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Report No. 330241-192

Certification of the effectiveness of a mobile air purifier to reduce aerosol concentrations in closed indoor areas

Carried out on behalf of

Sana-Medizintechnisches Servicezentrum GmbH

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Table of contents

Change history	3
List of abbreviations, equations and units of measure	4
1 Introduction	7
2 Task and objective	8
3 Object of the study	9
4 Materials and methods	10
4.1 Materials and measuring instrumentation	10
4.1.1 Test environment	10
4.1.2 Aerosol generator	11
4.1.3 Selection of surrogate viruses.....	11
4.1.4 Aerosol concentration	13
4.1.5 Temperature and humidity.....	14
4.1.6 Volatile organic compounds.....	14
4.1.7 Ozone.....	15
4.1.8 Aldehydes and ketones	15
4.2 Method.....	16
4.2.1 Basic test set-up and procedure	16
4.2.2 Detecting the airborne surrogate viruses	18
4.2.3 Evaluation procedure	19
4.2.4 Method validation.....	19
5 Results	23
6 Summary of the test	28
7 Bibliography	29

Change history

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	Initial report	Daniel Benz July 18, 2022
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List of abbreviations, equations and units of measure

Abbreviation	Definition
°C	Degree Celsius
BCV	Bovine coronavirus
CAPE	Clean And Protective Environment
COVID-19	coronavirus disease 2019
D90	Area-specific radiation doses (inactivation around 90 %)
DEHS	Di-ethyl hexyl sebacate
DNPH	Dinitrophenylhydrazine
FFU	Filter Fan Unit
ft ³	cubic foot/feet
g	gram
GCMS	Gas chromatograph with mass spectrometer
h	hour
HCoV	Human coronavirus
HPLC	High performance liquid chromatography
IBP	Institute for Building Physics
ICT	IPA CAPE Test Center
IGB	Institute for Interfacial Engineering and Biotechnology
IPA	Institute for Manufacturing Engineering and Automation IPA
IZS	Institute Center
K	Sensitivity constant
K	Kelvin
CW	Calendar week
l	liter
LLOQ	Lower limit of quantification
Log	Logarithm
m	meter
m ³	cubic meter

Abbreviation	Definition
min	minute
ml	milliliter
MP	Measuring Point
MS2	Bacteriophage MS2
N/A	not applicable
ng	nanogram
nm	nanometer
OPC	Optical particle counter
PFU/pfu	plaque forming unit
P1,...,P4	Phases of the test series
Phi6	Bacteriophage Phi6
PBS	Phosphate buffered salt solution
ppb	parts per billion (=10 ⁻⁹)
ppm	parts per million (10 ⁻⁶)
r.h.	relative humidity
RNA	Ribonucleic acid
rpm	revolutions per minute
RT-qPCR	quantitative real-time polymerase chain reaction
RV I	Reference value
s	second
SARS-CoV-2	Severe acute respiratory syndrome coronavirus type 2
SVOC	Semi volatile organic compounds
µm	micrometer
µg	microgram
UPLC	Ultra-performance liquid chromatography
UV	Ultraviolet spectral range
UV-C	C-band of the ultraviolet spectrum
VDI-ER	Association of German Engineers - Expert Recommendation

Abbreviation	Definition
VOC	Volatile organic compounds
VVOC	Very volatile organic compounds

1 Introduction

Based on current scientific knowledge, infections with the coronavirus SARS-CoV-2 which causes the respiratory disease COVID-19 occur largely via aerosols. Especially in closed, poorly ventilated or non-ventilated indoor areas with several people, recommendations on keeping one's distance, hygiene measures and wearing a mask are often not sufficient to protect against infection. Without countermeasures, bioaerosols containing the pathogen SARS-CoV-2 exhaled by infected persons can remain suspended in a room for a very long time and thus represent a higher and uncontrollable risk of infection. Mobile air purifiers are therefore increasingly gaining attention as a measure that can be implemented quickly to reduce the risk of infection.

To compare the suitability and effectiveness of air purifiers, they must be evaluated under objective, representative and comparable test conditions.

2 Task and objective

To assess whether and under which general conditions it makes sense to deploy a mobile air purifier to reduce aerosol concentrations and thus the risk of infection, the effectiveness of each air purifier must be ascertained individually and empirically.

The aim of the study is to evaluate the effectiveness of the air purifier provided by the customer to reduce and inactivate airborne surrogate viruses¹ in a specially equipped test room (see Chapter 3).

¹ enveloped Phi6 bacteriophages with a structure, genome, particle size and environmental stability comparable to SARS-CoV-2
[1],[2],[3],[4],[5]

3 Object of the study

The specifications of the air purifier correspond to the technical data supplied by the manufacturer and are listed in Table 1.

Table 1: Device specifications

Device name	Potok M-150-01
Manufacturer	Sana-Medizintechnisches Servicezentrum GmbH
Serial number	N/A
Functional principle	Decontamination plus filter
Volume flow	up to 300 m ³ /h
Installation	Stand-alone system
Dimensions	Height: 880 mm; width: 720 mm; depth: 446 cm
Room size	up to 30 m ² (75 m ³)
Measuring period	CW 20.2022



Figure 1: tested air purifier Potok M-150-01

4 Materials and methods

To establish a quantitative and comparable method for assessing the effectiveness of mobile air purifiers according to VDI EE 4300 Part 14, first an infrastructure consisting of

- a test environment (Chapter 4.1.1),
- aerosol generators to produce the aerosols (Chapter 4.1.2) with a suitable surrogate material (Chapter 4.1.3), and
- measuring instrumentation to measure the
 - aerosol concentration during the test (Chapter 4.1.4),
 - ambient temperature and humidity (Chapter 4.1.5) and
 - by-products such as ozone, ketones, aldehydes and other volatile organic compounds (VOCs) (Chapters 4.1.6, 4.1.7 and 4.1.8)

was set up and made ready for the tests [13]. Based on this, a method was developed and validated for evaluating the mobile air purifiers (Chapter 4.2).

4.1 Materials and measuring instrumentation

4.1.1 Test environment

To create a controlled environment, the CAPE® developed by Fraunhofer IPA was utilized. This is capable of achieving air cleanliness classes of Class 3 and better, as defined in ISO 14644-1. According to VDI EE 4300 Part 14, such an environment is suitable for evaluating the effectiveness of the mobile air purifier to reduce the introduced aerosols [19].

