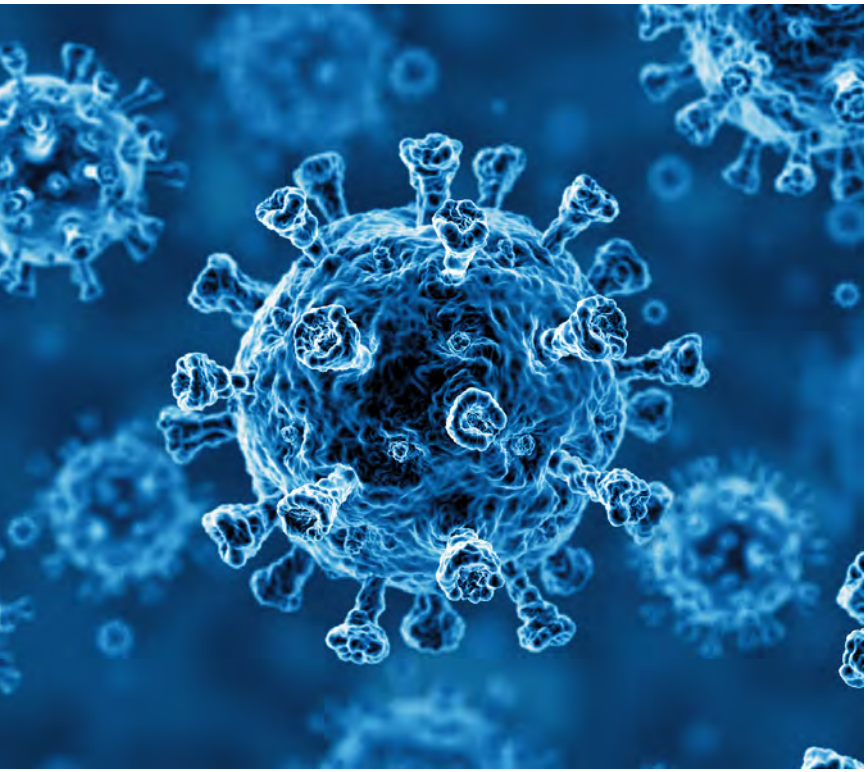
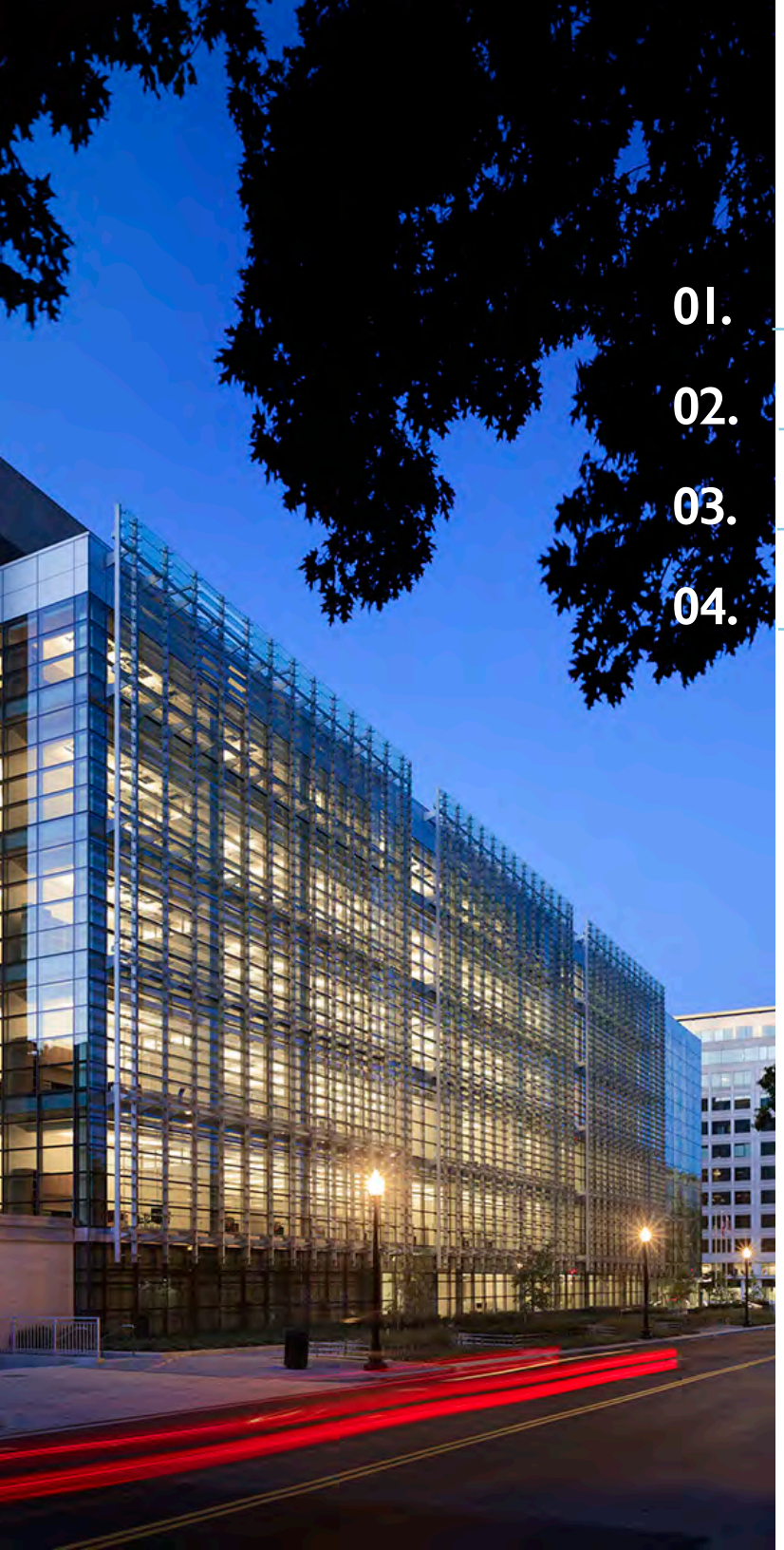
An Ounce of Prevention II



