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FRESH AIR AGAINST COVID-19

COVID-19 pandemic has posed many new questions to professionals and made them look more into the process of viral particles spread in order to develop more efficient methods for combating viral infections. Upon the results of numerous studies, scientists have reached a conclusion that a leading role in the spread of the SARS-CoV-2 virus has aerosols emitted by a person during breathing. This conclusion fully shifts the priorities when it comes to prevention of the disease and puts forward premises airing and ventilation.

It is traditionally believed that the predominant way of viral particles spread is the airborne way. This way of transmission means the following: virus enters the environment in large quantities together with saliva and mucus micro-droplets, which are emitted by an ill person when coughing and sneezing. Given that such droplets have its own weight, they quite quickly accumulate on surfaces in a 1.5 m radius from the source. Bearing this in mind, professionals have already long ago developed a number of universal measures to prevent viral diseases, including wearing medical face masks, maintaining required distance between people, reducing social contacts, as well as other methods. Given that not one viral disease in the past few decades has grown into a pandemic and sooner or later dwindled away, the above taken measures were considered to be the only correct and efficient ones for a long time. That is, before COVID-19 came.

And then it appeared that stopping disease spread with the customary means is not always seems possible. There are many known cases when virus behaved completely unpredictable and befuddled scientists and doctors. Thus, for example, a great number of healthcare professionals got infected with the SARS-CoV-2 virus, who had the state-of-the-art personal protective equipment, while people who were exposed to ill people without any protection remained absolutely healthy. COVID-19 posed many questions to the medical professional community that required an answer. And such an answer was found.

Results of a new research of SARS-CoV-2 viral particles behavior put into question the leading role of the airborne way of the infection transmission and, consequently, the efficiency of the customary prevention measures. In particular, in April this year, a well-regarded medical journal The Lancet published an article where quite convincing arguments were provided in favor of the air-aerosol way of SARS-CoV-2 virus transmission. The authors of the article provide data that allows to make a conclusion that viruses are spread predominantly with aerosols, i.e., the smallest particles that are emitted by infected people when breathing. Such particles have such a small size and weight that they are able to remain in the air for an extended period of time and travel significant distances. Obviously, all other known ways of virus transmission also make its contribution to the infection spread, however, the predominant way of transmission is specifically the air-aerosol way.

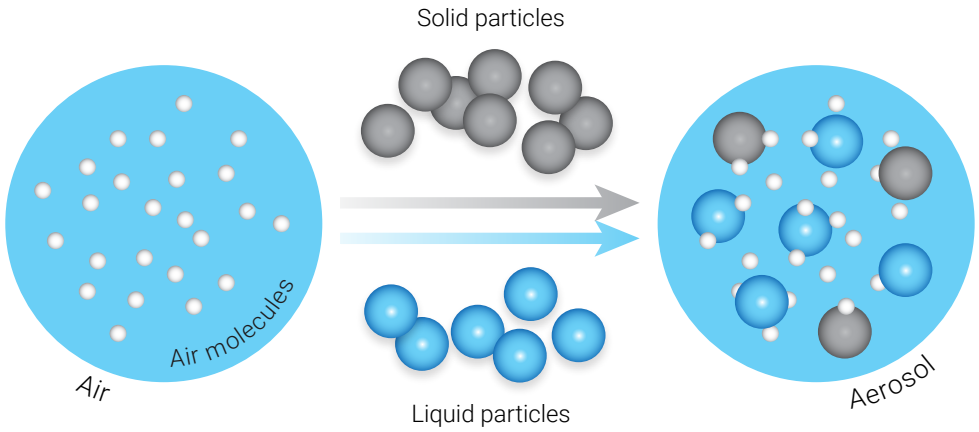
Of the same opinion are also many other high-profile international organizations that conduct their own research of aerosols behavior. In particular, experts of the international organization “Association for Aerosol Research” (Gesellschaft für Aerosolforschung e.V., GAeF), which was created in 1972 and united representatives of various industries, medical research institutes and universities from all over the world, have recently published some of their conclusions and a list of the most efficient measures for COVID-19 pandemic spread prevention, which we provide below.

At a first glance, the scientists’ conclusion on predominant role of the air-aerosol way of SARS-CoV-2 viral particles spread does little to change our understanding of the disease spread mechanism, because both droplets and aerosols are of the same nature and are transmitted through air. However, it fully shifts the priorities in terms of disease prevention measures.

