4 nm to 1,400 nm.



Cigarette smoke size distribution measured with U-SMPS

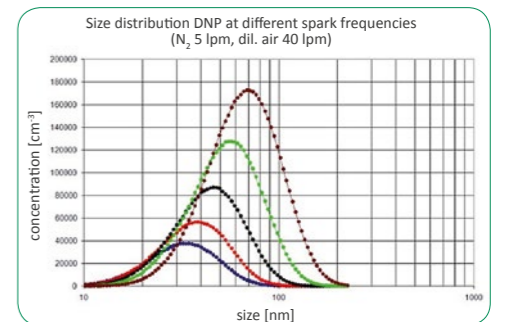
Over 30 years of experience

Palas® GmbH has been engaged in the determination of particle size and number in gases for several decades. This also includes experience with rendering ultrafine particles measurable through condensation. The condensation particle counters from Palas® are patent protected. The technologies for discharging electrically charged aerosols and measuring electrically charged aerosols have also been part of the company's expertise for many years.

Particles can be measured with aerosol spectrometers, such as the welas® digital 1000 system, up to a size of 120 nanometres. In order to measure smaller particles, they have to be artificially enlarged. Condensation particle counters (e.g. UF-CPC) are used for this purpose. Palas® quality is revealed in detail: Various working fluids can be used in the UF-CPC from Palas®, such as butanol or water – UF-CPC is certified for both. This innovation too is patent-protected.

Top reliability and precise measurement results

We have developed nanoparticle measurement systems over recent years based on our longstanding experience in aerosol technology. They cover most of the requirements that are demanded in this special discipline. As with all our measurement systems, users can depend on premium reliability of our instruments in practical use and on precise measurement results.



DNP size distribution measured with U-SMPS



Production of the Charme®



QUALITY + COST-EFFICIENCY

Safe investment through high compatibility

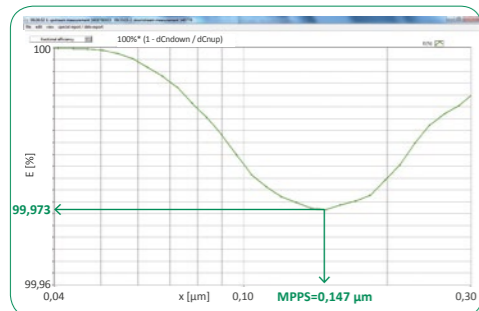
Nanoparticle measurement systems from Palas® offer the user a high degree of flexibility. The individual systems are compatible with one another while integration and combination with devices from other manufacturers are also possible without difficulty. If the measurement tasks change or become more complex, the system can be extended and modified, as necessary. This provides for very high investment protection for the nanoparticle measurement infrastructure.

All device components are assembled exclusively in-house at Palas® and undergo strict quality assurance testing. The Palas® quality management system is DIN EN ISO 9001:2008 certified.

Simple operating concept, service and consultation

Alongside top precision and reliability, our devices offer a simple and consistent operating concept. Various interfaces allow uncomplicated integration in the infrastructure. Palas® starts with sound advice. Together we analyse the measurement task and recommend the best possible solution. The focus is always on optimum benefit for our customers, also with remote device maintenance and online support.

The quality and technical advantages are the reason that the nanoparticle measurement systems from Palas® not only work extremely reliably, but are also particularly cost-effective in their operation as a result of their minimal maintenance costs. These factors help you drop your operating costs.



U-SMPS measurement: Fractional separation efficiency measurement of a filter medium below 300 nm



Production of the welas® digital 1000



STANDARDS + DIRECTIVES

In the development of its particle systems, Palas® closely follows the current discussion of the relevant norms, standards and directives in industry and research. The company's employees actively participate in many working groups. Users can therefore rest assured that the measuring devices always represent state-of-the-art technology. In most cases the respective requirements are significantly exceeded.

