EXPERT'S REPORT

QUANTITATIVE INVESTIGATION OF AEROSOL FORMED IN DENTAL INTERVENTIONS AND DETERMINATION OF THE EFFICIENCY OF THE VACSTATION EXTRAORAL DENTAL VACUUM SYSTEM USED DURING TREATMENTS.

MADE FOR DR. VOLOM DENTAL

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Content

Objective

The tests aim to quantify the aerosol formed during dental procedures and to determine the efficiency of the VacStation Extraoral Dental Vacuum System used during the treatments.

Applied methods

We measured the amount and characteristics of the aerosol generated by the turbine and accelerator using a plastic phantom head in a dental office. Three different measuring instruments were used to measure the concentration and size distribution of aerosol particles: an optical particle counter, an aerodynamic particle sizer, and a scanning mobility particle sizer. The instruments were able to determine the above parameters from 10 nm up to 32 µm particle size.

Description of the measurement methods

Several measurement methods are available to study the concentration and size distribution of aerosol particles, such as gravimetric, beta-ray absorption, vibrating quartz, electrostatic, aerodynamic, and optical [1]. The optical method has the shortest sampling time to determine the aerosol concentration as a function of particle size in real-time [2-5]. An optical, an aerodynamic, and an electrostatic instrument were used for the measurements.

The **optical measurement method** is based on illuminating the aerosol sample with a beam of light and examining the properties of the light scattered from the particles.

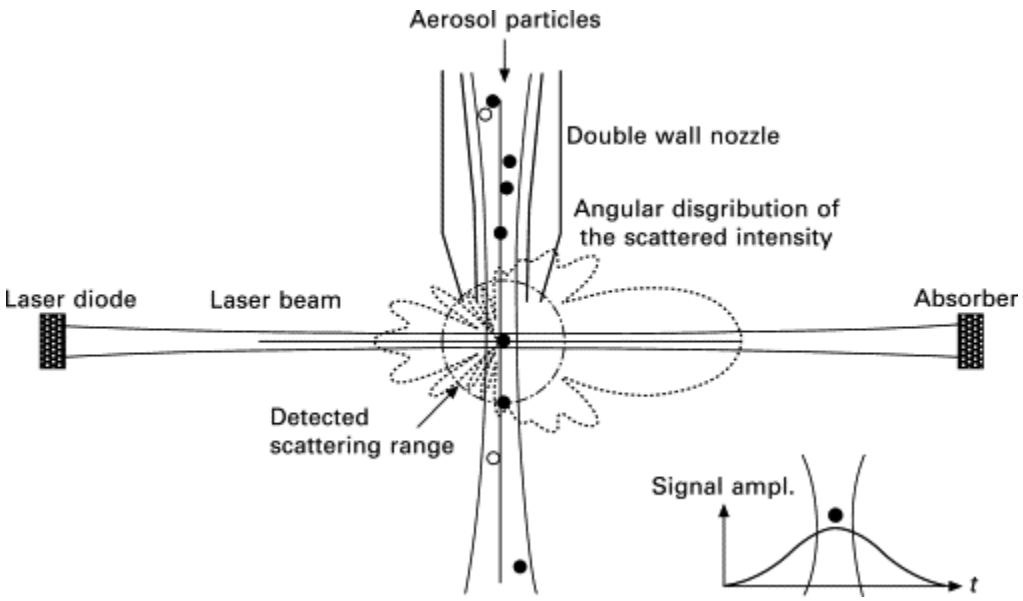


Figure 1. Light scattering on individual aerosol particles, the dashed line shows the spatial distribution of the intensity of the scattered light on a 1 µm particle with a refractive index of 1.3 in the case of red laser light.

The intensity of the scattered light depends on the size and the concentration of the particles in the illuminated volume. There are two optical methods for determining the concentration of aerosol particles: the method of measuring integral light scattering when there are many particles in the illuminated volume at a time, and the method of **optical particle counting** when there is only one particle in a small illuminated volume at a time.

In optical particle counters (OPC), a small-diameter jet is formed from the aerosol to be measured by aerodynamic focusing, which is illuminated by a focused laser beam (Fig. 1). If the entire cross-section of the stream is illuminated, each particle passes through the laser beam, so that all particles are detected by the instrument. To determine the concentration, the volume of the sucked aerosol is also measured with a flow meter.

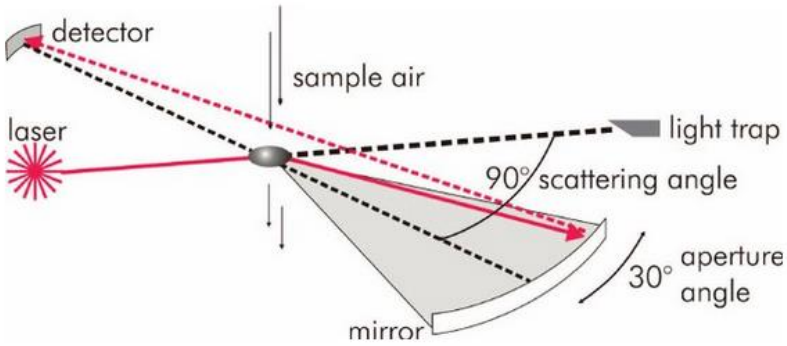


Figure 2. Schematic drawing of the principle of operation of optical particle counters.

The size and the concentration of the particles can be determined from the light scattering of the aerosol particles entering the laser beam (the number of photoelectric pulses corresponds to the number of particles and the amplitudes of the pulses are proportional to their size). In terms of particle size, the detection threshold is usually around 0.25 to 0.3 micrometers (3 x 10^{-7} m), however, the maximum size is not limited, it can be up to 100 micrometers [6,7].

Although there are optical particle counters that can measure below 100 nm (70-90 nm), due to their limitations a more robust method is commonly used to detect smaller particles. In condensation particle counters (CPC) the aerosol particles to be measured are passed through a condensation chamber filled with supersaturated steam before optical measurement, where their size increases to a range of a few microns, which can already be detected by light scattering. Condensation particle counters typically detect particles from 4-5 nm up to 2-3 µm, and their concentration limit is 10^5 particles/cm^3 in single counting and 10^7 particles/cm^3 in photometric mode.

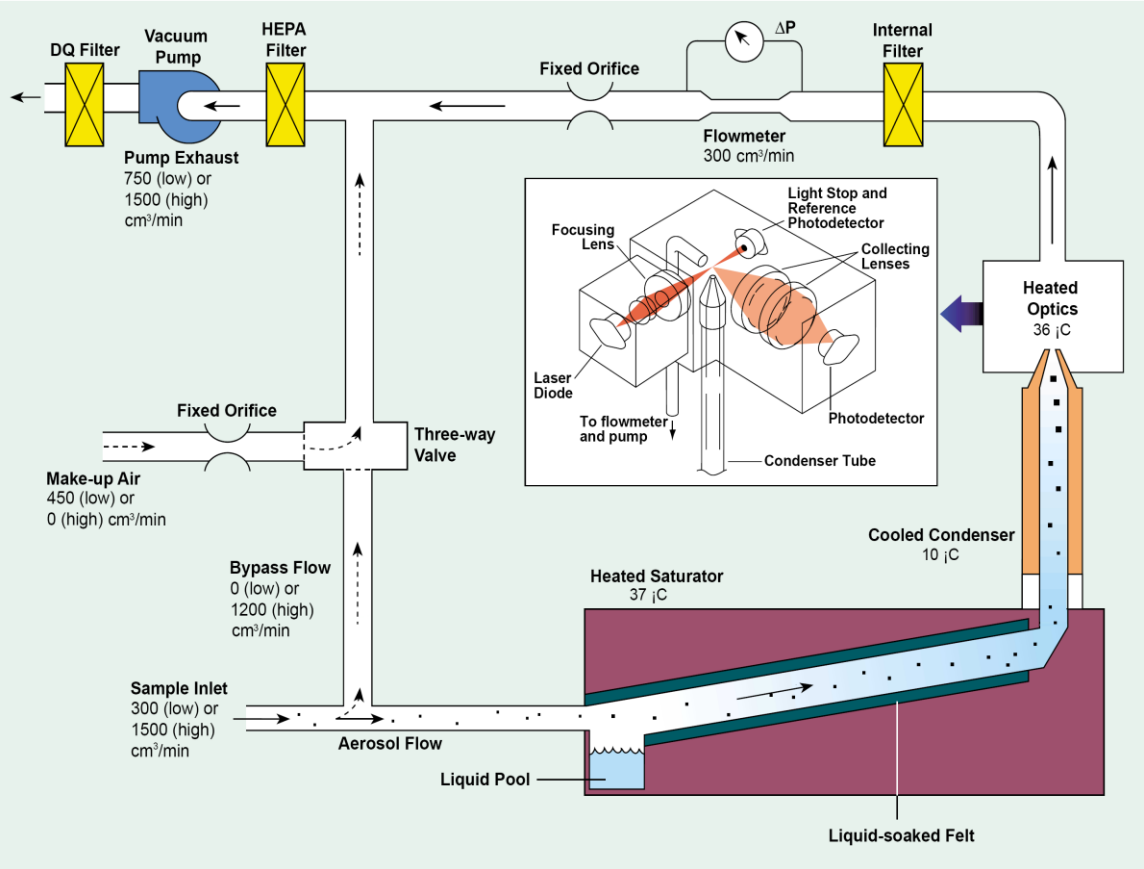


Figure 3. Schematic diagram of the operating principle of the condensation particle counter. [TSI website]

The sensitivity of condensation particle counters in terms of size can be extended down to 2-3 nanometers (more recently, the 1 nm limit is besieged by developers). However, it should be noted here that since the growth of the particles in the supersaturated vapor is not always proportional to their original size, the size distribution in the submicron range cannot be determined directly by CPC.

Differential mobility analyzers (DMA) combined with condensation particle counters are typically used to determine the size distribution of particles in the submicron range. In a differential mobility analyzer, the charged aerosol particles move in a laminar clean (filtered) air flow in an electric field. In the electric field, charged particles follow a parabolic trajectory whose curvature depends on the charge/mass (e/m) ratio. In the DMA, the electric field is created between two concentric cylinders, where the particles are introduced through a special ring placed on top.

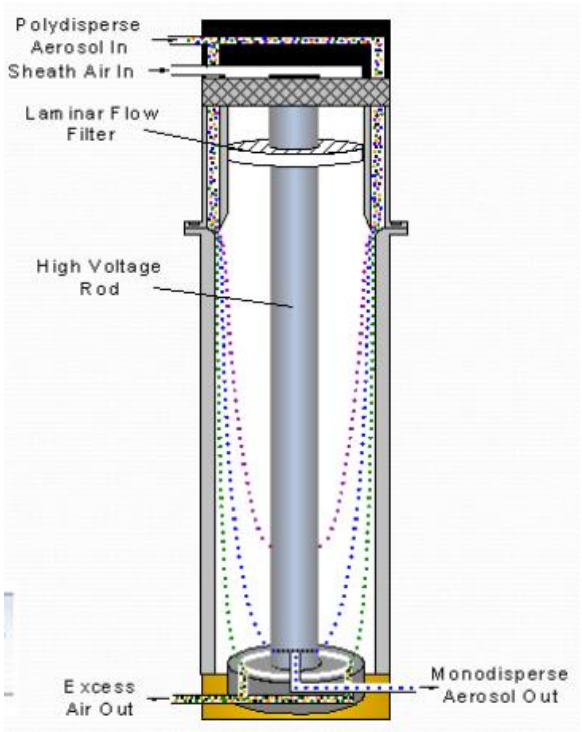


Figure 4. Schematic diagram of a differential mobility analyzer.

