OurAir Anti-Viral Air Purification Systems

Simulation and Verification of Efficiency

December 2020

More information
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Leadership in Filtration

MANN+HUMMEL

OurAir Anti-Viral Air Purification Systems Clean Air Matters

In the fight against the Sars-COVID-19 virus, but also to reduce other airborne pollutants, it is essential to minimize aerosol concentrations in closed spaces. This is achievable by using HEPA H13* and H14* filter technology in room ventilation systems or mobile air purifiers. In this paper, the impact of the use of mobile devices will be analyzed in more detail.

For the dimensioning of indoor air purifiers in larger rooms it is recommended to simulate the aerosol or particle concentration. Based on the simulation, the number and size as well as the best possible positioning of the units in the room are identified.

VALIDATION OF SIMULATION RESULTS BY KIT

The accuracy of MANN+HUMMEL's simulation results has been proven by various test setups at the Karlsruhe Institute of Technology (KIT), Germany. Example study in a classroom **From page 3**

PARTICLE SIMULATION

In order to visualize the distribution of aerosols in a room exactly with simulation, a complex model is required. Indicator in the sophisticated model is the behavior of the particle concentration in the room. This indicator is also used to show the reduction of particles when operating an indoor air purifier. **From page 8**

OTHER SIMULATION METHODS

Easier methods illustrate the spread of clean air not considering particulate movement in every detail. Those simulations are faster and less elaborate, however they give still a pretty good image of clean air distribution. **From page 12**

OurAir SQ 2500

- For rooms up to 200 m²
- With HEPA H 14* filter that captures > 99,995% of viruses, bacteria and other micro-organisms
- Quiet operation with high volume flow 1.250 m³/h at 50 dB(A)
- Low energy consumption due to innovative ePTFE HEPA filter technology

OurAir TK 850

- For rooms up to 70 m²
- With HEPA H 14* filter that captures > 99,995% of viruses, bacteria and other micro-organisms
- Low energy consumption due to innovative ePTFE HEPA filter technology
- Smooth-running wheels for easy positioning

* according to ISO 29463 and EN 1822

KIT case study in a classroom Reduction of aerosol level with the OurAir SQ 2500

Picture of classroom

STUDY DESCRIPTION

Under the leadership of Prof. Achim Dittler of the Karlsruhe Institute of Technology (KIT), Germany, various studies were conducted in a classroom and a seminar room under real conditions to test the effectiveness of indoor air purifiers. In the test setup described here, aerosols were first blown into the room with an aerosol generator for 45 minutes. Two fans accelerated the homogeneous distribution of the artificially generated aerosols in the entire room before the air purifiers were put into operation. To measure the aerosol concentration during the experiment, two measurement devices were placed at opposite spots in the room. In separate series of measurements, on the one hand the reduction effectiveness of the indoor air purifier in general was examined, and on the other hand it was analysed if there is an effect when the position of the air purifier is changed.

TEST SETUP

1 OurAir SQ 2500

2 Particle measurement F1

3 Particle measurement F2

4 Aerosol generator

5 2 Fans

ROOM DIMENSIONS

V_{room} = 14.77 x 6.09 x 2.98 = 268.05 m^3

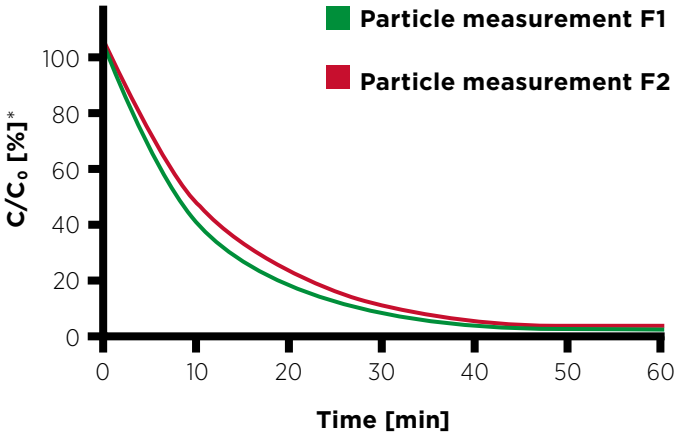
KIT case study in a classroom
Position 1 of air purifier

The OurAir SQ 2500 air purifier was placed in the center aisle of the rows of tables. When the air purifier was switched on, the following could be observed:

- Reduction of the aerosol concentration can be proven at both measuring sensors F1 and F2
- The air cleaner OurAir SQ 2500 produces evenly distributed room air quality. Both measurement devices at the opposite ends of the room show similarly good reduction effects (F1 which is positioned closer to the air cleaner shows slightly better results).
- In the first 10 minutes, the graph drops relatively quickly, flattens out somewhat up to minute 35 and is asymptotic from minute 40 onwards.