Standards and directives for nanoparticle measurement technology

(without claiming to be exhaustive)

- **ISO TC 146/SC 6/WG 21**
Focus: Indoor measurements
- **ISO/CD 16000-34**
„Strategies for the measurement of airborne particles“
- **ISO/CD 16000-37**
“Strategies for the measurement of PM_{2.5}”
- **ISO 28439:2011 from 1. April 2011**
Workplace atmospheres – Characterization of ultrafine aerosols / nanoaerosols
- **ISO/TR 27628:2007**
Workplace atmospheres - Ultrafine, nanoparticle and nano-structured aerosols - Inhalation exposure characterization and assessment
- **CEN/TC137/WG3**
Use of CPCs at workplaces (currently being prepared)
- **VDI 3867 Sheets 1 – 6**
Particle measurements in outside air with counting measuring methods
- **ISO 15900**
Differential electrical mobility classifier (DEMC, formerly DMA)

ISO, CEN, DIN, VDI

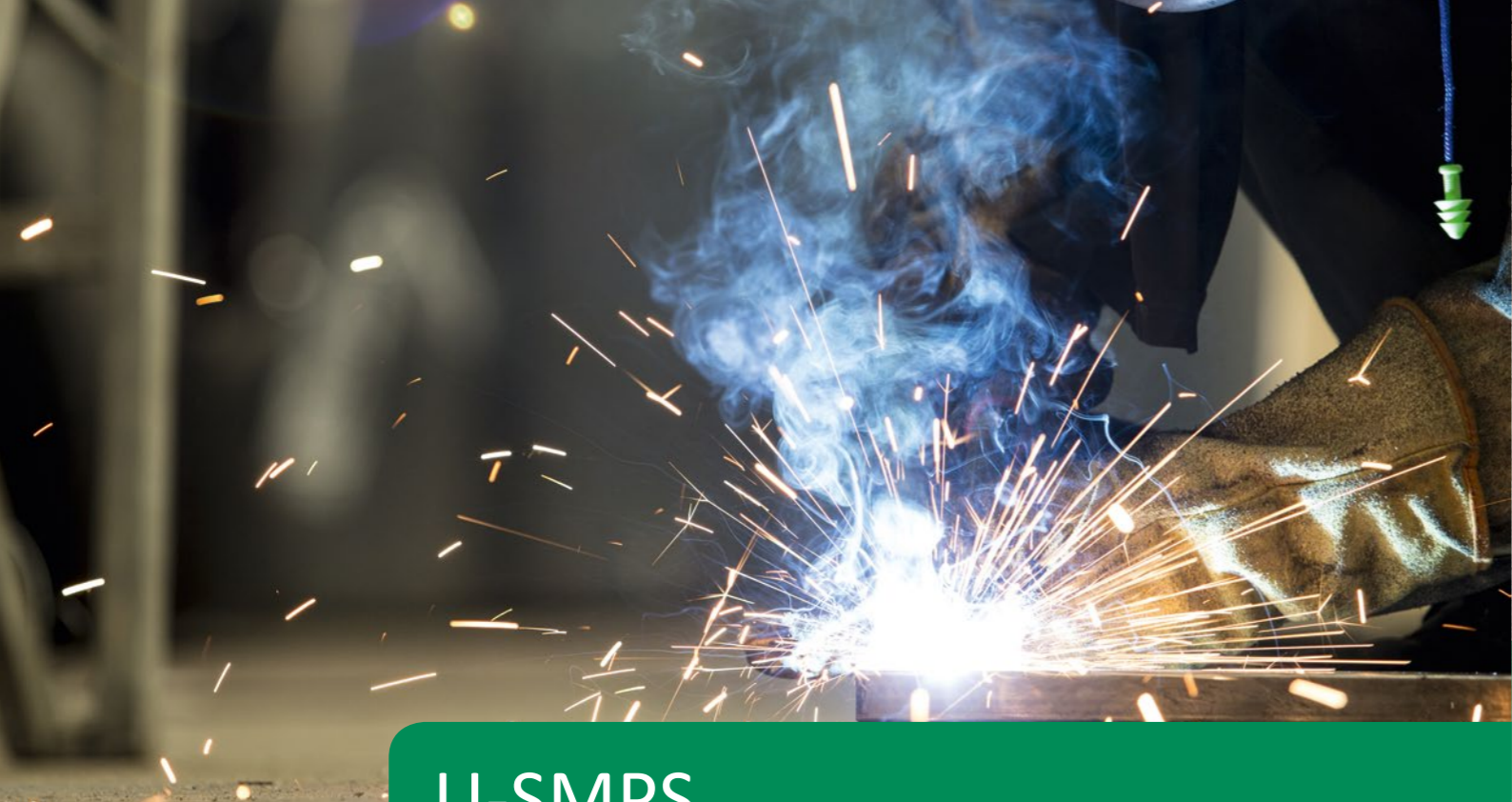
The Palas® employees' expertise and the quality of the Palas® products contribute to the standardization process.



