REPORT

(Replacement for report 2219039-1)
on the implementation of the
Inspection
regarding
Reduction of fine dust pollution
by means of a
photocatalytically active coating
- ACTIVE COATING -
in the interior

Environmental measurement technology

Bruck/Mur, 10.05.2019

Our reference: JGe, TKö

Report number: **2219039-2**

Test period: 16 and 17 April 2019

Client Aich 44 85667 Oberpframmern	:	Nanoenergy GmbH
Location of test 5411 Oberalm	:	Löwenstrasse 4
Responsible specialist.	:	Johann Geineder

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1. DESCRIPTION OF THE TEST TASK

1.1 Client

Nanoenergy GmbH, Aich 44, 85667 Oberpframmern, Germany

1.2 Location of the test

Löwensternstrasse 4, 5411 Oberalm, Austria

1.3 Date of the test

16 and 17 April 2019

1.4 Reason and task assignment

The implementation of the tests to determine the “reduction of fine dust pollution by means of photocatalytically active coatings in interiors” was to be accompanied by an experimental set-up. The aim of the test was to prove whether the air quality with regard to ultra-fine dust is influenced or can be improved by a photocalatytically active coating of the interior surfaces.
The execution of the tests, including the provision of all necessary test bench structures and measuring devices, was carried out exclusively by the client.
The report was reissued to present the test results better. Compared to report no. 2219039-1, only formal changes have been made. These have no effect on the test results.

1.5 Coordination of the test plan

The test plan was coordinated with Mr. Robert Kummerer (Nanoenergy GmbH).

1.6 People involved on site

Robert Kummerer (Technical Director Nanoenergy GmbH)
Johann Geineder (Responsible specialist - TÜV Süd)
Thomas Königshofer (Technician - TÜV Süd)

1.7 Other participating institutes

None

1.8 Responsible specialist

Johann Geineder; Telephone +43 5 0528 - 4080

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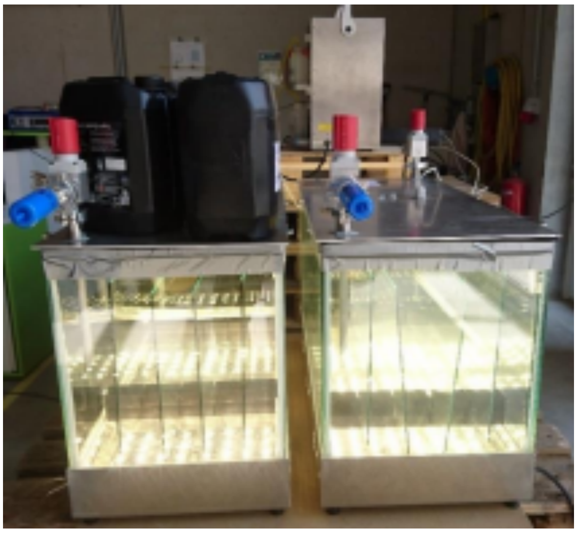
2. Description of the experimental setup

2.1 Type and purpose of the tests

In the area of measuring fine and ultra-fine dust pollution in indoor areas, there is currently no test standard.
In order to be able to make a qualified and reproducible statement about the effectiveness of the “Active-Coating” coating developed by Nanoenergy, a test setup as shown below was chosen.
For this purpose, two identical glass chambers with the dimensions 790 x 355 x 400 mm were set up. These correspond to a volume of 0.11 m3. One chamber was equipped with uncoated glass, hereinafter referred to as the reference chamber, and the second with active coating coated glass, hereinafter referred to as the active chamber. The glass surface is 3.04 m2 per chamber. The coating of the glass surfaces of the active chamber with active coating took place 3 weeks before the tests.



Shut-off valves were attached to the covers of the chambers in order to be able to check the tightness of the chambers on the one hand and to enable the attachment of a filter on the inlet side and the connection of the measuring device on the outlet side on the other. The filter mounted on the inlet side (Brand: Parker, model BALSTON, type 1-800-343-4048) was used to clean the air drawn in from ultra-fine dust. A measuring device (CPC) was connected on the output side, which determines the number of particles in a defined volume flow. The light required for the photocatalytic reaction was generated by means of LED lighting in the floor of the glass chambers. It should be mentioned here that the photocatalytic reaction starts to work from approx. 1,000 lux.

