NanoCleanAir

April 23

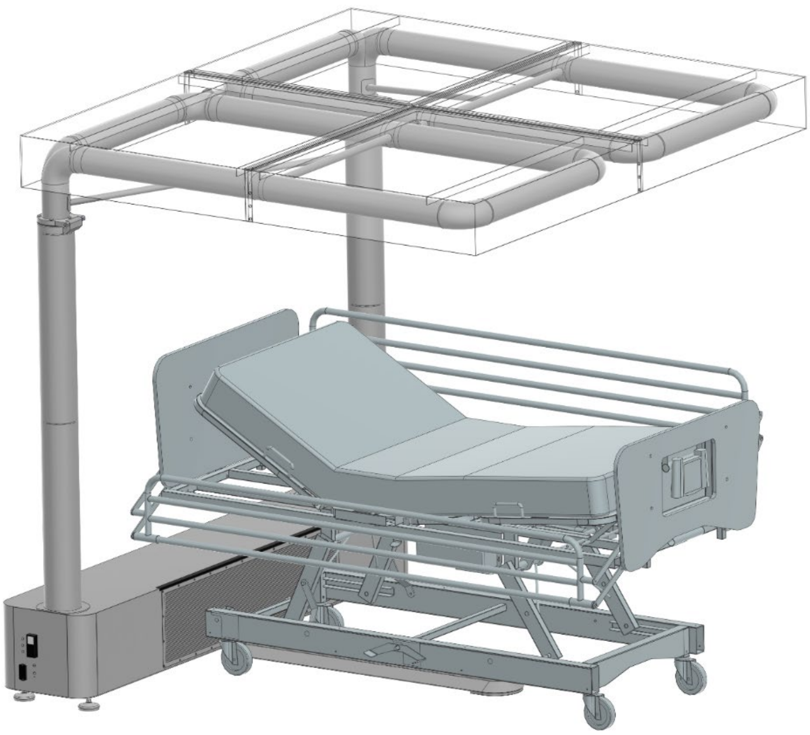
Virus protection in the patient room

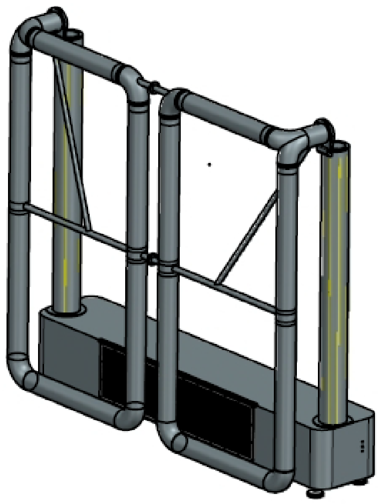
Background

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 airborne for long periods of time, spread throughout a room by diffusion and air currents, they must be removed before they reach other people. Places where this is particularly important are patient rooms in hospitals or rooms in nursing homes. 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 goal is to achieve the most vertical flow possible by exhausting air upward and recirculating it near the floor, thus minimizing air exchange between people. The effectiveness of this approach was first demonstrated on a pilot system in a classroom at the Rudolf Steiner Special School in Lenzburg.





Next, a system was developed for use with hospital beds. Here, the air exhaled by the patient is extracted above the bed in a kind of baldachin, filtered and returned below the bed. The picture on the left shows a schematic of the system: the air is extracted through perforated tubes above the bed. A Plexiglas hood prevents air exchange further up. In the two supports on the left and right of the bed, the extracted air is fed to the filter and blower and blown out again at the bottom behind the bed. The system can be easily folded and thus transported on wheels (right pictures above).