Production of Promo® 1000



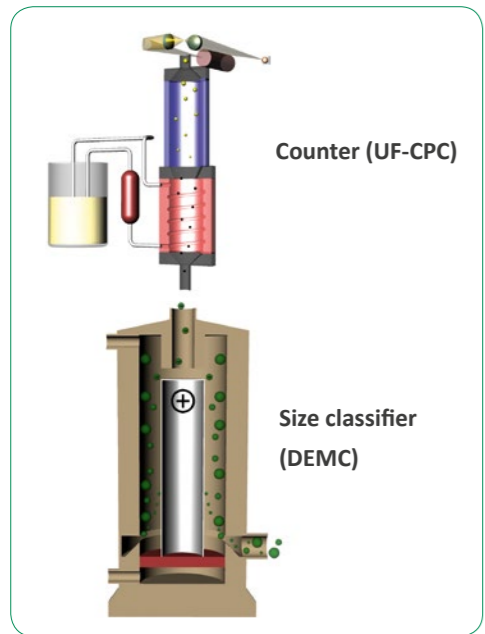
Calibration of UF-CPC 100



U-SMPS



U-RANGE



Functional principle of the U-SMPS with UF-CPC



U-SMPS 1100

Determination of particle size and number of ultrafine particles from 4 nm to 1,400 nm

The **Universal Scanning Mobility Particle Sizers (U-SMPS)** from Palas® cover a very large proportion of nanoparticle measurement technology requirements and are available in two models: The 1000 series with short classification column is particularly well suited for high precision measurements of particle size distribution in the 4 nm to 600 nm range. The 2000 series with longer classification column can be used for reliable particle size distributions from 8 nm to 1,400 nm.

Combinable with condensation particle counters or aerosol electrometers

The U-SMPS systems consist of a **size classifier (DEMC)**, in which the particles are selected according to their electrical mobility in mono-disperse aerosols. The concentration can subsequently be measured with a **condensation particle counter** such as the **UF-CPC** or an aerosol electrometer like the **Charme®** from Palas®. Palas® offers various UF-CPC models for different concentration ranges. Prof. Wiedensohler (IfT Leipzig, Germany) developed the algorithm used by Palas® for inversion of the data of the measured particles to yield the particle size distribution.

The **Charme® aerosol electrometer** is used in combination with the size classifier for measurements in very high concentrations (e.g. following a combustion process) in the U-SMPS 1700/2700 systems. These systems measure electrical charges on the aerosol particles with high sensitivity in order to thus determine the number concentration.

U-RANGE 2000 – the „zenith“ of aerosol measurement technology

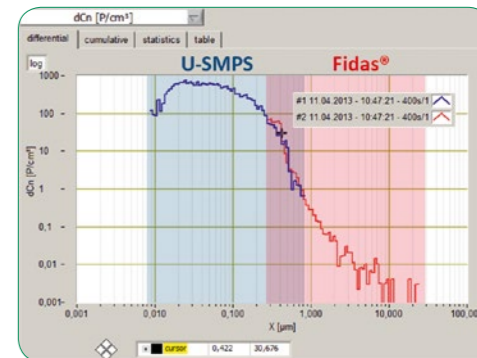
Often only a sub-analysis is performed for the determination of the aerosol concentration at the workplace, within an interior space or in the environment. In the case of mass determination, such as the fine dust fractions $PM_{2.5}$ or PM_{10} , ultrafine particles and nanoparticles are often not measured. Especially these particles penetrate most deeply into the airways and find their way into the bloodstream, e.g. via the pulmonary alveoli.

The **U-RANGE 2000** combines the U-SMPS system with the optical aerosol spectrometer Fidas® and therefore allows continuous measurement of airborne particles in the **size range from 8 nm to 40 µm with the highest precision and reliability**. The fine dust fractions (e.g. PM_{1} , $PM_{2.5}$, PM_{10}) are also measured. With this wide measuring range, the U-RANGE 2000 is the “zenith” of aerosol measurement technology. The time resolution of the system is very high. This allows measuring and evaluation of the dynamic timing of an aerosol throughout a working day, for example.

Certified fine dust measurement system

The **Fidas®** fine dust measurement system detects the light scattered by the individual particle. The devices are equipped with a **white light source** and an **unique calibration curve**. This Palas® technology is protected by three patents. The Fidas® 200 S is the world’s only optical fine dust measurement system certified according to DIN EN 15267 and approved by the German Federal Environmental Agency for single particle analysis in $PM_{2.5}$ and PM_{10} measurements.