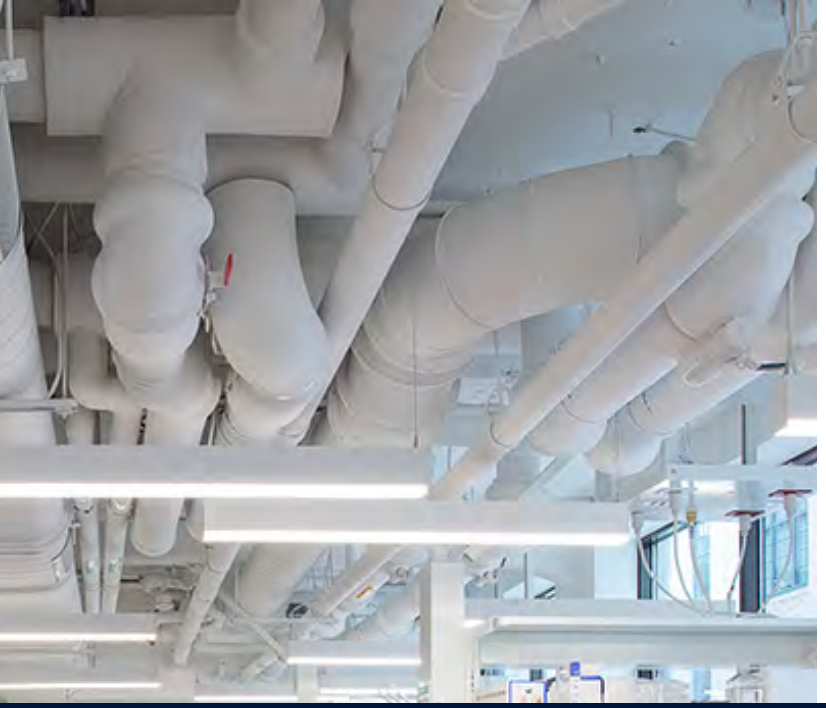
Steps You Can Take to Reduce the Potential for Spread of SARS COVID-19 at Your Facility

July 2020

VANDERWEIL



Contents



Recommendations

Reducing the Spread of SARS COVID-19

INTRODUCTION

As the world works through the effects of the global SARS COVID-19 pandemic via social distancing, many commercial building managers and facility operations executives are beginning to discuss moving towards recovery with a specific goal to reduce the potential risks for spreading the disease once businesses re-open. Unfortunately, as has been well documented, there is no "silver bullet" that will eliminate all potential risk. This paper is intended to help guide building owners and operators through the various solutions being publicized with a focus towards HVAC system design and operations so that, based on client risk assessment, options that best fit both immediate and long-term needs can be implemented as quickly and effectively as possible.

While there are volumes of information being published and made available online at this time, much of the data has not been extensively reviewed or validated through independent long-term studies. Most of the recommendations presented here are therefore based solely on the opinions of nationally and internationally recognized bodies such and the Center for Disease Control and Prevention (CDC), the World Health Organization (WHO), the American Society of Heating Refrigerating and Air Conditioning Engineers (ASHRAE) and the Federation of European Heating, Ventilation and Air Conditioning Associations (REHVA) rather than individual independent studies or data produced by product vendors.

Discussion with Building Owners should clearly focus on the prioritization of the below "General Operating Guidelines" before considering more-costly infrastructure changes. As noted in the March 24, 2020 ASHRAE Journal Newsletter article titled Guidance for Building Operations During the COVID-19 Pandemic:

"SARS infected people over long distances in 2003. SARS-CoV-2 has been detected as an aerosol in hospitals, and there is evidence that at least some strains of it remain suspended and infectious for 3 hours, suggesting the possibility of aerosol transmission. However, other mechanisms of virus dissemination are likely to be more significant, namely:

- Direct person to person contact
- Indirect contact through inanimate objects like doorknobs

- Through the hands to mucous membranes such as those in the nose, mouth and eyes
- Droplets and possibly particles spread between people in close proximity

For this reason, basic principles of social distancing (1 to 2 m or 3 to 6.5 ft), surface cleaning and disinfection, handwashing and other strategies of good hygiene are far more important than anything related to the HVAC system."

