Operation of ventilation and air-conditioning systems under the boundary conditions of the current Covid-19 pandemic
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From an energetic and hygienic point of view, ventilation and air-conditioning systems are an essential prerequisite for the operation of many buildings. A regular maintenance and servicing is of crucial importance for a safe operation of a system.

Against the background of the current Covid-19 pandemic, operators of HVAC systems are confronted with questions regarding the handling of the systems which are covered by this statement. The associations BTGA and FGK as well as the HVAC manufacturers' association have summarised the current recommendations, and pass on these recommendations on the basis of the current state of knowledge.

HVAC systems already provide a high degree of safety by filtering the outside air, the recirculation air and the supply air, as small particles and droplets can be separated in the system according to the filter class used. Due to the secure supply of cleaned supply air, the operation of an HVAC system always results in a dilution of possible material loads, but also of the virus load, in the rooms to be ventilated in the building. In addition, a targeted humidification of the indoor air can reduce the risk of infection. Professional planning, operation, zoning and maintenance of the pressure also ensure that pollutants from the exhaust air of one room may not spread throughout the entire building. An unfiltered operation of recirculation air should be avoided wherever possible.

Fundamental questions on the transmission of corona viruses

According to the current knowledge, corona viruses are transmitted by smear infection but mostly by droplet infection and via aerosols. For this reason, good ventilation of the interiors with the highest possible proportion of outdoor air always is recommended. This reduces the viral load in the interiors by supplying filtered and conditioned outdoor air and by removing polluted indoor air. Therefore, the following recommendations for the planning and operation of the systems arise:

- Air-conditioning systems should not be switched off, and the outdoor air volume flows should not be reduced but, if necessary, even increased. When planning the systems, not only the minimum outdoor air volume flow rate should be taken into account, but also the power reserves that allow an increase in air volume in the event of a possible germ contamination.
- Recirculation air components, if present in the systems, should be reduced or avoided in favour of the outdoor air components. If recirculation air is used, it should be filtered appropriately in order to significantly reduce the germ contamination.
- If necessary, extend the operating times of the systems before and after the regular time of operation.
- Systems with secondary air units (fan coil units, induction devices) do not lead to the transmission of contamination if they are only intended for operation within one zone. Here too, the primary air contributes to the dilution of a possible viral load in the interiors. In systems without direct connection to primary air, an adequate ventilation must be ensured by mechanical ventilation systems or by window airing.
- Ventilation systems achieve a dilution effect through the exchange of air in the respective interior, the specific load on possibly existing viruses in the interior per m³ decreases. In principle, this reduces the risk of infection. The targeted supply of treated outdoor air and the removal of polluted indoor air significantly improves the dilution and further reduces the virus load.

- An air exchange or overflow between different zones should be minimized or avoided (preferably balanced air volume flows in the zones). It should be noted that an air exchange or overflow in normal buildings via doors, windows and leaks can practically never be avoided, but a switching off the air-conditioning system would always lead to an increase in the average virus concentration.
- Devices with humidification should be set to an acceptable humidity (40 to 60%) because:
  - the vulnerability of humans to infections is relatively reduced by a suitable air humidity,
  - if the air is too dry, the droplets shrink more due to evaporation and remain suspended for a longer time (aerogenic transfer),
  - particles adhere better to surfaces at higher relative air humidity and are less whirled up and
  - most seasonal respiratory viruses are inactivated in the medium humidity range of 40 - 60%.
- If recirculation air cannot be avoided in winter - for energy reasons, for example - the filtration must be adapted and the use of suitable disinfection measures (UVC disinfection) has to be considered.

Transmission of corona viruses by HVAC systems

Based on currently available information, the transmission of corona viruses via air-conditioning systems as well as via ventilation systems can be excluded if the air supplied to the interior is filtered in accordance with the standards. Droplets which could contain the corona virus cannot be transported into the interiors via the outdoor air and supply air ducts, even if they are filtered. Exhaust air ducts that take up droplet-laden exhaust air from the interiors do not transport them to other areas, since the systems are operated in negative pressure, and therefore no exhaust air can escape even if the ducts leak.

Depending on the design, leaks in the air handling unit and in the heat recovery unit (HRU) can result in a small proportion of the exhaust air being transferred to the supply air. A correct system design with modern concepts prevents this by:

- Overpressure in the supply air section compared to the extract air section: Due to the arrangement of overpressure areas as well as negative pressure areas, no extract air can be transferred to the supply air even through heat recovery systems such as rotary heat exchangers.
- If the supply air units and exhaust air units are designed separately, e.g. with circuit connecting systems for heat recovery, the transfer of exhaust air to the supply air can be excluded.

Filtration

Air filters ensure a significant reduction of the dust and aerosol concentrations in HVAC systems and in the supply air of interiors. Already with the use of the filter class ePM1≥ 60% (former F7), a significant reduction is achieved. With this filter quality, viruses and bacteria are reduced by a power of ten. A double filtering (two times ePM1 ≥ 60% / previously F7) therefore removes 99% of airborne bacteria and viruses from an airflow.

