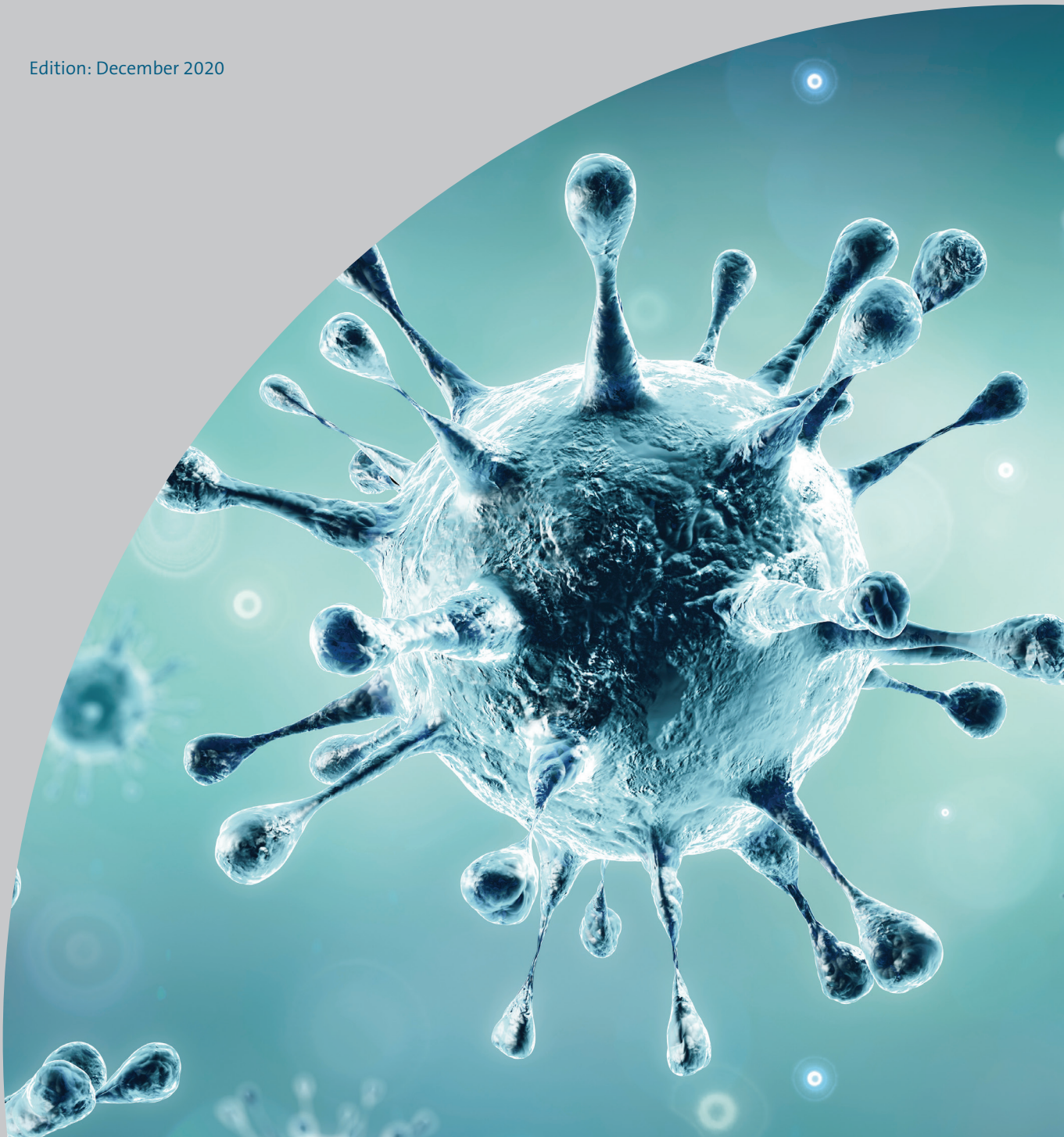
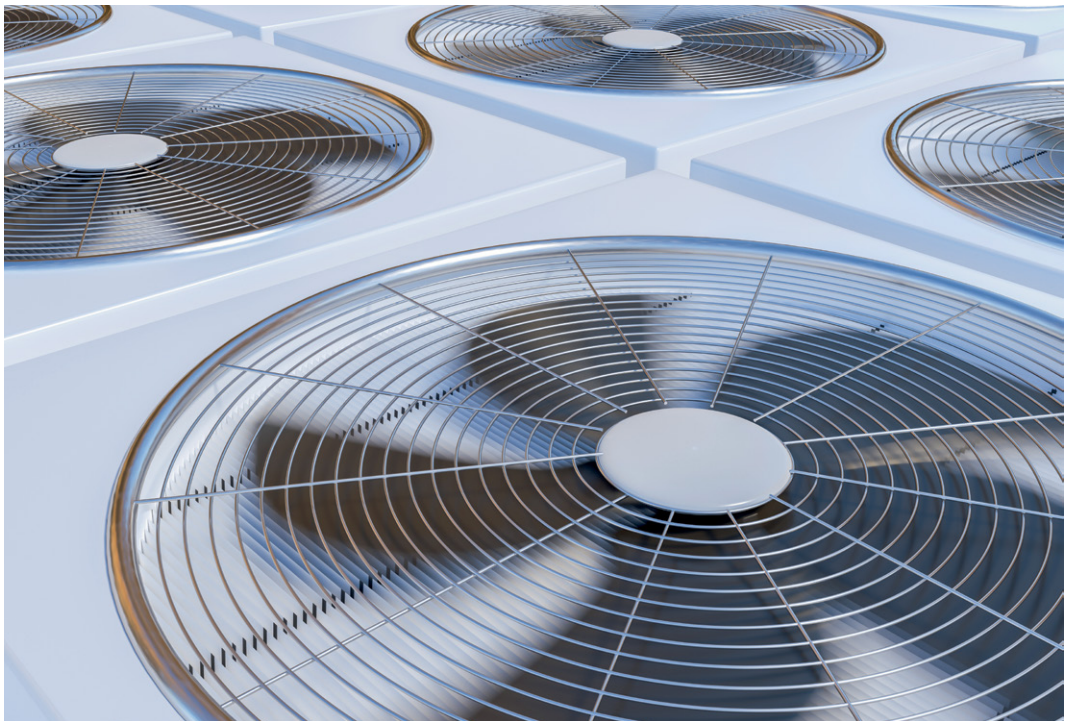
Air Handling Technology

