Improving Occupant Safety Inside Buildings

(During & Post COVID-19)

Reference Material for Building Owners, Managers, Operators, & Occupants of Buildings

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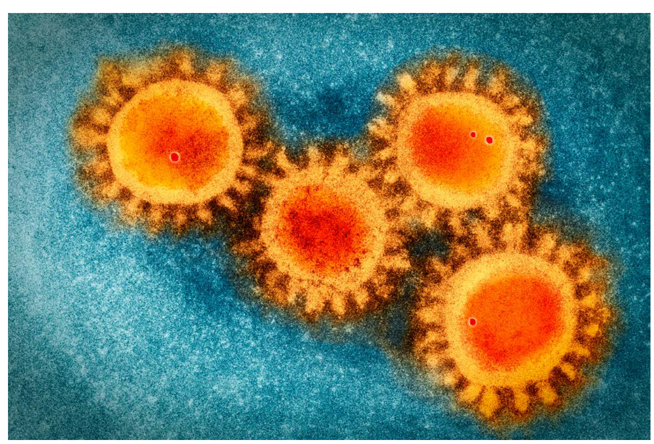
The coronavirus disease 19 (COVID-19) pandemic has alarmed building owners, managers, and occupants to the public health risk associated with interior spaces. As normal business has continued to be interrupted and the global death count increases, the ability of building systems to facilitate and proliferate the spread of COVID-19 is under much debate in the scientific community. The relative impact of the control of the spread of the disease from building systems is thought to be less than other measures such as social distancing, mask wearing, cleaning and disinfection of surfaces. As more studies are performed, there is increasing evidence the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) can be found further than 6 feet (1.8 m) from the source and in some cases well within the ductwork systems indicating the potential spread as an aerosol. Industry organizations, such as the American Society of Heating Refrigeration, and Air-Conditioning Engineers in conjunction with the Centers for Disease Control and Prevention (CDC), The Federation of European Ventilation and Air Conditioning association (REHVA) and the World Health Organization (WHO), have prepared guidance documents on operational and design considerations for building systems that serve as useful reference materials for owners and operators. Navigating these challenges of today's world can be difficult and confusing to building owners and managers. These challenges include understanding the risk, understanding these guidance documents, and leveraging new technologies to combat these risks. At Jacobs, we recognize the complexities of your goals and understand not all solutions are a quick-fix, but we press forward to apply the right strategy and technologies to solve your problems.



It is widely reported that the primary method of spreading the SARS-CoV-2 virus which causes COVID-19 is through respiratory droplets from close contact with those already infected with the virus.[1] These droplets which contain SARS-CoV-2 are emitted when we talk, sneeze, cough, run, and even sing. The primary reason that masking and social-distancing measures are highly recommended by both the CDC and WHO is due to the larger sized droplets, which are sized greater than 5 micron, weigh more, fall to the ground faster and are more easily captured by masks. The wearing of facemasks serves as an initial protective barrier both to contain droplets from an infected person at the source and from inhalation of droplets containing the virus. Another potential method of spreading the virus is by touching a surface or an object that has the virus on it and then touching your own mouth, nose or eyes. This is not believed to be a common method of transmission of the virus[1]

It is now recognized that smaller droplets (less than 5 micron) containing the virus can spread the virus, especially in enclosed poorly ventilated spaces[1]. The health and safety risks associated with the aerosol spread of the virus are compounded since these droplets are light enough to be carried on air currents within a room for hours, and potentially even spread throughout a building's HVAC system.

Currently, the data indicates the spread of SARS-CoV-2 as an aerosol to be less than the spread associated from close contact[1]. Questions remain regarding the quantity of virus required to infect another person. Clearly activities such as singing in closed poorly ventilated spaces can increase risk for occupants.[2] In addition, one recent study[3] found viable SARS-CoV-2 virus in air samples over 15 feet (4.6 m) away from a patient with COVID-19. The experimental findings need further testing to understand both the quantity of the virus contained within these particles as well as the quantity of the virus required to infect another person.

Another study, conducted at the Oregon Health and Science University in Portland, Oregon, USA[4], documented evidence of SARS-CoV-2 viral RNA from swab samples taken within HVAC systems. Positive samples were found at the inlet to pre-filters (10 micron), the inlet to "final" filters (MERV-15) and inlet to the supply air dampers. Considering positive samples were found at the supply air dampers, which were downstream of the MERV-15 filters, raises concern of the potential for aerosolized spread of COVID-19. From this study, the viability and infectivity of the virus sampled was unknown.