2.2 Description of the rooms

The experimental setup and the implementation of the experiments took place in a building of the Nanoenergy company at Löwenstrasse 4 in 5411 Oberalm.

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2.3 Description of the experimental set-up components and measuring devices used

The description of the measuring devices provided by the client was provided by the client.

2.3.1 2.3.1 Condensation Particle Counter – CPC

A condensation particle counter (CPC, see figure) was used to determine the concentration of the ultrafine dust. Airborne particles with a diameter smaller than the wavelength of commercially available lasers (approx. 250 nm) are usually measured with a condensation particle counter. Air is sucked in, the particles it contains are enlarged by heterogeneous condensation and then optically detected using a laser diode. With this device aerosol particles with a diameter between 5 nm and 2 µm can be counted.
The measuring device was calibrated in the week before the experiment by the Leibniz Institute for Tropospheric Research in Leipzig (Tropos).

Manufacturer	:	Grimm Aerosol Technik
Model	:	5.416
Serial number	:	54161007
Airflow	:	0.3 l/min

2.3.2 Lux meter

A lux meter as shown was used to determine the lighting intensity.

2.3.3 Precision measuring device/data logger and humidity sensor

The measurement of the ambient conditions was carried out with the measuring device listed below.

- Measuring procedure
  - Temperature: Thermoelement
  - Relative humidity: Humidity sensor
  - Air pressure: Absolute pressure sensor
- Standard/Guideline: EN 16911-1
- Measuring device: Manufactured by Ahlborn, Type FHAD36R
- Display device: Manufactured by Ahlborn, Type Almemo 2690-8
- Adjustable measuring range
  - Temperature: 0 - 1,250 °C
  - Humidity: 0 - 100 %
  - Air pressure: 700 - 1,100 mbar
- Process parameters
  - Measurement uncertainty temperature: ± 2 K
  - Measurement uncertainty humidity: ± 2
  - Measurement uncertainty air pressure: ± 1.2 mbar
- Quality assurance measures: Requirement according to EN 17025

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2.3.4 Generator

The exhaust gases from a 4-stroke engine of a generator were used as test aerosols for ultra-fine dust.

Manufacturer	:	ENDRESS
Model	:	ECOPOWER LINE
Type	:	ESE 200 BS
Fuel	:	Petrol

3. Description of the measurement procedure

A total of four test measurements were carried out over two days, with the reference chamber and active chamber being checked alternately. The test duration was set at 90 minutes in each case. Before each test, the test set-up was checked for leaks in order to prevent the measurements from being falsified by air leakage. A zero adjustment was then carried out on the CPC. This was achieved by connecting a filter (Brand Parker) directly to the measuring device and sucking in ambient air. This was followed by approx. 6 sec. of gassing the respective chamber with exhaust gases from the generator. This gassing should achieve an initial concentration of more than 120,000 particles per cm3 in the chambers. At a concentration of over 100,000 particles per cm3, the CPC calculates the number of particles, and below 100,000 particles the number is determined exactly by counting. The evaluation of the tests began after approx. 100,000 particles per cm3 were measured again in the chambers (see diagrams under point 4.1).
After the gassing, the filter was mounted on the inlet valve of the chambers so that no particles could flow into the chamber via the sucked in room air.

3.1 Measurement procedure - Reference chamber

Measurement 1

Date	:	16.04.2019
Time period	:	13:21 - 14:51
Seal tightness	:	checked
Zero adjustment	:	checked
Ambient temperature	:	22 °C
Relative humidity	:	34 %
Air pressure	:	965 mbar
Lighting intensity	:	5,600 Lux

Measurement 3

Date	:	17.04.2019
Time period	:	09:09 - 10:39
Seal tightness	:	checked
Zero adjustment	:	checked
Ambient temperature	:	16 °C
Relative humidity	:	46 %
Air pressure	:	970 mbar
Lighting intensity	:	5,850 Lux

3.2 Measurement procedure - Active chamber

Measurement 2

Date	:	16.04.2019
Time period	:	17:14 - 18:44
Seal tightness	:	checked
Zero adjustment	:	checked
Ambient temperature	:	18 °C
Relative humidity	:	40 %
Air pressure	:	964 mbar
Lighting intensity	:	5,900 Lux