The environment is also temperature and humidity controlled (IPA Cape Test Center, ICT: 75 m³) and meets the following general conditions:

- Temperature of wall surfaces 23 °C ± 2 K
- Ambient air temperature approx. 25 °C ± 2 K
- Ambient humidity approx. 48 % ± 10 % r.h
- Air exchange rate 0 1/h (static)



Figure 2: Setup for evaluating mobile air purifiers with the aid of virus surrogate aerosols (left) and surrogate DEHS aerosols (right) at Fraunhofer IZS in Stuttgart

4.1.2 Aerosol generator

To spray the particle suspensions as aerosols into the air (virus surrogates), aerosol generators are used with an additional magnetic stirrer to ensure that the particle suspension is mixed well. The following AGK 2000 aerosol generator from Palas GmbH was used in the tests with the following parameters.


	Technical data:	
	Operating pressure:	1.5 bars
	Magnetic stirrer:	300 rpm

Figure 3: AGK 2000 aerosol generator from Palas GmbH for atomizing the virus surrogates

4.1.3 Selection of surrogate viruses

In principle, several viruses which are comparable to SARS-CoV-2 can be used as surrogates for the highly pathogenic SARS-CoV-2:

- human coronavirus 229E (HCoV-229E), which is a common and widespread cold virus,
- bovine coronavirus BCV, which is an animal pathogen, and
- the bacteriophage Phi6, which is not pathogenic

The bacteriophage Phi6 was chosen. With its membrane envelope and RNA genome, it is very similar to the SARS-CoV-2 virus. However, because it does not harm animals or humans in any way, it can be dispersed as an aerosol in the tests without risk. After taking cultures of these bacteriophages, a scaled-up procedure based on a liquid culture was established to ensure the appropriately large and constant supply of the surrogate viruses required for the tests.

Remarks:

- Tests on the activity of the virus on surfaces require a different method because the stability of viruses in liquids (smear infection) must be taken into account here. There is a significant amount of literature or data on inactivating viruses in liquid media and on surfaces. However, results cannot be transferred to airborne microorganisms due to the potential and varying effects of the media on the microorganisms, which are not yet quantifiable.
- Due to insufficient data (Table 2) regarding the sensitivity of the viruses or phages to UV radiation at 254 nm in aerosols, at the present time it is not possible to transfer the inactivation of Phi6 phages to SARS-CoV-2. As another example, MS2 phages are over ten times more sensitive to 254 nm UV radiation according to Tseng than according to Walker, and moreover, relative humidity has opposing effects (Table 2).

Table 2: Sensitivity constant k and area-specific radiation doses D_{90} (inactivation by 90 %) from literature for the phages Phi6 and MS2 as well as for a coronavirus. Only values for the irradiation of airborne phages or viruses with 254 nm UV radiation are considered.

Phage/virus	Publication	Medium relative humidity	k in m^2/J	D_{90} in J/m^2
Phi6 phage	according to Tseng et al [11]	Aerosol, 55 % r.h.	0.43	5.35
		Aerosol, 85 % r.h.	0.31	7.43
MS2 phage	according to Tseng et al [11] [12]	Aerosol, 55 % r.h.	0.81	2.84
		Aerosol, 85 % r.h.	0.64	3.60
	according to Walker et al [12]	Aerosol, 32-50 % r.h.	0.045	51.4
		Aerosol, 74-82 % r.h.	0.054	42.8
Coronavirus	according to Walker et al [12]	Aerosol, 50 % r.h.	0.35	6.56

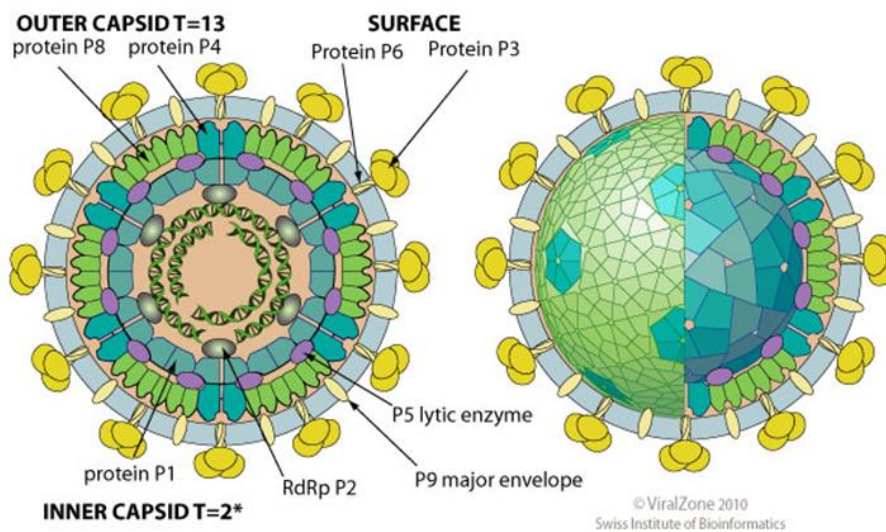


Figure 4: Phi6 is a bacteriophage belonging to the Cystoviridae family; its size (100 nm), membrane envelope and RNA genome make it a suitable surrogate for Sars-CoV-2. Source: ViralZone 2010

4.1.4 Aerosol concentration

To measure the aerosol concentration, optical particle counters and air samplers are used:

- Optical particle counters (OPC) are used to measure the physical aerosols. They are capable of detecting airborne aerosol particles ranging from $\geq 0.2 \mu\text{m}$ to $\geq 20 \mu\text{m}$ in size in six different size channels.
- Bio-aerosols are collected with an air sampler on a gelatin membrane, which is subsequently dissolved and analyzed.

Particle concentrations are measured with the PCSS Air LDS328 optical particle counter from Klotz. This detects particles based on the principle of scattered light and has 3 measuring channels; results can be displayed directly. The flow rate is 2.83 l/min (0.1 ft³/min) and particles ranging from $\geq 0.2 \mu\text{m}$ to $\geq 20 \mu\text{m}$ can be detected. The measurement interval is 1 reading per minute and the size channels $\geq 0.2 \mu\text{m}$, $\geq 0.5 \mu\text{m}$, $\geq 1.0 \mu\text{m}$, $\geq 5.0 \mu\text{m}$, $\geq 10.0 \mu\text{m}$, and $\geq 20.0 \mu\text{m}$ are recorded. The device was calibrated at the middle of 2021. The calibration record is available for viewing if required.


