Testo
White paper
testo DiSCmini

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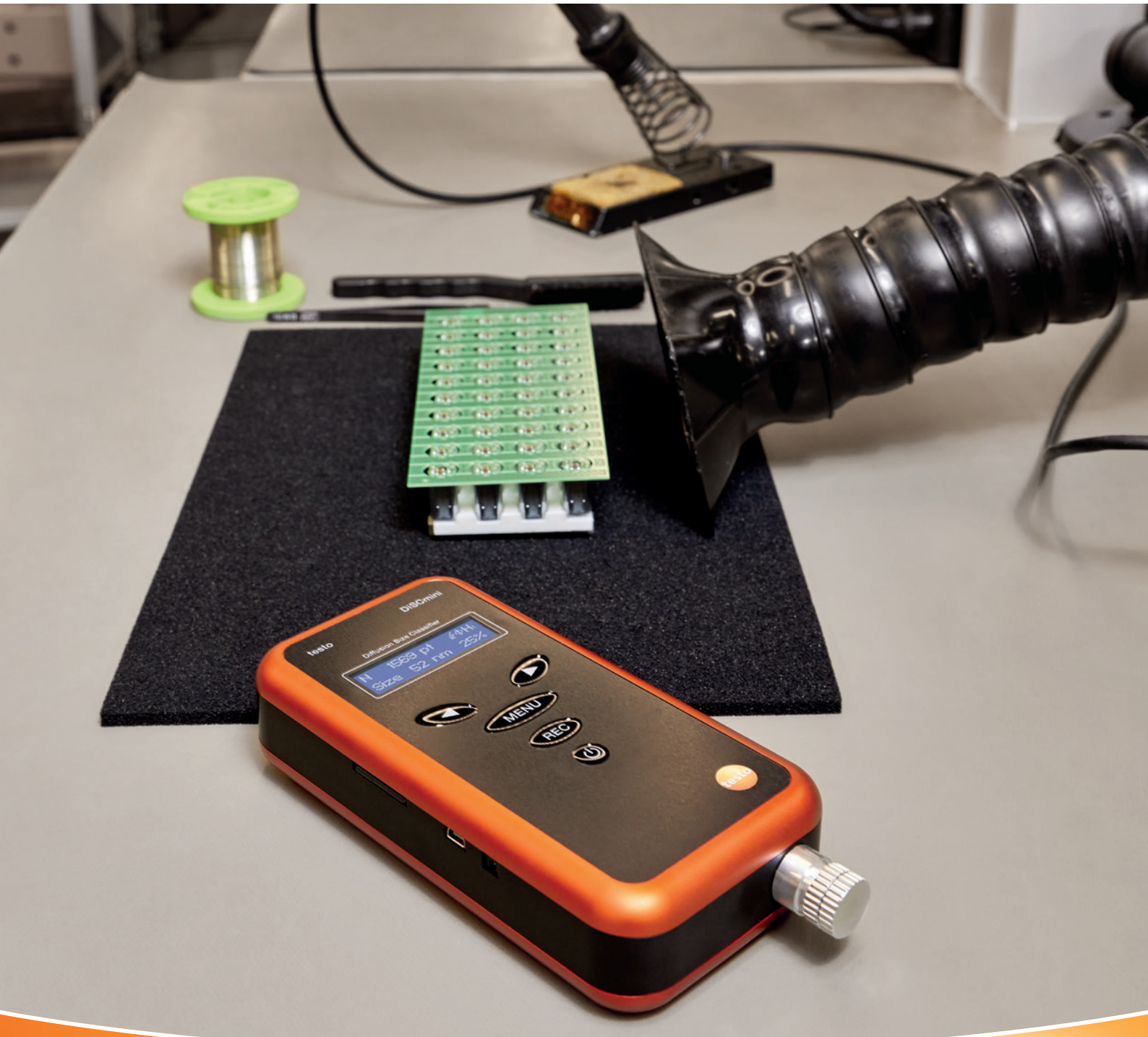
Verifying the efficiency of soldering fume extraction and measuring nanoparticle exposure during soldering with an iron with the testo DiSCmini



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Safe working conditions?