Measurement 4

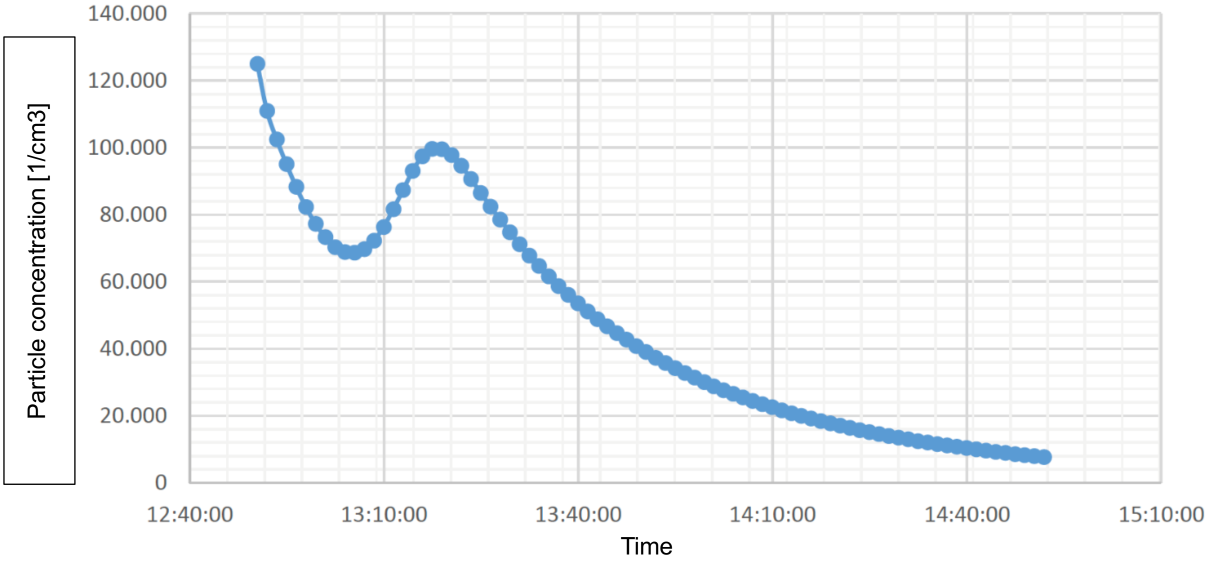
Date	:	17.04.2019
Time period	:	11:32 - 13:02
Seal tightness	:	checked
Zero adjustment	:	checked
Ambient temperature	:	17 °C
Relative humidity	:	45 %
Air pressure	:	969 mbar
Lighting intensity	:	5,200 Lux

4. Comparison of the measurement results

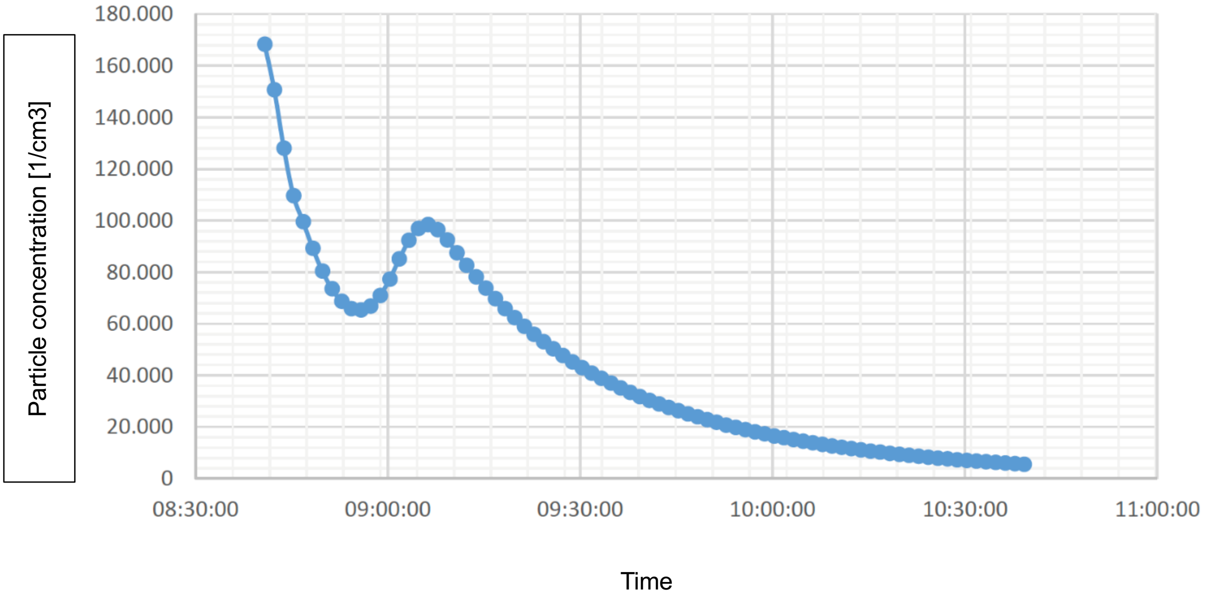
4.1 Graphic representation of the individual measurements