While these general operating guidelines are most effective, ASHRAE does acknowledge "Transmission of SARS-CoV-2 (COVID-19) through the air is sufficiently likely that airborne exposure to the virus should be controlled."

GENERAL OPERATIONAL GUIDELINES

As noted, the primary methods for controlling the spread of SARS COVID-19 are social distancing, surface decontamination and personal hygiene. The WHO has identified the following facility operations items that must be addressed first and foremost:

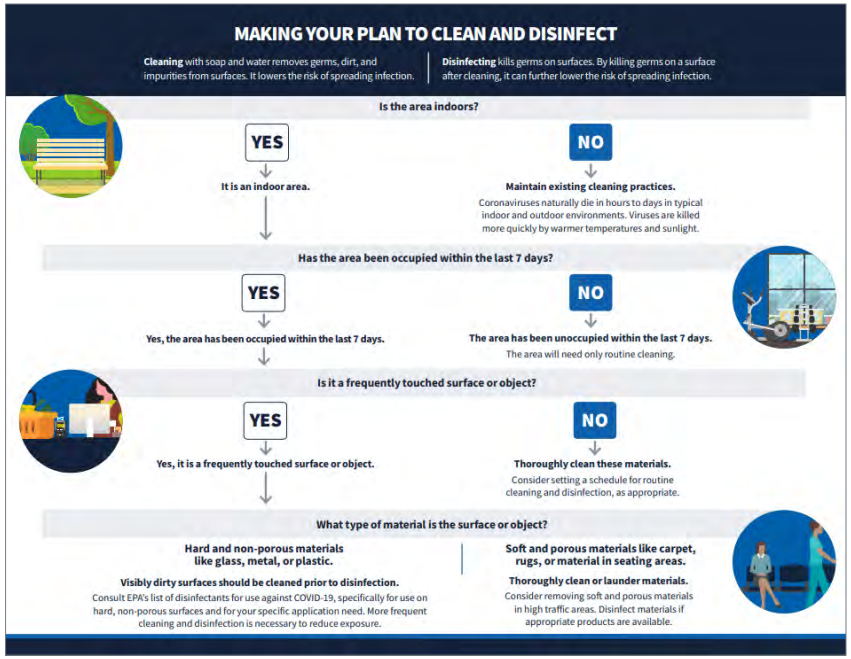
- Ensure workplaces are clean and hygienic by regularly wiping surfaces (desks and tables) and objects (telephones, tablets, keyboards and computer mice) with disinfectants. Updated information from the CDC indicates that touching surfaces may not be the main way virus spreads but still recommends routine cleaning and disinfection of touched surfaces.
- Promote regular hand washing by employees, contractors and all visitors to the facility.
- Promote good respiratory hygiene like covering mouths and nose when sneezing and coughing or using face masks. The facility should consider including closed bins for disposal of potentially contaminated face masks or gloves.
- Promote compliance with national travel advisories before traveling on company business.
- Clearly enforce restrictions on employee and visitors entering the building. This includes potentially limiting number of people that can attend in person to allow physical separation (distancing).
- Prepare a plan to isolate a person who becomes ill (dry cough, fever or malaise). Also consider maintaining details of date, time and participants for a minimum of (1) month and notify all participants should one person be suspected of having COVID-19.

Additional WHO information can be found at:

https://www.who.int/docs/default-source/coronaviruse/getting-workplace-ready-for-covid-19.pdf

Other items that can easily be implemented include:

- Provision of additional hand sanitation dispensers.
- Consider shutting down break rooms that include food preparation. This includes coffee stations that have microwave ovens.



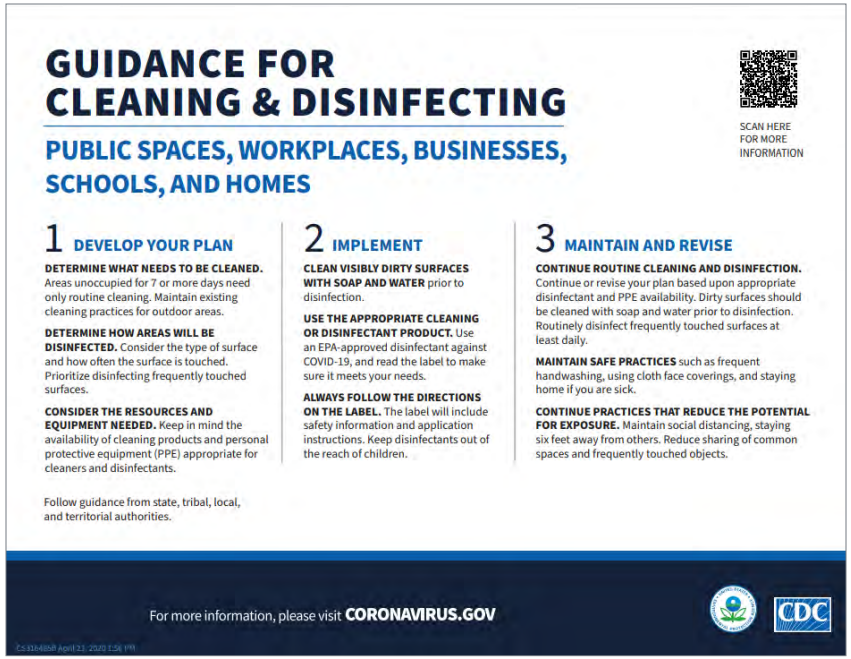
- Encourage staff to bring water from home rather than using shared water fountains or bottle filling stations and sinks.