An earlier study in Guangzhou, China[5] documented the spread of COVID-19 from an infected person in a restaurant to individuals sitting at nearby tables. Despite the limited information in the study, it concluded that the spread was facilitated by the respiratory droplets being carried by strong air currents present due to the exhaust fans and air conditioning systems. The study documented that only a portion of those within the direct airstream was infected while others in the restaurant remained unaffected. The study noted that the distance between the initially infected individual and the most remote impacted individual was well over 6 feet (1.8 m). Smear samples taken from the air conditioner equipment and ductwork were negative of nucleotides. The results of this study tend to demonstrate lower possibility of aerosol transmission, but also highlights the ability and potential for droplets to spread further than six feet in favorable conditions.

The relative degree to which SARS-CoV-2 can be transmitted as an aerosol is extremely important to understand, as it not only impacts public health and the precautions that should be taken, but also affects the protocols and modifications necessary within building systems to help combat the spread of the virus. While continued studies are required, the uncertainty at this time whether COVID-19 spreads through aerosol transmission as a primary mechanism should not be dismissed. As scientific understanding of the SARS-CoV-2 pathogen continues to evolve, plus anticipating unknown future viruses, the most prudent and effective path at this point is to consider aerosol transmission within the design of building systems.

Based on recent studies, increasing temperature and humidity have direct impacts on the inactivation of SARS-CoV-2 on surfaces.[6] In addition, these conditions can reduce the transmission rates of virus in outdoor conditions.[7] It should be noted that higher levels of humidity (relative humidity of 80% and higher) tend to negate these effects. Natural sunlight, which contains both UV-A and UV-B waves, has been determined to have a much more significant effect on the inactivation of SARS-CoV-2 than either temperature or humidity.[8] UV-C light has been shown to be highly effective in the inactivation of SARS-CoV-2 and is more effective than UV-A.[9] While temperature and humidity can be controlled within indoor occupied spaces, UV-A, UV-B and UV-C light can not be used with direct exposure inside of occupied spaces due to the negative health effects.

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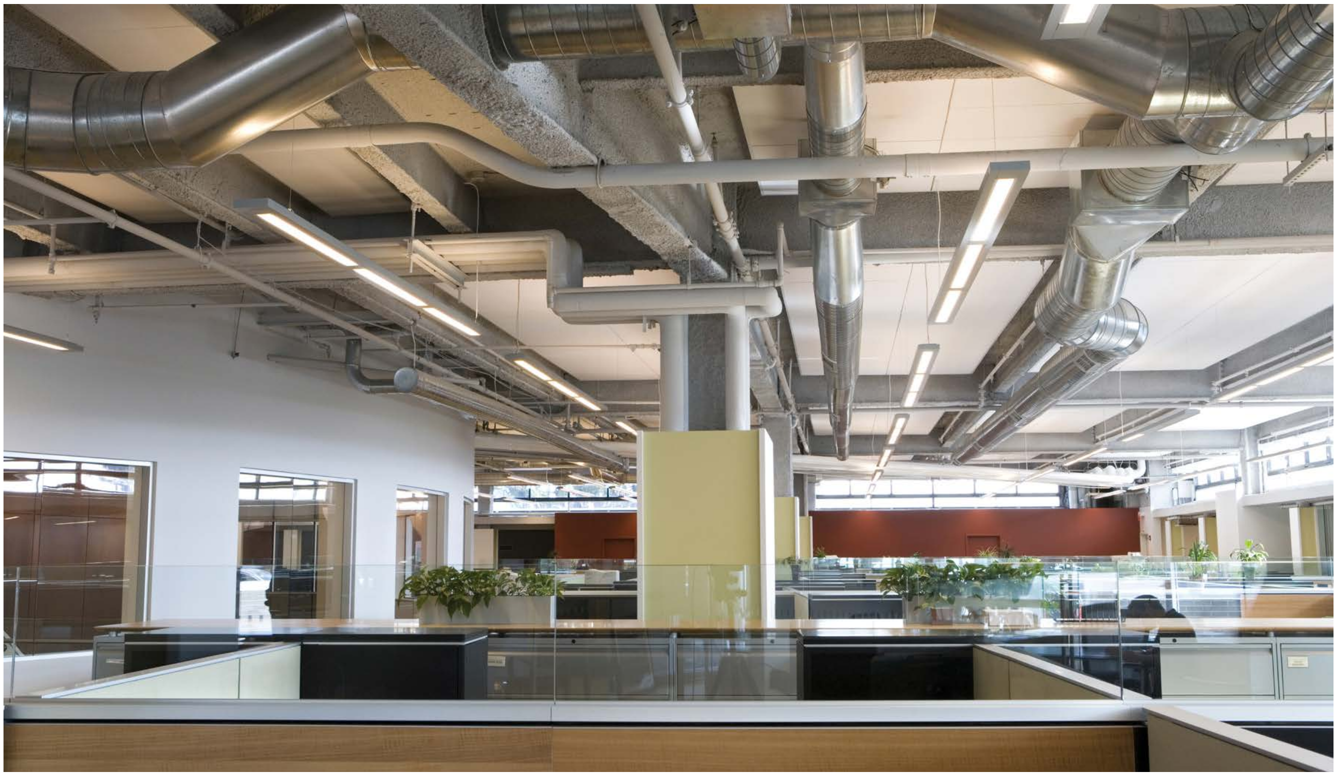
Based on the US Department of Homeland Security simulation models, which estimates the surface decay of SARS-CoV-2, the half-life of the pathogen at 74°F (23.3°C) and 20% relative humidity (RH) is almost 15 hours. Increasing the temperature to 80°F (26.7°C), with a relative humidity of 60%, decreases the half-life to slightly over 6.5 hours. Similarly, these models estimate the airborne decay of SARS-CoV-2 related to UV Index (UVI), temperature and relative humidity, and the importance of each in reduction of the virus. With a UVI of 0, temperature of 73°F (22.8°C), and humidity level of 20% RH, the half-life was shown to be almost 27 hours. Increasing the temperature to 78°F (25.6°C) at the same UV and humidity levels decreases the half-life to just under 3 hours. Increasing the relative humidity to 40% further decreases the half-life to 41 minutes, while an increase to 60% humidity drops the half-life to 23 minutes. By comparison, with a UVI of 2, temperature of 73°F (22.8°C) and 20% RH, the half-life is significantly reduced to just under 12 minutes. While the impact of UV light is important to discuss, the impacts of temperature and humidity are not marginal. Considering the human body is at a higher risk for viruses at lower temperature and lower humidity when mucus membranes are dry and more susceptible to infection, the benefits of increasing humidity levels are further increased.[10]