The following diagrams show the particle concentration over time. The diagrams show the course over the entire implementation period. To ensure that a comparison of the individual measurements was possible, the measurement period of 90 minutes defined in point 3 was used for the respective test evaluation.

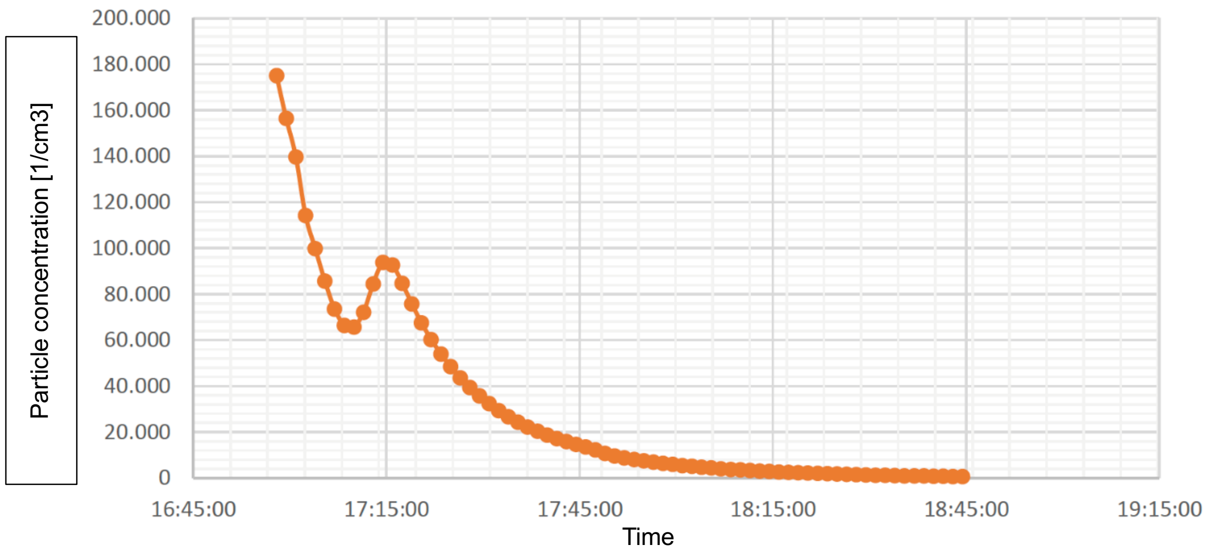