That manual soldering produces harmful substances in the form of aerosols is a known problem in the electric and electronic industry. The lead-free electronics solders used today have done little to change that. The soldering fumes still contain particles which are formed by the solder and the flux agent. These particles have a high potential of causing permanent damage to the workers' health. Due to their small diameter between 10 and 150 nm, they can penetrate all the way into the alveoli. But numerous studies also show that nanoparticles can reach all areas of the body through the bloodstream [1].

According to the definition of the Technical Regulations for Hazardous Substances 528 [2], hard soldering and soft soldering are welding processes and are treated in the scope of occupational medicine and hygiene. For reasons of prevention, employers have a duty to reduce the hazards for employees to a minimum for these processes. In practical application, this is usually achieved with ventilation measures such as extracting the soldering fumes where they arise.

Until now, it was difficult to verify the effectiveness of the safety measures accurately. Detecting nanoparticles and particularly determining their number with reproducible results required complex instruments until now. Gravimetric analyses also proved unsuitable for determining particle concentration in the workplace due to the low mass of nanoparticles. Verification of the safety measures was therefore usually limited to using flow tubes or vane anemometers to detect the function of the ventilation. This process left many questions unanswered, however: What is the particle exposure for the worker? What is the particle emission from the soldering fumes? Which particle volumes are already present in the ambient air? Does the workstation have a practical setup or could a changed arrangement already achieve essential improvements?

Comprehensive measuring with the testo DiSCmini!

The testo DiSCmini nanoparticle measuring instrument quickly and easily records all parameters relevant for assessing health and safety:

- the particle number in Pt/cm^3 for nanoparticles with a diameter from 10 to 700 nm for assessing the exposure
- the modal value of the particle size, i.e. the size of the particles with the highest number concentration, for nanoparticles with a diameter from 10 to 300 nm for evaluating the particle size distribution
- the active particle surface area as LDSA (lung deposited surface area) in µm^2/cm^3 for evaluating the impact on the human organism.

In the following, the suitability of the testo DiSCmini for evaluating health and safety measures is demonstrated on the example of several measurements at a soldering workstation. First, the particle number and the modal value of the particle size in the background levels are measured without extraction and without soldering. In a second step, the two measurement parameters and additionally the LDSA value are recorded during soldering, once with and once without extraction.

The measuring setup

A temperature-controlled soldering station of type Weller WSD81 at a temperature of 360 °C is used for the test measurement together with lead-free tin solder with colophonium in a composition of SN95 5AG3.8 Cu0.7. The model Easy ARM 1 from ERSA is used for extracting the soldering fumes.

The nanoparticle measuring instrument testo DiSCmini picks up the air at the workstation through an impactor which is positioned to the right of the workpiece. The position of the of the impactor as the sampling location corresponds to the height and position of the worker's face from the soldering point. This means only those particles are measured which are breathed in during work with a high probability.

The impactor separates out particles with a size over 700 nm as these are not captured by the testo DiSCmini. Impactor and measuring instrument are connected with a special hose made of a material which prevents the aspired particles from being deposited on the inner wall.

Fig. 1: testo DiSCmini.

Fig. 2: Setup of the measuring environment with soldering station and extraction.

Measuring the background levels

For measuring the particle exposure with the testo DiSCmini, first a measurement is taken at a distance of about 1 metre around the workstation to record the background levels in the ambient air. The soldering station and the extraction system are not yet activated for this.

Measuring the particle number in the production area and in the surroundings of the workstation.
An mean particle number of 2,427 Pt/cm³ during a 7 minute period made it clear that the air in the production area contained only low concentrations of nanoparticles. This can be attributed to the efficient air processing which ensures a low particle number in the production area.