Ventilation and air conditioning systems in a time of COVID-19

Basic principles for operation and use

Edition: December 2020





This document is based on the best facts and knowledge available as at April 2, 2020.

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Operation and use of air handling systems in a time of COVID-19

Introduction

With this document, the experts at VDMA's Air Handling Technology trade association provide recommendations on operating and using ventilation and air conditioning (VAC) systems and devices during the COVID-19 pandemic, in order to prevent the spread of COVID-19 via VAC systems. It will also give advice on how ventilation and air conditioning technology can reduce the concentration of aerosols – and therefore also viruses – in buildings. It is largely based on a document from REHVA (Federation of European Heating, Ventilation and Air Conditioning Associations), which has been adapted to the requirements of the German market. It is intended primarily for VAC professionals and facility managers, but may also be useful for occupational and public health specialists, for example.

The building-related precautions are limited to commercial and public buildings (e.g. offices, schools, shopping areas, sport premises, etc.) where only occasional occupancy of infected persons is expected; hospitals and healthcare facilities (usually with a larger concentration of infected people) are subject to specific rules and are therefore excluded.

Transmission routes

During every pandemic, it is important to know the transmission routes of the infectious agent. According to current knowledge, the coronavirus SARS-CoV-2 is primarily transmitted directly from one person to another, e.g. when talking, coughing or sneezing. COVID-19 is predominantly passed on through the transmission routes described in the following:

Transmission through inhalation of large droplets (> 5 micrometers) that are released, or through contact with droplets that have fallen on surfaces about 1–2 m from the infected person. Droplets are primarily formed from coughing and sneezing (sneezing typically forms many more particles). Most of these large droplets fall on nearby surfaces and objects – such as desks and tables. People can catch the infection by touching those contaminated surfaces or objects and then touching their eyes, nose or mouth. If people are standing within 1–2 meters of an infected person, they can catch it by breathing in droplets released by them.