4.1.1 Reference chamber - Measurement 1



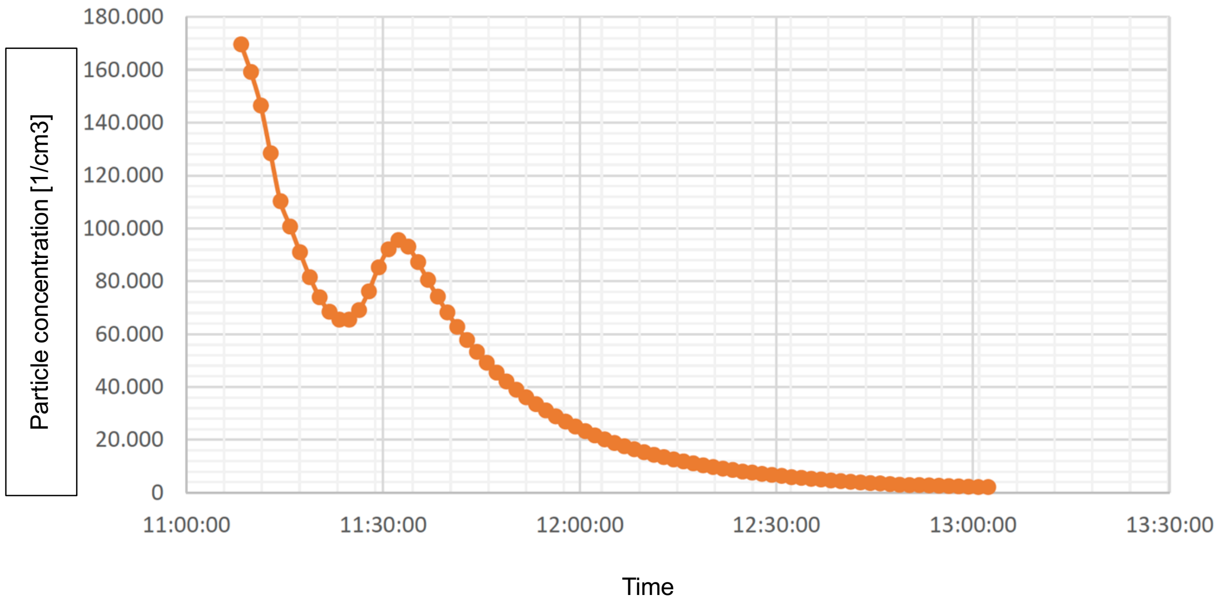
4.1.2 Reference chamber - Measurement 3



4.1.3 Active chamber - Measurement 2



4.1.4 Active chamber - Measurement 4



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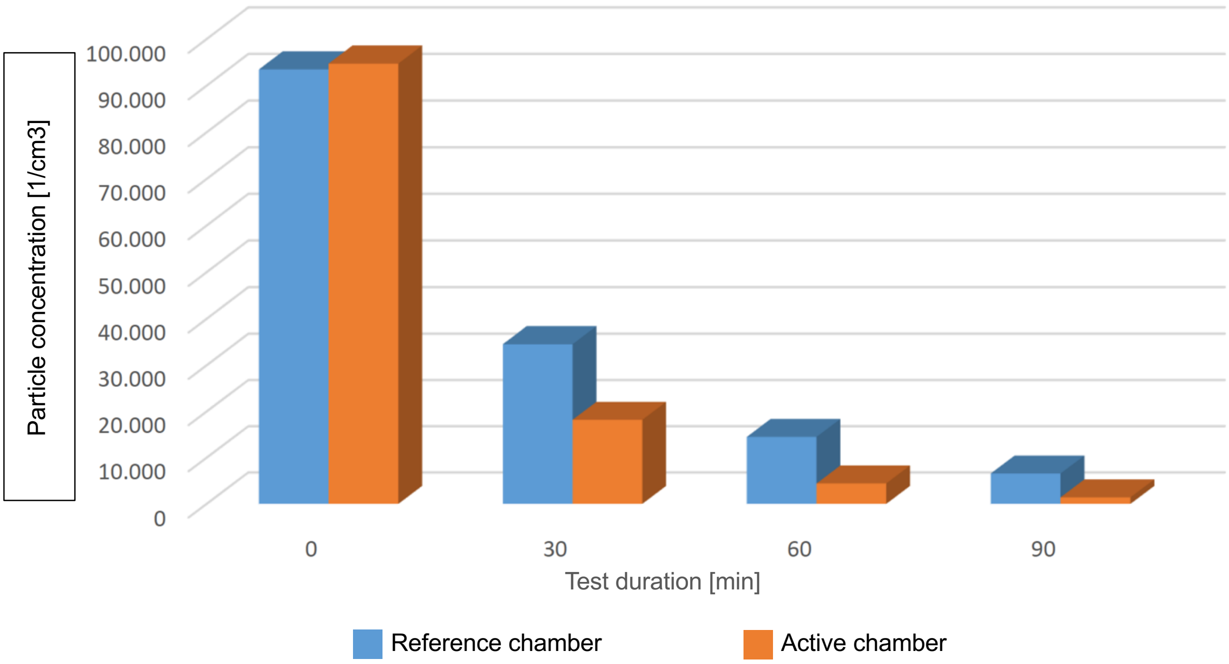
4.2 Tabular and graphical representation of the results