Estimated Surface Decay of SARS-CoV-2 vs Temperature and Humidity

Temperature	Humidity	Half-life (Hours)
74°F (23.3°C)	20%	15
74°F (23.3°C)	40%	11.8
74°F (23.3°C)	60%	8.7
80°F (26.7°C)	20%	12.7
80°F (26.7°C)	40%	9.7
80°F (26.7°C)	60%	6.5

Estimated Airborne Decay of SARS-CoV-2 vs Temperature, Humidity and UVI

UVI	Temperature	Humidity	Half Life
0	73°F (22.8°C)	20%	27 hours
0	78°F (25.6°C)	20%	3 hours
0	78°F (25.6°C)	40%	41 minutes
0	78°F (25.6°C)	60%	23 minutes
2	73°F (22.8°C)	20%	12 minutes



It is important to understand that HVAC systems do not eliminate the possibility of COVID-19 transmission within a building. One of the primary goals of successful HVAC systems is to increase the health and safety of building occupants by reducing the contamination levels within the building. In order to accomplish this, containments should be contained and restrained as close as possible to the source. It is for this reason why wearing high quality masks within public spaces is vitally important. Once a droplet of aerosolized spread virus is released from an infected individual, it can travel through the room, increasing the opportunity to infect other people. This can make it exceedingly difficult to implement measure to control the spread. Even with this consideration, there are still measures within HVAC systems that can be implemented to reduce the contamination potential within the room, and in turn reduce the health and safety risk to the building occupants.

Like HVAC systems, plumbing systems can also impact the potential to spread the SARS-CoV-2 virus to occupants within indoor spaces. Infectious virus has been discovered in both urine and fecal matter.[11] When toilets and urinals are flushed by an infected individual, the flushing causes water droplets to become airborne. The restroom air patterns have the potential to carry the virus within these air patterns to nearby surfaces. The spread of the virus could be through fecal–oral transmission as is caused by particles settling on surrounding surfaces, which are touched by other people, and then transmitted to eyes, nose, or mouth or through fecal–respiratory transmission in which particles in the air are inhaled. These transmission pathways should also be considered.

Considering guidance documents from various industry organizations including ASHRAE, REHVA and the WHO, the **following are recommendations for commercial buildings:**

Verify and document the current condition and operating state of the existing systems. This verification includes:

- System components and configuration
- Confirmation outside air meets or exceeds current requirements
- Sequences of operation
- Installation and condition of filters as well as the ratings
- Ensure the systems are balanced and air flows are as intended based on the design.