The trajectories of the particles in the laminar flow can be modified by changing the electric field strength and can be described with the motion equations (where the parameters are the flow equations, geometrical parameters, air viscosity, field strength, particle mass, etc.). At a given field strength, particles with a given e/m ratio leave the DMA through a narrow circular gap at the bottom of the inner cylindrical electrode (where geometric data, viscosity, flow parameters - as constant parameters are included). The size distribution can be determined based on this principle, by varying the electric field strength between the two cylindrical electrodes (i.e., the voltage). If there are particles having a charge of 1e-2e or 3e, then the instrument selects all of them for a given voltage, and provide 3 characteristic peaks at a given size. Modern systems can correct the measured size distribution data for multiple charged particles and also for inlet and counting efficiencies when calculating the real size distribution [8 -12].

When a CPC is integrated with a DMA that can be controlled from a common computer and the concentration is measured at a given voltage range, the concentration and size distribution over the nanometer range can be determined. Such an instrument is called a Scanning Mobility Particle Spectrometer (SMPS).

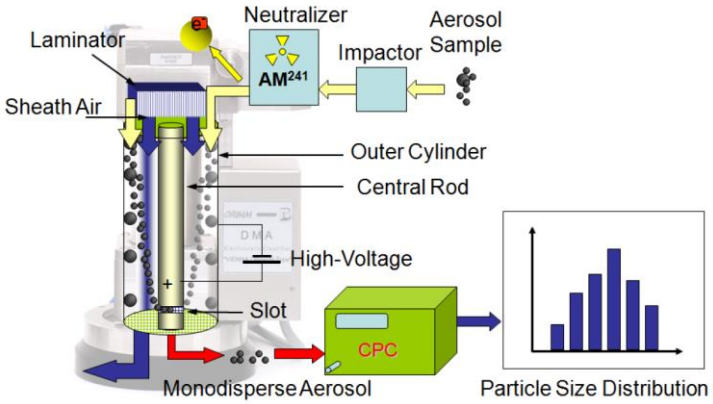


Figure 5. Schematic diagram of a Scanning Mobility Particle Sizer (SMPS) [13].

In addition to the gravimetric method which is utilized in cascade impactors, the particle size determining the flow properties of the particles can be measured by an aerodynamic particle sizer (APS). In these devices, the sample air stream containing the aerosol particles is accelerated by aerodynamic focusing through a special nozzle and passed through two parallel laser beams after the accelerating phase. As the particle passes through the two laser beams, the pulses generated by the scattered light are detected and the time elapsed between them is measured. In the accelerating phase of the flow, the particles acquire different velocities depending on their aerodynamic size. In this way, by measuring the time of flight, their speed can be determined, from which their aerodynamic size can be calculated.

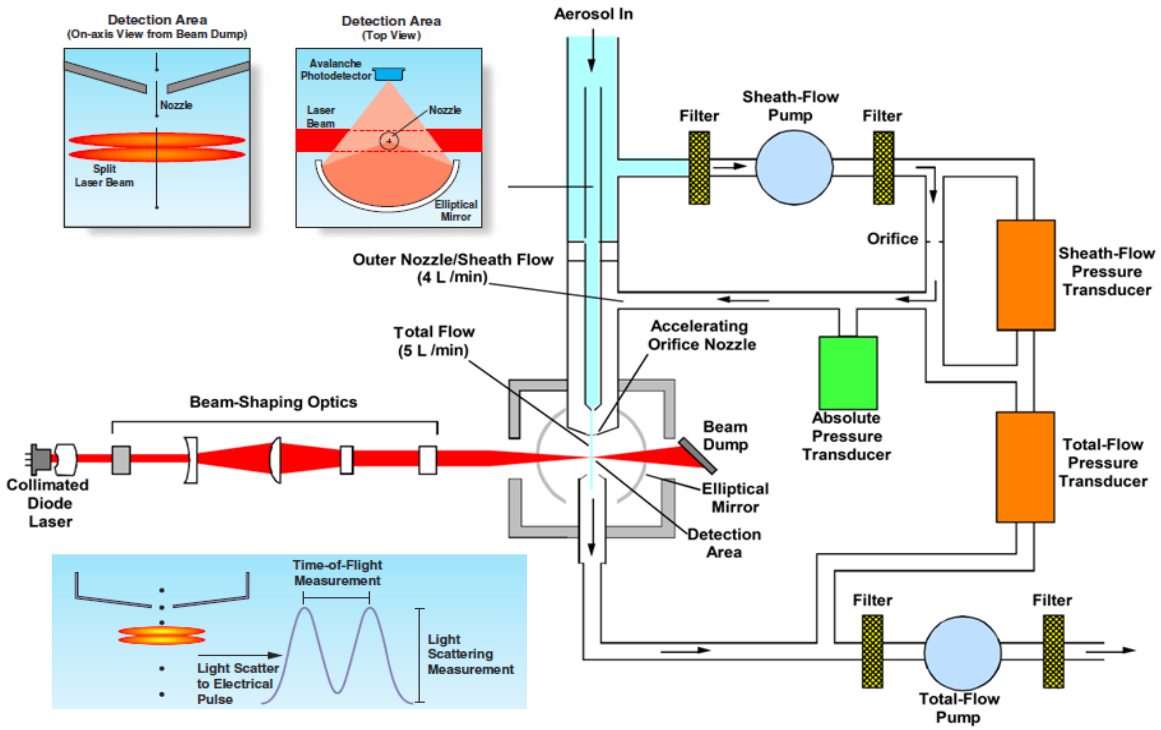


Figure 6. Schematic diagram of aerodynamic particle size measuring equipment [TSI website].

The advantage of the method over the optical particle counting method is that the flight time, and thus the aerodynamic size, is not affected by the optical properties of the particles, nor do the monotonicity problems derived from the scattering theory occur during instrument calibration.

Determination of particle size

In the world of aerosols, multiple sizes can be assigned to the same particle. The physical size of the particles can be measured with an optical or electron microscope. Optical particle counters measure the optical size of aerosol particles, which depends not only on the physical size of the particle but also on its optical properties. SMPS determines the mobility size of particles, which in addition to the physical size also depends on the density of the particles. The flow properties of particles are determined by their aerodynamic size, which is defined as the diameter of a spherical particle of unit density that behaves in a flowing medium in the same way as the particle in question.
Besides the different size ranges of the applied instruments, even the size they determine must be aligned when examining particle properties over several orders of magnitudes of sizes.

Sampling

When measuring aerosol concentrations, isokinetic sampling must be provided for real data. This means that the aerosol must not be diluted or compressed during sampling. This is most easily achieved by maintaining the same flow velocity near and at the entrance of the sampling tube. This can be achieved by choosing the proper diameter of the sampling tube and the proper shape of the intake section. The Reynolds number of the flow should also be considered to ensure the isokinetic condition

(https://www.chemicalprocessing.com/articles/2012/don-t-be-fazed-by-multiphase-sampling/).

Literature

1. A. Czitrovszky, Laser light scattering methods and their application in micron and sub-micron particle measurement, in ***Trends in laser development, application, and technologies, book chapter,*** book, Ed. by A. Czitrovszky, Technoorg-Linda Ltd, Budapest, 1997. pp. 105-127, Sponsored by EC HU 9305-04.02/1661.

2. A. Czitrovszky, P. Jani, Application examples of APC-03-2 and APC-03-2A Airborne Particle Counters in a highly contaminated environment, ***Journal of Aerosol Science***, vol. 26, pp. 793-794, 1995.

3. A. Czitrovszky, P. Csonka, P. Jani, Á. Ringelhann, J. Bobvos, Measurement of the air pollution within the city of Budapest, ***Egészségtudomány***, XI., pp. 215-225, 1996.

4. A. Czitrovszky, P.L. Csonka, P.Jani, Á. Ringelhann, J. Bobvos, Comparison of different measurement methods of airborne dust pollution within the city of Budapest, ***Journal of Aerosol Science***, 27s, 19-20, 1996.

5. A. Czitrovszky, P.L. Csonka, P. Jani, Á. Ringelhann, J. Bobvos, Complex measurement of airborne dust pollution within the city of Budapest, ***SPIE***, vol. 2965, pp. 103-112, 1996.

6. A. Czitrovszky, P.Jani. New design for a light-scattering airborne particle counter and its application, ***Optical Engineering***, vol. 32, No 10, pp. 2557 - 2562, 1993.

7. A. Czitrovszky, P. Jani. The efficiency of sampling by the APC-03-2A single-particle counter, ***Journal of Aerosol Science***, vol 25, pp. 465-466, 1994.

8. A. Czitrovszky, P. Jani, P.P. Poluektov, G.Yu. Kolomeitsev, V.G.Yefankin, A new method for laser analysis of aerosol particles to determine the distribution of electric charge, size, density and concentration, ***SPIE***, vol. 1983, pp. 969- 970, 1993.

9. Nagy, W.W. Szymanski*, A. Czitrovszky, C. Schindler*, P. Jani: Modelling of a dual-wavelength optical system for the estimation of the refractive index of aerosol particles in APC, ***Journal of Aerosol Science***, 32, 1028-1029 (2001)

10. A. Czitrovszky, P. Jani, A Nagy, C Schindler, W. W. Szymanski, An approach to a simultaneous assessment of aerosol particle size and refractive index by multiple angle detection, ***Journal of Aerosol Science***, vol. 31, pp. 761-762, 2000.

11. Nagy, W.W. Szymanski*, A. Czitrovszky, P. Jani: Modelling of a new optical aerosol particle analyzer for the simultaneous measurement of size, complex refractive index and density, ***Journal of Aerosol Science***, 32, S83-S86 (2001)

12. W. Szymanski, A. Nagy, A. Czitrovszky, P. Jani: A new method for the simultaneous measurement of aerosol particle size, complex refractive index, and particle density. ***Measurement Science and Technology***, Vol. 13, 303-308 (2002).

13. X. Guo et al., "New Methods for Real-Time Measurement of Environmental Airborne Particles" 2010 4th International Conference on Bioinformatics and Biomedical Engineering, Chengdu, 2010, pp. 1-4, DOI: 10.1109/ICBBE.2010.5516480.

14. A. Czitrovszy, A. Nagy, P. Jani, Environmental monitoring of the atmospheric pollution by aerosols, ***Journal of Aerosol Science***, vol. 34, pp. s953-954, (2003).