What are aerosols?

An aerosol is a gaseous environment with weighted solid and/or liquid particles in it, the size of which may be in the range of from 0.1 to 1000 μm. In the process of breathing a person inhale and exhales gaseous mixes. During inhaling, atmosphere air that contains 20.94% of oxygen, 78.03% of nitrogen, and 0.03% of carbon dioxide enter into a person's lungs. When exhaling the composition of the gaseous mix is different: 16.3% of oxygen, around 4% of carbon dioxide and 79.7% of nitrogen. Along with the exhaled gaseous mix, a person also exhales into the environment moisture that behaves itself differently depending on the size of micro-droplets: bigger droplets quite quickly accumulate on surfaces, while smaller ones either rather quickly evaporate or get mixed with air flows and travel tens of meters. Aerosol exhaled by a person is easy to see in cold seasons when during an exhale the so-caller vapor is formed, and to be more precise – a mist that consists of many micro-droplets that form as a result of moisture condensation. Such aerosol does not accumulate on ground and various surfaces, but gradually dissipates and gets blown away in different directions. This is where its inherent underlying hazard lies.

The main issue of the problem is that SARS-CoV-2 viral particles have even smaller size (50–200 μm) and may freely escape together with aerosol micro-droplets. Given that bigger droplets containing virus cells that are emitted by an ill person during coughing and sneezing quite quickly accumulate on various surfaces, pathogens contained in an aerosol on the contrary may remain in air for a long time and enter lungs of other people. And that's not all of it! Given that a person breathes constantly, such viruses are emitted not periodically, but with each single exhale 24/7. That is why even small concentration of an aerosol is enough for eventually contaminating environment with a significant number of viral particles.



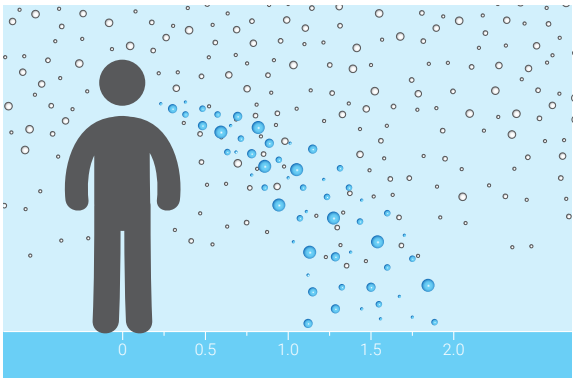
This conclusion requires some rethinking of previously adopted rules and recommendations in respect of combating COVID-19, in particular, related to the use of ventilation systems in premises, which today may be a decisive factor in combating the disease spread.

Pockets of infection – indoor areas

According to the statistics, around 90% of their time a person spends in indoor areas, such as homes, apartments, offices, education institutions, concert halls, stores, transport, etc. And only 10% of the time we spend outdoors. This statistic is also true for the infected people. This means that the main places of accumulation of viral particles are indoors areas. Let's simulate a situation where viruses are spread outdoors and indoors taking into account the hazard that aerosols pose.

In outdoor spaces aerosols, which are emitted by an ill person, quickly travel together with the moving air in an environment and dissipate, which results in elimination of pockets of high viral concentration. An ill person themselves usually also moves, thereby spreading pathogens over large distances, which also excludes the possibility of virus accumulating in one place. There is yet another important factor: in outdoor areas an ill person is unlikely to have a prolonged contact with other people.

In indoor areas everything happens to the exact opposite. When there is no ventilation or it is insufficient, aerosol particles containing viruses will remain in the indoor air for a long period of time dissipating only within its limits. An infected person with each exhale will generate pathogens, which in turn leads to the increase of its number in the room. And if for an extended period of time other people will remain close to such a person (family members, relatives, work colleagues, etc.), which is the case most of the time, then the risk of infection for those people will be as high as possible.



It is known that getting infected with virus infections is possible when organism gets exposed to a critical (infectious) dose of viral particles. It is quite possible that several dozens or hundreds of particles will be insufficient for infecting an organism and developing of a disease. That is why the chances of getting the infectious dose are minimal in the outdoor areas and maximal in an insufficiently aired room.