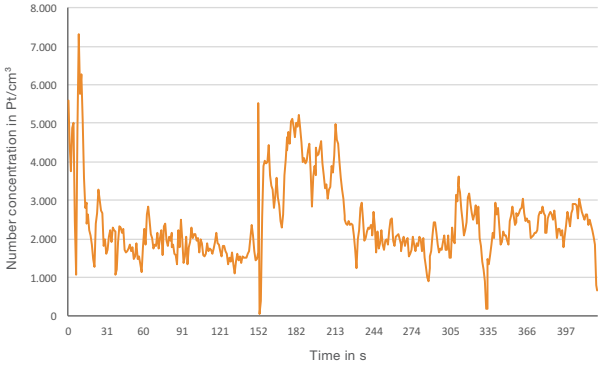

Diagram 1: Measuring the background levels – particle number.

Measuring the modal value of the particle size in the surroundings of the workstation.
The modal value of the particle size shows the maximum of a curve which describes the particle size distribution. A mean particle size of 42 nm was determined during the measurement in the surroundings of the workstation. The small particle size suggests the conclusion that only few of the detected particles originate from the production process and rather enter into the production area with the ambient air.

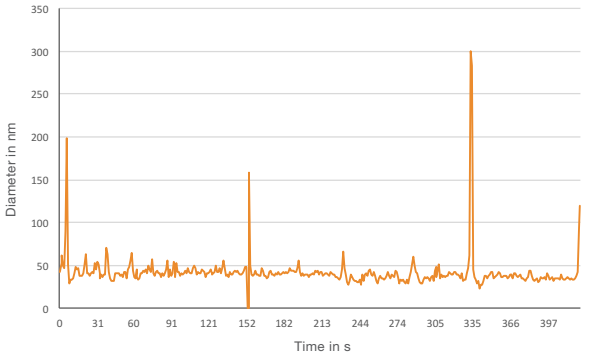

Diagram 2: Measuring the background levels – particle size.

Measurement during soldering with active extraction

During soldering, a worker applies soldering points to a PCB at regular time intervals. For measuring during operation, the soldering station and the extraction system were activated and the impactor was brought to the height of the face during soldering. Contamination of the measurement with nanoparticles in the exhaled air seems negligible considering the substantially higher particle emission from the soldering fumes.

Measuring the particle concentration during soldering with extraction

After starting soldering, the mean value of the particle concentration increases only slightly. The measurement of 2,782 Pt/cm³ provided verification that the extraction system works effectively and only few particles enter into the breathing air for the worker. The deflections in the middle of the measuring period can be attributed to turbulences in the working area.

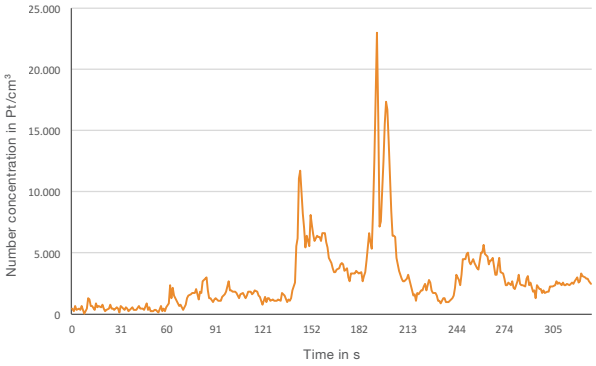

Diagram 3: Soldering with extraction – particle number.

Measuring the modal value of the particle size during soldering with extraction

Measurement of the particle size confirmed these findings. The mean particle diameter of 44 nm mostly corresponded to the previously conducted measurements in the surroundings without soldering and extraction.