15. I. Balásházy, Á. Farkas, A. Czitrovszky, D. Szigethy, J.Nagy, Modelling local deposition patterns of inhaled aerosols in bronchial human airways, ***Journal of Aerosol Medicine***, vol. 18, No 1, pp. 98-99, 2005.

16. Á Farkas, I. Balasházy, A. Czitrovszky, A. Nagy, Simulation of therapeutic and radioaerosol deposition, ***Journal of Aerosol Medicine***, vol. 18, No 1, pp. 102-103, 2005.

A. Czitrovszky, in Handbook of Solid-State Lasers*, 2013,*
https://www.sciencedirect.com/topics/engineering/optical-particle-counter

Selection of the instruments required for the measurements and their specifications

The instruments used in the measurement set-up, their type, key parameters, and measurement methods are described below.

Optical particle counter: GRIMM 1.109 type laser particle counter with a size range from 0.25 to 32 micrometers in 31 channels with a concentration range of 2 x 10^6 particles/liter (0.1 to 100,000 µg/m^3). The sampling volume is 1.2 liters/minute. The instrument also displays cumulative and differential concentrations and can be controlled by a computer, where the measurement cycle time, number of measurement cycles, and storage and display parameters can be set. The minimum measurement cycle time is 6 sec, communication is via USB (RS 232) port. The measured data is also displayed on the instrument for information purposes, however, control and reading are easier to do with a PC. The instrument also has a built-in memory card and a medium-capacity battery, with which the instrument is also suitable for autonomous measurement as a portable instrument. The manufacturer guarantees proper operation between +4 and 40 °C, up to 90% humidity.

Figure 7. The GRIMM 1.109 optical particle counter.

Differential Mobility Analyzer: we used a Vienna type DMA in our measurement set-up, in which the voltage can be automatically adjusted in 1 V steps up to 10 kV. The size selection range is from 10 nm to 1100 nm, with a concentration limit of 10^7 particles/cm^3. The upper size range of the device overlaps with the lower measuring range of the optical particle counter so that the size range from 10 nm to 32 micrometers can be covered. The device can be controlled by a computer, which also displays and stores the data. The DMA used in our equipment is integrated with a condensation particle counter - these form the scanning mobility particle sizer.

Figure 8. The GRIMM differential mobility analyzers.

Condensation Particle Counter + Differential Mobility Analyzer - Scanning Mobility Particle Sizer (SMPS + C): The type 5416 SMPS is manufactured by GRIMM Aerosoltechnik and is calibrated to measure concentration and size distribution. The condensation particle counter, which is integrated with a differential mobility analyzer, measures the concentration of the particles in 128 channels from 10 nanometers. The size is selected by the DMA while scanning the internal field strength, and the concentration in the selected size range is determined by the CPC. The maximum measurable concentration is 10^7 particles/cm^3. The most important parameters are the DMA selectable upper size limit - 1094 nm, the sample airflow 0.3 liters/minute, the clean airflow - 3 liters/minute, automatic mode with own control software, analog inputs for connecting external sensors, and anti-spill CPC saturator design. The apparatus is shown in Figure 9.

Figure 9. The GRIMM Scanning Mobility Particle Sizer (SMPS)

Aerodynamic particle sizer: The APS 3321 device manufactured by TSI (Figure 10) detects light scattered from particles in the range of 0.37 to 20 µm and measures the aerodynamic size, concentration and size distribution of particles in the range of 0.5 to 20 µm in 51 channels.

The dual-beam illumination optical arrangement provides reliable, low-coincidence measurements up to a concentration of 10^3 particles/cm^3. The aerodynamic size of the particles is determined by the time of flight measurement, which is not affected by the optical properties of the particles. The sample airflow in the unit is 1 liter/minute, while the clean airflow is 4 liters/minute. The equipment is computer-controlled, with a minimum measurement cycle time of 1 second.

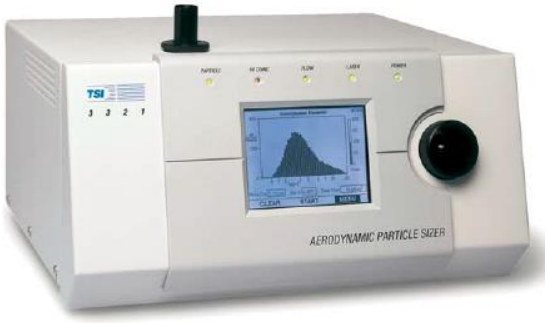


Figure 10. The TSI Aerodynamic Particle Sizer (APS)

Estimation of the mass

The software of all three presented devices are also able to calculate the mass concentrations from the measured data, so in addition to the number size distribution, the curve of the mass size distribution can also be drawn. When converting the particle number to mass, it is assumed that the particles are spherical, and it is also necessary for the user to provide an estimate of the average density.

Measurement layout

The three devices were placed on a movable table made of stainless metal in the dental treatment room close to the stand holding the phantom head (Fig. 11). The length of the sampling tubes was 70 cm for the OPC and APS instruments and 140 cm for the SMPS (a longer sampling tube was required due to the charge conditioning unit). For the OPC and APS instruments, 4 mm inner diameter Festo sampling tubes were used, and for the SMPS, a 6 mm inner diameter carbon-impregnated silicone conductive sampling tube was used due to the electrostatic measurement principle. The three sampling tubes were first fixed 40 and then 15 cm away from the phantom head to the stand holding the head at the same height as its mouth opening. In this way, we ensured typical distances of dental treatments and that the three instruments sample from the same location.

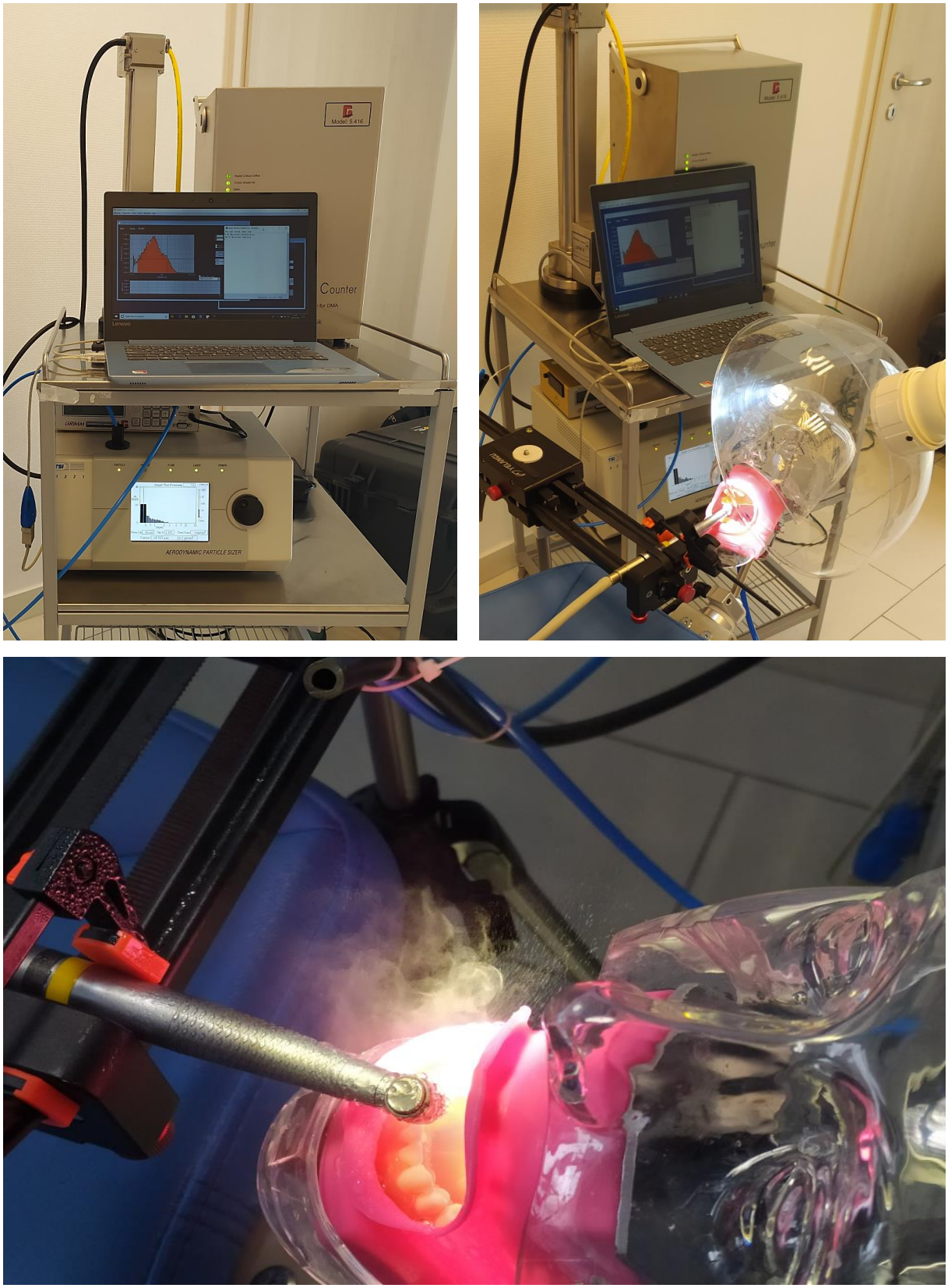


Figure 11. The three measuring instruments and the plastic phantom head during aerosol formation in the dental office

Description of the measurements

Taking into account the sample airflow of the equipment, the length, and inner size of the sampling tubes, we determined the residence time of the particles in the sampling tubes. This was 0.44 s for OPC, 0.52 s for APS, and 7.9 s for SMPS.

Sampling times for OPC and APS instruments were set to 1-minute averaging, and the SMPS worked with 4-minute cycles.

First, we measured the background concentrations in the dental treatment room with the three instruments. The sampling tubes were fixed 40 cm from the mouth of the phantom head, the extraction device was turned on, and its transparent plastic bell was placed slightly sideways above the phantom head (Fig. 11). The aerosol formation was started by starting the turbine. In the next set, the extraction device was switched off. In the next set, we placed the sampling point (the tubes) closer to the mouth of the phantom head, approximately at a distance of 15 cm. The extraction device was then restarted for the next sampling. To test the efficiency of the extraction equipment, the sampling point was moved to its outlet (where it blows the purified air back into the room). During these measurements, the turbine was operating continuously, the aerosol formation was continuous. In the next set, the turbine was switched off and the room was ventilated by opening the window. Then the extractor was restarted in the closed room, thus examining its air-cleaning efficiency.