This conclusion is supported by numerous studies conducted by scientists around the world. In particular, according to the information of the World Health Organization that were published in the Report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19), the majority of people in China got infected with SARS-CoV-2 virus not on the streets, but in their houses, apartment and during prolonged contacts with family members. Other countries' experience also supports this conclusion. Therefore, the successes of combating viral diseases in many ways depends on the measures taken for decreasing virus concentration in enclosed spaces. This means that the role of ventilation here cannot be overstated. Only ventilation of premises ensures continuous removal of virus-contaminated air and supply of clean outdoor air, thereby decreasing the chances of getting the infectious dose.

It’s all about the infectious dose

This term means the number of viral particles that need to get into a human organism so that person’s immune system would not be able to deal with it and therefore leading to infecting and disease development. When a lesser amount of pathogen than the infectious dose enters into a person’s organism, the disease may not develop at all, or may develop as a mild sickness. According to Erin Bromage, the Associate Professor of Biology at the University of Massachusetts Dartmouth, when it comes to COVID-19 disease, the infectious dose is about a thousand SARS-CoV-2 virus particles. The scientist notes that such evaluation is based on the research of corresponding doses that are applicable to such acute respiratory syndromes as MERS and SARS.

The majority of people get infected in their own houses, apartments, offices, educational institutions and other premises where they have an extended contact with infected people. In outdoor spaces viruses spread over the vast distance, therefore a human exhale dissipates quite quickly. In this case, virus dose exhaled by an ill person will be insufficient for infecting a healthy individual. That said, getting the infection dose may be achieved in many ways. “Infection could occur, through 1000 infectious viral particles you receive in one breath or from one eye-rub, or 100 viral particles inhaled with each breath over 10 breaths, or 10 viral particles with 100 breaths. Each of these situations can lead to an infection” explains Erin Bromage. This means that during a very short contact with and infected person, for example, with a person running past you, it is unlikely to get exposed to an infectious dose.

How many COVID-19 pathogens are emitted with each breath is not known for certain. Erin Bromage cites research data according to which in case of an ordinary flue an ill person spreads from 3 to 20 viral particles per minute. If this data is also true for COVID-19 pathogen, then one must inhale all particles emitted by an infected person over the period of 50 minutes in order to get the infectious dose of 1000 particles. That is why the majority of SARS-CoV-2 infection cases occur in indoor areas with insufficient airing where constantly present and accumulate aerosol particles that may contain sufficient infectious virus dose.

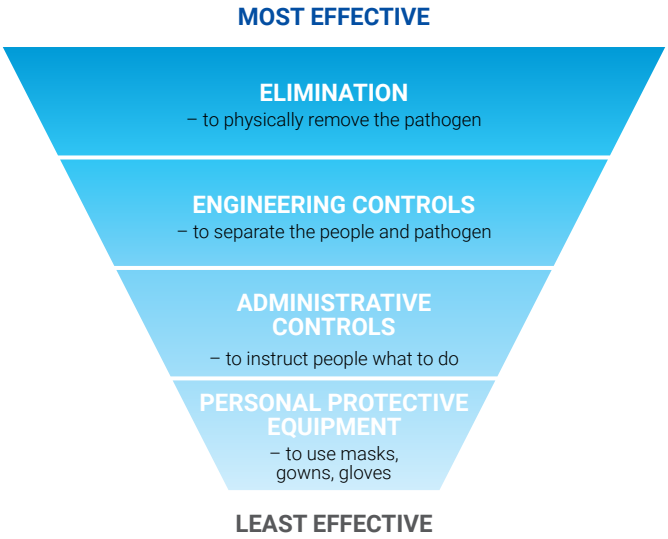
Main COVID-19 spread prevention measures

In order to decrease COVID-19 disease spread, it is required to implement a number of measures that prevent inhaling infectious aerosols and eliminate pockets of infection with high virus concentration in the aerial environment. It is obvious that in indoor areas such measures include ventilation, air filtration, decreasing the amount of people present and the time they spend in premises, correct use of personal protective equipment, etc.

GAeF experts, upon the results of their own research, published a number of conclusions and a list of the most important measures for prevention of the COVID-19 pandemic spread.