- Increase filtration level to a MERV 13 quality or better. A tight fit around the filter is also necessary to ensure the effectiveness of the filter in order to ensure that no unfiltered air bypasses the filter element. When upgrading the appropriate filtration elements, it is important to ensure that the fan is capable of supporting the airflow to maintain design conditions considering the upgraded filter will become more restrictive as it becomes loaded (dirty). The more restrictive filter increases the pressure required to operate the HVAC system. Fans and fan motors may need to be modified to upgrade filters for some units.
- Considering both space conditions for temperature and humidity, increase the HVAC systems ventilation (outdoor air) rates as high as possible without negatively impacting these conditions. As more fresh air is delivered to the space, potentially contaminated room air is displaced to the exterior removing contaminates from the room and the air within the room is diluted with cleaner outdoor air. It is important to consider the air quality of the ventilation air so that adding more air does not detrimentally impact indoor conditions. Opening windows when the conditions outside are appropriate is another method of increasing ventilation air within spaces.
- Utilize portable HEPA air cleaners in higher risk spaces. Spaces may include elevator lobbies, entry lobbies, conference rooms, kitchen areas, and waiting areas. For these types of units to be effective it is important to select units that can create significant amounts of air turnover with the space.

- Consider increasing the temperature and humidity within indoor spaces to the higher side of the acceptable ranges (76ºF-80ºF (24.4ºC- 26.7ºC) and 40-60% relative humidity per ANSI/ASHRAE Standard 55) , as this provides the optimal environmental condition for both inactivation of the virus as well as human defense of the virus. If the existing HVAC system does not have a humidifier and it is decided to add one for drier environments, it is important to identify potential issues associated with condensation to the building envelope. Condensation will occur if the envelope is not designed for higher humidification levels and can be a contributing factor to mold growth inside the building.
- Always operate HVAC systems when occupants are inside the building, including janitorial and security staff.
- Consider discontinuing the use of ceiling and wall fans which increase airflow patterns within interior spaces and can contribute to further spreading of the virus.
- When transitioning between unoccupied and occupied mode, operate HVAC systems with maximum outdoor air for at least two hours before and two hours after building becomes occupied. This would include all exhaust systems as this provides a flushing of the building at the beginning and end of the operating cycle.
- Energy recovery systems have the potential to contaminate fresh air intakes with increasing risk depending on the type. Consider disabling higher

- risk systems especially in higher risk areas, if possible. It is important to evaluate whether the system will meet the design conditions without these components in operation.
- Consider the addition of UV-C (UVGI) ultraviolet germicidal irradiation to HVAC units that recirculate air, especially those in areas of high traffic and higher occupant risk.
- Demand control ventilation is used as an energy savings feature within many HVAC systems to allow for lower levels of outside air when certain measured parameters are within acceptable ranges. This feature should be disabled when buildings are occupied in order to maximize the amount of outside air that is delivered to the space during building occupancy.
- Upper room UV-C is a technology that should be considered in higher risk areas. This technology is implemented by installing UV lights in the upper levels within a room. At least one foot of headspace is needed to provide an adequate zone of exposure for this technology. These lights operate when the building is occupied and provide a continuous means to inactivate a virus that is carried within the room air currents into this zone of exposure. These lights are harmful to humans when direct exposure of the light makes contact with skin or the eyes. Upper room UV-C lighting should be mounted high enough to provide a safe height considering occupant safety within the room. Consideration should be given to the materials of construction within this zone of exposure and the contents within the room, as UV light can rapidly degrade and discolor many materials.
- There are exciting emerging technologies (bi-polar ionization, photo-catalytic oxidation, Far-UV, etc.) which have shown promise. It should be noted that substantial third-party peer reviewed evidence as reported by ASHRAE and the CDC is not available for some of these technologies. In addition to the claimed benefits, it is important to consider the long-term operating costs and the potential negative or unintended effects when considering implementation of these strategies. Continuous monitoring to determine both the positive benefits as well as the negative effects is recommended should these technologies be implemented.
- Ensure exhaust fans in bathroom are in good operating condition and that the exhaust flow rate is as high as possible without impacting adjacent spaces. Toilet lids could be used to limit the spread of the airborne virus during flushing.
- Increase “contactless” technology to restrooms and sanitary devices, such as faucets, flush valves, towel dispensers, sanitary napkin dispensers, soap dispensers, and doors. Set metering faucets so that occupants can wash hands for recommended twenty seconds.
- Increase frequency of cleaning and disinfection of surfaces within kitchens, breakrooms, restrooms, conference rooms, and other public spaces.

Each of these building system recommendations can help reduce the risk of exposure of the SARS-CoV-2 virus to occupants within indoor spaces. The specific risks associated for a given space or building will dictate the appropriate recommendations that should be considered for implementation.

Our team of experts understand that there is no single “quick-fix” solution for all building types and systems. We are available to help you navigate through developing complexities to find the optimal solution for your building.

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