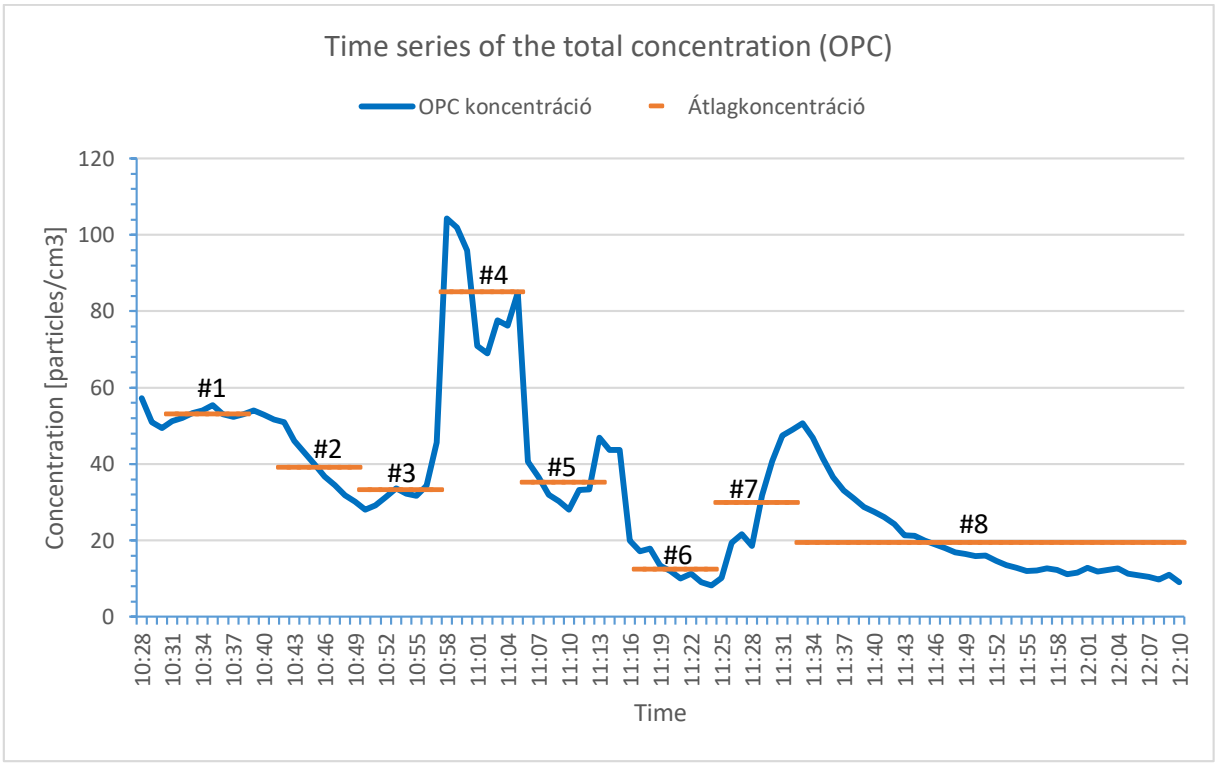
We measured for 8 minutes at each set, while 2 cycles were measured by the SMPS and 8 cycles were measured by the OPC and APS.

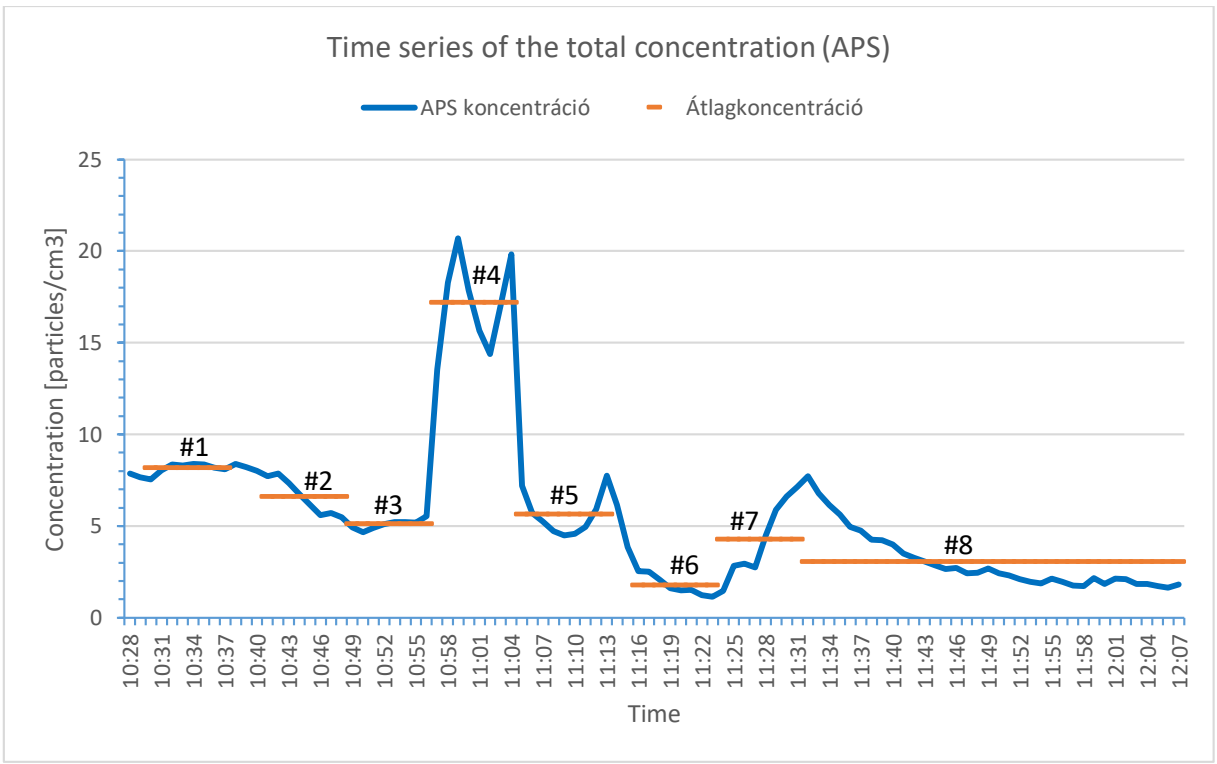
The measurement settings are summarized in the following table:

#		9:45		Installation of the instruments
		10:15		Start of the measurements
1		10:30		Measurement of the background – in a closed room
2		10:43		Measurement with extraction at 40 cm distance
3		10:51		Measurement without extraction at 40 cm distance
4		10:58		Measurement without extraction at 15 cm distance
5		11:06		Measurement with extraction at 15 cm distance
		11:15		relocation of sampling
6		11:17		Measurement at the exhaust outlet
7		11:25		switch off extractor, ventilation
8		11:34		measurement in a closed room, extractor operates
		12:10		end of the measurement, stop

Presentation of the measured data

The figures below show the time series of the total number concentrations measured by the OPC, APS, and the SMPS (for the size range measured by the instrument) during the tests. For the sake of uniformity, hereinafter the unit of the number concentration values is [particles/cm^3].





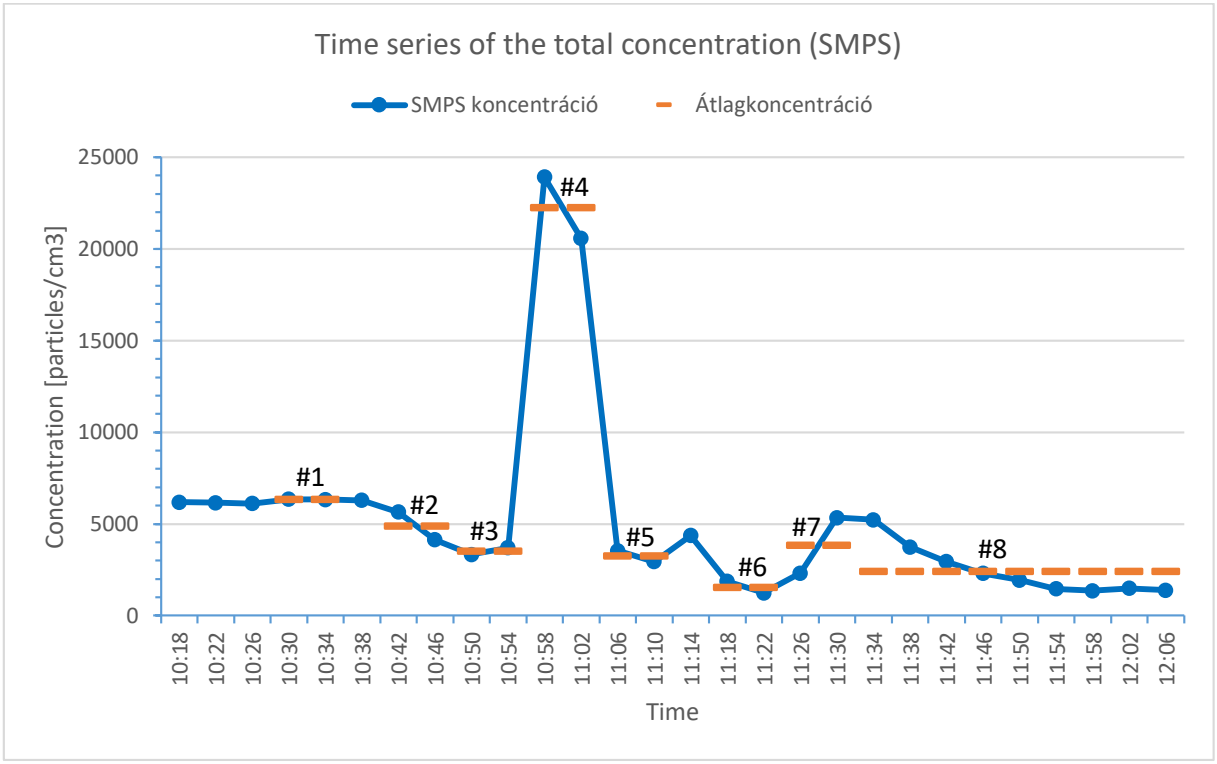


Figure 12. Time series of the total concentrations for the three instruments (OPC, APS, SMPS)

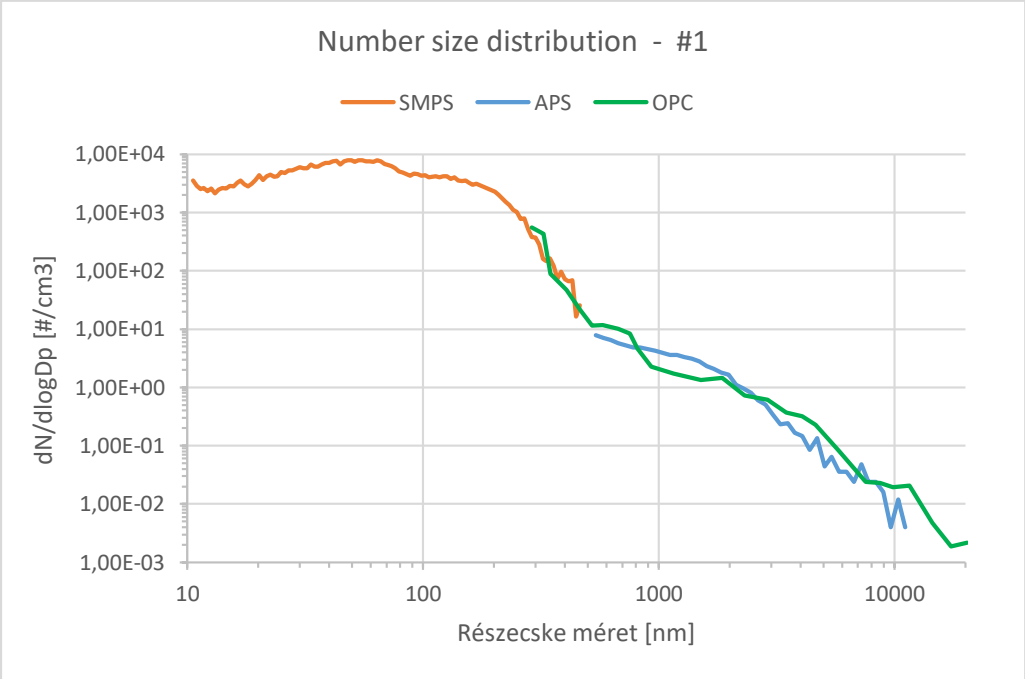
In Figure 12, yellow lines indicate the 8-minute averages for each measurement point (except for set #8, where a longer average is applied). The figure illustrates how the measured concentration values change even within the 8-minute time intervals associated with the measurement sets. Such variability of the data is characterized by the standard deviation parameter during statistical processing.