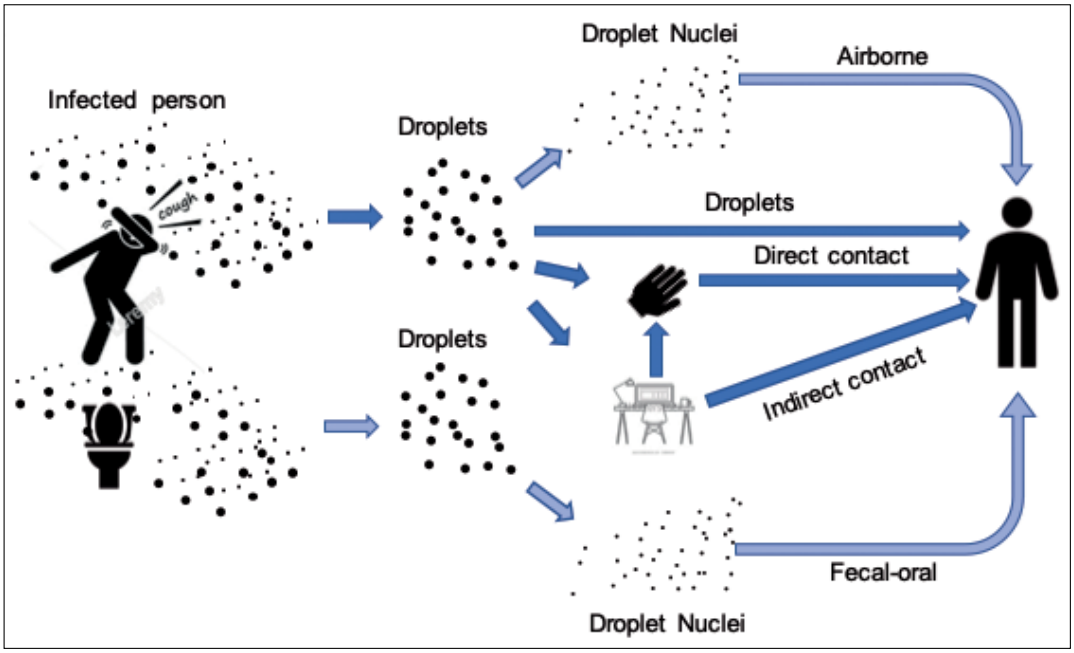

Figure 1. Exposure mechanisms of COVID-19 SARS-CoV-2 droplets reported by the WHO (dark blue). Light blue: Airborne transmission mechanisms seen in SARS-CoV-1 and other influenza viruses. No evidence is currently available for SARS-CoV-2.

Close contact transmission through aerosols that stay airborne for a long time and can be transported long distances (droplets and solid particles measuring < 5 micrometers).
Aerosols are also generated by coughing, sneezing and talking. Coronaviruses (SARS-CoV-2) measure 80–160 nanometers and can stay active in the air for long periods of time, using the airborne aerosol to travel and its fluid to survive. The virus-carrying aerosols can theoretically circulate with the air and spread through airflows in the room or through the extract air ducts of air conditioning systems. Transmission of the SARS-CoV-2 coronavirus through high aerosol concentrations has been proven by many infection events, in particular when a large number of people were together in insufficiently ventilated indoor areas. The concentration of airborne aerosols that can transport the virus must therefore be kept as low as possible. High-quality air filter systems in VAC systems and mobile room air cleaners equipped with the appropriate filters can achieve this effectively.

Practical recommendations

for the safe operation of your building with VAC and indoor air cleaning systems to provide support in rooms with insufficient ventilation.

Air filter systems

The role of air filters is to prevent contamination of the air handling components and the air guidance system and to ensure a quality of inlet air that is acceptable for health (as defined in VDI 6022). There is no question that the use of effective air filters is essential for maintaining VAC systems in a perfectly hygienic state. Using suitable, coordinated filter systems allows the inlet air to be protected against unwanted contamination from particles, aerosols, microorganisms and gases. Air filter systems with filters tested in line with ISO 16890 and EN 1822 / ISO 29463 offer a protection technology that has been proven for decades – and which also, and especially, protects from viruses. Rooms equipped with this technology enable the required air purity, depending on the respective filter class.