	Technical data:	
	Flow rate:	2.83 l/min
	Measuring range:	0.2 - 20 μm
	Max. concentration particles /cbf:	2,000,000
	Measuring channels:	up to 16
	Count rate:	max. 250,000 particles/s
	Light source:	Laser diode

Figure 5: OPZ PCSS-Air from Markus Klotz GmbH for measuring aerosol concentrations

The bacteriophages in the room are sampled with MBASS30 Version 3 and the FA30 filter adapter from Holbach. The MBASS30 V3 is capable of impacting and filtering the bacteriophages. Commercially available gelatin filters in sterile disposable units are used as sampling media. A sample of the ambient air is taken at specific intervals over a defined period of time and then analyzed.


	Technical data:	
	Volume:	1500 l
	Sampling volume:	50 l/min

Figure 6: Holbach MBASS30 V3 system for sampling active bacteriophages in a room.

4.1.5 Temperature and humidity

The ambient parameters of temperature and humidity are recorded by the Testo 175H1 data logger, which monitors and documents the temperature and relative humidity in the test room. The external humidity sensor (stub) ensures a fast response time. The measuring interval is 1 reading per minute. The calibration records are available for viewing if required.


	Technical data: Temperature		Technical data: Relative humidity	
	Measuring range:	-20 to +55°C	Measuring range	0 to 100 %
	Accuracy	±0.4 °C (-20 to +55 °C) ±1 digit	Accuracy	±2 % (2 to 98 %) at +25 °C ±0.03 % /K ±1 digit Drift < ±1 % / year at +25 °C
	Resolution	0.1 °C	Resolution	0.1 %

Figure 7: Testo 175 H1 data logger for measuring temperature and humidity

4.1.6 Volatile organic compounds

Volatile organic compounds (VOC) are quantified by active sampling on a suitable adsorbent material (in this case: Tenax TA). This is then followed by thermal desorption and analysis with a gas chromatograph coupled with mass spectroscopy (ATD-GC/MS) according to ISO 16000-6 and 16017-1, respectively.



	Technical data	
	Measuring range	0.1 µg/m ³ - 10,000 µg/m ³ (scalable by sampling)
	Sampling flow rate	100 ml/min
	Sampling time	60 min

Figure 8: ATD-GC/MS (PerkinElmer)

4.1.7 Ozone

Any ozone generated by the purifier as a by-product is measured and analyzed using the Model 106-L ozone monitor from 2B Technologies. Model 106-L measures and documents the ozone concentration in the air once a minute. In the subsequent analysis, the read-out shows the average amount of ozone emitted over one hour.




Technical data	
Measurement principle	UV absorption at 254 nm
Linear dynamic range:	0-100,000 ppb (0-100 ppm)
Resolution	0.1 ppb
Flow rate (nominal)	~ 1 l/min

Figure 9: 2B Technologies ozone monitor 106-L for measuring any ozone emitted.

4.1.8 Aldehydes and ketones

Gaseous aldehydes and ketones are quantified by active sampling on DNPH cartridges followed by elution and analysis by liquid chromatography (UPLC) according to ISO 16000-3.



Technical data	
Measuring range	1 $\mu\text{g}/\text{m}^3$ - 1,000 $\mu\text{g}/\text{m}^3$ (scalable by sampling)
Sampling flow rate	20 l/min
Sampling time	90 min

Figure 10: UPLC

4.2 Method

4.2.1 Basic test set-up and procedure

The set-up is based on that described in DIN ISO 16000-36 [6] for studying airborne bacteria and is realistically adapted to the specific requirements of viruses:

- The air purifier is placed close to the floor and realistically (Figure 11: Set-up of the air purifier in the ICT with aerosol generator (dosing device), sensor equipment and particle counter
-).

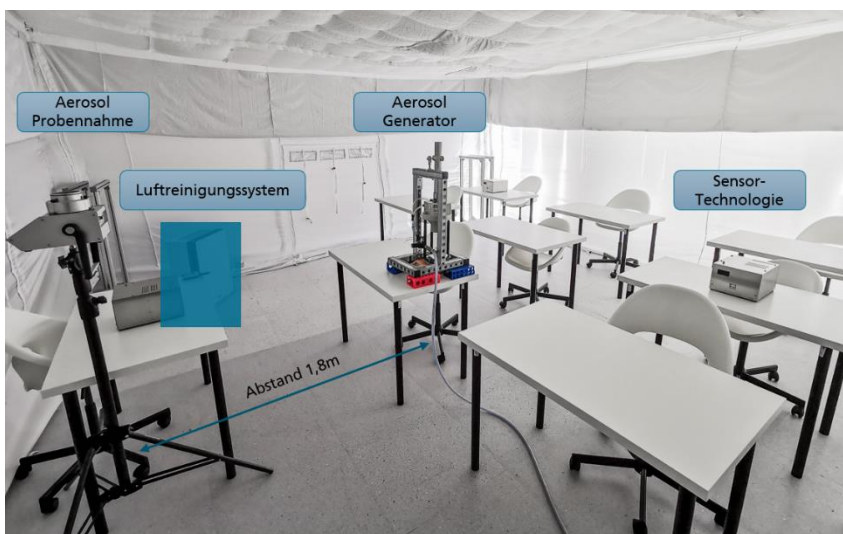


Figure 11: Set-up of the air purifier in the ICT with aerosol generator (dosing device), sensor equipment and particle counter

- The bacteriophages are dispersed into the room at a distance of about 1.8 m in front of the air sampler. To start with, the dosing device is operated without switching on the purifier in order to achieve a high concentration in the room. The dosing device and air purifier are then operated simultaneously to ascertain phage reduction.
- Finally, the air purifier is operated on its own to evaluate its effectiveness to reduce the phages.
- This three-phase test set-up is operated for a total run time of about 3 hours. Particle distribution, temperature and humidity in the room are all measured continuously over the entire run time.
- The collected data is then reviewed and analyzed after the test is completed. The sensor equipment is given a 15-minute running-in phase. Each particle counter measures the particle concentration in its surroundings once a minute. This results in a chronological curve, which is later depicted in graphic form.
- In addition to the effectiveness of the purifier, the natural, time-dependent loss of activity in suspension also potentially affects phage concentration. For this reason, the bacteriophage titer (pfu/ml) of the suspension is also measured at the beginning and at the end of the experiment.
- In compliance with Federal Environment Agency specifications, when using air purification technologies that produce ozone (UV-C, plasma technology; ozone, direct injection), the by-products generated during

operation must be measured. The reference value I (RV I) describes the concentration of a substance in the indoor air at which, according to current knowledge, no adverse health effects are to be expected, even if a person is exposed to this substance for the rest of his life. In addition to measurements with an ozone meter, samples are taken on suitable adsorption tubes to detect VVOCs and VOCs and analyzed by gas chromatography-mass spectrometry. Samples are also taken on DNPH cartridges to determine selected ketones and aldehydes and analyzed using high-performance liquid chromatography-diode array techniques.[14] [15],[16].

