Mitigating Airborne Infection Transmission in HVAC Systems

By Robert F. Goodfellow

There is a lot of practical advice available to help minimize the chance of spreading SARS-CoV-2 (the virus that causes COVID-19). Infection control is about reducing risk, not the elimination of possibility. A broad systems approach, with purposeful redundancy, is required. HVAC systems represent just one part of the equation.

According to Erin Bromage, Ph.D., Associate Professor of Biology at the University of Massachusetts Dartmouth, infection requires an infectious dose of the virus. An infectious dose is the product of concentration and time. Some experts estimate that inhaling 1,000 infectious virus particles is enough to allow a virus to take hold. As a frame of reference, studies based on influenza suggest that normal breathing (at rest) releases about 20 viral particles/minute. Speaking increases respiratory droplet production to about 200/minute. So, a direct, face-to-face conversation could infect another person within about five minutes, in the unlikely event that the recipient inhales all the particles exhaled by an infected person.

The SARS-CoV-2 virus itself is relatively small, in the ~0.1155-micron range. When it is coughed, sneezed, or exhaled, it becomes part of larger 0.6 to 10+ micron droplet nuclei. The larger of these droplets will fall to the ground quickly, which is why there is a focus on social distancing. However, when aerosolized, smaller droplets can remain suspended, and can make their way into HVAC systems. According to the American Society of Heating, Air Conditioning and Refrigerating Engineers (ASHRAE), transmission of SARS-CoV-2 through the air is sufficiently likely that

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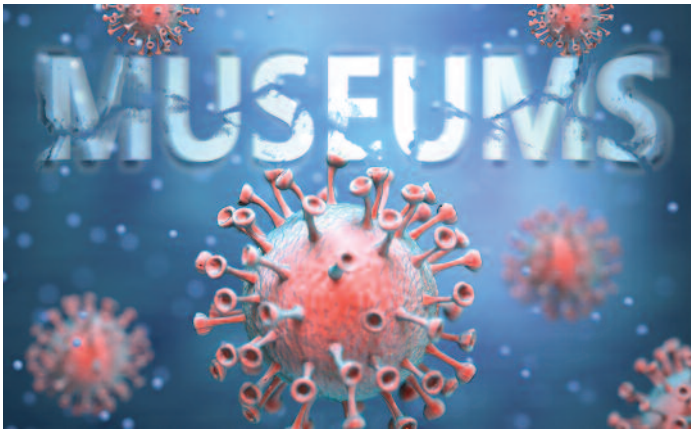

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heating, ventilating, and air-conditioning systems should be controlled to reduce airborne exposure to the virus.

There are many different types of HVAC systems used in museums and galleries, so it is necessary to adapt guidelines to specific cases. General guidelines in relation to HVAC systems include the following.

1. Inspection and Maintenance

Assessing the condition of systems that have not been running, and making any necessary repairs before starting up systems.

2. Ventilation

Increasing outside air to dilute indoor contaminants is a first line of defense. For every cubic foot of fresh air that comes in, a cubic foot of potentially contaminated indoor air is expelled as exhaust. It should be noted that this approach is likely to increase utility costs when it is necessary to heat or cool incoming ventilation air.

3. Air Filtration—Central HVAC

Given how the coronavirus transmits from person to person in its aerosolized form, improved air filtration can reduce the risk of transmission by reducing the concentration of infectious particles in the air. However, because improved air filtration in HVAC systems will not address the short-distance spread of large droplets, it cannot be considered as a standalone solution to the control of airborne infections.

ASHRAE recommends MERV-13-rated filters if this would not adversely affect system operation. MERV, otherwise known as Minimum Efficiency Reporting Value, is a system used to evaluate the efficiency of an air filter, based on how effective it is at catching particles of varying sizes. The higher the MERV rating, the higher the air filtration capabilities of a particular filter.

