

Preparing HVAC Systems Before Reoccupying A Building

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As states across the U.S. roll out new phases of reopening and ease social distancing restrictions instituted to “flatten the curve” of infection from SARS-CoV-2 (the virus that causes COVID-19), commercial building owners and facility managers are seeking direction in preparing their spaces to a return to near-normal levels of occupancy. World Health Organization (WHO) and Centers for Disease Control and Prevention (CDC) recommendations have focused on “de-densifying” spaces and disinfection of surfaces, while the ASHRAE Epidemic Task Force’s comprehensive Building Readiness guidance addresses strategies for preparing HVAC systems for buildings reopening after COVID-19 closures.¹ Still, facility engineers have been wondering whether disinfecting their facility’s HVAC system is a further protective step to take to prepare for reopening—and about what else they should do.

While no blanket answer exists to fit every scenario and every building type, the current science² indicates that, in general, disinfection of mechanical systems is not likely to be necessary. However, that doesn’t mean there isn’t work to be done—or risks to address before reopening or expanding the number of occupants in the space. To prepare buildings for a return to full occupancy, there are a number of steps to take with HVAC systems that have been operating at significantly

reduced loads or turned off as an energy-saving measure.

How SARS-CoV-2 Transmission Impacts Disinfection Recommendations

To understand why HVAC system disinfection may not be necessary to safely reopen or increase occupancy of your facility, it’s best to start with a clear understanding of the biological distinctions around the viral threat in question. Building owners and managers seeking to

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make sense of this virus may fall back upon training for handling familiar risks, including mold or *Legionella*, but significant differences exist between these threats that should drive an entirely different response. First, understand that SARS-CoV-2, like all viruses, is not a living organism. Viruses are a combination of nucleic acid (RNA or DNA) and other “chemicals” that take over the cellular machinery of a living host and use that machinery to replicate themselves. This replication is entirely dependent upon having a living host to support them. This means that viruses cannot replicate and proliferate on any inanimate surface in the environment, including the surfaces within an HVAC system.

It has long been recognized that respiratory viruses can be transmitted via droplets that are generated by coughing or sneezing.³ Further, this virus relies on a protective envelope of mucous in the respiratory droplets to aid it in achieving “primary host” to “secondary host” transmission. Upon initial expulsion into the general environment via a cough or a sneeze, most of these droplets are in the size range of 30 µm to 100 µm in diameter and will start to settle out of the air quite rapidly and deposit on nearby surfaces.⁴

However, as noted in a recent study in *Environment International*,⁵ “immediately after droplets are expired, the liquid content starts to evaporate, and some droplets become so small that transport by air current affects them more than gravitation. Such small droplets are free to travel in the air and carry their viral content meters and tens of meters from where they originated.”

Although the number of these aerosol particles may be relatively small compared to the number released from the original “cloud,” and the fraction that contains active viruses may be even smaller, effective ventilation systems will be important in minimizing potential infections. As stated in the newly released “ASHRAE Position Document on Infectious Aerosols,”⁶ “the risk of pathogen spread, and therefore the number of people exposed, can be affected both positively and negatively by the air-flow patterns in a space and by [HVAC] and local exhaust ventilation (LEV) systems.”

Unlike a virus, mold is a living organism capable of self-replication upon environmental surfaces. This means that mold can multiply itself and colonize on HVAC system surfaces under the right conditions. Similarly, *Legionella* is a living bacterium capable of colonizing suitable environments and replicating on its own

without the assistance of a host. Although disinfectants can be used to kill these living organisms as well as viral particles, viruses will lose the ability to cause infection on their own without a living host.

Science on Transmission

The science is continuing to evolve on the understanding of the long-term viability and risk of the SARS-CoV-2 virus on surfaces. Two preliminary studies on this topic have indicated that the amount of time before the SARS-CoV-2 virus degrades depends upon the surface to which it attaches. A recent study showed that after inoculation on stainless steel, the concentration of SARS-CoV-2 was reduced by 50% after 1.8 days and by 90% after 5.96 days.⁷ A second study, published in a letter in *The Lancet Microbe*,⁸ found no traces of infectious virus on stainless steel surfaces at seven days (half-life of 14.7 hours).