Both systems of the U-RANGE 2000 can also be used on their own. Used in combination, the data are saved in one file.



Measurement of the number concentration with U-RANGE 2000



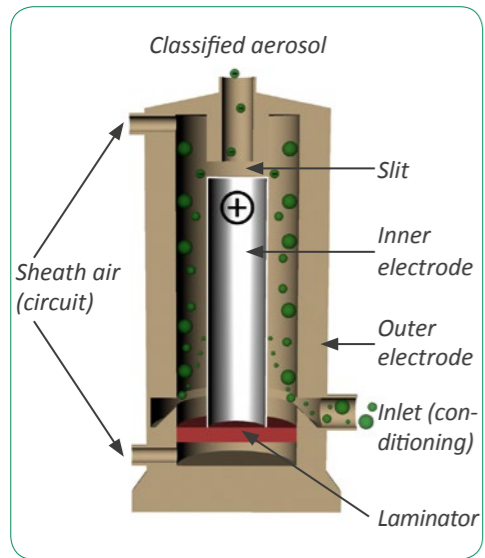
U-RANGE 2000: U-SMPS and Fidas® 200



DEMC



UF-CPC



Functional principle of the DEMC



DEMC 2000

Palas® is the first manufacturer to develop a SMPS with graphical user interface and the “up and down scan” function.

DEMC – Differential Electrical Mobility Classifier

The DEMC (often also known as DMA) is used to select aerosol particles according to their electrical mobility and pass them to the outlet of the device. Starting with polydisperse ultrafine aerosols, monodisperse particle fractions with up to 64 size classes per decade can be classified. The system is used with a short classifying column (DEMC 1000) for the size range from **4 nm to 600 nm** and with the long classifying column (DEMC 2000) for the size range from **8 nm to 1,400 nm**.

Meaningful data evaluations

The field-tested data evaluation allows the user convenient operation and delivers meaningful and reliable results. Various data export options are also offered.

Combinable with devices from other manufacturers

A special advantage is that the DEMC from Palas® can be combined universally with other manufacturers’ CPCs. As the software is developed in-house, Palas® can quickly and cost-effectively integrate the system in an existing infrastructure.

UF-CPC – Universal Fluid Condensation Particle Counter

The UF-CPC measures the total particle concentration of ultrafine particles and nanoparticles suspended in air and other carrier gases. The particles are enlarged by a condensation process in order to enable the precise determination of their number with an optical light scattering detector.

Palas® offers the **UF-CPC** condensation particle counter for low, medium and high concentrations. This enables individual particle counting up to 1,000,000 particles/cm³.

Besides the number, also the size of droplets can be measured by all the devices. The user thus obtains additional information on the condensation process.

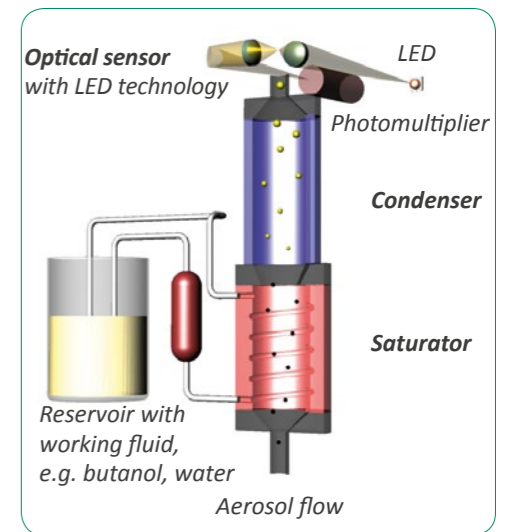
High flexibility through the selection of the working fluid

The Palas® novel and **patented working fluid delivery system** means that butanol, water or another fluid best-suited for the respective process can be used.

Besides intuitive operation via a touch display, the user is supported in data evaluation by highly developed software.

Universally network-compatible

The UF-CPC, which is equipped with an integrated data logger, is also suitable for process monitoring. The condensation particle counter supports a standardised interface, through which various protocols (e.g. Modbus) can be selected. There are other features too, such as remote access and data storage via the Internet or internal networks.