In addition to the above procedures, there is also a significant push for owners to consider thermal imaging as part of facility entry protocols. These devices, when properly installed and calibrated, are intended to notify security or reception staff when a person has a fever. With the current pandemic response focused on health safety there is significant misinformation circulating on the use of such devices as well as those attempting to profit from this pandemic. Where thermal imaging is to be considered the accuracy of the thermal imaging device, including the effects of the surrounding environment, will need to be considered.

Owners should be made aware there are only a few FDA-approved, temperature-sensing thermal cameras and software solutions available. These approved thermal camera temperature solutions are governed by ISO 13154 as medical instruments. This standard identifies the requirements for the application and guidelines for identifying fevers using a screening thermograph.

The FDA notes that other devices not covered by the FDA can be marketed and sold for other applications such as construction, implying that they may not provide measurable benefit for detecting fevers or COVID-19 infected individuals. Owners should be made aware that installation of FDA approved devices carry a high cost that can still have significant benefits in medical facilities but that non-regulated options may not provide a measurable benefit in commercial facilities.

For health care waiting rooms, consider implementation of access management plans that limit occupancy. Where this is unlikely mechanical system changes should be considered.

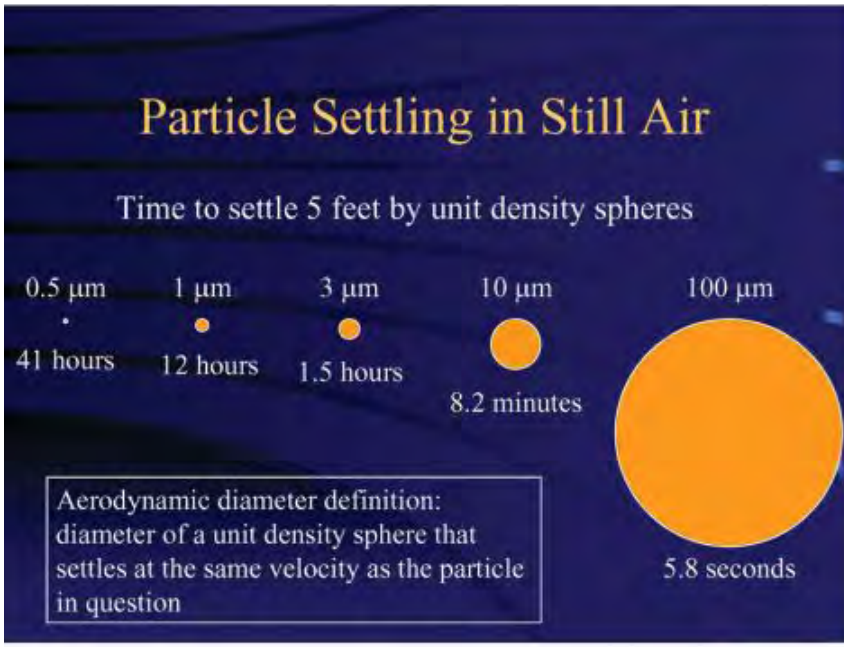


MECHANICAL SYSTEM DESIGN & OPERATIONS

For mechanical systems, ASHRAE issued the following statement on April 20, 2020 regarding HVAC system operation which serves as the basis for recommendations provided:

> "Transmission of SARS-CoV-2 (COVID-19) through the air is sufficiently likely that airborne exposure to the virus should be controlled. Changes to building operations, including the operation of heating, ventilating, and air-conditioning systems, can reduce airborne exposures.
>
> Ventilation and filtration provided by heating, ventilating, and air-conditioning systems can reduce the airborne concentration of SARS-CoV-2 and thus the risk of transmission through the air. Unconditioned spaces can cause thermal stress to people that may be directly life threatening and that may also lower resistance to infection. In general, disabling of heating, ventilating, and air-conditioning systems is not a recommended measure to reduce the transmission of the virus.
>
> HVAC filters, along with other strategies, help to reduce virus transmission while removing other air contaminants that may have health effects."

While HVAC systems may help in reducing exposure, owners should be made aware that ASHRAE goes on to indicate that "even the most robust HVAC system cannot control all airflows and completely prevent dissemination of an infectious aerosol or disease transmission by droplets or aerosols. An HVAC system's impact will depend on source location, strength of the source, distribution of the released aerosol, droplet size, air distribution, temperature, relative humidity, and filtration."



These limitations on effectiveness are likely based on the ability of HVAC systems to only address bioaerosols being generated and not in reducing the predominant cause of spread which is the heavier than air droplets that fall onto surfaces and people.