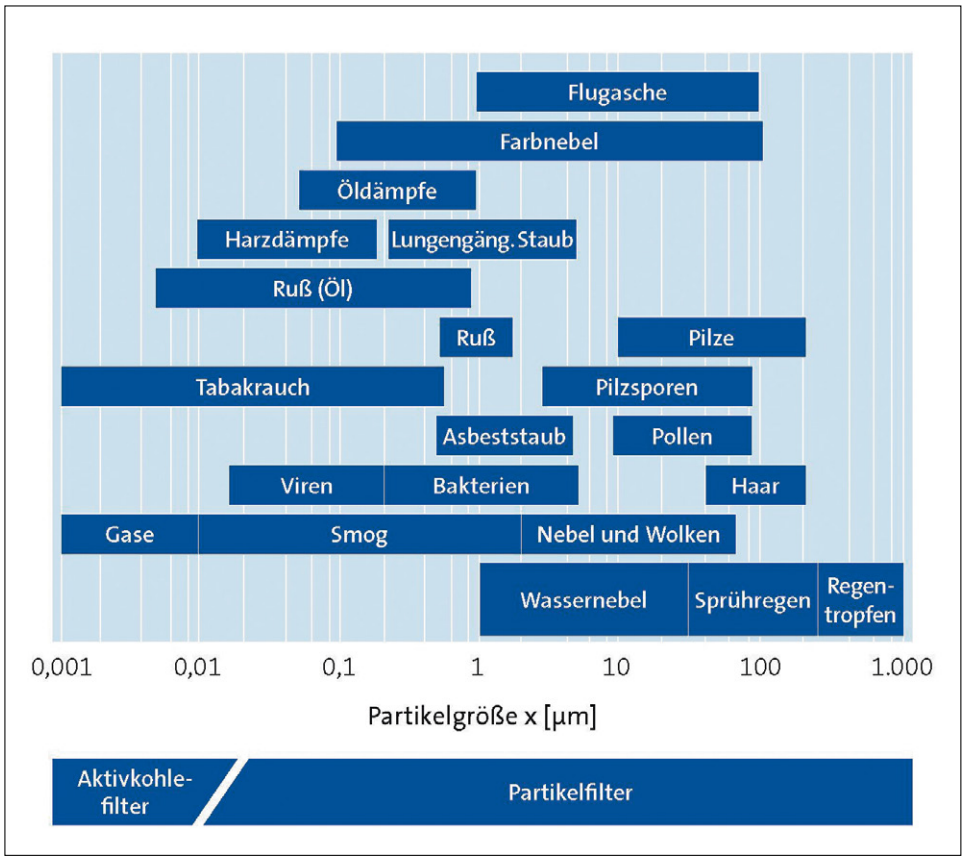

Figure 2. Size comparison of particles and filters

In order to separate particles and aerosols, fine filters compliant with ISO 16890 are to be used. The federal government calls upon operators of VAC systems to check their proper functioning and install state-of-the-art fine filters. Eurovent 4/23 gives a good overview of which filter level is necessary in order to achieve the required indoor air quality (depending on the outdoor air quality). When there is an increased risk of airborne contamination, the filter systems should be designed with poor outdoor air quality (ODA 3) and the best supply air quality (SUP 1) in mind, where this is technically possible:

In order to ensure efficient separation of 99.95% of SARS-CoV-2 viruses (size: 80–160 nm), high-efficiency particulate air filters of at least filter class H13 in accordance with EN 1822 are required. For many years, the corresponding HEPA filters have been a proven and reliable technology for achieving the requisite sterility in clean rooms. They are indispensable in pharmaceutical production, in operating rooms or in the sterile processes used in the food industry, to name just a few. On the other hand, HEPA filters exhibit a comparatively high flow resistance (pressure difference). In VAC systems used in general building technology that

Table 1

Filter classification in order to achieve the necessary indoor air quality depending on the outdoor air quality

Outdoor air quality (ODA)		Supply air quality (SUP)				
		SUP1	SUP2	SUP3	SUP4	SUP5
ODA 1	Example 1	ePM10 50% in combination with ePM1 60%	ePM1 50%	ePM2.5 50%	ePM10 50%	ePM10 50%
	Example 2	ePM1 70%	–	–	–	–
ODA 2	Example 1	ePM1 50% in combination with ePM1 60%	ePM10 50% in combination with ePM1 60%	ePM1 50%	ePM2.5 50%	ePM10 50%
	Example 2	ePM1 80%	ePM1 70%	ePM2.5 70%	ePM10 80%	–
ODA 3	Example 1	ePM1 50% in combination with ePM1 80%	ePM1 50% in combination with ePM1 60%	ePM10 50% in combination with ePM1 60%	ePM1 50%	ePM2.5 50%
	Example 2	ePM1 90%	ePM1 80%	ePM2.5 80%	ePM10 90%	ePM10 80%

Source: Eurovent

are not designed for the use of HEPA filters, this can lead to a considerable drop in the transported air volume, increased leakage in the air lines and thus, for example, put the pressure cascade out of operation (example: overpressure in the false ceiling and associated contamination in the rooms below).

Air supply and recirculation

The concentration of airborne viruses is at its lowest outdoors (i.e. in the air sucked in from outside the building). It is therefore important to replace as much of the used indoor air as possible with treated outdoor air. In buildings with VAC systems, extended operating times are recommended. In rooms occupied by a large number of people, the room air should be exchanged at least five times per hour. If possible, the VAC system should run all the time (with a night-time reduction if necessary) in order to continuously reduce the aerosol concentration.