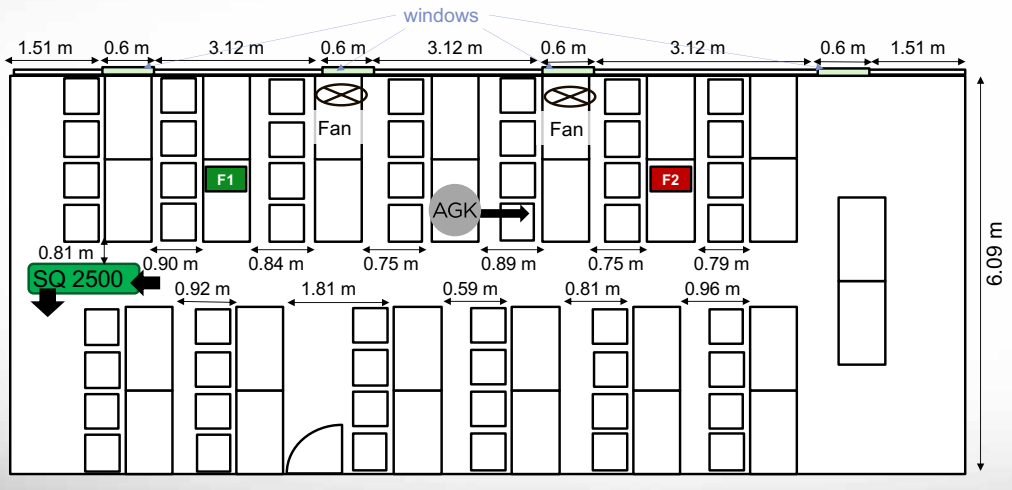
DIAGRAMM (C_0= 896-921 #/cm³)

*Relative particle concentration



SCHEMATIC OVERVIEW

V_{room} = 14.77 x 6.09 x 2.98 = 268.05 m³



OurAir SQ 2500
Anti-viral air purifier

F1 | Particle measurement sensor

F2 | Particle measurement sensor

AGK | Aerosol generator

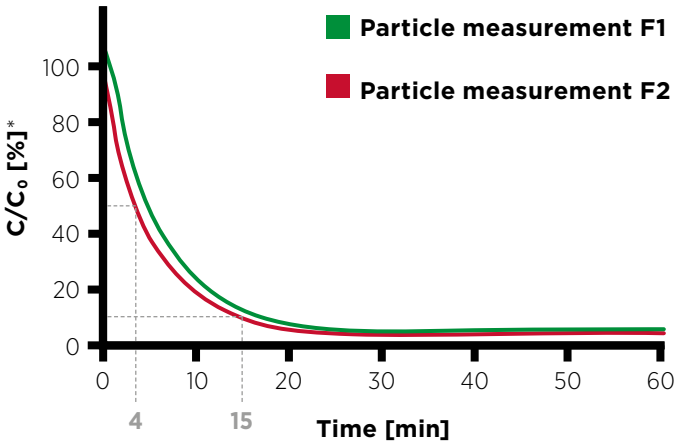
KIT case study in a classroom Position 2 of air purifier

The OurAir SQ 2500 was placed parallel to the rows of tables. When the air purifier was switched on, the following could be observed:

- Reduction of the aerosol concentration: **50% = 4 min; 90% = 15 min**
- Asymptotic course after 20 min
- The air cleaner OurAir SQ 2500 produces evenly distributed room air quality. Both measurement devices F1 and F2 at the opposite ends of the room show similarly good reduction effects (F1 which is positioned closer to the air cleaner shows slightly better results).
- **With the right choice of position the separation efficiency of air cleaners can be optimized.**