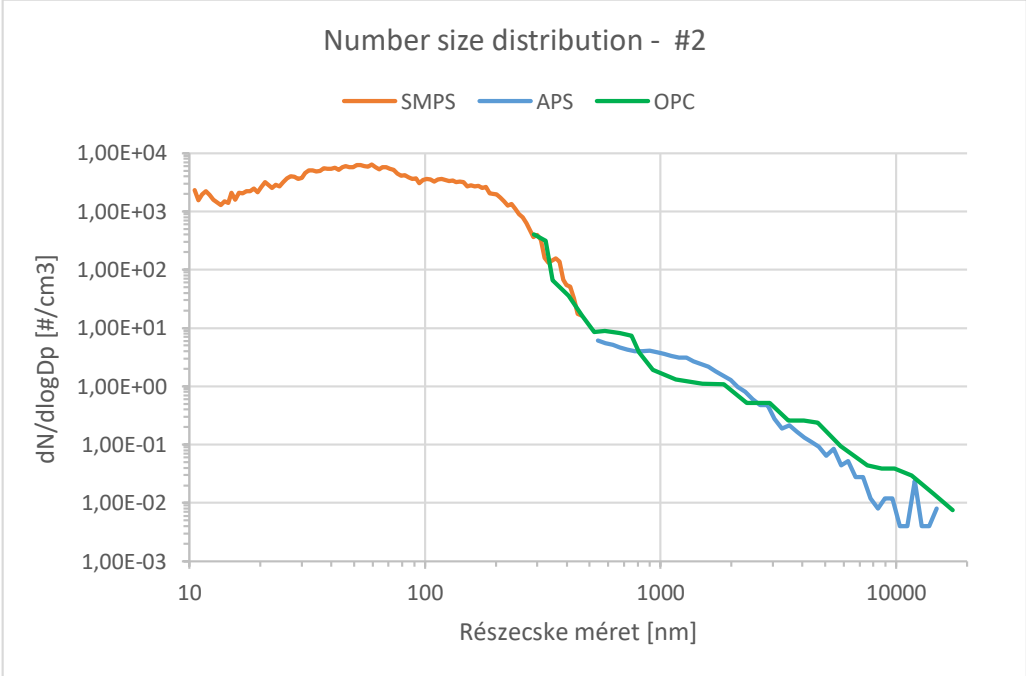
$$\text{Average:} \quad \bar{C} = \frac{1}{N}\sum_{i=1}^{N} C_i; \quad \text{standard devition:} \quad D = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(C_i - \bar{C})^2}.$$

Hereinafter the size ranges are determined according to the PM10, PM2.5, and PM1 categories for the environmental and health impact assessment.

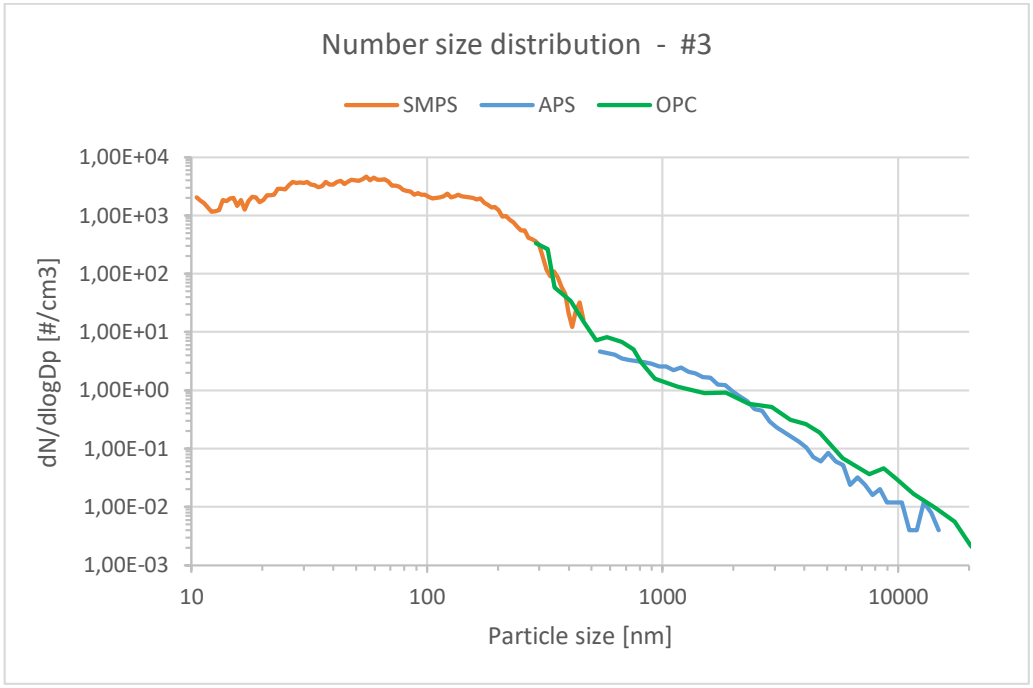
Number size distribution curves for each set

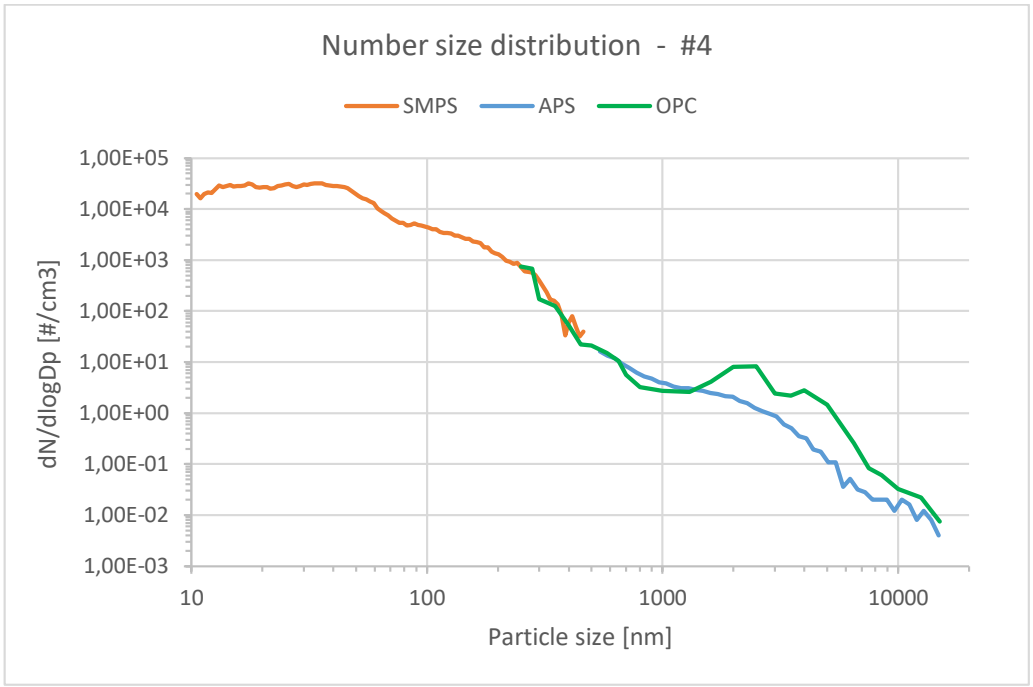
The following figures show the size distributions recorded by the three instruments during each measurement set. Since we do not have information on the shape of the particles, we assume that they are spherical. The optical size measured by the OPC was converted to aerodynamic size: $D_{aer} = \sqrt{\rho} \cdot D_{opt}$, where ρ is the density of the particle in [g/cm^3]. During the calculations, we used a value of ρ = 1.35 g/cm^3 for the density at the measurement sets #1,2,3,6,7,8 and ρ = 1 g/cm^3 at the sets #4 and 5. The above values were determined from the measured data by fitting.