- At specific intervals, an air sampler² collects the bacteriophages from the ambient air on a gelatin membrane as described in DIN-ISO 16000-16. The impacted gelatin membrane filters are processed in compliance with DIN ISO 16000-17 within one hour, evaluated after 24 hours (Figure 12: Microbial analysis with a plaque assay test
-) [7],[8] and sent to the lab for microbial analysis by the plaque assay method [9],[10]. The natural half-life of the Phi6 bacteriophages is taken into account when calculating the effectiveness of the purifier.

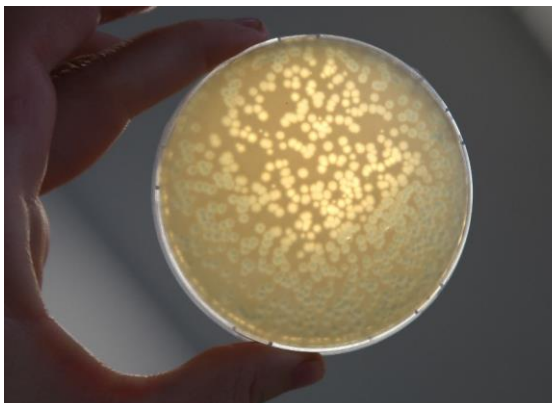


Figure 12: Microbial analysis with a plaque assay test

The following procedure was used to develop and validate the method for evaluating mobile air purifiers in the test set-up:

² MBASS30 Version 3 adapted for filter operation from Umweltanalytik Holbach GmbH, Wadern, Germany



Figure 13: Test set-up for evaluating mobile air purifiers with virus surrogate aerosols at STEP Stuttgart Engineering Park in Stuttgart Vaihingen.

Surrogate viruses are cultivated for the test system. A biological analytics laboratory on the Fraunhofer campus in Stuttgart was used to detect bacteriophage activity as well as to analyze the number of genomes. Finally, a high quality method for generating virus aerosols and sampling was implemented.

4.2.2 Detecting the airborne surrogate viruses

To atomize the surrogate viruses efficiently, the aerosol generator AGK2000 from Palas was used. A defined quantity of the surrogate virus solution was sprayed into the air by the aerosol generator. The solvent used for the surrogate viruses is a nutrient medium which, compared to phosphate buffered saline (PBS) or water, preserves the activity of the virus for a long time after aerosolization.

To effectively sample the surrogate viruses dispersed in aerosols, an air sampler from Holbach was used, which is capable of detecting up to 10^6 pfu/m³ Phi6 after a 60-minute atomization period and 30-minute sampling time (50 l/h).

In order to detect bacteriophages before and after inactivation by the test air purifier, methods for detecting viral activity as well as for identifying the number of viral genomes were developed. To detect viral activity, samples of the virus are diluted in series and spiked with host bacteria. Soft agar is added to the virus/host bacteria suspension and plated on nutrient agar plates. After plating and in the presence of active surrogate viruses, lysed areas form in the bacterial layer within 24 h which correlate with the number of infectious viruses. In addition to the plaque assay method, which is used to identify infectious bacteriophages, a further method is implemented to quantify the number of viral genomes - RT-qPCR. As a preparatory step for the RT-qPCR test, the viral RNA of the bacteriophages is isolated from the samples. The viral genomes are multiplied during the RT-qPCR test, making them easy to detect and quantify. The results of the RT-qPCR test serve as a reference for inactivation, as well as a measure of virus reduction during inactivation. Quantification by RT-qPCR can be optionally performed upon customer request.



Figure 14: Culture-based detection of viral infectivity (top) and molecular analysis of the number of viral genomes (bottom), which can be used to evaluate the effectiveness of indoor air purifiers

4.2.3 Evaluation procedure

To achieve a defined initial state, the sensor equipment is switched on at the beginning. The evaluation of the test starts at Minute 0 and can be divided into three (3) phases (P1 – P3):

- P1: Sampling in the period from 30 min to 60 min: Aerosol generator ON, air purifier OFF (corresponds to reference measurement)
- P2: Sampling in the period from 103 min to 133 min: simultaneous operation of aerosol generator and air purifier
- P3: Sampling in the period from 163 min to 193 min: Aerosol generator OFF and air purifier ON

The effectiveness of the purifier is evaluated on the basis of the readings after Minute 60, 103, 133 and 193. The curves shown in the following chapter reflect the measuring ranges of the particle measuring devices (PCSS Air/Markus Klotz GmbH). The PCSS Air (200 nm to 20,000 nm) spans the nanoscale range up to 20,000 nm, thus covering the range of airborne single viruses (virus size approx. 100 nm) as well as aerosol-borne viruses (particle size approx. 1 to 3 µm). After switching on an air purifier with a built-in filter or similar, all size ranges of the particle measurement values drop within minutes.