Based on this current science of the virus’ infectivity, the CDC has recommended⁹ that no disinfection beyond normal cleaning is required on surfaces within buildings that have had no occupants for seven days. Within days, if not hours, of landing on a typical surface, the SARS-CoV-2 virus begins to degrade and significantly reduce its viral load. This is one instance where time can be a useful disinfectant.

The current science¹⁰ also indicates that infectious doses of the SARS-CoV-2 virus don’t appear to travel long distances through the air. While there is not yet a complete picture around the virus’ behavior, early research¹¹ indicates this virus does not present a far-field aerosol transmission problem. However, the guidance from authoritative sources can sometimes appear to be inconclusive. That is primarily due to the different risk potential that can be encountered in various environments. For example, the WHO says, “in these events, short-range aerosol transmission, particularly in specific indoor locations, such as crowded and inadequately vented spaces over a prolonged period of time with infected persons, cannot be ruled out.”¹¹ However, in its guidance for health care the WHO states, “COVID-19 appears to spread most easily through close contact with an infected person. When someone who has COVID-19 coughs or sneezes, small droplets are released and, if you are too close, you can breathe in the virus.”¹²

CDC recommends modified airborne, in addition to standard (contact) and droplet precautions, for the care

of COVID-19 suspected or confirmed patients, especially when aerosol generating procedures (e.g., intubation) are performed.¹³ For the general public, however, the CDC describes SARS-CoV-2 transmission as primarily by droplets from coughs or sneezes, which “land in the mouths or noses of people who are nearby or possibly inhaled into the lungs.”¹⁴

Because of this, facilities beginning to reopen aren't likely to need a heavy investment in air cleaning technologies for central air-handling units, beyond ensuring filters are rated at MERV 13 or above. The most necessary investment may simply be a strategy for maximizing the amount of outdoor air within the capacity of the air-handling unit.¹⁵

The growing science¹⁶ around far-field aerosol transmission essentially negates the need for in-duct or air system control technologies such as UV lights. While these products and services may serve a useful function, in most applications, they may not meet the specific need that's called for in mitigating the hazards of SARS-CoV-2.

Of course, specialized applications may exist where added levels of in-space or in-room protection may be useful, most notably in health-care and long-term or senior-care facilities. For example, portable HEPA units are very effective in filtering airborne pathogens from the air before recirculating essentially particle-free air back into areas in which they are used.¹⁷ Properly sized and mounted portable HEPA units can also be used to establish directional flows in various settings ranging from temporary surge rooms in health-care facilities to nurses' rooms in school buildings.

In this type of application, potentially contaminated air can be extracted from an inner, physically isolated zone by the HEPA filtration system, where it is cleaned of pathogens and then discharged into an adjacent outer zone. This type of application not only cleans the air but helps maintain a negative pressure relationship to the inner, potentially infectious zone relative to adjacent areas.¹⁸

Exceptions to Air Cleaning Recommendations

Despite the broad recommendation that supplementary air treatment isn't required, certain circumstances may exist in which some level of HVAC disinfection is warranted. Generally speaking, this will involve specialized locations that could be considered higher-risk

areas. These could be specific areas of health-care facilities, such as ER waiting rooms, treatment facilities where there is a risk of aerosol production or ICUs;¹⁹ elderly care facilities; or transportation terminals for airlines, buses or trains.²⁰

In addition, some areas in commercial buildings could require greater effective air exchange rates via air cleaning technologies, such as upper room UV or localized higher-efficiency filtration. These include areas that see high densities of people or where increases in outdoor air cannot be achieved for increased air dilution.

The Real Challenge of Reopening

Does this mean that building engineers can rest easy knowing there's no action to take to protect building workers? Not exactly. However, the risk that comes with reopening may not be where most building owners are focusing. (See Reference 1, the ASHRAE Epidemic Task Force's “Building Readiness” guide, for additional guidance on reopening.)

Many office, retail and institutional buildings looking to reopen have operated at low or nearly no HVAC load for several months. As these buildings come back online, many are increasing the amount of outdoor air coming in, or they are returning to full operation to condition air for what may be a fraction of typical building occupancy levels. These dramatic shifts can lead to significant maintenance issues and operational concerns.

