Virus protection for indoor areas

The Corona pandemic has shown that a large proportion of infections occur through aerosol transmission indoors. The same applies to many other viruses (influenza, colds). To prevent this route of infection as much as possible, aerosol transport from person to person must be minimized. Since aerosol particles can remain in the air for a long time and are distributed throughout the room by diffusion and air currents, they must be removed before they reach other people. In the NanoCleanAir (NCA) concept, this is achieved by a vertical air flow upwards. This flow is supported by thermal convection from body heat, so the direction of flow must be upwards.

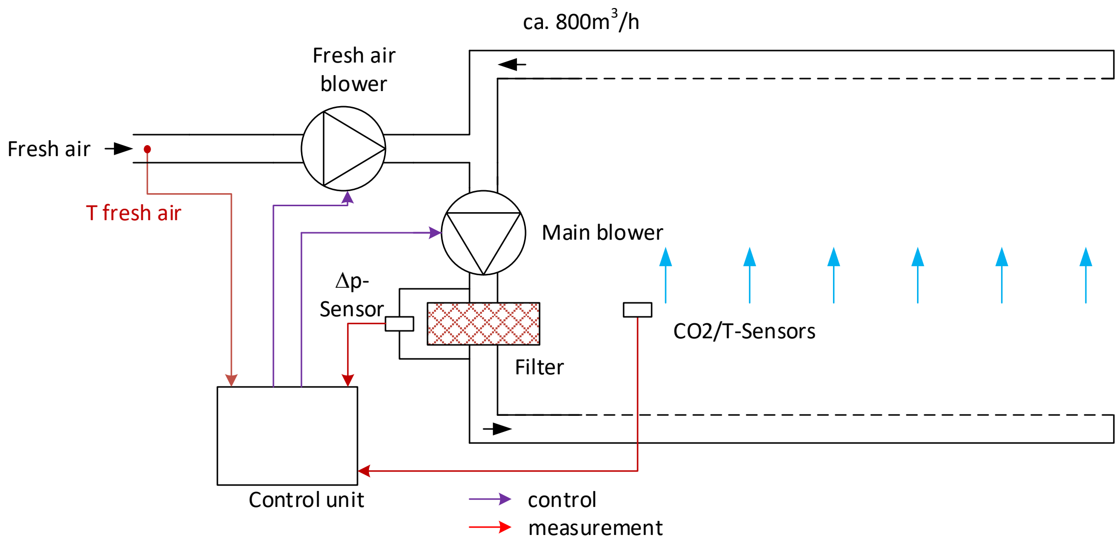
The NCA concept

NCA with its partners University of Applied Sciences Northwestern Switzerland (FHNW), Adolphe Merkle Institute (AMI) and Combustion Flow Solutions (CFS) have developed a concept for virus protection in rooms. The aim is to achieve the most vertical flow possible by extracting air at the ceiling and recirculating it near the floor, thus minimising the exchange of air between people. The effectiveness of this approach was demonstrated in a pilot installation in a classroom at the Rudolf Steiner Special School in Lenzburg.

The picture shows the realisation in the classroom: The air is extracted from the room through perforated pipes suspended from the ceiling, fed into a collection duct (above the wall panel) to the 'technology cabinet' (left of the wall panel). The cabinet contains a fan for extraction, after which the air is filtered and returned to the room via a duct near the floor (below, behind the blackboard).

Layout

Via a radial fan (main fan), the air extracted from the ceiling is fed to the filter, which also has the role of a sound absorber. The system is activated via a motion detector. The pressure drop across the filter is monitored; if it is too high (filter occupied) or too low (problem with the fan), an error message is issued. The CO_2 concentration in the room is measured and used to regulate the supply of fresh air via another fan.



Filter

NCA uses ceramic 'wall-flow' filters, such as those used for exhaust gas purification in petrol engines. Such filters are produced in large quantities and are therefore inexpensive, they achieve efficiencies well above 99%, can be easily heated and thus sterilized in hygienically demanding applications (hospital), are easy to clean and therefore have a very long service life in contrast to fibre filters, which have to be changed when they are occupied. Experiments show that these filters can also filter viruses highly efficiently (Rüggeberg et al., 2021).

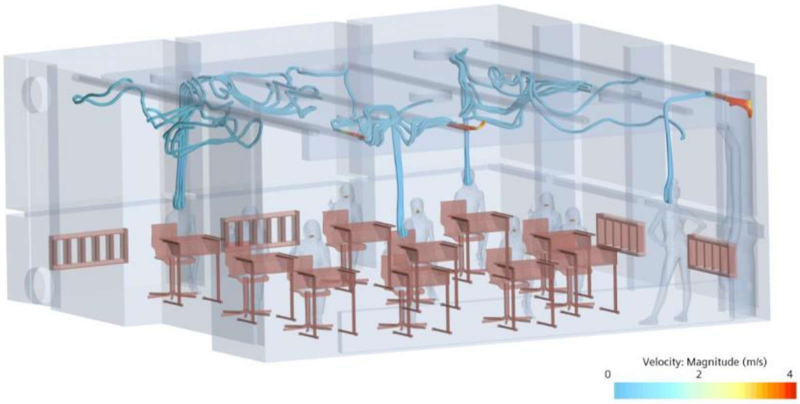
These filters are prefabricated in square blocks (140x140x152 mm) and have an internal surface area of 2.46 m2. Such a unit can be used up to a throughput of about 90m3/h (spatial velocity SV max 10 1/s, face velocity 1 cm/s). Depending on the required flow rate, several such blocks can be glued together to form a larger filter. The illustration shows such a filter block consisting of 9 individual filters as used in a classroom (room volume 140m3).