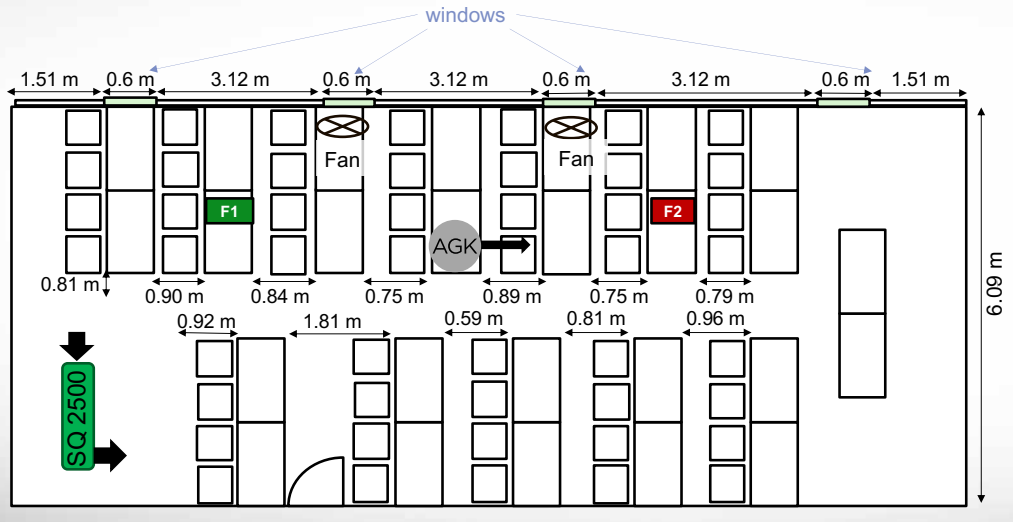
DIAGRAMM (C_0= 911-940 #/cm³)

*Relative particle concentration



SCHEMATIC OVERVIEW

V_{room} = 14.77 x 6.09 x 2.98 = 268.05 m³



KIT case study in a classroom Different positioning of an air purifier in the room

DIAGRAMM POSITION I (C_0= 896-921 #/cm³)
*Relative particle concentration

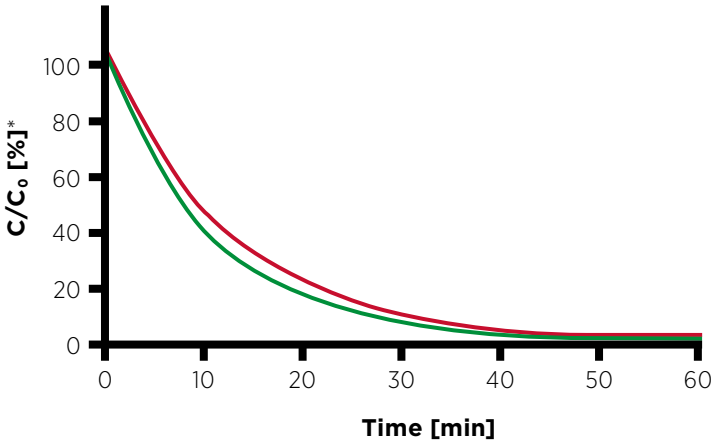
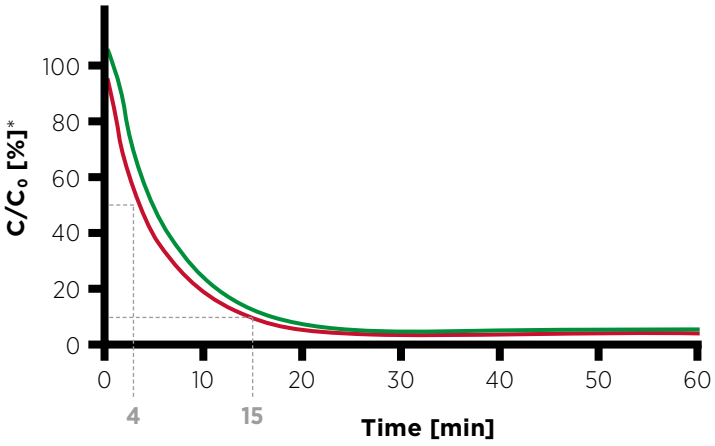


DIAGRAMM POSITION II (C_0= 911-940 #/cm³)
*Relative particle concentration



Particle measurement F1 **Particle measurement F2**

50% = 4 min **90% = 15 min**

SUMMARY

- Regardless of positioning, an effective reduction of the aerosol concentration is achieved in both cases.
- It has been proven that the position of the measurement devices is of less importance. Cleaning efficiency is very similar at all measured locations in the room.
- In order to gain maximum cleaning efficiency, circulating flows of clean air re-entering the device have to be limited. This is achieved by the correct positioning of the air purifier.

CONCLUSION

- Positioning of the air purifier is crucial for the speed of concentration reduction.
- Even if placed in a non-optimal way the reduction effect of the OurAir SQ 2500 indoor air purifier is significant.
- With optimized installation the speed of aerosol reduction can be considerably increased. **The aerosol concentration drops almost twice as fast with optimal positioning.**
- Thus for best placement expert judgement is mandatory.