4.2.4 Method validation

The following figures show representative results of the reduction in active Phi6 bacteriophages or particles in a pre-test with an indoor air purifier (name not mentioned for data protection reasons). The cleanliness of the test

room was ascertained before and after the test (negative control); in each case, no active Phi6 bacteriophages were detected (not shown). The test scenario is divided into three clear phases:

- Phase 1: Atomization (aerosol generator ON, air purifier OFF), blue
- Phase 2: Air purification during atomization (aerosol generator ON, air purifier ON), green
- Phase 3: Air purification without atomization (aerosol generator OFF, air purifier ON), orange

Zeitpunkt		Aerosolgenerator	Luftreiniger	Luftkeimsammler	Sensortechnik
- 15 - 0 min	NK	Aus	Ein	Ein Negativkontrolle	Ein
0 - 30 min	Zerstäubung Phagen	Ein	Aus	Aus	Ein
30 - 60 min		Ein	Aus	Ein Probe 1	Ein
60 - 73 min	UV Warmlaufen	Ein	Ein	Aus	Ein
73 - 103 min	Zerstäubung Phagen und Luftreinigung	Ein	Ein	Ein	Ein
103 - 133 min		Ein	Ein	Ein Probe 2	Ein
133 - 163 min	Luftreinigung	Aus	Ein	Aus	Ein
163 - 193 min		Aus	Ein	Ein Probe 3	Ein
193 - 208 min	Reinigung Raum	Aus	Ein + FFU	Aus	Ein
208 - 223 min	Reinigung AGK2000	Ein (H2O)	Ein + FFU	Aus	Ein

Figure 15: Detailed description of the test procedure for evaluating the effectiveness of an indoor air purifier to reduce phi6 phages

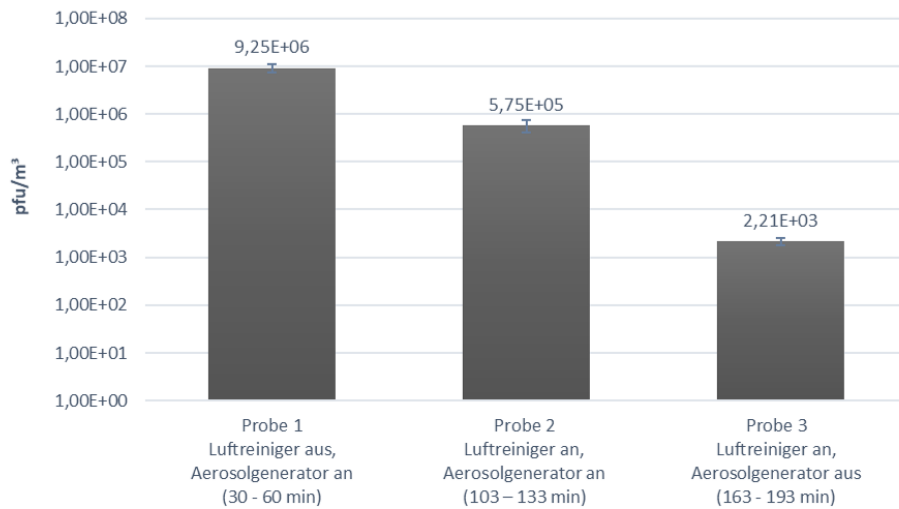


Figure 16: Representative result of the evaluation of an air purifier: reduction of surrogate viruses before and during air purification

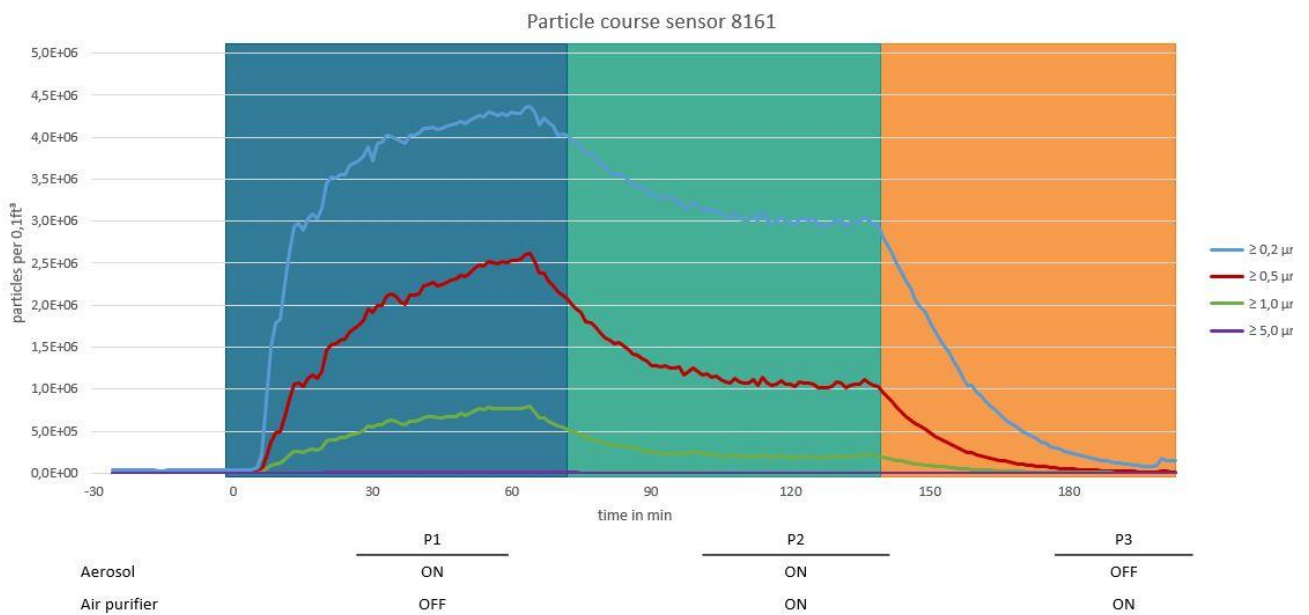


Figure 17: Representative result of the evaluation of an air purifier: particle reduction before and during air purification

When validating the method, first of all the test set-up was established by trying out various test scenarios. This made it possible to effectively reduce the surrogate viruses and also to transfer the method in order to evaluate different indoor air purifiers.

The aerosol generator and sensor equipment are mounted at a height of 1.00 m, corresponding to the normal sitting height.

The distance of the aerosol generator away from the air sampler (1.80 m) or sensor equipment (1.50 m), respectively, is comparable for all tests.

The different indoor air purifiers are placed halfway between the aerosol generator and the air sampler, with the air inlet of the purifier facing the aerosol generator and the air outlet facing the sampler. When establishing the test set-up, other particle measuring devices were used to study distribution in the room. The reproducibility of the defined test set-up was also confirmed.