UF-CPC functional principle



UF-CPC 100



Charme®

Charme® – Reference aerosol electrometer

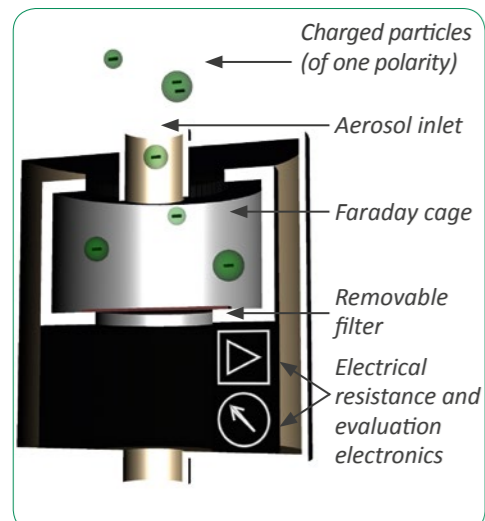
The **Charme®** reference aerosol electrometer from Palas® is used to measure the mean charge of an aerosol. The extremely high performance Faraday cup aerosol electrometer for concentration measurements within the size range of 2 nm to 100 µm features reliable performance, components of optimal quality, and easy touch screen operation. It also impresses with especially fast measurement (10 Hz) of particle concentration and of the electrometer current, which can be displayed in real-time.

In the case of polydisperse aerosols, a charger or neutralizer is frequently used to generate a defined charge distribution. If a particle size is set using an upstream classifier (e.g. Palas® DEMC), then it is possible to determine the number concentration of the particles indirectly based on a current measurement (charge/time).

Replaceable gravimetric filters

Charme® is equipped with a gravimetric filter which can be replaced by the user for in-situ correlation of the measured current with the mass concentration. This makes the aerosol spectrometer especially suitable for investigating high particle loads in the environment and at the workplace.

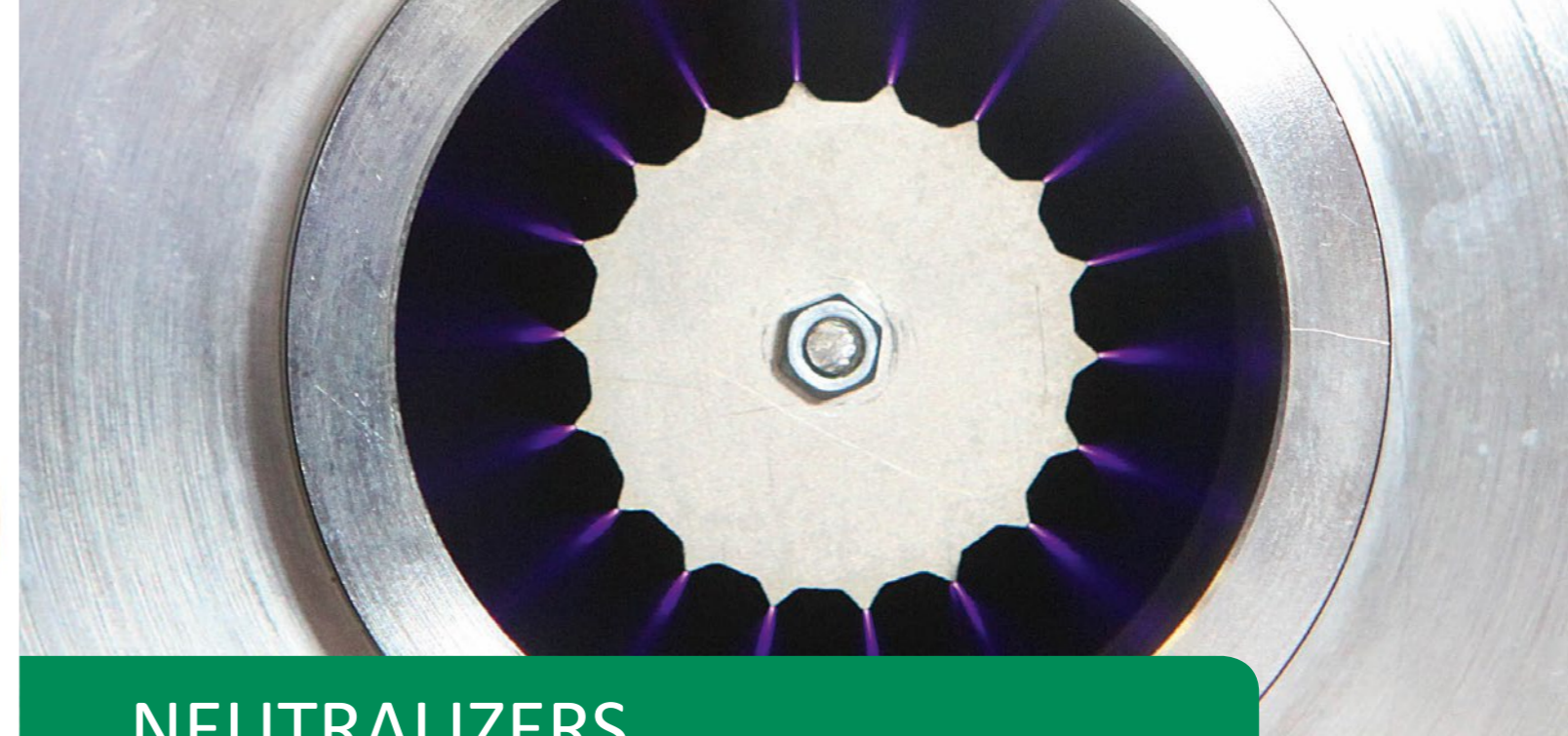
Charme® is also ideally suited for calibrating condensation particle counters.