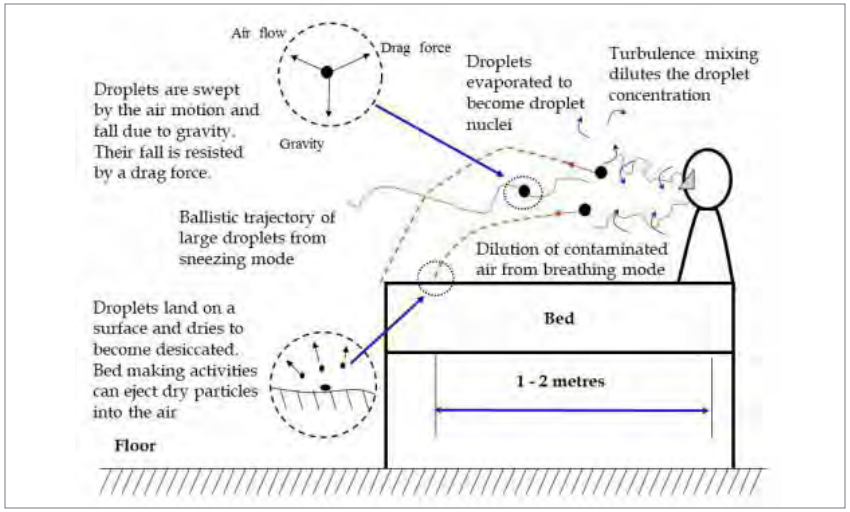
The National Research Council manual, Biosafety in the Laboratory: Prudent Practices for Handling and Disposal of Infectious Materials notes that "Infectious aerosols… do not settle quickly and can be dispersed widely through a ventilation system or otherwise carried long distances by air streams. In contrast, droplets (particles typically larger than 5 microns in diameter) remain airborne only for a short period of time and are non-respirable." ASHRAE acknowledges this in their position document on Infectious Aerosols by stating "General dilution ventilation and pressure differentials do not significantly influence short-range transmission."

Based on this information, proposed changes to HVAC operations suggested by ASHRAE will only address airborne exposures by reducing the spread of bioaerosols to spaces other than the space where the COVID-19 infectious aerosol is generated. Consistent with this understanding and based on our experience designing biological containment laboratories, air circulation through the room and exhausted will provide dilution after the generation stops but this circulation will provide little or no initial protection from exposure within the space. Protection in the space from droplets or even the aerosols is best provided by containment (face coverings) and not the HVAC system. Owners should keep this in mind when considering changes to the mechanical systems and operation.

With the above in mind, the ASHRAE Position Document on Infections Aerosols has identified the following HVAC strategies that have potential to reduce the risks of infectious aerosol dissemination:

Adjust Air Distribution Patterns: Recommended by ASHRAE "based on at least fair evidence."

- This option is typically used for design of patient rooms where dilution of room air around a known patient source is provided with removal of infectious agents through exhaust or HEPA filtration above the patient bed. ASHRAE notes "it remains unclear by how much infectious particle loads must be reduced to achieve a measurable reduction in disease transmissions (infectious doses vary widely among different pathogens) and whether these reductions warrant the associated costs."



Maintain Differential Room Pressurization: Recommended by ASHRAE "based on at least fair evidence."

- As with air distribution patterns, differential pressure is typically used, preferably with vestibules to contain known infected patients and would only apply in commercial buildings to isolate someone once exposure is established.

Enhance Filtration (central or local): Strongly recommended by ASHRAE "based on good evidence."

- Local filtration has typically been used for single room applications where recirculating HEPA filter units can be "highly effective in reducing/lowering concentrations of infectious aerosols in a single space". This assumes that the spaces where installed are anticipated to house infected people. Again, note that if used this will not address droplet exposure in direct vicinity of infected people.

- Central filtration of return air can assist in preventing spread through supply ducts but should be considered only if alternatives that protect the return duct system cannot be implemented.

Controlling Temperature and Relative Humidity: Recommended by ASHRAE "based on at least fair evidence."

- While there are many opinions regarding the potential for higher humidity levels or higher temperatures to reduce viability of COVID-19, both ASHRAE or REVHA note that study results are inconsistent and therefore do not make definitive recommendations on setpoints and suggest that projects should use studies to make decisions on a case-by-case basis.

- To make project specific decision we note that the below from the 2016 ASHRAE Systems and Equipment Handbook does indicates that maintaining humidity between 30% and 60% is the optimum range for indoor environment. Some of ASHRAE recommendations cite benefits of providing 40% RH minimum humidity levels.

Ultra Violet Germicidal Irradiation (UVGI): Strongly recommended by ASHRAE "based on good evidence."