5 Results

The following graph gives an overview of all the measuring points for determining the particle concentration (MP A to MP C), temperature and relative humidity (T°), the bacteriophages with the air sampler (H) and the aerosol source (x). The air purifier The Potok M-150-01 (★) was operated realistically.

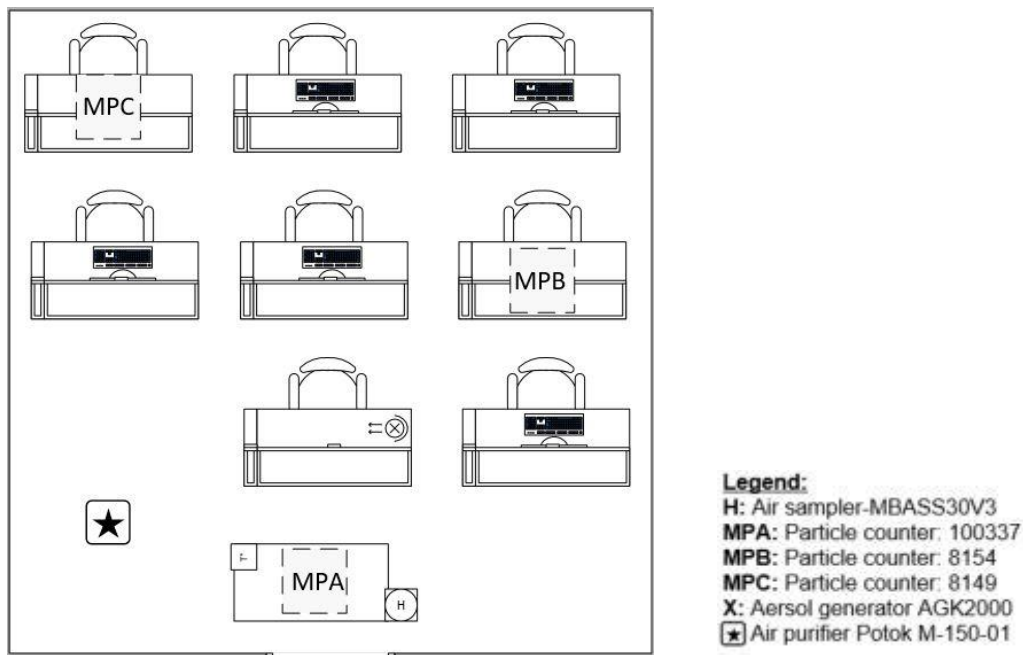


Figure 18: Overview of the measuring points in the room

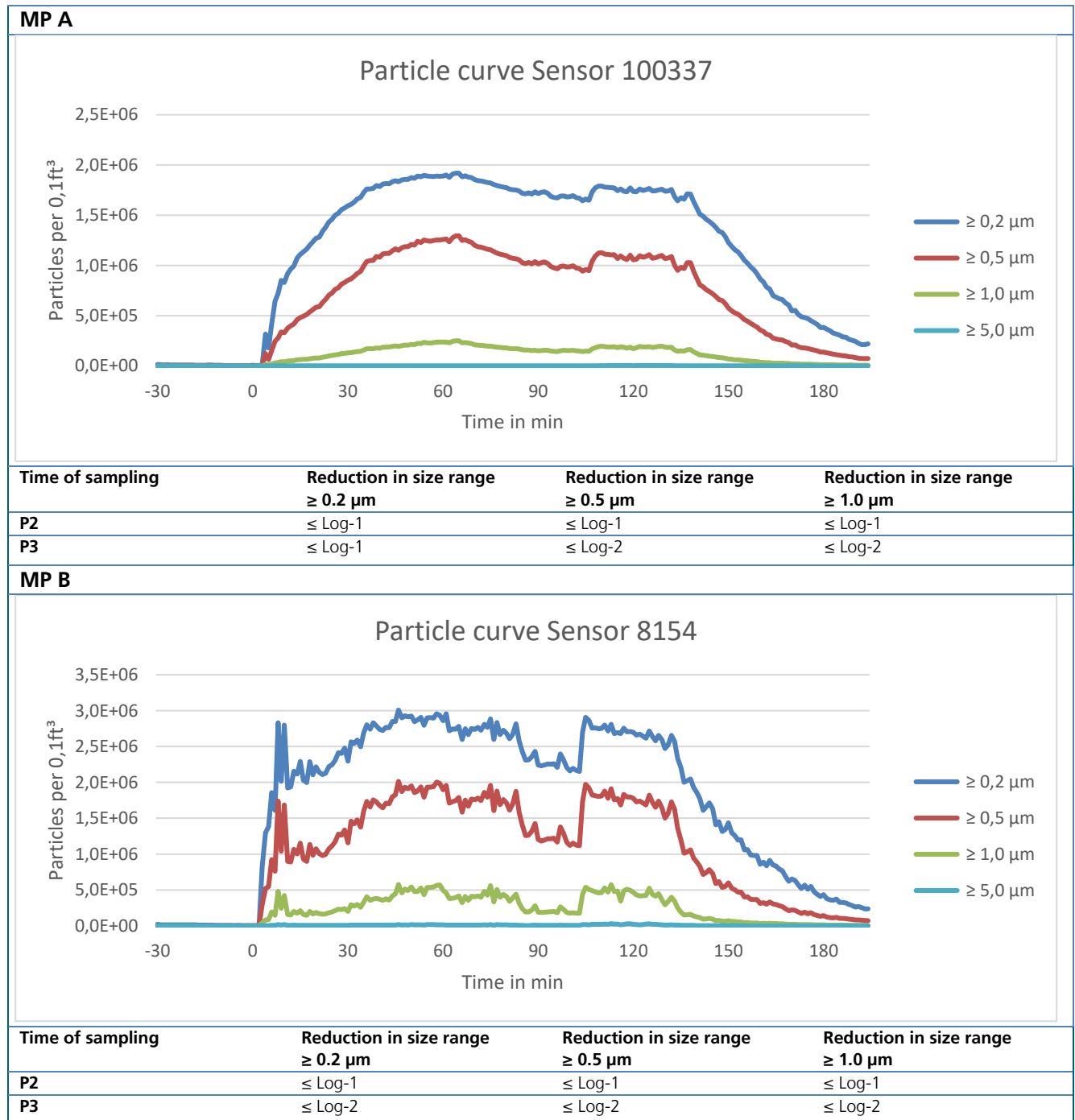
The method described and validated according to VDI EE 4300 Part 14 in Chapter 4 was used to test and evaluate the mobile air purifier provided by the customer and mentioned in Chapter 3. The results are summarized in Table 3.