The pressure drop across the filter is 180 Pa at maximum fan power.

Results

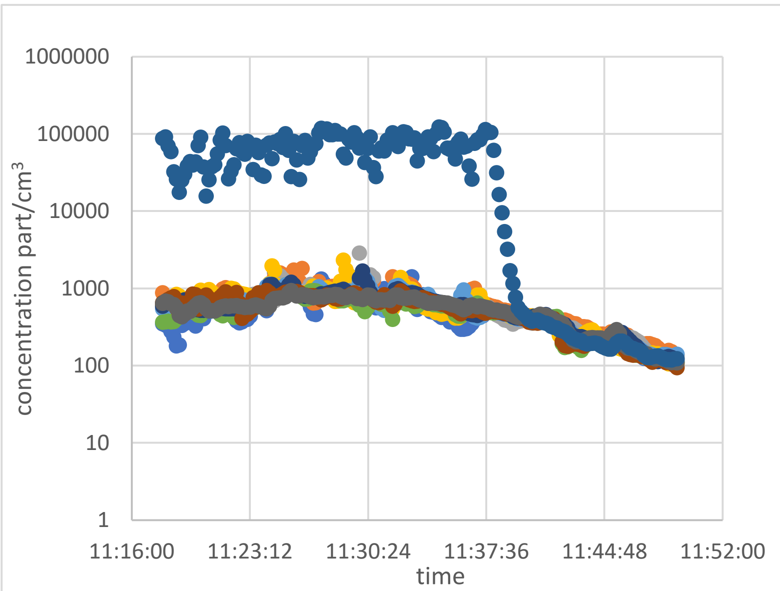
The efficiency was investigated in three ways:
- Flow simulations
- Flow visualisation using smoke
- Aerosol measurements.

[1] Rüggeberg, T., Milosevic, A., Specht, P., Mayer, A., Frey, J., Petri-Fink, A., Burtscher, H., Rothen-Rutishauser, B. (2021). A Versatile Filter Test System to Assess Removal Efficiency for Viruses in Aerosols. Aerosol Air Qual. Res. 21, 210224. https://doi.org/10.4209/aaqr.210224



Example of a flow simulation showing that a good vertical flow is achieved.

For the aerosol measurements, a source (salt particles by spraying a salt solution) was installed on a desk and a sensor measuring the particle concentration was installed on each desk. Measurements were taken in an empty classroom, with body heat simulated by hot plates, as shown in the picture on the left, but also during class. The results are very similar.



Example of a measurement during class. The blue curve shows the particle concentration at the source, the others show the concentration at the individual desks. It can be seen that the concentration at the desks is about 2 orders of magnitude lower and that this reduction is achieved at all desks.

Applications

The principles of this solution, i.e. highly efficient purification of the breathing air from all particulate matter by nanofiltration and permanent recirculation, as well as ensuring a laminar vertical flow, which even avoids contagion of neighbors, are generally applicable and can be used in a similar form in waiting rooms of medical practices, in restaurants or meeting rooms. Even the secondary conditions, such as maintaining an extremely low noise level of 40 dB(A) and controlling the CO_2 concentration, have been solved. The most important elements of this solution were anchored in patents, and the production and procurement of the core elements such as the nanofilters, the exhaust pipes and the elements for flow control were secured. Since the filters are easy to clean, there are hardly any maintenance costs and a long service life can be assumed. We do not know of any competing systems that even come close to the protection efficiency of this system and we recommend the installation in existing rooms as well as the consideration of this conception in new planning, for which we are happy to offer advice as well as the design and procurement of the special elements.

Please refer to our homepage www.nanocleanair.ch or contact us for a non-binding consultation.

____

NanoCleanAir: We are an engineering group that has been working for a long time on ultrafine particles in the air we breathe, their measurement, efficient filtering and prevention of their harmful effects on human health and the climate. Together with SUVA and BAFU, we created the basis for the introduction of the soot particle filter in the late 1990s, which is now the state of the art for all combustion engines worldwide, preventing millions of premature deaths and making a major contribution to mitigating the effects of global warming.

At the beginning of 2020, we decided to pool our know-how in order to develop, together with the newly founded NanoCleanAir GmbH and partners in research and industry, efficient measures against the risk of contamination by airborne bio-aerosols, especially viruses, which are similar in size to soot particles. BAFU-UTF supported our work, so that we could prove the correctness of our approach with the help of Swiss virologists from the Universities of Bern and Fribourg, and subsequently develop technical solutions for all important hot-spots.

Clean breathing air
Free of virus and nanoparticles

Analyse, filtration and
System development

NanoCleanAir GmbH
Fohrhölzlistrasse 14 b
CH-5443 Niederrohrdorf
+41 56 4966414
a.mayer@nanocleanair.ch
www.nanocleanair.ch