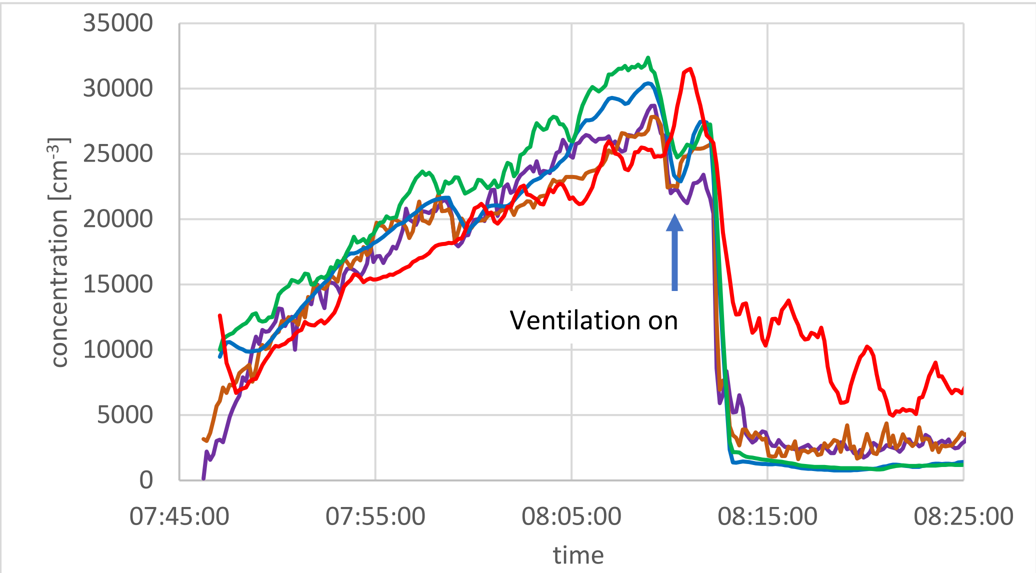
Structure

The air extracted from the ceiling is fed to the filter via a radial fan. Silencers are housed in the two support tubes, and the filter also acts as a silencer. The pressure drop across the filter can be measured to provide information about the occupancy of the filter.

Filter

NCA uses ceramic 'wall-flow' filters, as used for exhaust gas purification in gasoline 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 applications with special hygienic requirements (hospital); are easy to clean and therefore have a very long service life in contrast to fiber filters, which have to be replaced when they are occupied. Experiments show that these filters can also filter viruses highly efficiently (Rüggeberg et al., 2021[1])

Results of aerosol measurements



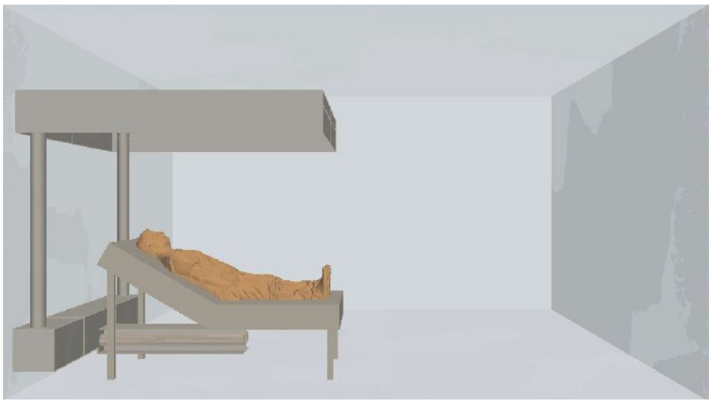
The figure on the left shows the efficiency of the system. With the ventilation initially switched off, aerosol particles are generated by spraying a saline solution. In this measurement, four sensors were placed in the corners of the canopy and one under the canopy roof (red curve).