Table 3: Measurement of viral infectivity or reduction of viral concentration

Time of sampling	Determination of active PFUs with standard deviation in pfu/m ³	Measured reduction in concentration of infectious viruses (measurement data in relation to P1)
P1	5,17U+06	-
P2	2,96U+05	≤ Log-2 (94.27 %)
P3	2,92U+04	≤ Log-3 (99.44 %)

*Concentration [%] = 100/P1*P2, or concentration [%] = 100/P1*P3, reduction [%] = 100 - concentration

The first 30 minutes (-30 to 0) are used to run in the sensor equipment and to clean the room with an air circulation system in order to create a standardized initial state.



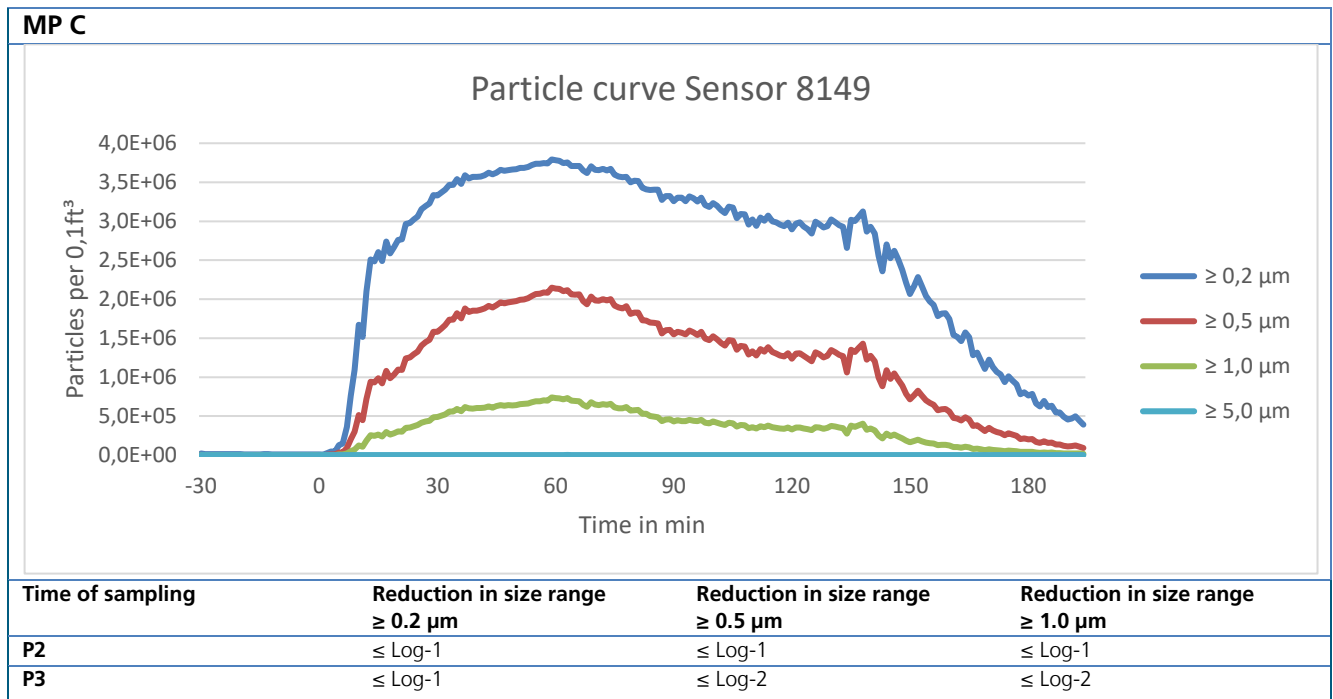


Figure 19: Particle concentration curve at the three measuring points in the test room
* 10 logarithm

Room temperature (red) and relative humidity (blue) were measured and documented throughout the entire test.

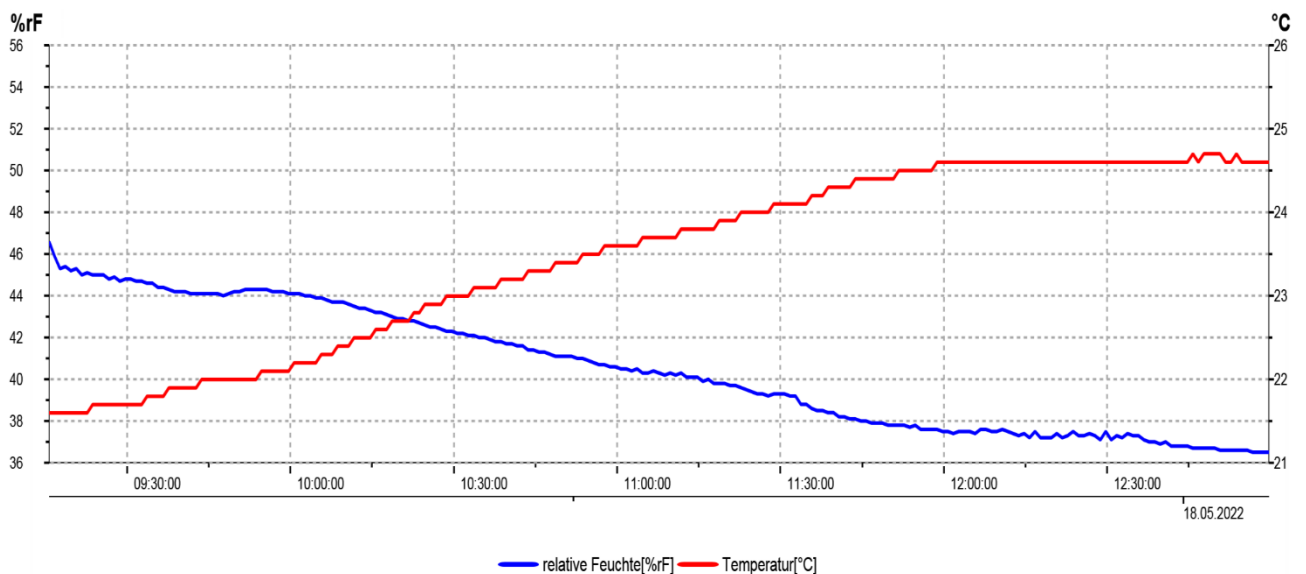


Figure 20: Temperature and relative humidity curve during the air purifier test

The graph below shows the amount of ozone emitted by the air purifier. Minute -60 to 0 give the reference measurement in the room; the mean value over 1 h is determined during this period (6.5 ppb). After switching on the air purifier, the hourly mean value is 5.8 ppb.