1. Maintaining social distancing between people, since with an increase in the distance between them, the concentration of viruses in the air decreases, which in turn decreases the infectious dose and the possibility of infection.
2. Use of medical face masks by infected people. Such masks allow filtering of the majority of large and small aerosol particles that are exhaled by an ill person that contain viruses, thereby decreasing pathogen concentration in the aerial environment. A simple mask is much more efficient if it is used by an infected person, and less efficient when used as a protective measure by a healthy individual. The latter is explained by the fact that aerosol particles that are present in the aerial environment evaporate with time and significantly decrease in size, which materially complicates its filtration. For more efficient protection respirators with high protection class are required, for example, FFP2, N95 and KN95.

3. Face visors used without also wearing a face mask are in most cases useless in respect of aerosol particles, because air containing these particles with viruses goes around the visor without any filtration. Mobile or stationary plexiglass barriers are largely inefficient against aerosol spread in a room. They may prevent aerosol spread on a small scale only in a short-term perspective, for example, at cash register area in a supermarket, but provide no protection in a long-term perspective. Face visors and plexiglass barriers are used mainly for protection from direct contact with splashes and large droplets.
4. In outdoor areas, infections that are caused by entry into respiratory organs of aerosol particles containing viruses, are pretty much never seen. At the same time, airborne infections may occur, especially in crowds, when no social distancing between people is maintained and they wear no medical masks.
5. Air purifiers can be a useful addition to reducing virus concentration in a room. When purchasing an air purifier, you should make sure that it has a performance sufficient for the room in question, which will allow to significantly reduce the amount of aerosol particles in the air and, accordingly, viruses.
6. And the most important factor – ventilation! Indoor areas require constant ventilation for exchanging the exhaled air containing aerosol particles with viruses with a fresh supply air. Based on this conclusion, governments of some counties have already amended their policies regarding COVID-19 disease by shifting the emphasis on premises ventilation. Thus, for example, National Health Service of the UK is already leaving in the past the "Hands. Face. Distance" slogan that was introduced a year ago and meant hands disinfection, face protection and maintaining social distancing. The new recommendations by these authorities place priority on airing rooms and spending as much time as possible outdoors.

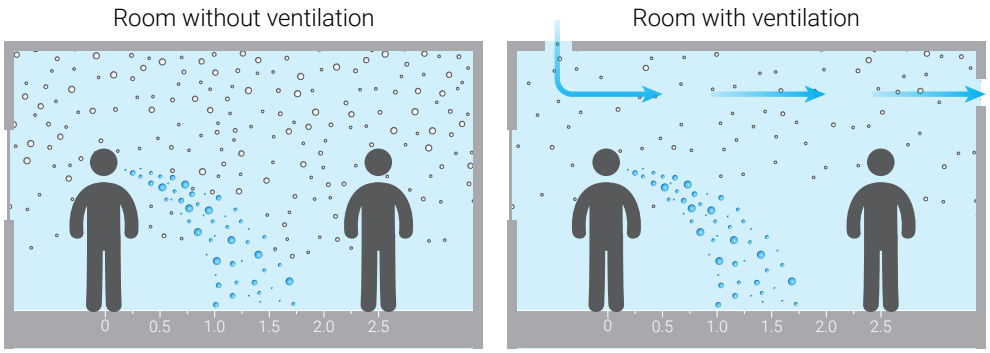


REHVA (Federation of European Heating, Ventilation and Air Conditioning Associations) provided a pyramid of methods of combating the spread of viral infections according to their effectiveness. The data confirms that the most efficient method at present is physical removal of pathogens, in particular, reducing virus concentration in the aerial environment. This reduction can be achieved in various ways, for example, by ventilation, air filtration and irradiation, and by utilizing ultraviolet filters. At the same time, if ventilation and air filtration are aimed at reducing the number of viruses in the air, ultraviolet irradiation is used to inactivate viral particles.