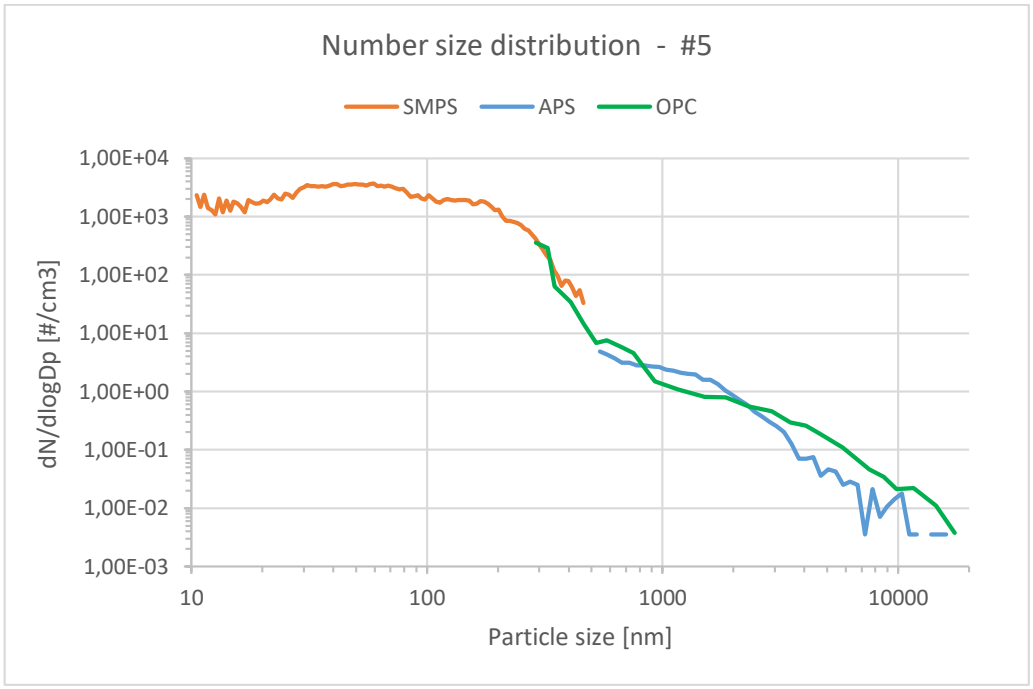


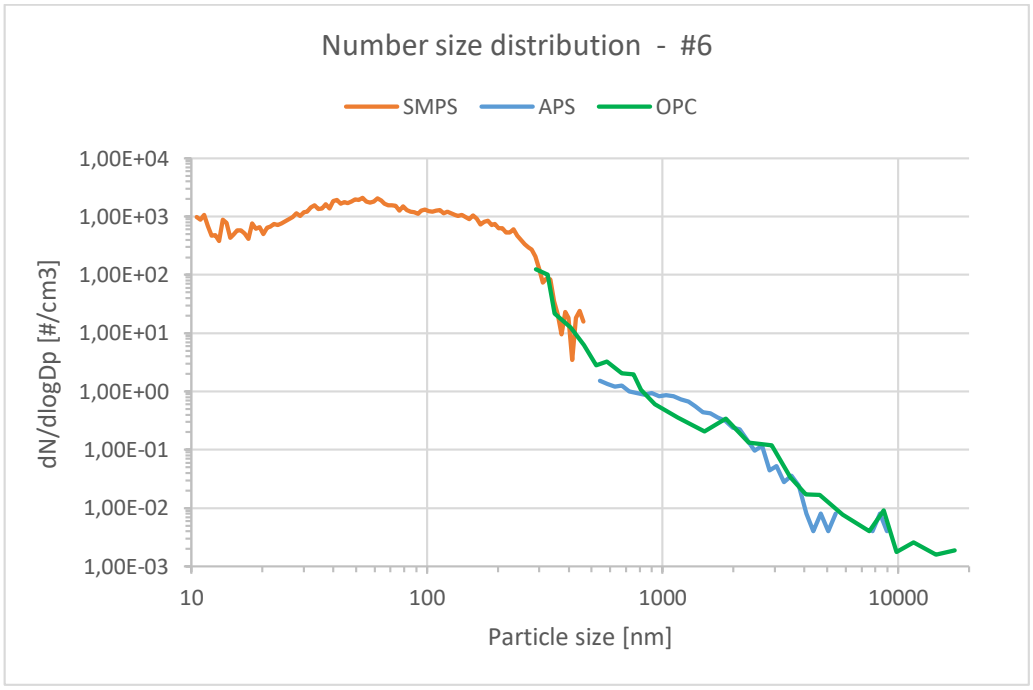


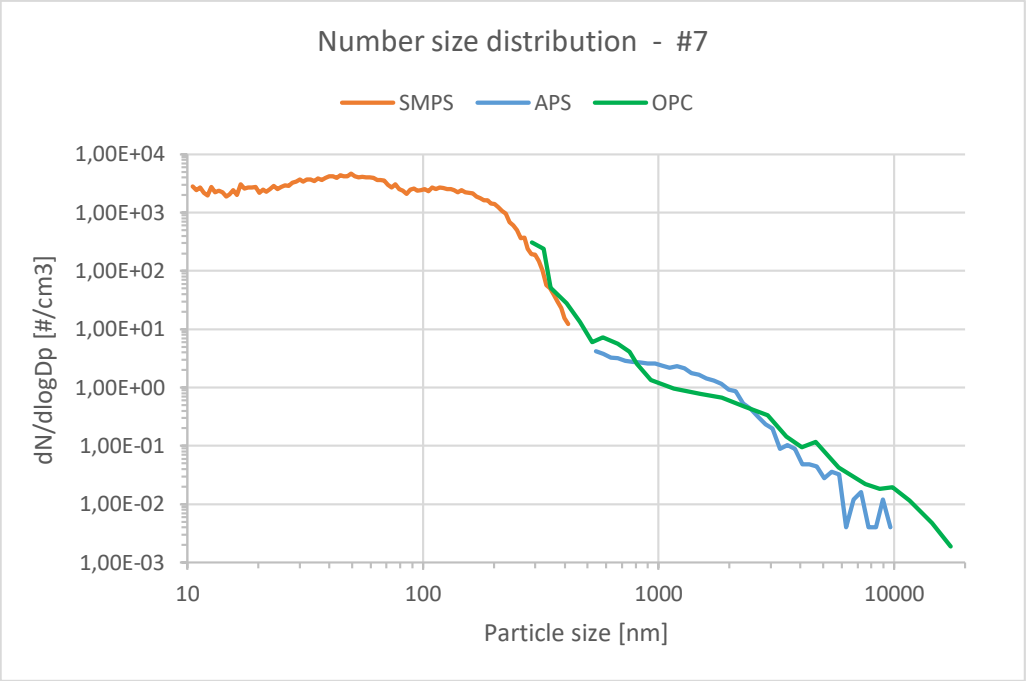
Analysis of the data revealed that the concentration of particles above 0.5 µm was so low that SMPS could no longer reliably detect it, so only the part between 10 nm and 500 nm was taken into account when examining the distributions.

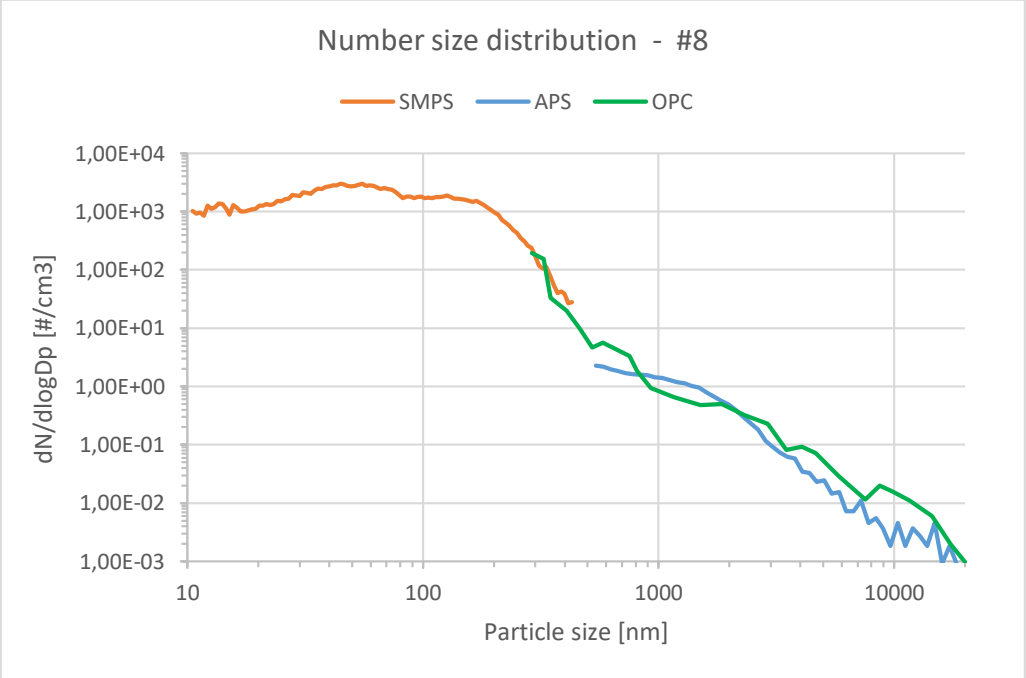





Number size distribution - #5
SMPS
APS
OPC
1,00E+04
1,00E+03
1,00E+02
1,00E+01
1,00E+00
1,00E-01
1,00E-02
1,00E-03
dN/dlogDp [#/cm3]
10
100
1000
10000
Particle size [nm]


Number size distribution - #6
SMPS
APS
OPC
1,00E+04
1,00E+03
1,00E+02
1,00E+01
1,00E+00
1,00E-01
1,00E-02
1,00E-03
dN/dlogDp [#/cm3]
10
100
1000
10000
Particle size [nm]





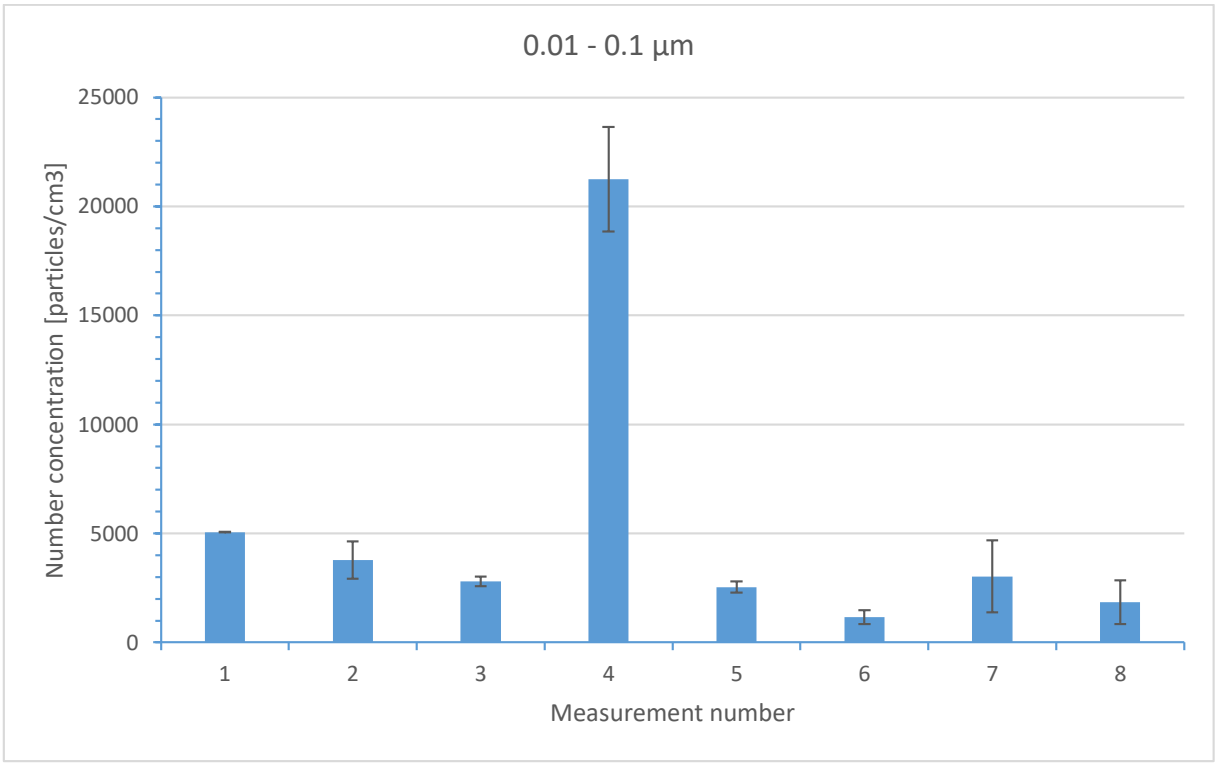
After analyzing the distributions, the submicron (the part below 1 µm) range was further divided into 0.01 - 0.1 µm, 0.1 - 0.5 µm, and 0.5 - 1 µm ranges based on the dynamics of the data.