4.2.1 Particle concentration and increase in reduction

The following table and the diagram show the particle concentration and the particle reduction in the reference chamber and the active chamber over the duration of the experiment. The measured values represent the mean values from each of the two tests. The table also shows the percentage increase in particle reduction from the active chamber compared to the reference chamber.

Experimental setup / Reduction		Test duration [min]			
		0	30	60	90
Reference chamber	[1/cm3]	93,548	43,545	14,490	6,569
	[%]	-	37.0	15.5	7.0
Active chamber	[1/cm3]	94,735	18,190	4,411	1,404
	[%]	-	19.2	4.7	1.5
reduction *)	[%]	-	84	70	79

*) Increase in the particle reduction in % of the respective starting value at 0 minutes



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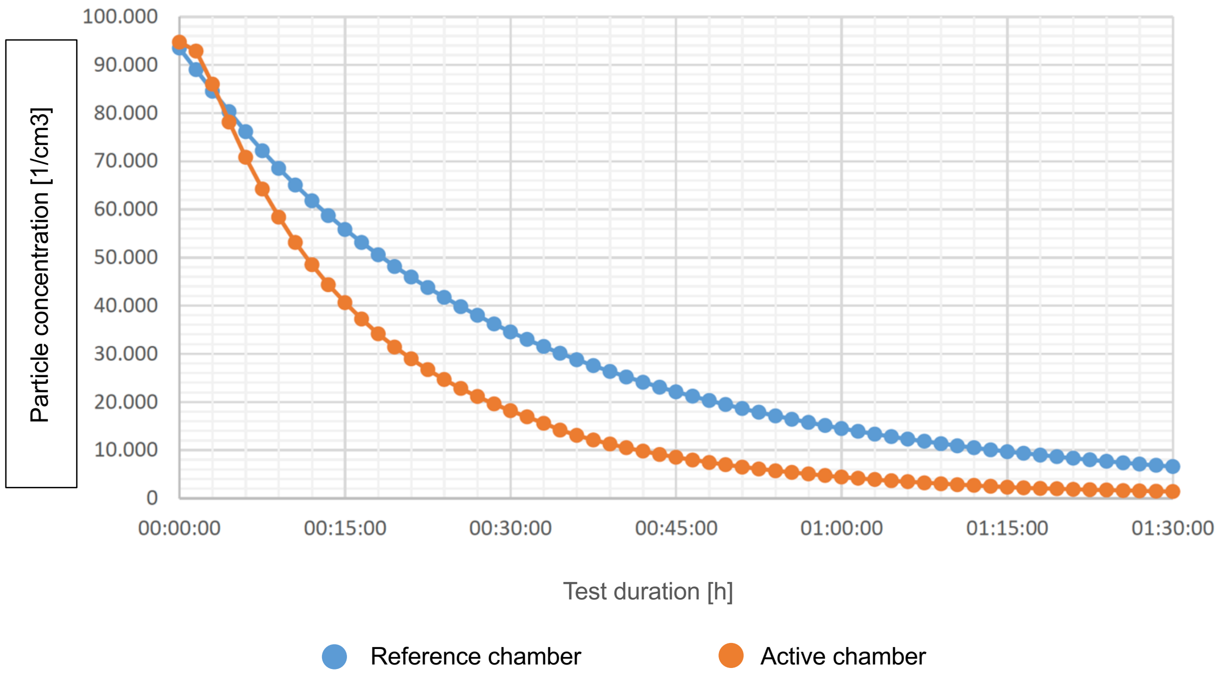
4.2.2 Course of the mean particle concentration

The following diagram shows the mean values of the particle concentrations in the active and reference chambers as a curve over the test duration of 90 minutes.



5. Conclusion

Based on the evaluations of the tests, it can be stated that a clear reduction in particles can be determined in the active chamber due to the coating.

Responsible technician:

Johann Geineder

Technician:

Thomas Königshofer

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