HVAC systems haven't been truly challenged in months. Bringing these systems online and expecting them to perform as they did on the building's last day of normal occupancy is a big demand. For buildings reopening today, it's best to address HVAC systems as if this were the first day of operation, following ASHRAE/ACCA Standard 180-2018, *Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems*.

If maintenance challenges aren't enough to convince building owners to reevaluate the mechanical systems in their building, they also need to consider that system control sensors may have failed or gotten out of calibration. The remedy for this condition is to go through a retro-commissioning process to make sure that all systems are running as intended and to check, repair and adjust as necessary all control sensors. See ASHRAE Guideline 1.2-2019, *Technical Requirements for the Commissioning Process for Existing HVAC&R Systems and Assemblies*,²¹ for guidance.

Completing this step will allow a building owner to get ahead of these potential problems. If a retro-commissioning program is not followed, there is a risk that occupants may find the building a bit stuffy or humid—and rapidly attribute that feeling of discomfort to an “unhealthy building.”

While the issues of ramping up operation, occupant comfort and building health may be separate, they’re easily blended in a situation like the one building occupants will be facing. Ample evidence exists that poor HVAC performance can negatively impact indoor air quality and result in the building being labeled a “sick building.” If systems are not optimized for comfort and health, a “sick building” can lead to a partial or even a full closure. Buildings still fine-tuning HVAC operation to meet today’s varying occupancy demands face this same risk. As a result, verifying that HVAC systems are functioning as intended becomes an important part of the overall strategy of assuring building occupants of an as safe as possible return to work.

Inspection and testing could also verify whether a real risk of infection exists beyond SARS-CoV-2. As long-empty buildings’ water systems come back online, building occupants face a far greater risk of adverse impacts from mold spores or infection from *Legionella* bacterium than they do from SARS-CoV-2.²² Both mold and *Legionella* are living, viable organisms found in damp areas (in the case of mold) or water supplies (for *Legionella*). The CDC notes²² that each of these organisms may remain viable for weeks or months, depending upon building- and plumbing-specific factors, including water heater temperature setpoints, water use patterns, disinfectant residuals and preexisting *Legionella* colonization.

Humidification systems, cooling towers and other HVAC equipment tied into water systems that have not been appropriately treated could generate infectious droplets that are respirable in size. (See ANSI/ASHRAE Standard 188-2018, *Legionellosis: Risk Management for Building Water Systems*,²³ for guidance.) Those droplets can be drawn into the mechanical systems and increase exposure risks.

Taking Steps to Return to Normal

A thoughtful, methodical approach to preparing buildings for re-occupancy can minimize the risks noted above. Now is the time to qualify the quality of the

indoor environment through a targeted inspection and testing program to ensure a “clean bill of health” prior to re-occupancy, and to document that the facility is meeting the appropriate standard of care. (See Reference 1 for additional guidance.) This will help ensure a safe and healthful environment for occupants and minimize legal and reputational risk for building owners and managers.

You might think of this check as your “preflight checklist.” Before any flight takes off, the flight crew will work through their checklist to make sure all components are operational before they actually back away from the gate and move to the runway. To assure building occupants that the physical work environment is as safe as possible, it will be critical to likewise run through a performance checklist that verifies that all building components are functional, operating appropriately and meeting performance requirements before reopening the building.

Now is the time to look at building systems in a more comprehensive way. Too often building operators focus on problems in isolation, such as shutting down dampers in one area to move more air to another trouble spot. Before long, the entire system has fallen out of calibration of ventilation air (flow rates, diffuser velocities) and related hydronics from the original design intent. Depending on the complexity of a building’s HVAC system, a verification process, including commissioning or recommissioning, may be necessary to ramp up the system and ensure it is performing to as-designed performance or to the conditions necessary for the new occupancy demands.

In addition, building managers should carefully examine each of the recommendations being offered currently to increase the amount of outdoor air being brought into the building. Some suggestions include limiting recirculated air by going to 100% outdoor air or, if that’s not possible, to increase air filtration with a higher quality filter.²⁴ The truth is, these adjustments can drive tremendous thermal imbalances as zones are turned on and off to reflect local occupancy density, as well as provide major challenges in appropriately conditioning the air. Although general guidance recommends staying within system capacity, adjustments made to reflect changing occupancy may disturb the air balance of the system. In those cases, a better solution may be to increase the efficiency of ventilation air, especially when system limitations will not allow increasing the amount

of outdoor air during high demand seasons.