As a general rule, the greater the air replacement rate, the lower the aerosol concentration in the room (when the other conditions remain the same). However, this is limited by the performance of the ventilation system, the comfort of the occupants (avoiding drafts), noise emissions (in the case of mobile ventilation devices in particular) and energy considerations. For energy-related reasons, VAC systems increasingly operate in recirculation mode during the hot and cold months of the year. In this case, and in accordance with the recommendations of the federal government and the Federal Institute for Occupational Safety and Health, these should be upgraded to at least class H13 HEPA filters in accordance with EN 1822, provided that the systems possess the necessary technical prerequisites for this. Modern systems with frequency-controlled fans generally have enough reserve capacity, making an upgrade with HEPA filters in the second filter stage possible.

To this end, many manufacturers offer corresponding filters for large air quantities in the dimensions specified by EN 15608, which enables retrofitting without having to convert the VAC system. To ensure the perfect functioning of the air handling system, the new configuration should be technically adapted to each individual system. This is especially important with regard to the overall operational pressure difference, as this has a significant impact on how many times the room air needs to be replaced.

It is possible that the fan performance is not sufficient or that the system does not have the requisite tightness for correct operation with high-efficiency particulate air filters. In this case, it is advisable to use high-separation ISO ePM1 filters in the recirculation paths. During recirculation, the air passes through the air filters multiple times. Therefore, even filters of the class ISO ePM1 80% and sufficiently high air exchange rates can quickly reduce concentrations of aerosols – and thus also viruses – in the rooms.

However, it is not recommended to use recirculation with filters of an efficiency class lower than ISO ePM1. The use of biocidal, germ-killing substances with ISO coarse or ISO ePM2.5 filters cannot contribute to more efficient separation or protection. Extensive separation on the available filter surfaces is necessary in order for substances of this kind to work, which does not take place to a sufficient degree in the case of SARS viruses on coarse filters. As a result, the retention times in the available filter medium are too short for any germicidal effect to unfold. Instead, there is a danger that substances with an unknown effect on human health enter the flow of fresh air, having a negative effect.

Exhaust ventilation systems of toilets should always be kept on in order to create underpressure and prevent fecal-oral transmission. The exhaust air from toilets must not enter the recirculating air.

Replacement of outdoor air filters is not necessary

In the case of COVID-19 it has often been asked whether the filters need to be replaced and what effective protection is available when replacing the filters.

Should microbial contamination such as viruses and bacteria enter the filters, these only have a very limited lifespan there due to the conditions in the filter medium and do not continue to multiply there, as has been confirmed by numerous investigations in the past. Immobilized viruses on filters in particular cannot continue developing without an appropriate host organism and therefore lose their virulent potential within a short space of time.

Filters should always be replaced according to normal procedure as per VDI 6022 and Eurovent 4/23 when pressure or time limits are exceeded. When replacing filters, normal maintenance procedures can be used while taking the usual personal protective measures. Once removed, filters should be wrapped in air-tight packaging and ideally disposed of in waste combustion plants. Filter replacement is therefore a non-critical procedure when the requirements of VDI 3803-4 and VDI 6022 are adhered to.

Further technologies for protecting from microbial contamination

Special UV-C air cleaners installed in the inlet air of air conditioning systems or in mobile room air cleaners can be an effective method of killing or disabling bacteria and viruses under certain conditions. Their efficiency is determined by the intensity of the irradiation and the retention time of the microbial contamination. For all separation technologies, it should be ensured that:

- The effectiveness of separation performance is clearly described and proven, in particular with regard to coronaviruses and their size.
- The separation performance is always guaranteed during operation and cannot decline compared to the state after commissioning.
- The power input required for the technology at the specified volume flow is provided.
- It has been proven that no foreign products that are harmful to human health are created, and that no other potential hazards occur.
- Elements to be replaced on a regular basis are replaced as safely as possible, disposed of in a proper and sustainable manner and contain no harmful substances.

Biocides or antiviral equipment of the air filters have also not been sufficiently investigated in connection with COVID-19.

Humidification and air heating have no particular effect on COVID-19

Transmission of some viruses in buildings can be limited by changing air temperatures and humidity levels. In the case of COVID-19, this is unfortunately not an option, as current findings show that the SARS-CoV-2 virus is very resistant to environmental changes and is susceptible only at a very low relative humidity and very high temperatures, which are not acceptable in buildings for reasons of comfort.