Charme® functional principle



Charme®



NEUTRALIZERS

Defined charge distribution

An aerosol neutralizer is used to produce a defined charge distribution for measurements with a scanning mobility particle sizer (e.g. Palas® U-SMPS). To neutralize the electrical charge and to set a defined charge distribution, we offer the bipolar **Krypton-85 neutralizer** with activities of 57 MBq or 370 MBq.

Compared to unipolar neutralization, bipolar neutralization has a crucial advantage: regardless of the initial state of charge of the particles, **a reproducible equilibrium charge distribution** is always established. On request, a lead-clad additional housing may be purchased from Palas® in which the **Kr-85-57** or **Kr-85-370** can be kept during operation.

With the **XRC 370**, Palas® also offers a non-radioactive neutralizer for setting a defined charge distribution using x-rays. The XRC 370 was compared with Kr-85-57 and Kr-85-370 in a bachelor's dissertation. It transpired that XRC 370 is an attractive alternative.

Further nanoparticle measurement devices from Palas®:

- **Promo® 1000** – The Promo® 1000 was developed for process monitoring and is equipped with an integrated PC and touch screen. It can be integrated in process control systems and operated and evaluated with external software. $dp_{min} = 120$ nm, optional overpressure to 10 bar.
- **welas® digital 1000** – The welas® digital 1000 enables precise particle size and concentration determination in very high concentrations to 10^6 particles/cm³ without dilution. $dp_{min} = 120$ nm, optional overpressure to 10 bar.

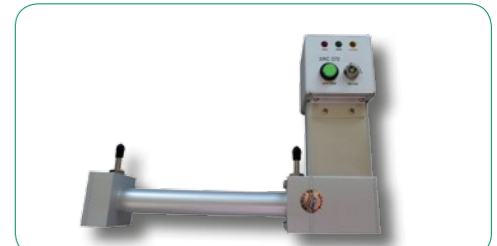
CORONA DISCHARGE

As the first company worldwide, Palas® used the principle of corona discharge in its filter test systems to neutralize the test aerosol. The innovation award was bestowed by the 'Technologiefabrik' [technology factory] Karlsruhe in 2010. The 1st prize was awarded for the development of a novel electrostatic soot separator for small heating plants by the Institute for Technical Chemistry at the Karlsruhe Institute of Technology (KIT) (Dr. Paur, Dr. Bologa, Mr. Woletz). The corona discharge showed above is an important part of this development.

Picture: Technologiefabrik Karlsruhe



Kr-85-370



XRC 370



PALAS® – MORE THAN 30 YEARS OF EXPERTISE IN AEROSOL TECHNOLOGY

With over 50 patents submitted, Palas® has set the standard in aerosol and particle technology for more than 30 years. Through continuous innovations, we achieve extraordinary quality and durability in our products.

The result is unique technical and economic advantages for our customers. Palas® has established itself as a global market leader in the fields of aerosol generation, aerosol dilution and aerosol particle measurement technology. Renowned companies, universities and research institutions in approximately 60 countries put their trust in Palas® precision technology.

OUR CORE COMPETENCIES

- Filter test systems*
- Aerosol spectrometer systems*
- Fine dust monitoring systems
- Nanoparticle measurement technology
- Particle generation systems*
- Dilution systems*
- Clean room particle technology
- Special developments
- Calibration systems*
- Services
- Training courses and seminars

* Palas® is the market leader in these product groups.

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