KIT case study in a classroom Measurement results compared to simulation

Prior to the test, the particle distribution in the test room and the reduction effect of the air purifier were modelled and simulated using an elaborate simulation model from MANN+HUMMEL. Diagram 1 shows the simulation graphs of the two measurement devices (small time offset of the curve due to the system). In diagram 2, the values measured in the classroom experiment with an OurAir SQ 2500 are laid over with the simulation curves.

Particle measurement F1

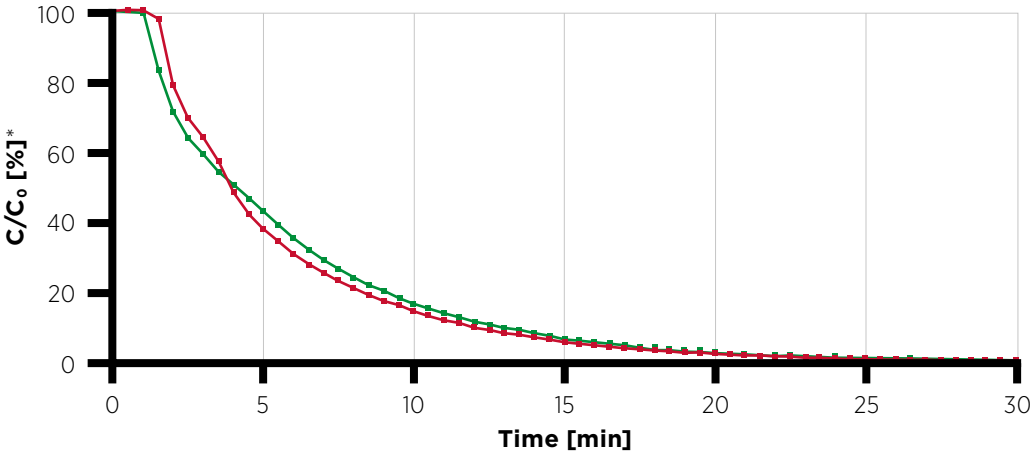
Particle measurement F2

Simulation

Measurement

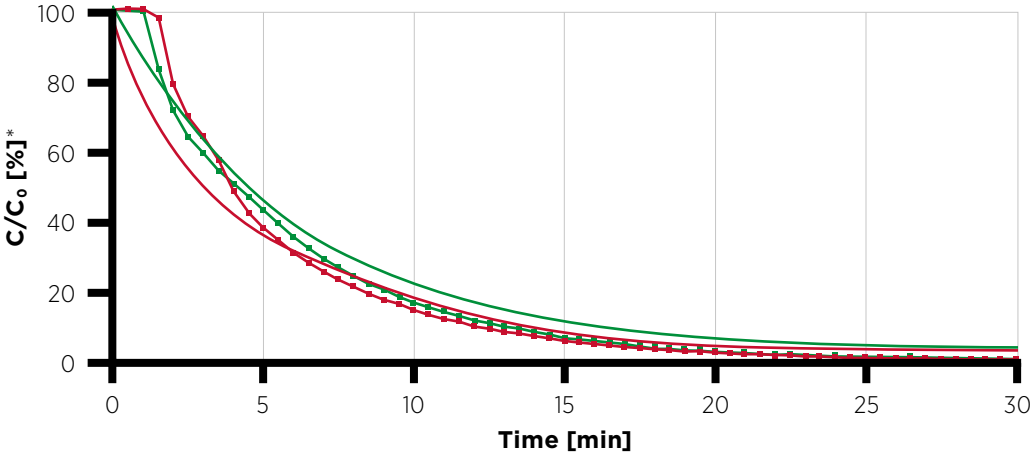
KIT SIMULATION HEADS-UP

*Relative particle concentration



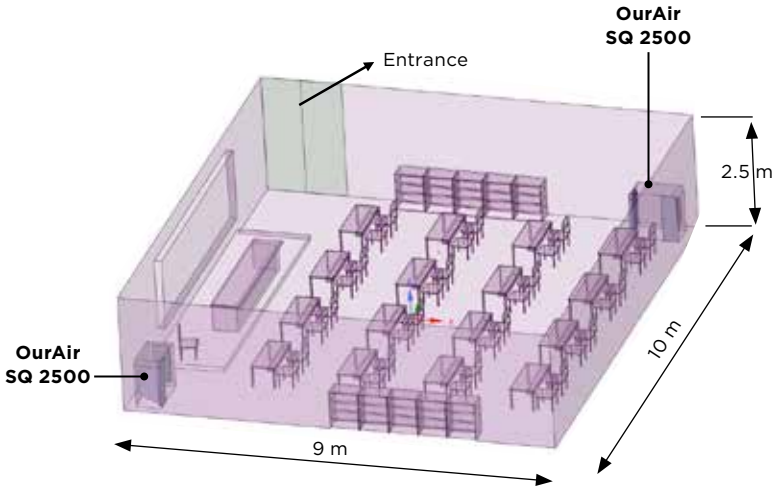
KIT SIMULATION HEADS-UP; OVERLAY

*Relative particle concentration



Result: The values measured by the test are almost identical to those determined by the MANN+HUMMEL simulation. This demonstrates the validity of the simulation model used.