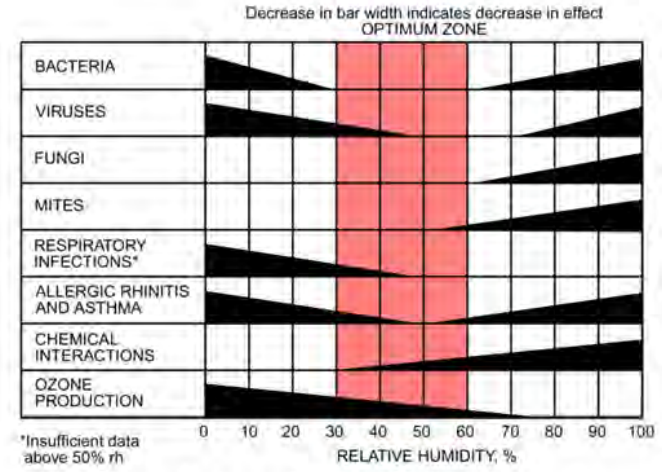


Fig. 1 Optimum Humidity Range for Human Comfort and Health
(Adapted from Sterling et al. 1985)

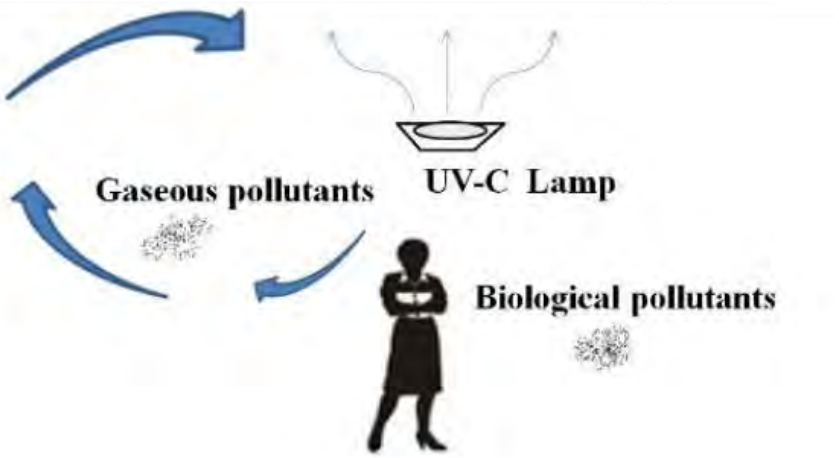
- While ASHRAE Position Document on Filtration and Air Cleaning (2018) does not make a recommendation for or against the use of UV energy in air systems for minimizing the risks from infectious aerosols, Centers for Disease Control and Prevention (CDC) has approved UVGI as an adjunct to filtration for reduction of tuberculosis risk and has published a guideline on its application (CDC 2005, 2009).

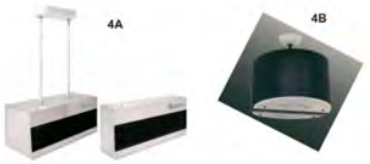
- Owners need to be made aware that while recommended by ASHRAE, there have been no specific tests of effectiveness on COVID-19 since as one owner of a UVGI manufacturer has stated publicly, there are no available COVID-19 samples (highly regulated) to be used by manufacturers for independent testing.

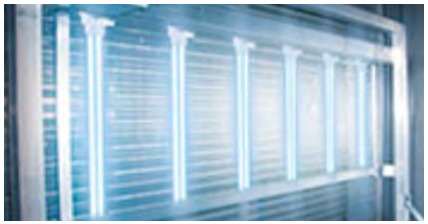
  Most data presented by vendors use surrogate bioaerosols (e.g. MS2) for testing, so effectiveness on COVID-19 is unknown.
- While direct exposure is of significant concern, the safe application of UV-C is well known but will require protocols to prevent exposure. While UV-C does not penetrate deeply into human tissue, it can penetrate the very outer surfaces of the eyes and skin, with the eyes being most susceptible to damage in as little as (3) seconds. Safety protocols, signage and shielding (for eye protection) are mandatory to prevent direct exposure.

o There are multiple ways to use UV-C Lighting

- In air handling systems to prevent growth on surfaces of coils and filters. Due to limited exposure time when passing through a duct system, typically these devices are more appropriate for surface decontamination. ASHRAE notes "These systems are generally not likely to eradicate virus in the airstream unless designed to deliver the necessary dose during the available exposure time. Such systems require a much higher UV output". A general guideline for sizing UV is to provide an intensity 5 times higher for air disinfection than coil/filter disinfection at 500 FPM air velocity.
- High in-room decontamination (tested for effectiveness against TB) which uses UV-C lighting aimed up towards the ceiling to decontaminate surfaces and some airborne agents.
- Portable UV-C units for nighttime room disinfection.







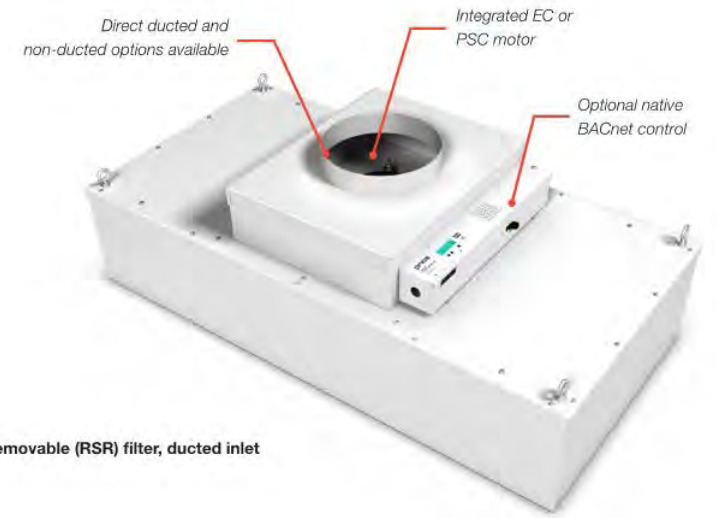
ASHRAE has noted that new filtration technologies other than UVGI have not been researched and validated and should be considered with caution.