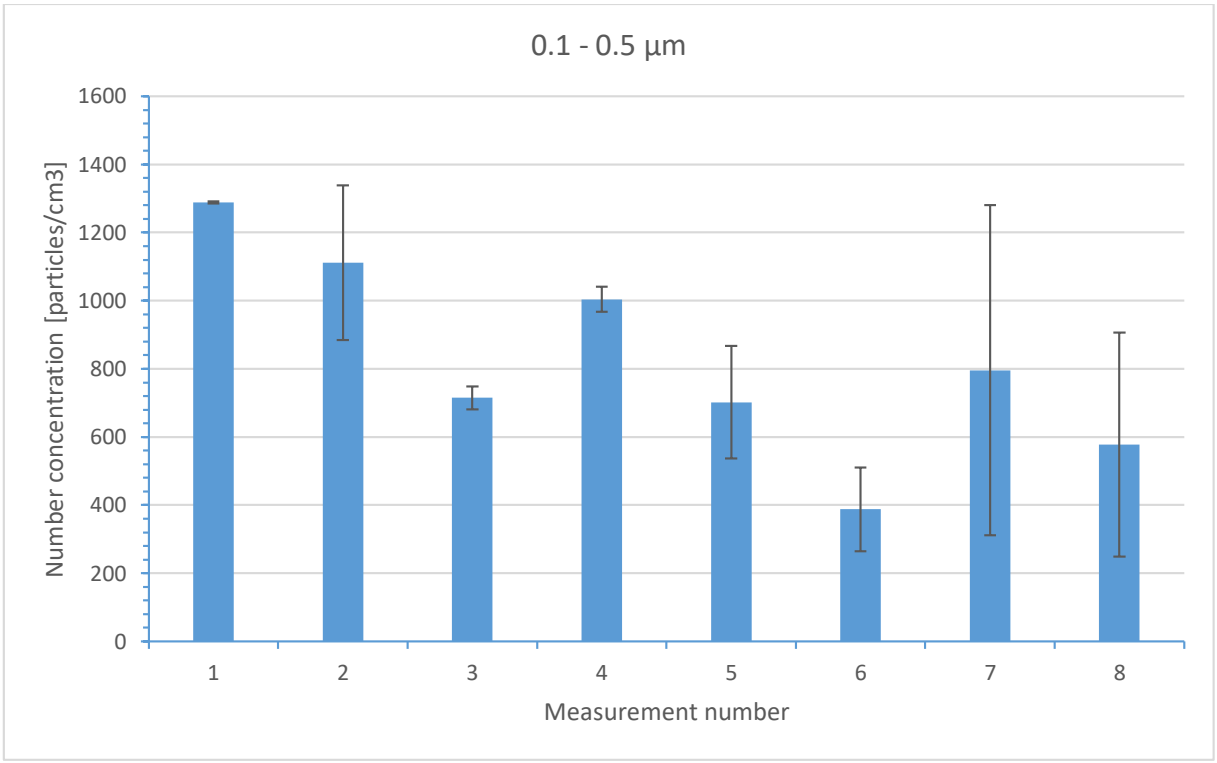
The mean and standard deviation of the concentrations measured at each set in the different size ranges

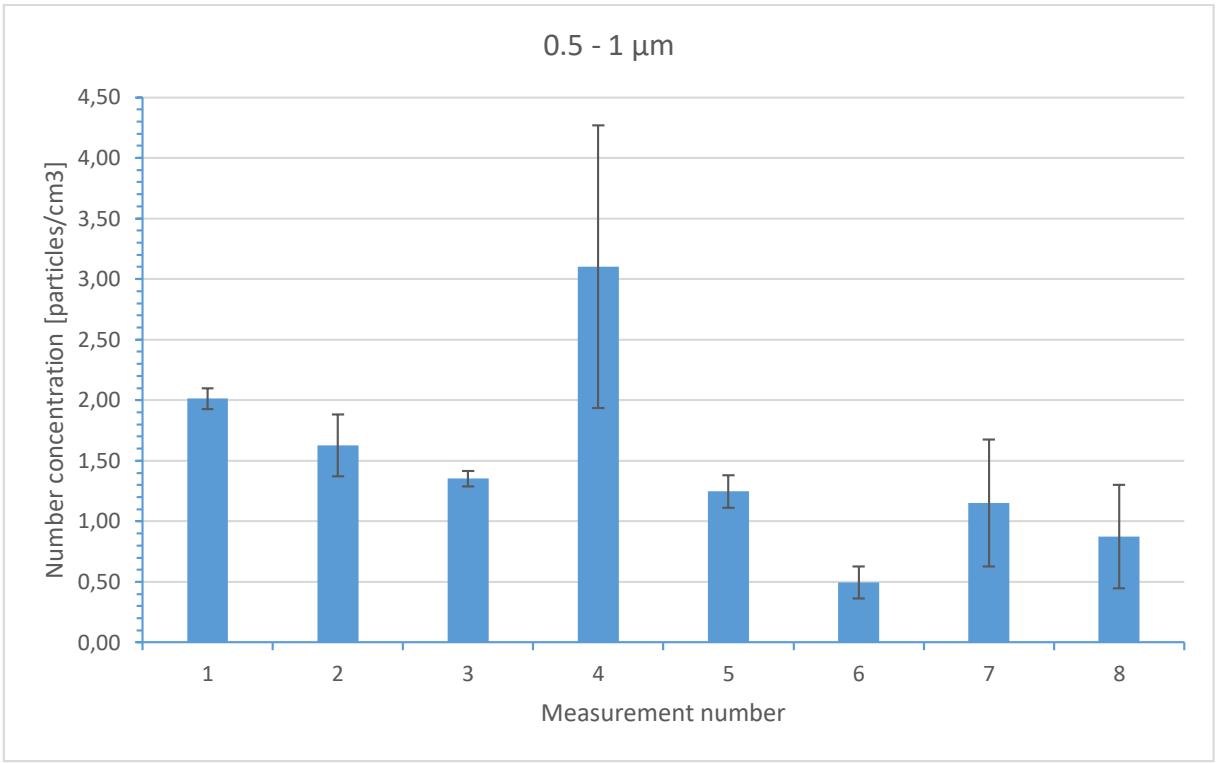
The following table shows the mean concentration and standard deviation values measured during each measurement set over the size ranges defined above.

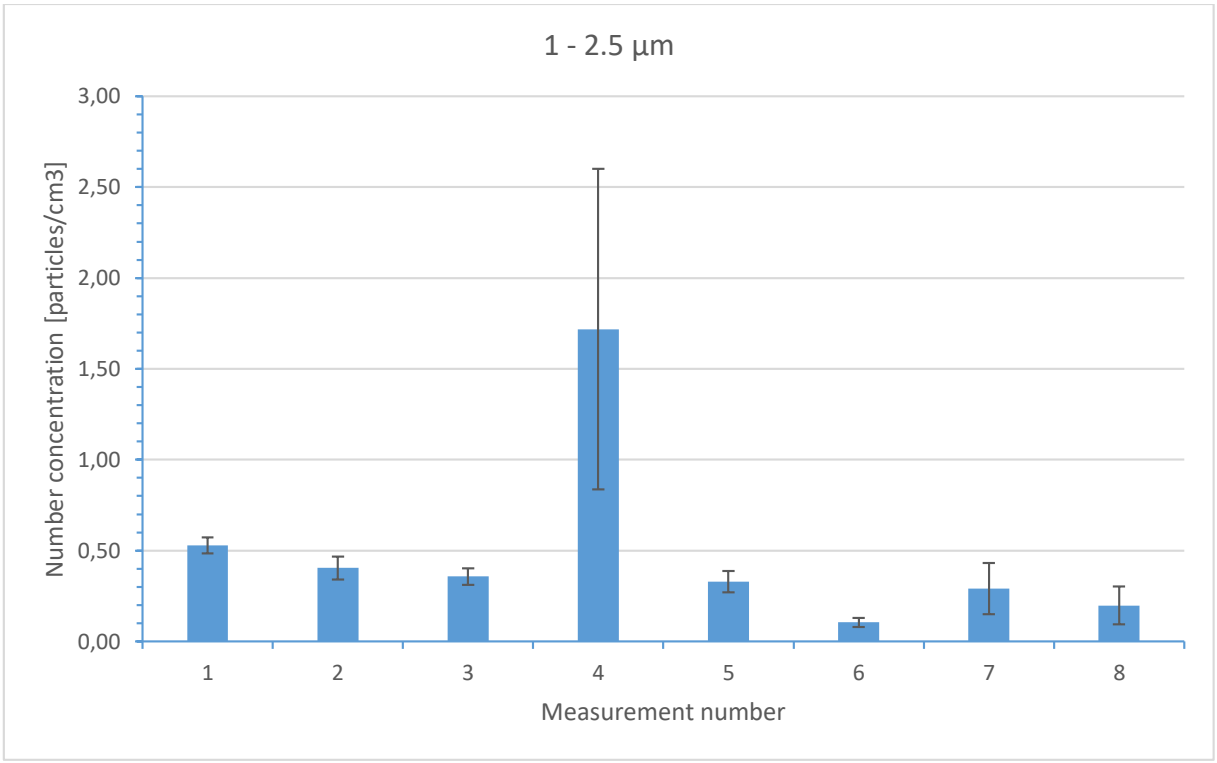
	#	0.01 - 0.1 µm	0.1 - 0.5 µm	0.5 - 1 µm	1 - 2.5 µm	2.5 - 10 µm
Mean [db/cm3]	1	5056	1288	2.01	0.53	0.13
	2	3783	1111	1.63	0.40	0.12
	3	2802	715	1.35	0.36	0.11
	4	21243	1004	3.10	1.72	1.41
	5	2539	702	1.25	0.33	0.11
	6	1161	388	0.50	0.11	0.02
	7	3031	796	1.15	0.29	0.06
	8	1848	578	0.87	0.20	0.04
Standard deviation	1	12.6	3.0	0.086	0.044	0.025
	2	848.5	227.3	0.256	0.063	0.015
	3	230.6	33.5	0.063	0.045	0.027
	4	2400.1	36.3	1.165	0.883	0.730
	5	258.1	164.7	0.134	0.058	0.035
	6	321.4	122.7	0.131	0.025	0.010
	7	1657.8	484.7	0.523	0.140	0.041
	8	1002.4	329.2	0.429	0.104	0.022