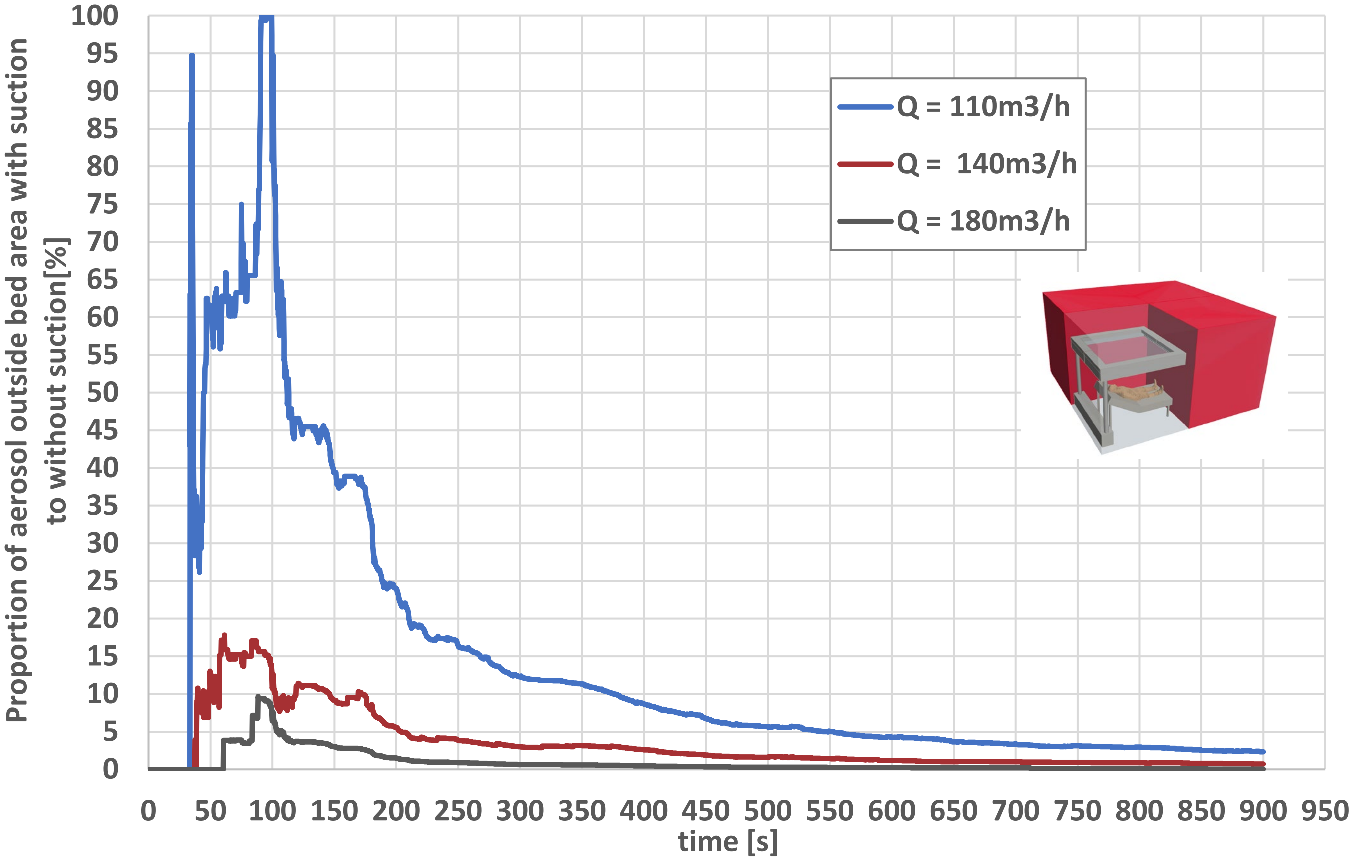
The particle concentration increases continuously. As soon as the fan is switched on, however, it drops again very quickly. The four sensors in the corners show negligible concentrations after a few minutes, but cleaning is also very effective under the baldachin.

[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

Flow simulations

Flow simulations were used to investigate how much aerosol can enact the space under the canopy. The picture on the left shows the arrangement. The bed with the patient under the canopy is in a corner of a patient room. The graph below shows the ratio of aerosol particles leaving the baldachin space with and without suction. The ventilation is turned on at time 40s, it then takes a few minutes for the flow to build up, then the proportion of 'escaped' aerosols becomes very small. Escaped means that the particles enter the red area of the room. Since the suction can always be switched on, only the final value is of practical importance and this is in the range of one percent. the figure shows very nicely that with increasing volume flow the equilibrium is established much faster, this is of very great practical importance, since we will always have disturbances in clinical operation (nursing, sitting up of the patient, air blast from a neighboring bed, etc.).)





Main technical data

Operating voltage: 230V, 50Hz

Power requirement: 2 x 26 W

Volume flow: 2 x 80 m^3/h

Sound level in the head area 44 dBA

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

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