- As one example, suggestions are being made to consider air cleaning systems such as Photocatalytic Oxidation Air Cleaning Technology (PCO). In regard to PCO effectiveness, ASHRAE Position Document on Filtration and Air Cleaning states "Evidence on Health Effects. No studies are available with respect to the direct health effects associated with the use of PCO air-cleaning equipment in indoor environments." In addition, inspection of test results from one vendor indicates a significant reduction below stated effectiveness for bioaerosol removal using a surrogate sample virus (MS2).

Personalized and Source Capture Ventilation

- Personalized ventilation systems, when coupled with localized or personalized exhaust devices, may enhance ability to mitigate exposure in breathing zones, however, there are no known epidemiological studies that demonstrate a reduction in infectious disease transmission.

Lessons learned from the 2003 SARS outbreak identified plumbing systems as one potential path for spreading the virus. It was specifically noted that floor drain traps had dried out allowing spread of virus when flushing of toilet occurred. In addition, closing of toilet seat covers where available can also reduce spread.



Room-side Removable (RSR) filter, ducted inlet

Standard 52.2 MERV	Arrestance Value	Example Range of Contaminants Controlled
E-1 Range		
MERV 16	N/A	0.3 to 1.0 µm size range:
MERV 15	N/A	bacteria, smoke (ETS), paint
MERV 14	N/A	pigments, face powder, some
MERV 13	N/A	virus, droplet nuclei, insecticide
		dusts, soldering fumes

RECOMMENDATIONS

Based on our initial review, we have found that many of the suggestions from these national and international agencies appear to be intended to enhance indoor air quality and general health rather than implying that these enhancements will specifically reduce potential exposures to the COVID-19 virus. This opinion is based on the statement in the ASHRAE Position Document on Infectious Aerosols that indicates "no controlled intervention studies showing the clinical efficacy of all of the above strategies have been conducted."

Based on this understanding, we have highlighted the below list of potential HVAC enhancements for consideration to supplement the effectiveness of the General Operational Guidelines provided above. We have noted negative effect on building operations below options. The options are provided in order of increasing cost, complexity, and operational cost:

- Inspect and service all HVAC and plumbing systems to ensure proper operation.
    - Inspect and maintain trap seals in plumbing systems.
- Confirm minimum ventilation rates are provided by each system per code and good engineering practice standards such as ASHRAE 62.1-2019 (commercial buildings) and ASHRAE 170-2017 (health care).
- Perform diagnostic and environmental sample testing for COVID-19 only in Biosafety Level 2 (BSL-2) laboratories. Consider Biosafety Level 3 (BSL-3) practice per the CDC and WHO guidelines. Perform virus isolation procedures in Biosafety Level 3 (BSL-3) laboratories with all BSL-3 practices.
- Adjust pressurization of spaces of concern.
    - In spaces adjacent to high occupancy lobbies, consider adjusting air balance so that air flows from the adjacent spaces into the lobby. Where lobby has doors to the exterior, maintain positive pressure to outdoors. For interior lobbies adjustments can be made to have a negative air balance.
    - For health care facilities follow good engineering practice design for isolation rooms by providing pressurization/directional airflow into contaminated spaces to minimize spread of bioaerosols. Where possible provide entry airlocks or vestibules to enhance directional airflow performance.
    - For health care waiting rooms, maintain adjacent spaces positive to the waiting room similar to commercial occupancy lobbies.
- Contain bioaerosols in spaces with high occupancy (e.g. lobbies and conference rooms) by replacing return registers with oversized filter grilles containing 2-inch thick MERV 13 filters. Oversized grilles and filters are required to minimize pressure drop effect on HVAC system fan performance.
    - Con: May increase return fan energy use.
- Where return grille replacement is not feasible, consider replacing air handling unit return filters in units with MERV 13 or higher rating filters. Seal filter edges to reduce bypass. Due to the additional pressure drop of higher rated filters adjustments to fans may be needed to maintain design airflow.
    - Con: May increase fan energy use.
- Disable demand control ventilation sequences to maintain full ventilation.
    - Con: Will increase heating, cooling and fan energy use.

- Shut down energy recovery systems that have potential to cross contaminate supply.
  - Con: Will increase heating and cooling energy use.
- Maintain system operation and ventilation 24 hours/day or consider shutting down for fewer hours per night. This includes operating toilet room exhaust continuously. As an additional enhancement would be to consider nighttime purge cycle for each system.
  - Con: Will increase heating, cooling and fan energy use.
- Consider increasing outdoor air beyond code or ASHRAE 62.1 minimum whenever possible based on limited installed heating and cooling capacity. WELL building standards suggest a minimum of 30% above code to enhance indoor air quality. Consider sequence of operation that maximizes outdoor air and only resets to lower outside airflow when discharge air conditions cannot be maintained.
  - Con: Will increase heating, cooling and fan energy use.
- Consider adding upper-room UVGI (ultraviolet germicidal irradiation) in high occupancy spaces like lobbies, waiting rooms and conference rooms. Layout in accordance with manufacturer recommendations to ensure space coverage.
  - Con: Protocols for safety are critical when applying UVGI.
- Consider adding humidification, at least in high occupancy areas to maintain a minimum of 30% relative humidity. While some biologists are suggesting 40% RH minimum relative humidity as optimal, care must be taken to prevent condensation on perimeter glazing and mullions that could also have a negative effect on health.
  - Con: Significant increase in energy use.
- For health care waiting rooms, after implementation of access management plans, consider converting HVAC to a once through air system exhausting all air or implementation of a high air change recirculating HEPA filter system to contain bioaerosols.
  - Con: Significant increase in energy use.