Small droplets (< 0.10 µm) evaporate quickly at the relative humidities (RH) that are usual in ventilation technology. Nasal passages and mucous membranes are more sensitive to infections at a very low RH (10–20%), which is why humidification is sometimes recommended in winter. Heating and cooling systems can be operated normally, as these do not appear to influence the spread of COVID-19. Therefore, it is generally not necessary to adjust the setpoints of heating or cooling systems.

Duct cleaning has no practical effect

There have been recommendations that air ducts should be cleaned in order to prevent SARS-CoV-2 transmission via such ducts. It is not sensible to clean the air ducts beyond the recommendations of VDI 6022 as a means of preventing room-to-room infections, as the ventilation system is not a contamination source. Viruses attached to aerosols do not collect easily in air ducts and are normally carried out by the air flow. Therefore, no changes to normal duct cleaning and maintenance procedures are needed.

Local, permanently installed recirculation cooling units without outside air

As several infection events have shown, localized systems with local recirculation can present a significant contamination risk.

Therefore, such localized systems should not be operated if possible in order to prevent contamination of the indoor air (especially when rooms are used by more than one person). If it is not possible to turn these units off (e.g. due to high or low outdoor temperatures), special measures must be taken here in order to operate the premises in a safe manner.

Local systems often have only coarse filters that are not able to provide sufficiently efficient filtration. If these units are not switched off, they must be included in the cleaning plan, as they can collect particles just like any other surface in the room. In this case, a sufficient supply of fresh air (e.g. through window ventilation) is decisive. The CO_2 concentration (e.g. in the form of a CO_2 traffic light system) can be used as an indicator of whether rooms are sufficiently ventilated.

Facade ventilation and induction units that work with outdoor air feeds are an exception to this recommendation, as they serve to improve indoor air quality in a comparable way to central systems.

Room air cleaners can be useful in specific situations

To support the fresh air supply or if recirculation is required for technological reasons, the viral load can also be reduced by using mobile room air cleaners. Such room air cleaners effectively remove particles from air, and in doing so sufficiently reduce the number of particles and germs when used properly. For this to have an effect in relation to COVID-19, the air cleaners must have an effective HEPA filter that achieves at least filter class H13 as per EN 1822 at the specified volume flow (≥ 99.95% separation performance at the most penetrating particle size (MPPS)). When choosing which filter media to use, importance should be attached to tried-and-tested and well-known filter media (micro glass fiber paper or membrane media), as they have proven effective over many years of practical use. When replacing filters, the measures outlined in VDI 3803-4 described above must be adhered to.

Air cleaners should always be compliant with VDI 6022. The device must not compromise thermal or acoustic comfort in the area frequented by people. The air input of these devices generates mixed ventilation, which is generally used to filter air even in clean rooms belonging to lower classes. When positioning the devices, it must always be ensured that no excessive turbulence is created in specific areas and that the entire room is ventilated as evenly as possible in order to achieve a homogeneous overall cleaning effect. The other relevant provisions and standards must also be adhered to when using these devices, such as the VDE or fire protection regulations.

Technical information must be specified in a transparent manner with regard to the operational volume flow. This includes sound power values and the electrical power consumption for specific volume flows. The sound power is to be determined through a normative procedure in accordance with accuracy class 1 (such as DIN EN ISO 3741). When designing the devices, the noise levels specified in the guide values for different rooms as per VDI 2081 should be taken into account.

This document is based on the best facts and knowledge available as at October 12, 2020 – no liability is accepted for direct, indirect or accidental damage, or for any other damage arising from the use of or in connection with the information contained in this document.

References

This document is partly based on a list of references, scientific papers and other documents, which you can find here:

https://www.rehva.eu/fileadmin/user_upload/REHVA_COVID-19_guidance_document_Bibliography.pdf

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https://www.rehva.eu/activities/covid-19-guidance

VDI Verein Deutscher Ingenieure e. V.
https://www.vdi.de/Eurovent Association for Indoor Climate, Process Cooling, and Food Cold Chain Technologies
https://eurovent.eu/

This information on air filters is published by the Air Handling Technology trade association. It has been compiled by the Air Filters working group.

Air Filters working group at VDMA e. V.

Leading German manufacturers of air filters work together in the working group under the VDMA umbrella. Regardless of their role as competitors on the market, the member companies focus on current and long-term issues, discuss them and attempt to develop solutions and assistance.

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