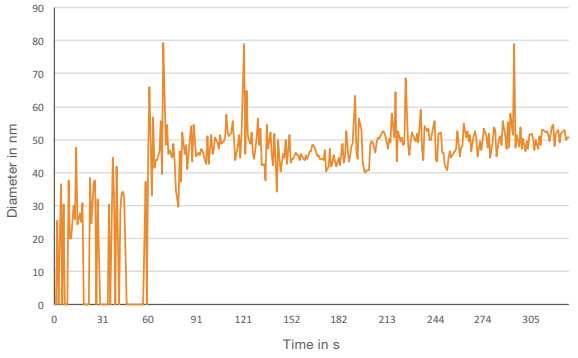

Diagram 4: Soldering with extraction – particle size.

Measuring the LDSA value during soldering with extraction

The provision of the active surface area of the particles deposited in the lung (LDSA) allows statements to be made on the biological burden. This is caused by the active surfaces of the particles themselves or by hazardous substances which adhere to the nanoparticles and can then enter the bloodstream. An average value of 7 µm²/cm³ is registered with active measurement.

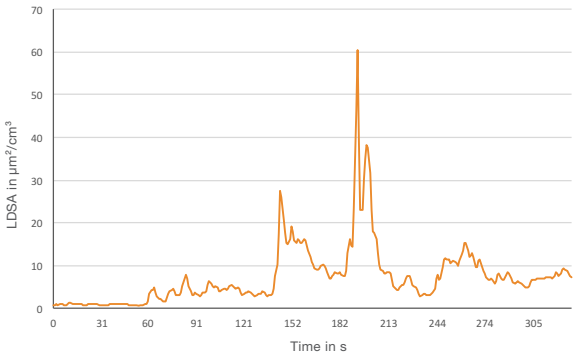

Diagram 5: Soldering with extraction – LDSA value.

Measurement during soldering without extraction

To get an idea of how many particles are generated in which size during soldering, we carried out a second measurement with the extraction system switched off. The results illustrate that short-term work without extraction already results in a significant increase in the concentration of nanoparticles at the workstation.

Measuring the particle concentration during soldering without extraction

With an average of 143,165 Pt/cm³, the number concentration is 51 times higher than with the extraction switched on. This means the extraction system contributes substantially to improving the working conditions.

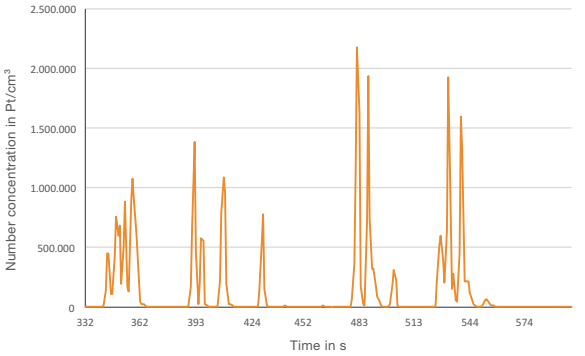

Diagram 6: Soldering without extraction – particle number.

Measuring the modal value of the particle size during soldering without extraction

As soldering even produces visible fume particles, it can be assumed that the measured diameters of the nanoparticles also increase clearly. As the diagram shows, the mean diameter of 89 nm is twice as large as during measurement with extraction. The diagram furthermore shows that the particle diameter is subject to strong fluctuations during the measuring cycle. Large particles occur whenever the soldering tin is melted and decrease again during the change to the next soldering point. The high time resolution of the testo DiSCmini allows the particle emissions to be directly allocated to the processes at the soldering workstation.

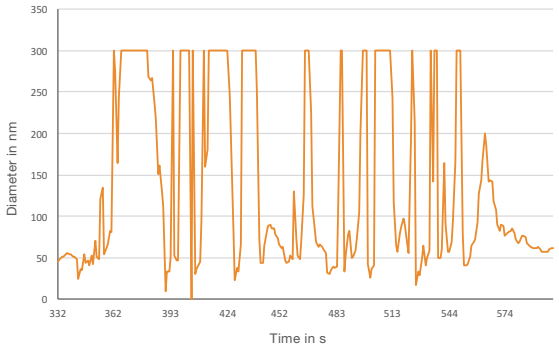

Diagram 7: Soldering without extraction – particle size.