Use case class room
Analysis by simulation



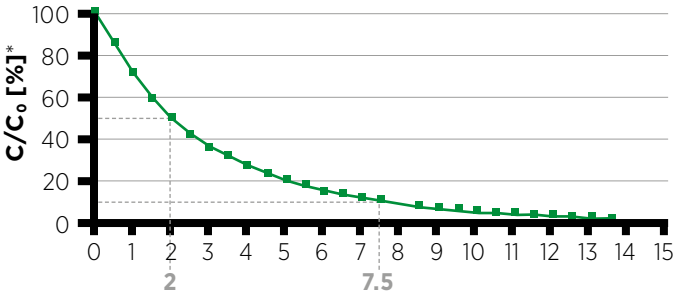
INFORMATION ABOUT THE SIMULATION

In order to provide a transferable scenario of the reduction effect of air purifiers in a classroom, an average sized classroom with standard furniture was modelled and simulated. As the children move through the whole room, it is of great interest how the particle concentration in the entire room decreases and whether there are any dead zones (e.g. disturbing influences of furniture).

- **After only 2 minutes the particle concentration in the room is reduced by 50%, after 7.5 minutes by 90%.**

VOLUME AVERAGE

*Relative particle concentration **Average decrease**

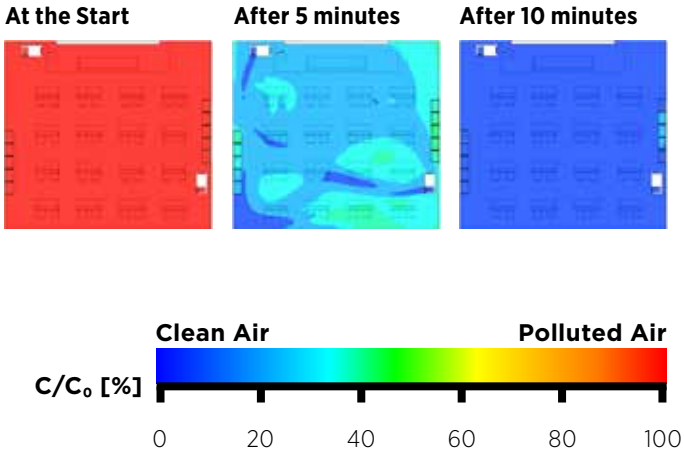


50% = 2 min. 90% = 7.5 min.

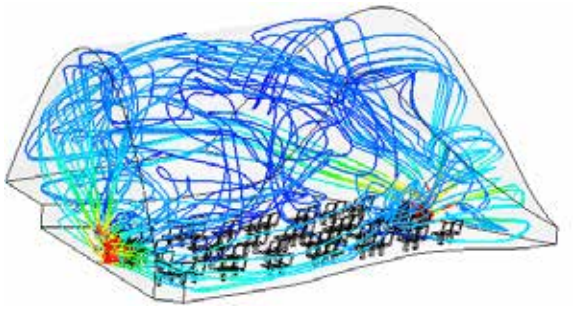
The simulation images illustrate a cross-section through the room at a height of 1.30 m (head height of pupils). The relative particle concentration is shown as contours. This indicates the spacial effect of the air purifiers.

