What are aerosols?

Aerosols are generally defined as fine distributions of the smallest suspended particles in a gas; which in our case is air.

The current discussion primarily involves all droplets of various sizes and in various quantities that human beings exhale with the air when breathing and speaking. Due to the force of gravity, larger droplets (> 5 µm) quickly sink downward, on the other hand, small and the minute droplets can remain suspended in the air for a long time. The mixture of these extremely small droplets (in particular suspended matter < 1 µm) and the surrounding air is referred to as an aerosol; the most minute droplets themselves are frequently referred to as aerosol particles – also to differentiate them from larger droplets.

In the case of infected persons, these exhaled droplets and aerosol particles contain infectious viruses, which are distributed via the aerosol in the ambient air. In closed rooms, in particular, indirect infection through aerosol transfer is considered an important transmission path [i, ii].

Is ventilation with the Blue.care+ air purifier superfluous?

Blue.care+ is an ambient air purifier and has been especially developed for separation of airborne viruses, germs, bacteria, and spores to clean the room air of harmful aerosols in the shortest time possible. This is done by reducing the infection risk.

The device does not convey fresh air from outside into the room. However, as is well known, in order to breathe, people need oxygen; moreover it is important that the CO2 exhaled by people does not concentrated excessively in the room. By the way, these correlations apply, wholly independent of the current corona pandemic. Consequently, rooms must also be regularly ventilated, as usual, to maintain good breathing air quality and to supply fresh air to the room.

How effective is the antiviral air purifier?

Our simulations show that when Blue.care+ is properly positioned and adjusted, it can reduce the viral load in a room by 50 % within 10 minutes. After 30 minutes a reduction of virus concentration by as much as 90 % can be achieved. Given this effectiveness the risk of indirect infection is significantly lowered.

To ensure the effectiveness of Blue.care+, it is important that the device's volume flow rate be properly adjusted for the size of the room (see "How high must the air exchange rate be for the air purifier?").

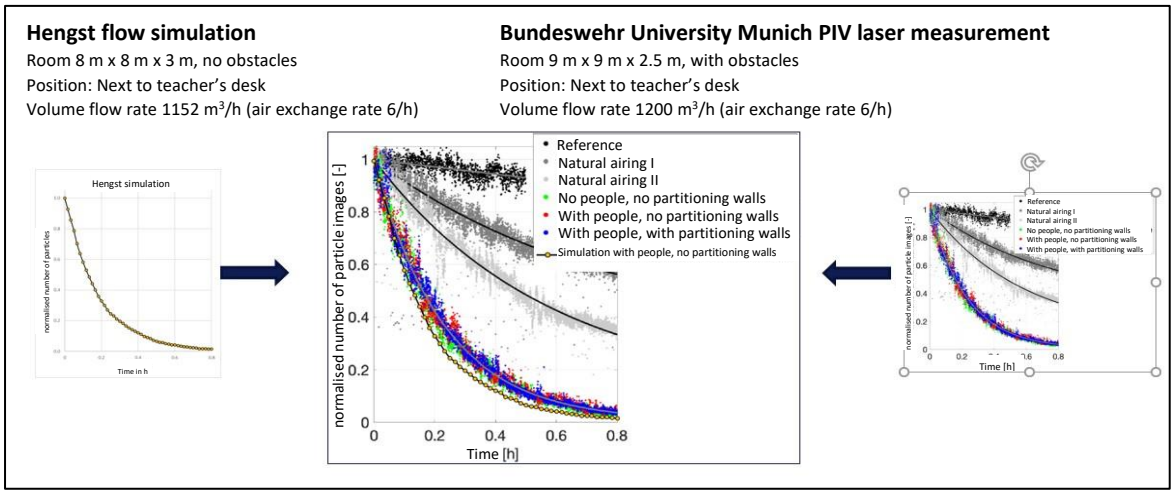

Figure 1: Comparison of the Hengst flow simulation and the measurement at the Bundeswehr University Munich in accordance with [3].