REHVA experts consider diluting the air containing virus-containing aerosol particles with clean supply air to be the most effective way to reduce concentration thereof. In outdoor areas, such dilution occurs continuously due to natural air movement, and in premises it can be achieved only as a result of efficient ventilation. Taking into account such a factor,

experts of the above organization have developed a guidance for HVAC systems operation during COVID-19 pandemic. In the context of a viral infection spread, it is recommended to take a number of practical measures to increase effectiveness of protective measures during operation of engineering networks, including ventilation systems. Among such measures the following is included:

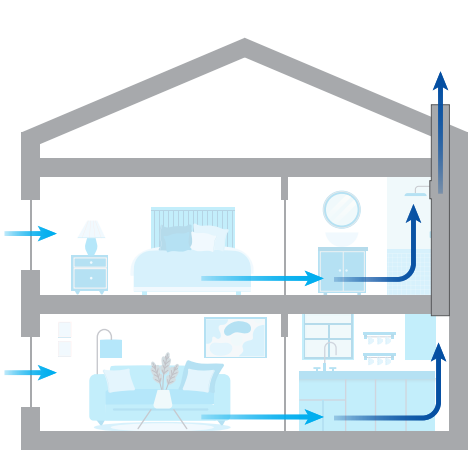
- ensuring forced ventilation inside premises with supply of outdoor air;
- starting ventilation system operation at a nominal speed not less than two hours before opening of the premises with setting the switching off or speed reduction mode two hours after closing thereof;
- departure from flexible ventilation mode so that the ventilation system would always operate in nominal mode;
- regular opening of windows, including in buildings with forced ventilation;
- ventilation equipment operation in bathrooms at a nominal speed;
- not opening windows in bathrooms, which will help maintain negative pressure and the correct direction of air flows during forced ventilation;
- switching air handling units with recirculation to 100% outdoor air inflow;
- installing a number of air quality sensors (CO_2 sensors) within the premises, which will allow residents or managers to monitor normal operation of the ventilation systems;
- carrying out works related to replacement and maintenance of filters in accordance with the standard operating procedures utilizing general safety measures, including respiratory protection.



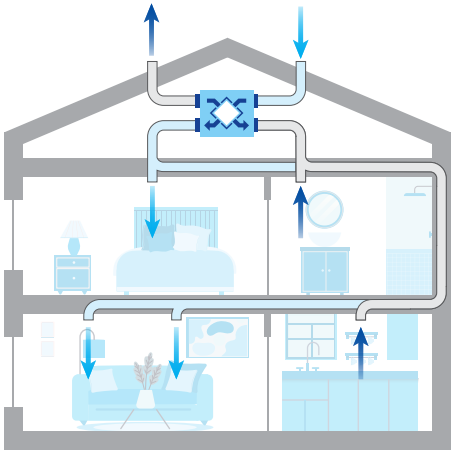
Airing or forced ventilation?

The required air exchange may be achieved via traditional airing of premises or with the help of forced ventilation with the use of ventilation equipment.

Airing implies periodical opening of windows. Till this day many residential and public buildings around the world are still not equipped with forced supply and exhaust ventilation systems, therefore manual airing is often the only solution to this problem. However, this method of ensuring air exchange has a lot of disadvantages that one needs to be aware of. If outdoor air is colder than the air inside a room, then opening of windows may cause a draft, i.e., directional air flow. A person staying on the way of such an air flow can experience local hypothermia and, as a result, a cold, sore throat, otitis and a number of other diseases. Another negative factor is extensive loss of heat during cold seasons, which leads to increased costs for heating. Another disadvantage is associated with the possibility of contaminated outdoor air entering the room. Outdoor air is not sterile, therefore insects, plant pollen, fluff, dust and various pollutants can easily enter the room when windows are open. Quite often such uninvited pollution can cause allergic reactions. Another unpleasant factor related with such airing is entering of the street noise into the room. Yet another important factor is the complexity of such air exchange regulation. Airing via open windows is usually irregular and may not be sufficient.