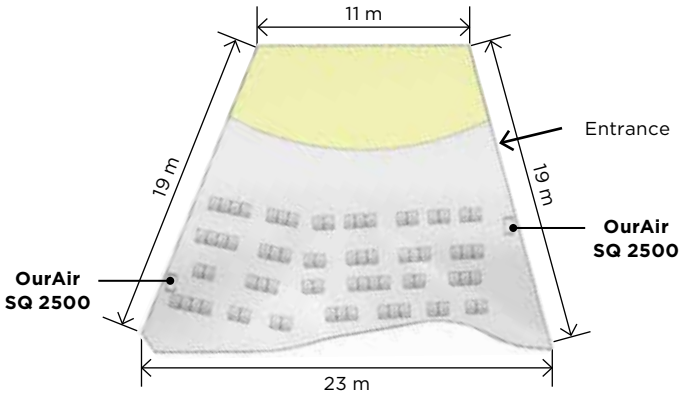
- At the beginning the room is completely and homogeneously filled with particles
- Shelves and obstacles can slow down the cleaning process locally and should be taken into account when positioning the air purifiers (after 5 min.)
- Nevertheless, even in these areas a high effect is achieved only a few minutes later (after 10min)

PARTICLE CONCENTRATION



Use case theater
Analysis by simulation





DESCRIPTION OF THE USE CASE

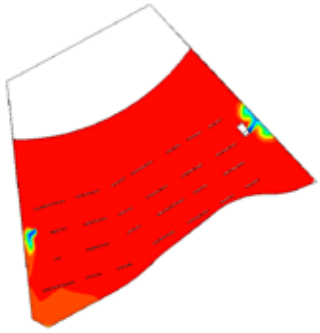
The “Theater unter den Kuppeln”, south of Stuttgart, Germany, comprises one open-air and two indoor stages. The hall which was examined offers 70 seats for guests on approx. 135 m². Due to its special architecture with a domed roof of 4 m - 5.70 m height, the hall is very challenging in respect of effective air purification. 2 simulation scenarios were performed: First, 2 OurAir SQ 2500 were placed on opposite side walls, in the middle row and at the back. Then 4 OurAir SQ 2500 were positioned on each side at the height of the first and the back row. In each case, the air is sucked into the air purifier at the side on spectator height, passes through the filtration stages and the cleaned air is blown out towards the wall. This offers the advantage that there are no high local flow speeds caused by the air blown out, which could be perceived as disturbing by the audience, and the cleaned air rises upwards along the wall. Since the air purifiers suck in air at a height of 1.50 m, the purified air falls from the ceiling downwards and an optimal distribution of the purified air in the entire room is created, regardless if 2 or 4 air purifiers are set in place.

CONCLUSIONS

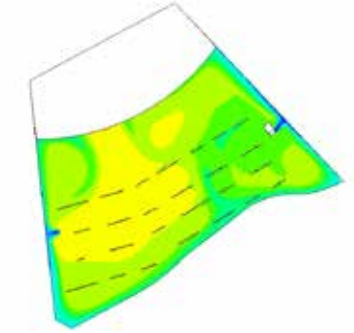
- Homogeneous cleaning of the air at head height of the spectators
- No dead zones without any cleaning effect in the auditorium
- Continuous air cleaning possible before, during and after a show (without interruption of air cleaning)
- No locally high wind speeds

Use case theater
Analysis by simulation

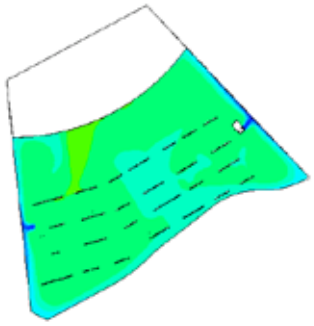
PARTICLE CONCENTRATION AT THE START



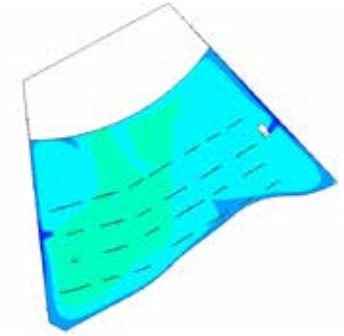
PARTICLE CONCENTRATION AFTER 10 MINUTES



PARTICLE CONCENTRATION AFTER 25 MINUTES

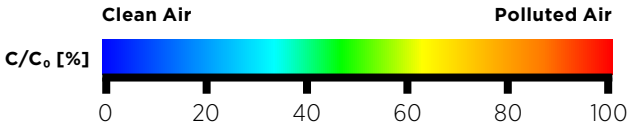


PARTICLE CONCENTRATION AFTER 35 MINUTES



REMARK

The air is also cleaned in the area of the stage. However, this cannot be seen in the simulation view shown, since a cross-section at 1.20 m is shown here (head height of seated visitors) and the stage height is 1.25 m.