Can an indirect infection be prevented with Blue.care+?
The two factors that are critical for the infection risk due to infectious aerosols in closed rooms are the viral load (i.e. viral concentration) in the room, on the one hand, and on the other hand the exposure time, i.e. the length of stay, i.e. how long a not-yet infected person stays in this room. As the viral concentration and the exposure time increase, the risk of an indirect infection also increases. How the risk can be precisely quantified, and precisely where the limit for an infection lies, are currently the focus areas of very extensive studies that are still underway, for example [iii, iv]. However it is not a simple matter to reduce the length of time people stay in a room, at school, for example, as long as the desire exists to maintain face-to-face classroom instruction. Consequently, air purifiers have the objective to reduce the other critical factor, which is the virus concentration in the room. In this regard see https://hri-pira.github.io [8], which discusses how the risk of infection can be assessed depending on room size, room occupancy, use of the room, as well as the aeration situation.
Blue.care+ is capable of very effectively reducing the concentration of (infectious) aerosol particles in interior spaces. Thus Blue.care+ considerably reduces the risk of an indirect infection through the SARS-CoV-2 viruses and other viruses.

Can use of the device substantiate an exemption from government agency requirements? No, the current applicable government agency requirements concerning distancing, mouth/nose protection, etc. are not suspended through use of the device. The combination of the AHA regulation with ventilation and filtration of the circulated constitute the best possible protection against infections.

How high must the air exchange rate be for an air purifier?
Various publications point out that the effectiveness of air purifying devices in interior spaces, particularly depends on achieving a sufficiently high air exchange rate. The air exchange rate is the ratio between the volume flow of the device and the room volume (in other words, floor area x height of the room). Studies that cite this correlation include [3, 4]. These studies show increasing the volume flow in relation to the room volume improves the cleaning performance accordingly – the opposite is also true.
On the other hand, an ever-increasing volume flow of circulating air in rooms has a negative effect on the well-being of the people in the rooms. In [7], an air exchange rate of 6 is recommended as an effective setting, to ensure adequate purification of the room air.
For a room with 8 m x 8 m floor area and a room height of 3 m (i.e. a room volume of 192 m³), the calculation results, for example in a six-fold air exchange rate at a volume flow of 1,152 m³/h.

What kind of filter element is used?
A HEPA combination filter, filter class H14, as stipulated in standard EN 1822 or ISO 29463, consisting of a specially matched pre-filter and main filter, is used. Pre-filter and main filter are offered as an integrated HEPA H14 filter set for easy handling.

Why is a filter class H14 HEPA filter used?
Many sources recommend that mobile room air purifiers should be equipped with high-separation, filter class H13 or H14 filters because only these filters are effective in reducing viruses in the air. One of these sources is the German Federal Environmental Agency (Umweltbundesamt) [v].

In the study conducted by the Bundeswehr University Munich [7], the effectiveness of air purifiers for filtration of infectious aerosols in the ambient air was investigated and use of H14 filters was explicitly recommended.

What is a HEPA filter?

With regard to their efficiency, air filters can be differentiated in the categories, coarse dust filters, fine dust filters, and high-efficiency submicron particulate air filters. In these categories the highefficiency submicron particulate air filters, (HEPA filters) are the filters with the highest efficiency. Suspended matter filters are standardized in the norms EN 1822 and ISO 29463.
HEPA filters are in the category of suspended matter filters and are used where high cleaning capacities are required, such as operating rooms in hospitals, for example. The abbreviation "HEPA" stands for "High Efficiency Particulate Air" filter.

What precisely is H14 and does a HEPA H14 filter really only filter particles from 0.1 to 0.3 µm in size?

Due to the effective separating mechanisms, a HEPA filter has a high degrees of separation for virtually all relevant particulate sizes. This is also important, since contaminants in the (breathing) air can have widely varying particle sizes. For example, viruses or smoke particles are significantly smaller than bacteria, and bacteria in turn are significantly smaller than pollen or grains of dust.
A HEPA filter is tested for its effectiveness in filtering particles of different sizes. For a HEPA filter to be designated with a specific filter class, it must achieve specific degrees of minimum separation for the particle size that it most poorly separates (the so-called MPPS "Most Penetration Particle Size"). This means that for all other relevant particle sizes, it must achieve even higher degrees of separation than the MPPS. This also applies for particles smaller than 0.1 µm.
The MPPS is usually in the range between 0.1 and 0.3 µm. A class H13 filter must achieve at least a 99.95 % degree of separation in MPPS. A class H14 filter must even achieve at least 99.995 % in this area. As stated: For all other relevant particle sizes the efficiency in this case is even higher. In addition, the standard prescribes that each individual filter element must be factory-tested for absence of leaks; thus there is a 100 % control of the performance of the filter elements. Therefore it can be assumed that in filter elements that have been qualified as H13 or H14 in accordance with the standards cited, virtually ALL particles are actually separated.
The filter set in Blue.care+ meets the rigorous requirements for filter class H14 at the rated volume flow and smaller air quantities.