In many ways the ventilation system acts as the primary engineering control for diluting viral particulates, helping to reduce overall concentration in a space. You want to have it effectively deal with the source. However, zone dampers should not be used to reduce the amount of air that’s being supplied to a space due to lower occupancy, as those lower levels of air circulation may not be able to effectively dilute particulates within the occupied zone. See Reference 1 for additional guidance. In those cases, the judicious use and proper sizing of localized HEPA filters could be a useful adjunct to increase the circulation of clean, essentially particle free air and to increase the localized effective air exchange rate within those spaces.

While the specifics of the performance checklist may vary across building types and sizes and the types of HVAC systems serving them, some general steps exist that all facilities engineers may want to consider (*Table 1*).

The length of time needed to perform this work will vary across building types and sizes and will also depend on the size of the staff managing it. In general, plan for two to three weeks of ongoing adjustments if you are doing it in-house. This gives facilities engineers time to fine-tune systems, order and install replacement parts and perform a systematic check of all systems.

Become Part of the Safety Conversation

HVAC system disinfection may not be necessary to reduce the spread of SARS-CoV-2, but that doesn’t leave building engineers in the clear. Now is the time to perform any deferred or near-due HVAC maintenance to ensure this system is working effectively. Keeping building occupants comfortable and safe will come down to solid equipment maintenance practices and a clear understanding of how your facility’s ventilation systems are meant to function.

It is also the time to talk with building owners about how critical HVAC performance is to ensuring a healthy building. Although dramatic decreases in COVID-19 infections occurred during the spring and summer of 2020, many areas are seeing another surge as they enter the cooler seasons of the year²⁵ and the use of outdoor air for increasing ventilation is being curtailed. Clearly, safe, effectively functioning buildings will play a critical role in mitigating ongoing risks. This makes it more important than ever that facilities managers

TABLE 1 HVAC system inspection.

UNIT	TASK	
AIR-HANDLING UNIT	Inspect All Components Within the Unit, Including Filters and Air Bypass Heating and Cooling Coils Condensate Pans Condensate Drain Lines Humidification Systems	Acoustic Insulation Fans and Fan Compartments Dampers Energy Recovery Devices General Unit Integrity
SUPPLY AIR	Air Duct Integrity Controls	Mixing/ Control Boxes Reheat Coils
RETURN AIR	Dampers Return Plenums	Grilles
EXHAUST AIR	General Exhaust Bathroom Exhaust	Heat Recovery Exhaust (If Present)

See the ASHRAE Epidemic Task Force “Building Readiness” guide’s preoccupancy checklist, preoccupancy building readiness assessment and school and university HVAC inspection checklist for additional guidance.

and building engineers become part of the discussion and decision-making process around keeping interior spaces safe. Coupling a thorough understanding of the science behind SARS-CoV-2 and other virus transmission with knowledge of building system performance makes building professionals’ voices a particularly critical part of the conversation around safety today and in the future.

References

- ASHRAE Epidemic Task Force. 2020. “Building Readiness.” ASHRAE. <https://tinyurl.com/y5r92ohs>
- ECDC. 2020. “Heating, Ventilation and Air-Conditioning Systems in the Context of COVID-19.” European Centre for Disease Prevention and Control.
- Wells, W.F. 1934. “On air-borne infection—Study II droplets and droplet nuclei.” *Am. J. Hyg.* 20(3):611–618.
- Gralton, J., E. Tovey, M.L. McLaws, W.D. Rawlinson. 2011. “The role of particle size in aerosolised pathogen transmission: a review.” *The Journal of infection* 62(1):1–13. <https://doi.org/10.1016/j.jinf.2010.11.010>
- Morawska, L., J. Cao. 2020. “Airborne transmission of SARS-CoV-2: The world should face the reality.” *Environment International* 139(June):105730.
- ASHRAE. 2020. “ASHRAE Position Document on Infectious Aerosols.” ASHRAE. <https://tinyurl.com/y8meg96z>
- Riddell, S., S. Goldie, A. Hill, et al. 2020. “The effect of temperature on persistence of SARS-CoV-2 on common surfaces.” *Virology* 17(145). <https://doi.org/10.1186/s12985-020-01418-7>
- Chin, A.W.H., J.T.S. Chu, M.R.A. Perera, K.P.Y. Hui, et al. 2020. “Stability of SARS-CoV-2 in different environmental conditions.” *The Lancet Microbe* 1(1):e10. [https://doi.org/10.1016/S2666-5247\(20\)30003-3](https://doi.org/10.1016/S2666-5247(20)30003-3)
- CDC. 2020. “Reopening Guidance for Cleaning and Disinfecting Public Spaces, Workplaces, Businesses, Schools, and Homes.” Centers for Disease Control and Prevention.