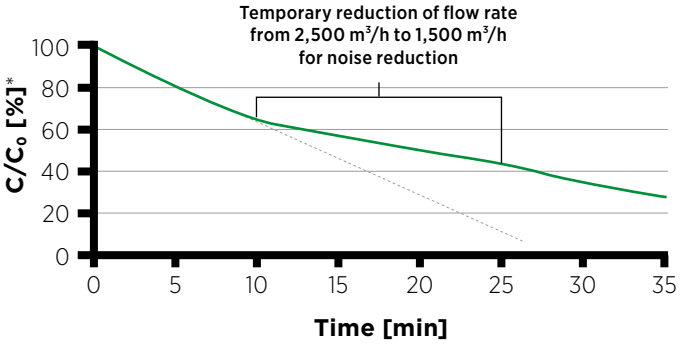


DESCRIPTION OF SIMULATION PROCESS 1

At the start of the simulation, an air volume flow of 2,500 m³/h of each unit was simulated, then the volume flow was reduced to 1,500 m³/h after 10 minutes. After minute 25 the air volume flow was increased again to 2,500 m³/h. By decreasing and increasing the air volume flow, it was examined to what extent a change in the air volume flow influences the reduction effect of the aerosol concentration. Since a lower air volume flow also results in a reduced noise level, it was investigated whether it makes sense to lower the air volume flow during some periods of time (e.g. full air volume flow prior to a show and during the breaks, reduced air volume flow while the show is running).

VOLUME AVERAGE

*Relative particle concentration



RESULTS

- 2 air purifiers OurAir SQ 2500 create a homogeneous reduction of the aerosol concentration in the complete hall
- Even if the volume flow rate is reduced for acoustic reasons during a show, the air purification process will continue and the decay curve decreases further, i.e. the particle and aerosol concentration continues to decrease
- This is to be particularly emphasized as an advantage over air cleaning by ventilation, whereby an air exchange only takes place at certain intervals and the particle and aerosol concentration rises again between the ventilation intervals.

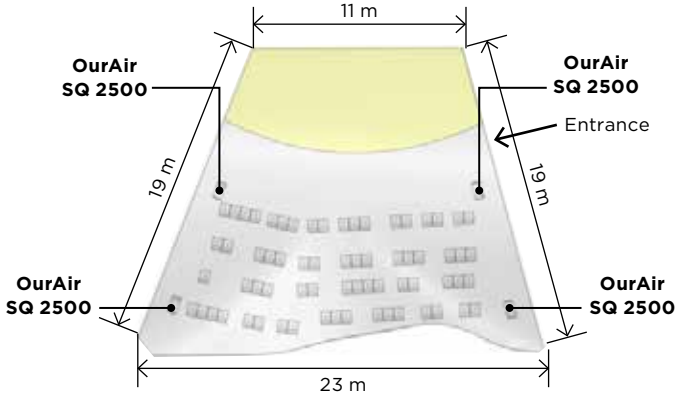
Use case Theater
Analysis by simulation

SIMULATION WITH 4 OURAIR SQ 2500

In a second simulation 4 OurAir SQ 2500 were placed in the auditorium. As expected, the speed of cleaning increases due to the higher air flow rate offered by four units instead of two. However, the time of cleaning is not halved by doubling the air volume flow.

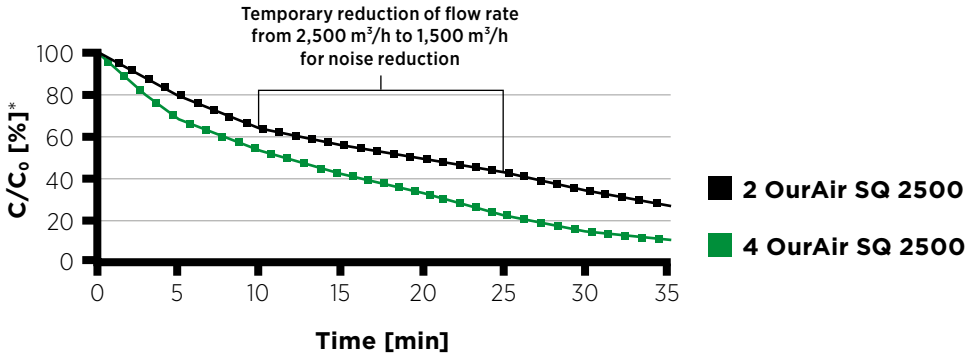
CONCLUSIONS

- A high flow rate alone is not indicative for the quality of the cleaning.
- More doesn't always mean better: With efficient use, the number of air purifiers required can be minimized and the best cost/benefit ratio achieved
- It depends on the correct positioning of the air purifiers to achieve an effect in the whole room
- MANN+HUMMEL's simulation expertise allows even complicated applications to be assessed in advance and to ensure that the number of devices, positioning and the operation are optimized.