Filter maintenance

Viruses always are bound to droplets or dust particles and therefore do not usually float freely in the interior. Like all other particles, the viruses are stored in the filter material. Personal protective equipment (PPE) must be worn when maintaining and replacing loaded filters. This includes protective gowns, gloves, mouth/nose protection FFP3 - if necessary, deviating according to the risk assessment - and safety goggles.

UVC irradiation of the supply air

Ultraviolet irradiation in HVAC systems has so far been used very successfully for water disinfection in humidifiers. However, direct irradiation of the supply air volume flow has rarely been used so far, although this solution has been available and used since 2000. UVC disinfection in combination with suitable filter technology can significantly reduce the germ contamination in the interior. The micro-organisms are inactivated practically instantaneously. The extent depends on the UVC dose. Resistance to UVC radiation cannot be built up. Generally, a radiation dose of 10 to 100 Ws/m² is required to kill micro-organisms, whereby individual organisms have very different radiation sensitivities ranging from 7 Ws/m² (Escherichia coli in air) to 1,000 Ws/m² (fungi). The effect of UVC radiation on corona viruses is well known. The D10 dose is about 40 Ws/m².

For detailed information, see supplement sheet "UVC irradiation of the supply air".

Indoor air humidity

Indoor air humidity plays a role in the transmission of viruses. Studies have shown that the transmission of influenza viruses and other respiratory viruses decreases at a relative indoor air humidity of 40 - 60%. The latest findings suggest that this circumstance also plays a role for corona viruses. If it is not possible to control the humidity with the ventilation / air-conditioning system, it should be carried out as follows:

- For systems without humidification, it is important to consider which ventilation rates are expedient among the current person occupancies.
- For systems without humidification, it should also be checked for winter operation which outdoor air volume rates are suitable, since a higher outdoor air volume leads to a reduction in the relative humidity of the indoor air. With low outdoor air volume rates, it is recommended to filter the recirculation air with high quality filters in order to reduce the microbial load of the supply air.
- For systems with a dehumidifying function, an excessive indoor air humidity should be avoided, since excessive indoor air humidity promotes germ growth.
- For systems without dehumidification, it also should be checked for summer operation which outdoor air volume rates are appropriate, since the outdoor air volume rate directly influences the relative humidity of the indoor air.

Continue to operate indoor and split air-conditioning devices

Regarding to the operation of indoor air-conditioning devices in monoblock, split and multisplit design, the Federal Environment Agency (UBA) states: "Decentralised air-conditioning devices that only cool and dehumidify individual indoors in a flat do not transmit viruses from one indoor to other areas of the building”. UBA also excludes the reproduction of the corona viruses in an air-conditioning device, as viruses need host cells, such as human cells, to reproduce. The device can therefore continue to be operated without worrying. However, it is important to ensure an effective outdoor air exchange rate at the same time in order to keep the virus load in the interior as low as possible. If there is no mechanical ventilation, ventilation should be carried out extensively by opening the windows. However, it must be taken into account that a window airing does not necessarily provide the required exchange of outdoor air.

Sources:

[1] Robert-Koch-Institut (RKI) / CCI: Sollen Lüftungsanlagen als Vorsorge gegen die Übertragung von COVID-19 ("Coronaviren") abgeschaltet werden?
Das RKI antwortete: Da es sich bei COVID-19 um eine primär über Tröpfchen verbreitete Infektion handelt (und nicht primär über die Luft übertragene Infektion), ist nach jetzigem Kenntnisstand nicht davon auszugehen, dass eine Weiterverbreitung von SARS- CoV-2 über betriebene Lüftungsanlagen (zum Beispiel in öffentlichen Gebäuden, Hotels) erfolgt.

[2] COVID-19
Guidance for infection prevention and control in healthcare settings
Department of Health and Social Care (DHSC), Public Health Wales (PHW), Public Health Agency (PHA) Northern Ireland, Health Protection Scotland (HPS) and Public Health England as official guidance:

[3] WHO, INTERIM GUIDANCE DOCUMENT Clinical management of severe acute respiratory infections when novel coronavirus is suspected: What to do and what not to do: Airborne precautions ensure that healthcare workers performing aerosol-generating procedures use PPE, including gloves, long-sleeved gowns, eye protection and particulate respirators (N95 or equivalent). Whenever possible, use adequately ventilated single rooms when performing aerosol-generating procedures.

[4] Kommentar Prof. Dr. med. Dipl.-Ing. Hans-Martin Seipp, Technische Hochschule Mittelhessen, 17.03.2020 Auszug:
Als Quelle für Dritte können RLT-Anlagen nur dann wirken, wenn man:
A) Umluft fährt OHNE HEPA-Filter (HEPAs sind ab H-13 völlig sicher!)
Ab F-9 – je nach Beladungszustand – beginnt eine Minderung des Risikos.
B) zu wenig Luftwechsel in den Raum bringt.