Follow CDC Air Change Clearance Rates (note these assume perfect mixing):

Table B.1. Air changes/hour (ACH) and time required for airborne-contaminant removal by efficiency *

ACH § ¶	Time (mins.) required for removal 99% efficiency	Time (mins.) required for removal 99.9% efficiency
2	138	207
4	69	104
6+	46	69
8	35	52
10+	28	41
12+	23	35
15+	18	28
20	14	21
50	6	8

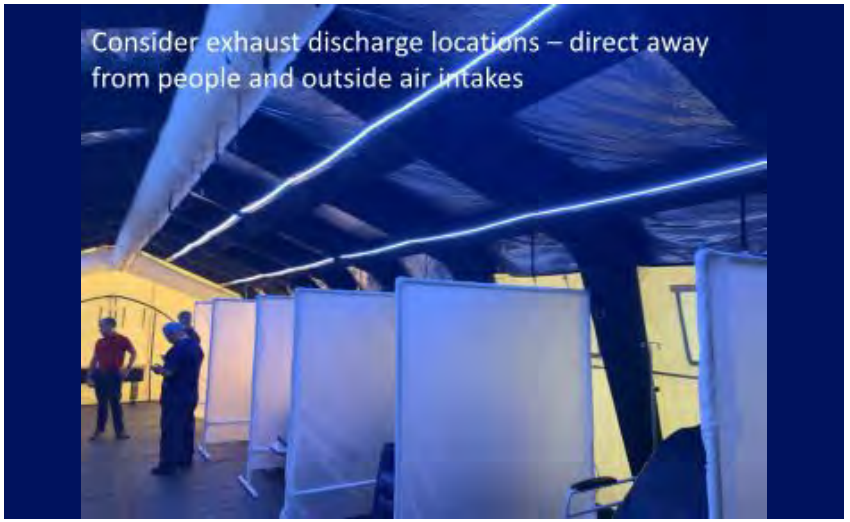
Note that each of the above recommendations should also be considered for new construction.

Additional suggestions for consideration but with little or no studies to prove effectiveness against spread of COVID-19:

- Consider use of Photocatalytic Oxidation Air Cleaning Technology - PCO (e.g. Trane) to enhance filtration and provide better indoor air quality. ASHRAE Position Document on Filtration and Air Cleaning notes "No studies are available with respect to the direct health effects associated with the use of PCO air-cleaning equipment in indoor environments."
  - Con: Unproven technology for use against COVID-19.
- Consider bi-polar ionization filtration systems (e.g. Plasma Air) to enhance filtration and provide better indoor air quality. Note that ASHRAE Position Document on Filtration and Air Cleaning indicates that "studies of ionizers have shown results ranging from no benefit to some benefit for acute health symptoms" and "A convincing body of scientifically-rigorous, peer-reviewed studies does not currently exist on this emerging technology; manufacturer data should be carefully considered. Must comply with UL 2996 and ASHRAE 62.1 as ozone build up can be harmful."
  - Con: Unproven technology for use against COVID-19.
- Consider portable room air cleaners with HEPA filters with UVGI if available to enhance filtration and provide better indoor air quality. ASHRAE notes "presently, minimal data are available on the health consequences of using packaged air cleaners employing multiple technologies."
  - Con: Requires multiple units and power connections per space due to limited coverage of portable units.
  - Con: Unproven technology for use against COVID-19.

Additional documents for specific applications can be found in the following documents:

- 2020 ASHRAE Epidemic Task Force Commercial
- 2020 ASHRAE Epidemic Task Force Healthcare
- 2020 ASHRAE Epidemic Task Force Schools
- 2020 ASHRAE Epidemic Task Force Building Readiness



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2017 ASHRAE Journal HVAC UV Germicidal Irradiation UV-C Fixtures
2020 ASHRAE Epidemic Tack Force Healthcare
2020 ASHRAE Epidemic Task Force Commercial
2020 ASHRAE Epidemic Task Force Schools
2020 ASHRAE Emerging Issue Pandemic COVID-19 and Airborne Transmission
2017 ASHRAE Low Humidity Effects on People
1985 ASHRAE Humidity Effect on Airborne Microorganisms
2020 ASHRAE How to Return the HVAC System to Normal Operation FAQ
2020 ASHRAE HVAC System Operation During Building Shutdown FAQ
2009 ASHRAE IAQ Guide
2015 ASHRAE Standard 185.1 UV-C Testing In Duct
2020 ASHRAE Reducing Infectious Disease Transmission with UVGI
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