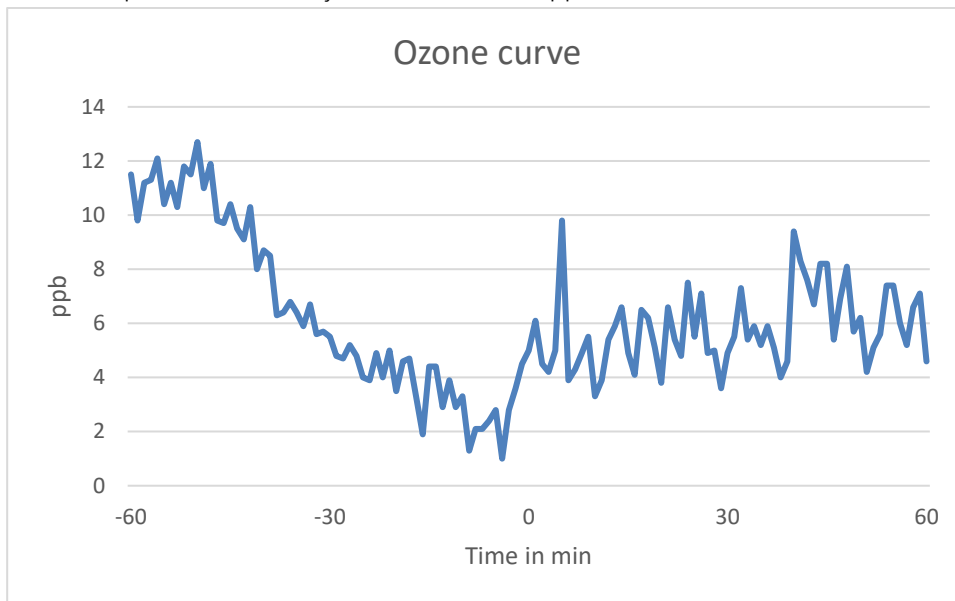


Figure 21: Ozone curve

In a final step, the air purifier was tested for undesirable by-products in an adjacent room. The VOC/SVOC analysis was carried out according to ISO 16017-1 and the ambient ketones and aldehydes were measured according to ISO 16000-3.

		VOC	SVOC	or
Supply air to purifier	Concentration	7.2E-05g/m ³	< 1.7E-07 g/m ³	7.2E-05 g/m ³
Exhaust air from purifier	Concentration	1.2E-04 g/m ³	3.5E-07 g/m ³	1.2E-04 g/m ³

Figure 22: Results of the VOC and SVOC analysis

The following concentrations^{3 4 5} were measured

Name	Concentration ng/m ³		
	Blank value Cartridge	Supply air to purifier	Exhaust air from purifier
Formaldehyde	< LLOQ	21	20
Acetaldehyde	< LLOQ	11	12
Acroleinaldehyde	< LLOQ	< LLOQ	< LLOQ
Acetone	< LLOQ	13	18
Propionaldehyde	< LLOQ	< LLOQ	< LLOQ
Crotonaldehyde	< LLOQ	< LLOQ	< LLOQ
Methacroleinaldehyde	< LLOQ	< LLOQ	< LLOQ
2-butanone	46	63	150
Butyraldehyde	< LLOQ	< LLOQ	< LLOQ
Benzaldehyde	< LLOQ	< LLOQ	2.9
Valeraldehyde	< LLOQ	< LLOQ	< LLOQ
m-tolualdehyde	< LLOQ	< LLOQ	< LLOQ
Hexaldehyde-2,4	< LLOQ	4.2	6.2

Figure 23: Results of measurement of ambient ketones and aldehydes

³ The concentration is calculated from the analyzed sampling volume, the detected concentration and the response of the external standard, which is also determined for each analysis batch, and the conversion factor calculated via the molar mass.

⁴ Only those substances are quantified whose identity is proven by the reference substance "Carb Method 1004 DNPH Mix 1, 3µg/ml in acetonitrile; Product No.: 47650-U Supelco". The concentrations of acetaldehyde / acetone, 2-butanone / butyraldehyde are less certain, because these substances do not elute far enough apart from one other under the specified chromatographic conditions.

⁵ For the purpose of comparability, the blank value of the cartridge is expressed as a concentration based on the analyzed gas volume of the corresponding sample.

6 Summary of the test



Summary of results

This is to certify that

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participated in the qualification of a mobile air purifier for reducing aerosol concentrations in closed indoor area with the device Potok M-150-01.
The test was carried out in accordance with the procedure described in VDI-EE 4300 Part 14.

The following averaged depletion results were found over three measurement positions in the room:

	Particle reduction		
	$\geq 0,2 \mu\text{m}$	$\geq 0,5 \mu\text{m}$	$\geq 1,0 \mu\text{m}$
P2	$\leq \text{Log-1}$	$\leq \text{Log-1}$	$\leq \text{Log-1}$
P3	$\leq \text{Log-1}$	$\leq \text{Log-2}$	$\leq \text{Log-2}$

Notes:

P2: Reduction with continuous aerosolization

P3: Reduction from initial level

The logarithms are the 10's logarithm.

	Determination of active units (plaque-forming units) with standard deviation in pfu/m ³	Measured reduction in concentration of active viruses (purely measured data in relation to P1)
P1	5,17U+06	
P2	2,96U+05	$\leq \text{Log-2}$
P3	2,92U+04	$\leq \text{Log-3}$


In a pre-test, the air purifier was assessed for critical by-products (ozone, aldehydes, ketones, VOC and SVOC).

Detailed information on the test method and analysis can be found in the Test Report (330241-192).

Stuttgart. May 31, 2022

Place, current date

on behalf of 
Division Director "Intelligent Automation and Clean Manufacturing"
Head of Department "Ultradlean Technology and Micromanufacturing"

on behalf of 
Project Manager

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