DUST VOLUME REDUCTION COMPARISON

*Relative particle concentration

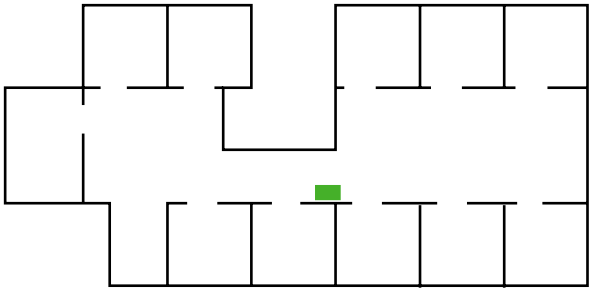


Use case office space Analysis

CASE A: 1 OurAir SQ2500 UNDER OPERATION

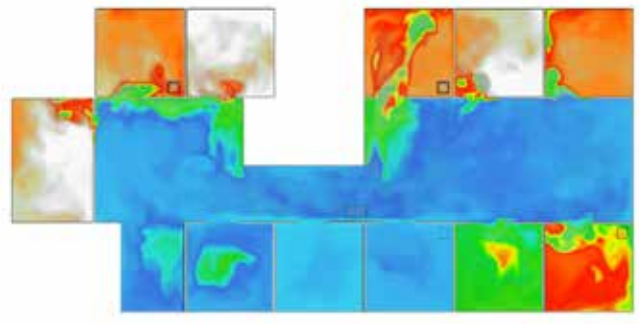
An assumed office space of a total of 302 m^2 is examined, divided into a large corridor (128 m^2) from which 11 individual offices lead off. First, a straightforward simulation method is used to determine the effect of 1 centrally positioned OurAir SQ 2500 with a volume flow of 2,500 m^3/h. The pictures below show that an air distribution effect is achieved in the corridor and in the individual offices closest to the air purifier.

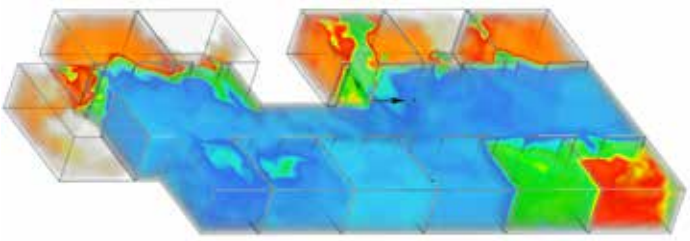
OFFICE FLOOR PLAN

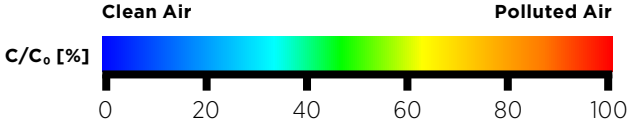


OurAir SQ 2500

PARTICLE CONCENTRATION AFTER 10 MINUTES





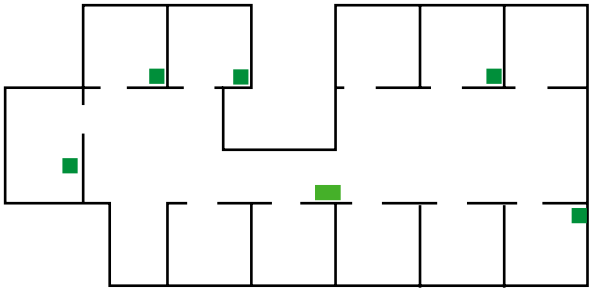


Use case office space Analysis

CASE B: 1 OurAir SQ 2500 AND 5 OurAir TK 850 UNDER OPERATION

The same office space as described before is examined. In addition to the centrally positioned OurAir SQ 2500, in this model 5 OurAir TK 850 are placed in individual offices. These each have a maximum air volume flow of 950 m³/h. An operating time of 10 minutes is simulated. In the pictures below you can see that an air distribution effect has now also occurred in the rooms, which hardly showed any cleaning in the first simulation.

OFFICE FLOOR PLAN



OurAir SQ 2500 **OurAir TK 850**

PARTICLE CONCENTRATION AFTER 10 MINUTES