Natural ventilation

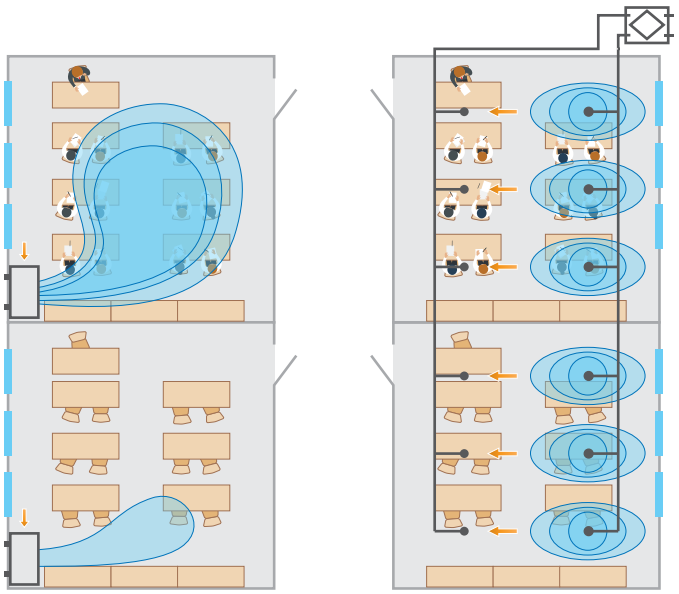


Mechanical ventilation

The above drawbacks are absent in forced ventilation, which can be achieved with the help of ventilation systems. Such systems are divided into centralized and decentralized systems. The former is used for a group of rooms or an entire building, the latter is used for separate small rooms.

Centralized ventilation systems are characterized by an extensive network of air ducts of various cross-sections with branching and coupling nodes. Supply of clean air and exhaust of extracted air are ensured by special air handling units with heat recovery or by individual fans. Heat recovery allows keeping the room warm in the cold seasons and cool in the warm seasons, thereby reducing the cost of heating and air conditioning, while integrated filters provide purification of the supply and exhaust air from various pollutants and allergens.

Decentralized ventilation systems comprise of individual, autonomous units that are mounted in the outer wall in each separate room or area. Due to the fact that such units do not require major renovation works and mounting of a duct system, they can be installed at any stage of the renovation works and even in completely finished premises. Such units are also equipped with heat exchangers and filters.



Decentralized ventilation

Centralized ventilation

Properly organized decentralized ventilation plays an important role in combating the spread of viral infection by air-aerosol way of transmission. First and foremost, this applies to buildings with a large number of separate rooms: children's institutions with play and sleeping areas, dining halls, educational institutions with classrooms and auditoriums, art centers, etc. Autonomous decentralized ventilation provides local ventilation of premises, and also allows you to change the parameters of the air environment according to a specific schedule.

It is obvious that forced ventilation has a number of significant advantages over traditional airing. It ensures constant movement of air within the room and required air exchange, which prevents an increase in concentration and accumulation of aerosols with pathogenic microorganisms. Due to the continuous supply of clean and fresh air from the street and removal of the exhaust air, aerosols present in the room are immediately removed outdoors. Such a simple but efficient solution allows constantly removing viral pathogens from a room, which eliminates pockets of infection and significantly reduces the likelihood of COVID-19 disease.

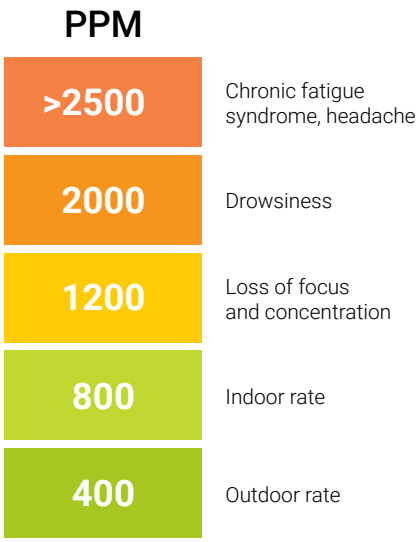
How can one understand that the air in a room does not meet the standards?

Sure enough, ventilation is extremely important for purifying air and removing viruses from a room, but how can one tell that the air in the room is polluted, contains a large number of pathogens, and quality ventilation is required? In this matter, one can rely on one's senses, which many do. As soon as a person begins to feel discomfort in the process of breathing, this is a clear signal that the air is stagnant and contains many harmful impurities, and therefore a large number of viral particles.

However, identifying air quality with our senses and responding each time to a problem that manifests itself in appearance of unpleasant symptoms is not the best solution. Discomfort may occur when air characteristics deviate largely from the norm, as a result of which the aerial environment in the room will already contain a large number of viral particles. An optimal solution in this case would be utilization of sensors. Modern equipment allows continuous control of the air quality in a room, responding appropriately to its deterioration and ensuring the required air exchange.

Unfortunately, there are no sensors for measuring virus concentration yet. However, the level of air contamination can be determined by the content of carbon dioxide (CO_2) in it.