<https://tinyurl.com/yaxeuvay>

10. CDC. 2020. "Scientific Brief: SARS-CoV-2 and Potential Airborne Transmission." Centers for Disease Control and Prevention.
11. WHO. 2020. "Transmission of SARS-CoV-2: Implications for Infection Prevention Precautions." World Health Organization. <https://tinyurl.com/y7hkuanl>
12. WHO. 2020. "COVID-19 Risk Communication Package for Healthcare Facilities." World Health Organization. <https://tinyurl.com/y4tl2rne>
13. CDC. 2020. "Interim Infection Prevention and Control Recommendations for Healthcare Personnel During the Coronavirus Disease Pandemic." Centers for Disease Control and Prevention <https://tinyurl.com/y8uypybh>
14. CDC. 2020. "How COVID-19 Spreads." Centers for Disease Control and Prevention. <https://tinyurl.com/we6oo8z>
15. Environmental and Modeling Group (EMG). 2020. "Role of Ventilation in Controlling SARS-CoV-2 Transmission." From the Scientific Advisory Group for Emergencies, Gov.UK. <https://tinyurl.com/yylbvtc>
16. Chirico, F, A. Sacco, N.L. Bragazzi, N. Magnavita. 2020. "Can air-conditioning systems contribute to the spread of SARS/MERS/COVID-19 Infection? Insights from a rapid review of the literature." *Int J Environ Res Public Health* 17(17):6052. <https://doi.org/10.3390/ijerph17176052>
17. Sehulster, L.M., R.Y.W. Chinn, M.J. Arduino, J. Carpenter, et al. 2003. "Guidelines for Environmental Infection Control in Health-Care Facilities." Recommendations from CDC and the Healthcare

Infection Control Practices Advisory Committee (HICPAC). Updated July 2019, Section C. <https://tinyurl.com/yauurla7>

18. NIOSH. 2020. "Engineering Controls to Reduce Airborne, Droplet and Contact Exposures During Epidemic/Pandemic Response. Expedient Patient Isolation Rooms." National Institute of Occupational Safety and Health. <https://tinyurl.com/yxeky4xh>
19. Santarpia, J.L., D.N. Rivera, V.L. Herrera, et al. 2020. "Aerosol and surface contamination of SARS-CoV-2 observed in quarantine and isolation care." *Scientific Reports* (10):12732. <https://doi.org/10.1038/s41598-020-69286-3>
20. Tellier, R., Y. Li, B.J. Cowling, et al. 2019. "Recognition of aerosol transmission of infectious agents: a commentary." *BMC Infectious Diseases* (19):101. <https://doi.org/10.1186/s12879-019-3707-y>
21. ASHRAE Guideline 1.2-2019, *Technical Requirements for the Commissioning Process for Existing HVAC&R Systems and Assemblies*.
22. CDC. 2020. "Guidance for Reopening Buildings After Prolonged Shutdown or Reduced Operation." Centers for Disease Control and Prevention. <https://tinyurl.com/y88kr2wv>
23. ANSI/ASHRAE Standard 188-2018, *Legionellosis: Risk Management for Building Water Systems*.
24. Morawska, L., J.W. Tang, W. Bahnfleth, P.M. Bluyssen, et al. 2020. "How can airborne transmission of COVID-19 indoors be minimised?" *Environment International* 142(September):105832. <https://tinyurl.com/y7jq8ge6>
25. CDC. 2020. "COVID Data Tracker." Centers for Disease Control and Prevention. <https://tinyurl.com/y4pdydwg> ■



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