Generally, the larger the HVAC system, the more feasible it will be to upgrade to MERV-13 air filtration. Some systems will not accommodate MERV-13 or better filters, either because of space within the system (e.g., ductless, mini-split systems), or because of system design. Older systems that were installed without high-efficiency air filtration may lack sufficient fan horsepower to push air through denser filter media and/or long duct runs.

An upgrade to high-efficiency filters may have other effects on the HVAC system. For example:

- Traditional high-efficiency filters have higher pressure drops than the standard filters they replace. Higher pressure drops mean reduced airflow, which reduces heating/cooling capacity.
- Increasing fan speed to overcome the increased pressure drop and maintain original airflow will increase motor load, so it is important to ensure that fan motors will not be overloaded.
- Traditional high-efficiency filters may need to be changed more frequently, which could become costly.

Even if filters are not upgraded to a minimum of MERV-13, consider upgrading filters to the highest MERV filter that will not compromise HVAC system performance. Further, it is very important that care be taken to seal any gaps or leaks that might allow air to bypass filters.

4. Portable Air Cleaners

Where MERV-13 filters cannot be used, including situations where there is no mechanical ventilation of a space, consider portable HEPA air cleaners for occupied spaces. HEPA stands for High Efficiency Particulate Air, and HEPA filters range from MERV-17 to MERV-20. A portable HEPA air cleaner has a fan to pull air through the unit, a pre-filter, and a final (HEPA) filter. A recent report from the Harvard School for Public Health recommends a minimum of 100 CFM (cubic feet of air per minute) for every 250 square feet of occupied space. A room with 1,000 square feet would thus require a minimum of 400 CFM.

5. UVC and Air Cleaning

Air cleaners such as germicidal ultraviolet light systems may also be considered to supplement ventilation and air filtration. UVC dosage is based on dwell time, proximity, and light intensity. Supplying a lethal dose instantly as droplet nuclei are expelled is not possible, and supplying the necessary dose in the fast-moving airstream of a duct is difficult and has many variables.

Although duct-mounted UVC systems can be quite effective at significant inactivation and reducing contaminant levels, this does not mean that all viruses in a space will be inactivated. UVC systems mounted in ductwork or HVAC systems should be used in conjunction with effective air filtration to ensure that inactivated pathogens are removed by the air filters. UVC systems do not impose a pressure-

For facilities with larger HVAC systems, where there is adequate space for air filtration, polarized-media air cleaners such as this one offer MERV-15 performance without increasing static pressure.

Product focused:

Remote-mount germicidal UVC lamps such as this can be installed inside HVAC systems, or inside ductwork, to supplement air filtration and reduce airborne contaminant levels.

drop burden on the HVAC system. UVC lamps are usually replaced every year or every two years, depending on the type of lamps used.

6. Bipolar Ionization

Bipolar ionization breaks air down into positive and negative ions. The ions diffuse through the space, and either react with or attach to particles. Reactions break down organic compounds to remove odors. Attaching to particles causes them to agglomerate into larger particles that fall to the floor, or are more readily filtered. As with UVC systems, ionization systems should be used in conjunction with effective air filtration to ensure that inactivated pathogens are removed by the filters.

The following information should be evaluated when considering bipolar ionization:

- There are no industry standards or test protocols for bipolar ionization systems, so performance is not verified. There is some track record for reducing odors and destroying volatile organic compounds (VOCs), but solid data on killing viruses is scarce.
- Technologies and equipment should be carefully evaluated to ensure proper safety for systems and occupants. Some ionization systems produce ozone as a by-product. Ozone is a disinfectant, but it is also an irritant. Ozone attacks rubber, and could lead to the deterioration of belts and gaskets in HVAC systems.

7. Humidity

Scientific evidence generally reflects the most unfavorable survival for microorganisms when relative humidity is between 40% and 60%. This is also usually the most comfortable level for building occupants.

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Once again, infection control is about reduction of risk, not elimination of possibility. For additional information on mitigating infection transmission in HVAC systems, visit the COVID-19 resource pages at www.ashrae.org.

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