Measuring the LDSA value during soldering without extraction

The measurement of the LDSA value also corresponds to the expectations. Without extraction, it increases more than 66-fold to a particle surface area of 467 µm²/cm³.

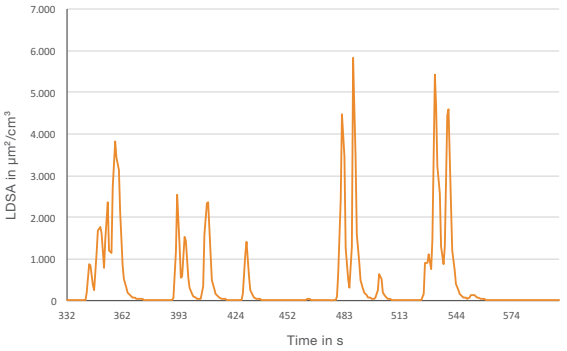

Diagram 8: Soldering without extraction – LDSA value.

A new level of health and safety.

The testo DiSCmini nanoparticle measuring instrument can detect the effectiveness of the extraction system during soldering very clearly. This means the measuring instrument can handle all tasks which were previously executed in measurement methods with flow tubes or vane anemometers.

Beyond verifying the effectiveness of the extraction system, the testo DiSCmini can be used to answer a number of other questions regarding particle exposure at soldering workstations:

- The testo DiSCmini provides information on the nanoparticle exposure for the employee. A hose and an impactor are used to accurately check the air in the area where the worker breathes it in. This allows excessive exposure to be identified easily, while the employees are made directly aware of the hazard potential from soldering fumes and the importance of a correctly configured extraction is illustrated.
- The testo DiSCmini additionally provides information about the background levels in the ambient air. A functioning extraction system at the soldering station can only provide protection for the worker if no other particle sources are present near the workstation. These particle sources can be located quickly with the testo DiSCmini.
- The testo DiSCmini also provides valuable support for the design of the workstations. Thanks to the high time resolution of 1 second, changes in particle number, particle size and the active surface (LDSA) are detected reliably during the measurement. This makes it easy to find and verify the most effective configuration, for example by altering the position of the extraction above the workpiece or with a globe for expanding the extraction area.
- The testo DiSCmini not only measures the particle number, but also supports the estimation of the biological burden by displaying the lung deposited surface area (LDSA). This value is relevant not in the least because hazardous substances are transported on the surface of relatively harmless particles, thereby finding their way into areas of the body where they would normally never reach.

The testo DiSCmini is designed for mobile operation. Measurements are carried out without operating media, unaffected by vibrations and independent of the position of the instrument. The instrument is easy to handle and its intuitive operating concept allows a quick introduction into the precise recording of nanoparticles.

Bibliography

[1] “Beurteilung eines möglichen Krebsrisikos von Nanomaterialien und von aus Produkten freigesetzten Nanopartikeln” (Assessment of a potential cancer risk of nanomaterials and of nanoparticles released by products), statement from the German Federal Environmental Agency dated 15/04/2010

[2] Technische Regeln für Gefahrstoffe – Schweißtechnische Anlagen (Technical Regulations for Hazardous Substances – Welding Systems) TRGS 528, Edition: 02/2009

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About Testo

Testo, with its headquarters in Lenzkirch in the Black Forest, is a world market leader in the field of portable and stationary measurement solutions. In 33 subsidiary companies around the world, 2,700 employees work in research, development, production and marketing for the high-tech company. Customers all over the world are impressed by the measuring technology expert's high-precision measuring instruments and innovative solutions for the measurement data management of the future. Testo products help save time and resources, protect the environment and human health and improve the quality of goods and services.

An average annual growth of over 10% since the foundation of the company in 1957 and a current turnover of over a quarter of a billion euros clearly demonstrate that the Black Forest and high-tech systems are a perfect match. The above-average investments in the future of the company are also a part of Testo's recipe for success. Testo invests about a tenth of its annual global turnover in Research & Development.

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