[5] Air, Surface Environmental, and Personal Protective Equipment Contamination by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) From a symptomatic Patient, JAMA, published online March 4, 2020

[6] Dr. med. Walter Hugentobler, Comment on COVID-19 guidance, 23.03.2020

[7] Annual Review of Virology, Seasonality of Respiratory Viral Infections Miyu Moriyama, Walter J. Hugentobler and Akiko Iwasaki, 2020

[8] POSIZIONE DI AiCARR, SUL FUNZIONAMENTO DEGLI IMPIANTI DI CLIMATIZZAZIONE DURANTE L'EMERGENZA SARS-COV2-19, AiCARR 2020

[9] Schmidt-Burbach, Gerhardt M.; Die Ultraviolettstrahlung und ihre Anwendung zur Desinfektion und Sterilisation, Biotechnische Umschau 1 Heft 11, 1977

[10] Wallhäußer, Karl-Heinz; Praxis der Sterilisation – Desinfektion – Konservierung, Georg Thieme Verlag, Stuttgart, 1995

[11] C. Kaup, Ultraviolettstrahlung zur Luftdesinfektion in RLT-Geräten, HLH, 7/2000

[12] J. Dreier, P. Bermpohl, P. Becker, K. Kleeseik; Transmission von Viren durch Raumlufttechnische Anlagen und Inaktivierung durch UVC-Strahlung, Gefahrstoffe – Reinhaltung der Luft 68 Nr. 9 – September 2008

[13] Gutachten über die Wirksamkeit der UVC-Luftentkeimungseinheit HOWATHERM UV-UNIT in Klimazentralgeräten in Kombination mit einer vorgeschalteten Filterstufe, ILH Berlin, 08/2000

UVC irradiation of the supply air

Ultraviolet irradiation in HVAC systems has so far been used very successfully for water disinfection in air humidifiers. However, the direct irradiation of the supply air volume flow has rarely been used so far, although this solution has been available and used since 2000. Ultraviolet radiation (UV) is the term used to describe the electromagnetic radiation that lies between the visible limit of the short-wave light of solar radiation and the range of X-rays and lies between 400 nm and 100 nm.

For the question of biological UV exposure, the wavelength range of UVC is of particular interest. In order for UV radiation to have an effect on biological matter, there must be an absorption capacity in the most important biological building blocks, namely proteins and nucleic acids. The maximum of the absorption spectrum of the characteristic amino acids is at 280 nm, which also can be found additively in the proteins and nucleic acids, and is about 260 nm. UV radiation thus acts on the cell nucleus and is able to destroy micro-organisms by damaging the DNA.

Artificial radiation sources (Hg low-pressure radiators) are particularly suitable for disinfection. As gas discharge lamps, they essentially excite the spectral lines at 185 nm and 254 nm wavelengths for emission. Since the photons of the spectral line at 185 nm are sufficiently energetic to split oxygen molecules, ozone is formed. Although this gas has a self-disinfecting effect as a strong oxidant, ozone also acts as an irritant gas on the mucous membranes of humans, so that the formation of ozone may only be permitted in certain exceptional cases and should generally be avoided. In order to avoid the formation of ozone, the radiation sources are manufactured with a glass material that absorbs the spectral line at 185 nm. This means that radiation sources are used whose effect is based almost exclusively on the emission of the spectral line at 254 nm.

Micro-organisms are inactivated almost immediately by this irradiation. The extent depends on the UVC dose. The resistance to UVC radiation cannot be built up. In general, a radiation dose of 10 to 100 Ws/m² is required to destroy micro-organisms, although individual organisms have very different radiation sensitivities ranging from 7 Ws/m² (Escherichia coli in air) to 1,000 Ws/m² (fungi). These values are the product of irradiance and irradiation time. The D10 value is the UV dose that reduces a certain initial number of germs by a power of ten (by 90%). The disinfection effect also depends on the degree of air pollution (shadow effect) and air humidity. Even at a relative humidity of 80%, the airborne germs are surrounded by a water film which reduces their sensitivity to UV radiation by a factor of up to 5 compared to dry air.

Air filtering is therefore absolutely necessary to reduce the dust pollution and thus to reduce the shadow formation. Thus, in addition to mechanical filtering, UV disinfection by means of UVC radiation remains for disinfection in HVAC devices, specifically for interiors in which an aerogenic infection is possible in principle.

Especially in combination with mechanical filtering, the disinfection measure is highly reliable. This is because the smaller the diameter of the germs, the worse the separating effect of the mechanical filtration. The disinfection effect of UV radiation which tends to increase with the smaller diameter of the germs, must be assessed in inverse proportion to the diameter of the germs.

The irradiation chamber should therefore be located at the end of the HVAC device. The reasons for this, in addition to the disinfection, are the existing environmental parameters, which here are at a temperature of around 22°C and a relative humidity of 30 to 60%.