Why are UV-C radiation or heat not used in the Blue.care+ device to destroy viruses?

Use of UV-C radiation has not been sufficiently tested in non-industrial applications. The possibility cannot be excluded that depending on the technology, waste products (endotoxins) occur, which under some circumstances are harmful for humans. Also German Federal Environmental Agency is critical of the use of this technology [8].
Thanks to the HEPA H14 filter, viruses and bacteria are reliably trapped inside the air purifier. In our view additional heating is not necessary because viruses cannot multiply in the filter element and in any case after a relatively short time on porous surfaces they become inactive ("die-off") on porous surfaces. Consequently, we dispense with unnecessary procedures for destroying viruses in the filter; such procedures only consume additional energy without ensuring additional protection.

How often must the filter insert be changed?
When used as intended, and for an average use time that does not exceed 40-50 hours a week, the filters must be changed every 6 months. Replacement filters are offered at www.hengst.shop. A shorter or longer service life can also be indicated depending on the room conditions and types of use. According to VDI 6022, a filter change must occur after 12 months, at the latest.

How do I change the filter?
The Blue.care+ device can be opened with the provided control cabinet key. The HEPA combination filter itself is clamped into the housing with two nuts, which can be unscrewed with an off-the-shelf wrench (AF17). In addition, filter replacement is presented simply and with many illustrations in the operating manual.

When changing the filter, what must I watch out for and how do I dispose of the installed filter?
When changing the filter, you must ensure that dust particles, which can come into contact with the mucous membranes, or that can be inhaled, are not inadvertently released. Bear in mind that during operation, an unmanageable number of contaminant types have collected in the filter during operation. Therefore, precautions are imperative; when changing the filter please wear the appropriate protective equipment specified in the Blue.care+ operating manual. The used filter must be disposed of in a tear-resistant, sealed, plastic bag of suitable size. The original spare part is packed in a bag that is suitable for disposal.
As a rule, the used materials of the filter can be disposed of in the household waste. However, if in doubt, check to ensure whether deviating local regulations are in force.

What are the relative advantages of a large air purifier as opposed to a small air purifier?

- Due to the design, with smaller devices the air exchange rate is significantly lower than the recommended 6x per hour, as a result they are only suitable for very small rooms. See => "How high must the air exchange rate be for the air purifier?".
- A smaller device outputs the purified air at body height, head height or even near the floor, the draft that occurs is perceived as unpleasant (direct air flow on the body, draft).
- It is only in a large device that the important HEPA filters have a sufficiently large filter surface to ensure long-term protection without constant filter replacement.
- To ensure minimal noise, adequate acoustic insulation must be installed, which can only be accommodated in larger devices.
- For the same reason, in a large device an appropriate high-capacity fan is used, which must not be used to full capacity in the specified rated range of the volume flow.

How much space does Blue.care+ require and where should I place the device?
The Blue.care+ dimensions are: Length 540 x width 730 x height 1,950 mm.
In principle the device can be placed at any point in the room, in the middle of the room, as well as further towards the edge of the room. The air inlet and air outlet should not be directly obstructed or covered, and must have a distance of at least 30 cm to walls.
Special considerations may be necessary for special room geometries, such as long hallways, or angled floor plans. The same applies for room dividers or particularly large pieces of furniture, which project

into the room, for example: In this regard, particular care is required to select a set-up location for the device that enables uniform through-out the room.
However, for very large rooms, or unfavorable floor plans, it may be necessary to use several room air purifiers.
If there is a joist in the room, it may be effective to set up the device directly on top of it, see => "I am using several Blue.care+ units, what is the best way to distribute them in the room?".