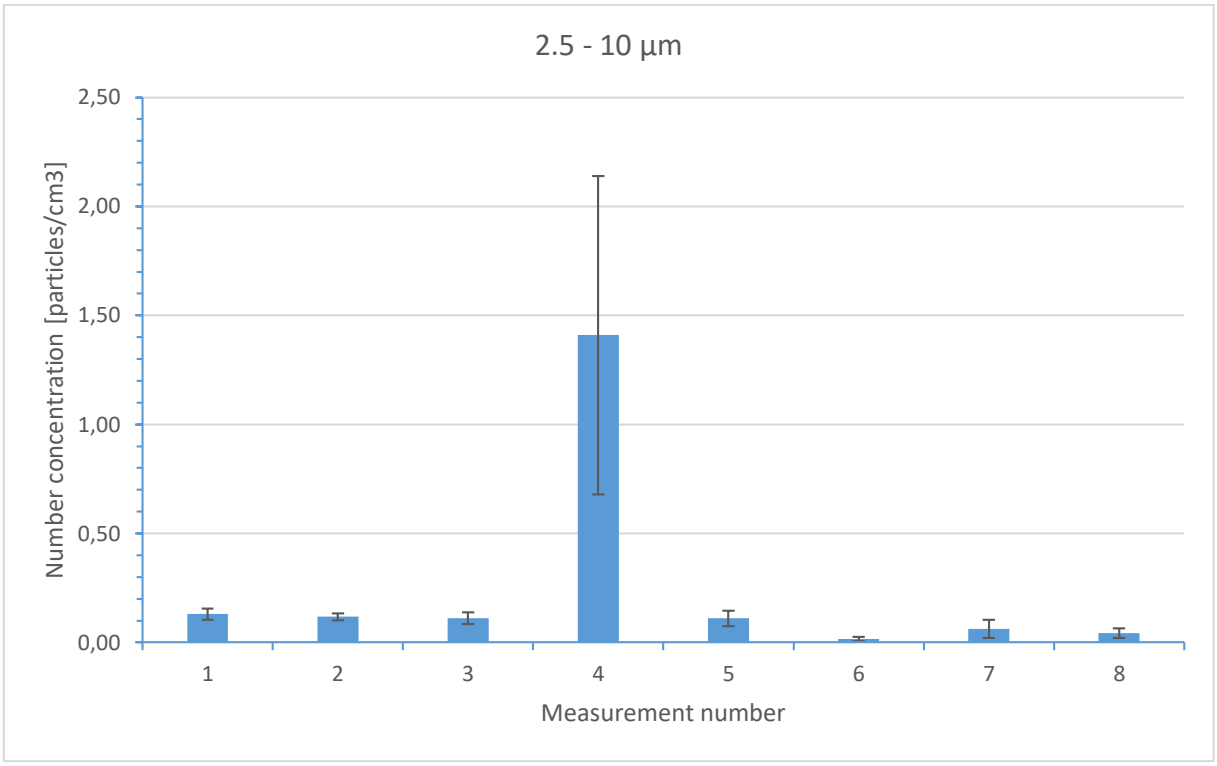
The following diagrams were made from the data in the table above. They show the average concentrations measured during each measurement set and the standard deviation of the measured data for each size range.


0.01 - 0.1 µm
Number concentration [particles/cm3]
25000
20000
15000
10000
5000
0
1
2
3
4
5
6
7
8
Measurement number

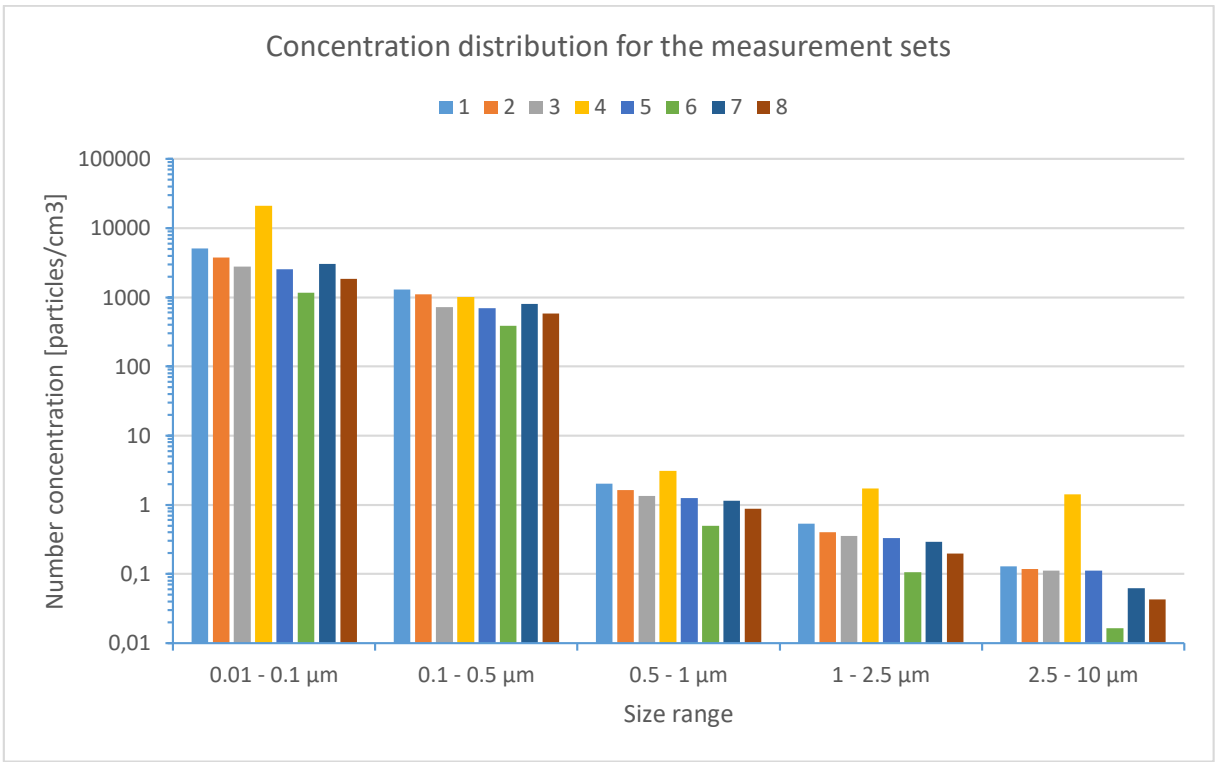

0.1 - 0.5 µm
Number concentration [particles/cm3]
1600
1400
1200
1000
800
600
400
200
0
1
2
3
4
5
6
7
8
Measurement number


0.5 - 1 µm
Number concentration [particles/cm3]
4,50
4,00
3,50
3,00
2,50
2,00
1,50
1,00
0,50
0,00
1
2
3
4
5
6
7
8
Measurement number


1 - 2.5 µm
Number concentration [particles/cm3]
3,00
2,50
2,00
1,50
1,00
0,50
0,00
1
2
3
4
5
6
7
8
Measurement number



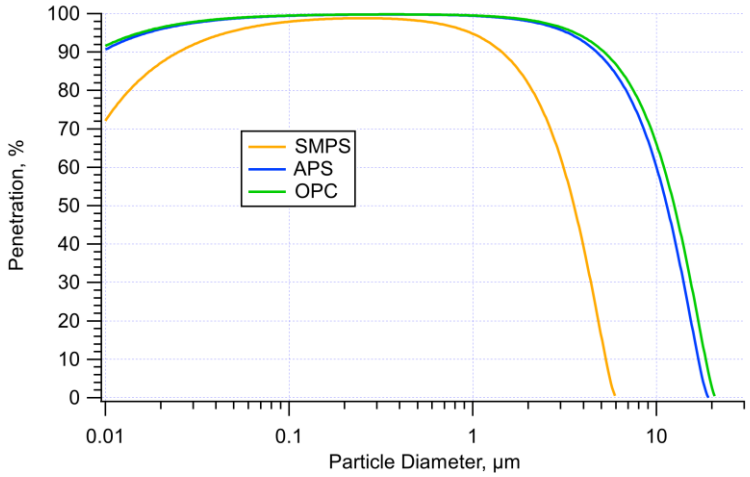
The following figure is a summary of the graphs above. Concentration was plotted on a logarithmic scale due to the large dynamic range.



Discussion

Based on the analysis of the data, it can be concluded that the three devices reliably recorded the particle size and concentration data in the dental treatment room. At the beginning of the series of measurements, during the background measurements, there were stable conditions in the closed room, and the number and size distribution of aerosol particles present in the air did not change significantly. The differences in the data measured by the three instruments can be attributed to physical reasons resulting from the differences in the measurement principles. During the series of measurements, the concentration values measured with the three devices showed a strong correlation with each other and with the measurement conditions.

The figure below shows the transmission characteristics of the sampling tubes connected to the three instruments, which in this case corresponds to the sampling efficiency. The calculation takes into account diffusion (ultrafine particles), sedimentation (large particle deposition), inertial (bends and constrictions), and turbulent flow losses in the tubes.



[Weiden, S.-L., Drewnick, F., and Borrmann, S.: Particle Loss Calculator - a new software tool for the assessment of the performance of aerosol inlet systems, Atmos. Meas. Tech., 2, 479–494.]

Considering the average residence time of the particles in the sampling tubes, for SMPS, it is likely that evaporation affects the measurements.

The study does not include data for particles larger than 20-30 µm. Larger particles, according to the video recordings made during the measurements, fall to the floor near the aerosol formation and do not spread farther.

Summary of results, conclusions

1. Based on the measured data, it can be stated that the used VacStation Extraoral Dental Vacuum System effectively filtered out the aerosol particles formed during the dental treatment.
2. During the measurement sets #2 and #3, when the sampling site was 40 cm from the aerosol formation site, the particle concentration decreased relative to the background, even after the extractor was turned off. This may be attributed to the fact that the particles did not reach such a distance (due to the flow and evaporation conditions) and the extractor started to clean the air in the treatment room.
3. For the measurement set #4, where the sampling site was moved to 15 cm from the aerosol formation and the extraction device was stopped, the OPC measured approx. triple, the APS measured approx. two and a half times and the SMPS measured approx. a 5-fold increase in concentration (for the full range of the instruments) compared to the previous condition. At the measurement set #5, the concentration returned to the previous (#3) level.
4. By analyzing the data of the measurement set #4, we can conclude that during the aerosol formation (dental treatment) in the treatment room the particle concentration increased by 8.4 times below 100 nm, 1.4 times between 100 and 500 nm, 2.5 times between 0.5 and 1 µm, 5.2 times between 1 and 2.5 µm and 12.7 times between 2.5 and 10 µm compared to the data measured with the extraction device.
5. The concentration measured at the outlet of the extractor is approx. dropped to 22% of the background in 8 min with a decreasing trend (based on data from the three instruments).
6. After ventilation in the room, the previously measured background concentration has been practically restored. By turning the suction pipe upwards, and operating the system as an air purifier, the concentration is approx. decreased to 23% of its initial value in the room after 35 min.