This function is performed by CO_2 sensors, which are widely available on the market today. Carbon dioxide is constantly emitted by any person in the process of breathing, and with inadequate ventilation, its concentration in the room will constantly increase. And the more people there are in the room, the faster the CO_2 content will increase. Since both carbon dioxide and aerosol particles are emitted by a person simultaneously during exhalation, an increase in the carbon dioxide content in a room will signify a commensurate increase in the content of SARS-CoV-2 viral particles.



CO_2 sensors can operate both as individual autonomous devices and in conjunction with ventilation equipment. In the latter case, the ventilation device can automatically turn on and off, as well as change its operating modes depending on the concentration of carbon dioxide in the room.

Some myths about ventilation systems

In various information sources, one can find advice and some people's concerns related to utilization of ventilation systems during the COVID-19 pandemic, which in most cases are ill-founded. Let's examine two of them as examples.

Partial mixing of clean supply air and contaminated exhaust air can occur in ventilation equipment heat exchangers, as a result of which viruses will return to the aerial environment of the room together with the supply air.

Indeed, many ventilation devices contain heat exchangers (recuperators) through which supply and exhaust air passes. The possibility of a slight mixing of these air flows exists if a ventilation unit with a rotary heat exchanger is installed. For this reason, it is not recommended to install air handling units with such type of heat exchangers in many medical facilities. If it is required to completely eliminate the possibility of mixing air flows, this can be easily achieved using a glycol heat exchanger, which consists of two separate heat exchangers connected to each other in a closed loop with a heat transfer agent circulating in it (ethylene glycol or propylene glycol solution).

Ventilation ducts are a source of viruses.

According to REHVA experts, cleaning of air ducts in excess of the regulatory standards does not affect the behavior of viruses in any way, and, therefore, is of no practical use. More frequent duct cleaning is ineffective in terms of preventing room-to-room transmission of viruses

because ventilation system is not a source of infection. The smallest aerosol particles containing viruses, due to their low weight, do not accumulate in ventilation ducts, but are carried out outdoors together with the air flow. Therefore, there is no need to change air ducts routine cleaning and maintenance procedures. It is much more important to increase the supply of outside air and avoid recirculation of air in accordance with the above recommendations.

What should we do?

In order to minimize the risk of COVID-19 disease, one should ensure proper ventilation or airing of premises where the majority of all SARS-CoV-2 infections occur, spend more time outdoors, avoid prolonged close contact with other people, and use medical masks that filter out most of the micro-droplets of aerosols with viral particles, thereby reducing their concentration in the inhaled air.

In view of such conclusions, it would be appropriate to provide some recommendations for owners and managers of various premises with a large concentration of people.

For **office, industrial and warehouse premises**, regular disinfection of surfaces and maintaining social distance between employees can no longer be considered a sufficient measure in combating the spread of SARS-CoV-2. An important factor here is quality ventilation of the premises, which is ensured by utilizing ventilation systems.

For **cafés and restaurants**, placing tables at a greater distance from one another also cannot be considered a sufficient measure any more. The optimal solution here may be accommodating customers on open summer terraces and in outdoor areas during warm seasons. When it comes to indoor areas, an important role gains ventilation, which should be ensured either by regular airing via opened windows or forced ventilation.

For **shops and shopping malls**, along with maintaining the required distance in lines, wearing medical masks and other preventive measures, it is necessary to ensure necessary ventilation within the premises. When utilizing forced ventilation systems, an important factor is ensuring its continuous operation. If it is possible to control the performance of these systems, the air flow capacity should be variable, e.g., by increasing performance depending on the number of visitors present at a given moment.

For **kindergartens and schools**, it is very problematic to achieve continuous maintenance of the social distancing between children and correct wearing of protective masks by them. In this case, regular airing of the premises will be an important preventive measure for combating the spread of SARS-CoV-2. An optimal solution may be utilization of centralized or decentralized ventilation systems, which ensure constant air exchange and do not allow drafts. In the absence of such systems, it is necessary to air the premises in the traditional manner by opening windows as often as possible.

Fresh air is a nature's gift to us that we can enjoy without any limitations. And given that ventilation and airing of premises plays such an important role in the fight against the spread of COVID-19 and other viral diseases, then it would be a big mistake not to use this simple and effective solution. Nowadays, the market offers a lot of ventilation equipment and systems of any performance parameters, for any premises and for any budget, which can be installed in a matter of hours and without the need to perform any renovation works.

Be healthy and enjoy fresh air!

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