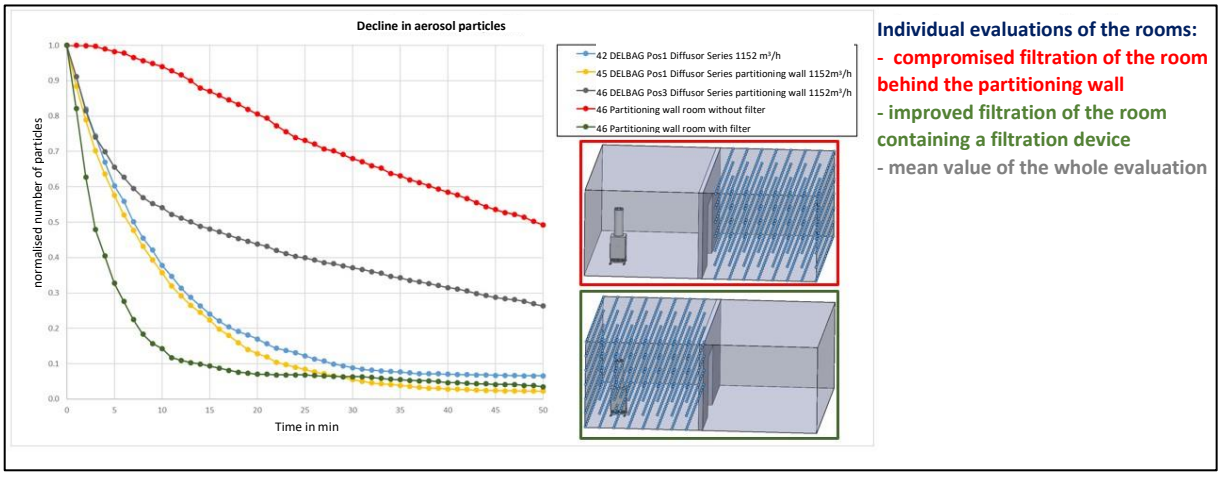

Figure 2: Different cleaning capacity in two rooms that are separated by a double door: ***Red:*** *Cleaning capacity in the room without device /* ***green:*** *Cleaning capacity in the room with device /* ***gray:*** *Mean value of the cleaning capacity*

How is uniform clean air distribution ensured?
The special structural shape of the Blue.care+ with its specifically developed design, ensures uniform, room filling ventilation with filtered air.
To achieve adequate cleaning capacity, first and foremost the right air exchange rate is significant, see => "How high must the air exchange rate be for the air purifier?"
Placement must be carefully planned, see => "How much space does Blue.care+ require and where should I place the device?"

Does Blue.care+ also work if there are large pieces of furniture or other obstructions that could divert the air flow in my room?
We have developed and designed Blue.care+ for fully occupied classrooms, offices, or restaurants. The simulations clearly show that the function is not restricted through a table, chairs or even people, for example. This is also substantiated in practical measurements, which have been undertaken by the Bundeswehr University Munich [7], for instance.
If there are no objects that directly cover the Blue.care+ unit, the function is not restricted. Placement must be carefully selected (see "How much space does Blue.care+ require and where should I place the device?").

I am using several Blue.care+ units, what is the best way to distribute them in the room?
This is particularly the case, if you want to equip a very large room or a room with angled geometry, such as an L-shaped floor plan.

In this case the devices should be set up so that they are spaced several meters apart. And they should be placed in such a manner that each device is "responsible" for purification of one part of the room. Ideally you will determine the ideal placement by imagining that you are dividing the room into two halves with a partition wall, and then appropriately placing the device in the respective half of the room.

With Blue.care+ can I quickly change the deployment site?
Thanks to stable casters and the device height of 1.95 m, which allow passage through all normal doors and elevators, the robustly constructed room air purifier can be quickly and easily moved to a different location.

For what room size can I use the Blue.care+?
The air purifier is capable of purifying the air in interior spaces (e.g. offices or classrooms) with up to 6x air exchange per hour. The precise adjustment of the volume flow regulator on the device is provided on the table:

room height / room area	2,5 m	3,0 m	3,5 m
	corresponds to the scale		
50 m²	50 m²	60 m²	70 m²
80 m²	80 m²	100 m²	120 m²
100 m²	100 m²	120 m²	MAX

The scale specified on the device is configured for a standard room height of 2.5 m. If you have a different room height, you can also calculate the suitable scale setting as follows:
Area in m² x your room height / standard room height = value of the scale
→ e.g. 50 m² x 3 m / 2.5 m = 60 m² on the scale

What must I be aware of at commissioning?
The Blue.care+ antiviral air purifier is delivered pre-assembled and equipped with a HEPA H14 filter set; commissioning requires only a few hand motions. The cold appliance plug must be plugged into the device and into a standard 230 V electrical outlet. You must switch the device on via the ON/OFF switch and set the volume flow regulator to the correct room size.

Is overnight operation necessary?
No, placing the Blue.care+ in service while the room is in use is fully sufficient. Boosting the device capacity to the maximum level during breaks, when a room is not in use, accelerates reduction of aerosol concentrations in the room.

What happens if I inadvertently leave the Blue.care+ running overnight?
The device is designed for continuous operation, and thanks to the robust construction this is possible with no problems.

What is included in the scope of delivery?
+ Blue.care+ antiviral air purifier with integrated HEPA H14 filter set
+ power connection cable
+ key for the maintenance hatch
+ operating manual

How is Blue.care+ delivered?
The Blue.care+ is delivered on a pallet, completely assembled and ready for operation; it can be further transported on this pallet. After unpacking, thanks to the casters, one person can easily push the device to its destination.

Does Blue.care+ have a CE mark?
The Blue.care+ is CE-conformant and has the appropriate certification.

How loud are the devices?
At rated capacity with a volume flow of 1,150 m³/h, i.e. at the setting for a room size of 80 m², the sound pressure level at a distance of 1 m is 50 dB(A) (January 2021).

Blue.care+ L: Sound pressure and sound power levels for the air purifier variants

Table 2: Sound pressure and sound power levels for the air purifier variants
Tabelle 2: Schalldruck- und Schallleistungspegel für die die Luftfilteranlagenvarianten

Bezeichnung der Geräuschquelle und Beschreibung der Betriebsbedingungen *Designation of the noise source and description of the operating conditions*	$L_{pA,1m}$ **in dB(A)**
Luftreiniger Blue.Care+ (ZA-Serie) *Air purifier Blue.care+ (ZA series)*	
Volumenstrom 400 m³/h *Volume flow*	34.2
Volumenstrom 600 m³/h *Volume flow*	40.4
Volumenstrom 800 m³/h *Volume flow*	44.1
Volumenstrom 1000 m³/h *Volume flow*	49.1
Volumenstrom 1150 m³/h *Volume flow*	50.4
Volumenstrom 1600 m³/h *Volume flow*	56.4
Volumenstrom 1800 m³/h *Volume flow*	57.9

Blue.care+ M: Sound pressure and sound power levels for the air purifier variants

Table 2: Sound pressure and sound power levels for the air purifier variants
Tabelle 2: Schalldruck- und Schallleistungspegel für die die Luftfilteranlagenvarianten

Bezeichnung der Geräuschquelle und Beschreibung der Betriebsbedingungen *Designation of the noise source and description of the operating conditions*	$L_{pA,1m}$ **in dB(A)**
Luftreiniger Blue.Care+ M *Air purifier Blue.care+ M*	
Volumenstrom 340 m³/h *Volume flow*	30.3
Volumenstrom 418 m³/h *Volume flow*	31.6
Volumenstrom 496 m³/h *Volume flow*	36.1
Volumenstrom 594 m³/h *Volume flow*	42.4
Volumenstrom 653 m³/h *Volume flow*	44.8
Volumenstrom 770 m³/h *Volume flow*	48.4

[i] Hartmann, Anne; Kriegel, Martin (2020): Parameter study for indoor risk assessment due to virus-laden aerosols. Technical University of Berlin.

[ii] Morawska, L.; Milton, D.K. (2020): It is time to address airborne transmission of Coronavirus disease 2019 (Covid-19). Queensland University of Technology, Brisbane, Qld, Australia and University of Maryland School of Public Health, College Park, Maryland, USA.

[iii] Müller, Dirk; Rewitz, Kai; Derwein, Dennis; Burgholz, Tobias M. (2020): Simplified estimation of the risk of infection by aerosol-borne viruses in ventilated rooms. RWTH Aachen University.

[iv] Buonanno, G.; Morawska, L.; Stabile, L. (2020): Quantitative assessment of the risk of airborne transmission of SARS-CoV2 infection: prospective and retrospective applications. University of Cassino and Southern Lazio, Cassino, FR, Italy and Queensland University of Technology, Brisbane, Qld, Australia.

[v] German Environment Agency (2020): Infectious aerosols in indoor spaces. https://www.umweltbundesamt.de/themen/ gesundheit/umwelteinfluesse-auf-den-menschen/innenraumluft/infektioese-aerosole-in-innenraeumen. Last accessed on 14.10.2020

7 Kähler, Christian J.; Fuchs, Thomas; Hain, Rainer (2020): Can mobile air purifiers effectively reduce an indirect SARS-CoV-2 infection risk through aerosols? Bundeswehr University Munich. Fluid Mechanics and Aerodynamics. https://www.unibw.de/lrt7/raumluftreiniger.pdf

8 https://hri-pira.github.io