TECHNOLOGIES FOR A SAFER POST COVID – 19 BUILDING OCCUPANCY

A Guidance Document developed by R.W. Sullivan Engineering
June 16, 2020

INTRODUCTION

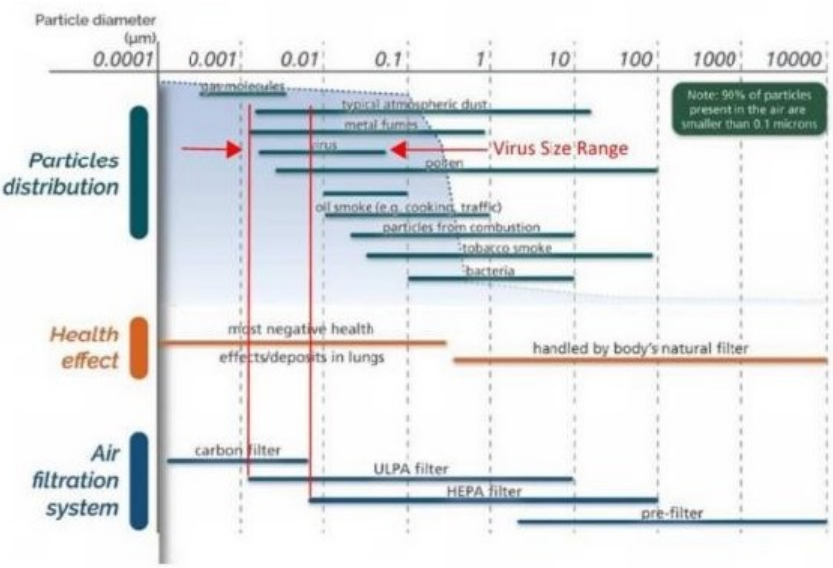
The spread of COVID-19 is a rapidly developing situation, but there are steps that can be taken for improving and modifying building systems to help prevent the spread of disease. There are various options that can be implemented throughout the building systems to accomplish this goal. R.W. Sullivan Engineering has prepared this paper to help guide building operators and stakeholders through the various solutions available including those based on the latest publications and recommendations from ASHRAE and the CDC. To be effective, these solutions need to be tailored based on the specific mechanical systems for each building. Some of these solutions will increase overall energy use of the building systems.

The R.W. Sullivan Engineering team can assist in selecting and implementing the best available technology for each building based on the specific existing building systems, building use, and specific short-term and long-term goals.

SCIENTIFIC DATA

The virus that causes COVID-19 is approximately 0.125 micron (125 nanometers) in diameter as depicted in recent studies by cryo-electron tomography and cryo-electron microscopy.

The virus that causes coronavirus disease 2019 (COVID-19) is stable for several hours to days in aerosols and on surfaces, according to a new study from National Institutes of Health, CDC, UCLA and Princeton University scientists in The New England Journal of Medicine. The scientists found that severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was detectable in aerosols for up to three hours, up to four hours on copper, up to 24 hours on cardboard and up to two to three days on plastic and stainless steel.



Air Filter Removal rating and Particle Sizes

RECOMMENDED TECHNOLOGIES & SOLUTIONS

Enhanced Air Filtration

The April 14, 2020, updated ASHRAE Position Document on Infectious Aerosols and the EPA website were referenced for the applicable options. The following was referenced for filtration:

- Air Handling Unit (AHU) Filters. Filtration particulate sizes ranges are compared to common pollutant particle size ranges. Options for higher efficiency filters can be beneficial as they can remove smaller particles.
- Portable High Efficiency Filtration Units. These ASHRAE recommended units can be moved to serve different areas for virus mitigation.

As recommended by ASHRAE, improving filtration of HVAC systems to MERV-14 or to the highest efficiency level feasible is an important factor in reducing the spread of COVID-19. More advanced measures, such as HEPA filters, can be considered when existing systems allows, but careful evaluation is required. As shown on the chart, the higher the MERV rating, the more effective the filter is at removing smaller particles in the airstream. This is easy to accomplish in new construction, however, may pose a challenge in existing systems. To increase the system spread prevention effectiveness, the enhanced filtration option shall be implemented together with the increased outdoor air option. Each building/system shall be evaluated in case by case basis.

MERV FILTER RATINGS

MERV	Min. Particle Size	Typical Controlled Containment	Typical Application
5-8	10.0 - 3.0um	Mold spores, dust mite debris, cat and dog dander, hair spray, fabric protector, dusting aids, pudding mix	Better residential, general commercial, industrial workspaces
9-12	3.0 - 1.0 um	Legionella, humidifier dust, lead dust, milled flour, auto emission, particulates, nebulizer droplets	Superior residential, better commercial, hospital laboratories
13-16	1.0 – 0.3 um	Bacteria droplet nuclei (sneeze), cooking oil,most smoke and insecticide dust, most face powder, most paint pigments	Commercial Hospital & general surgery
17-19 HEPA	0.3	Viruses, carbon, 99.97 – 99.995% Efficiency	Surgery, clean rooms
20+ULPA Filters	0.12um	Viruses, carbon, 99.9995 – 99.999995% Efficiency	Cleanrooms

Although higher efficiency filters can reduce the concentration of airborne respiratory communicable diseases, it should be noted that they do not necessarily inactivate or kill the viral or bacterial species. Care needs to be taken when changing out dirty filters and the use of personal protective equipment is recommended. Other types of filtration and air-cleaning systems are available such as Bipolar Ionization. Bipolar Ionization technology generates positive and negative and delivers the charged ions through the supply air to the space. Charged ions release their charge to particles (like dust, dander, pollen, bacteria and virus). The charged particles in turn seek out oppositely charged particles and stick together and grow larger (agglomeration). Larger particles get capture by the HVAC system. Since both polarities of ions are created, particles are not attracted to objects in the space and the overall net static charge is neutral.

PROS

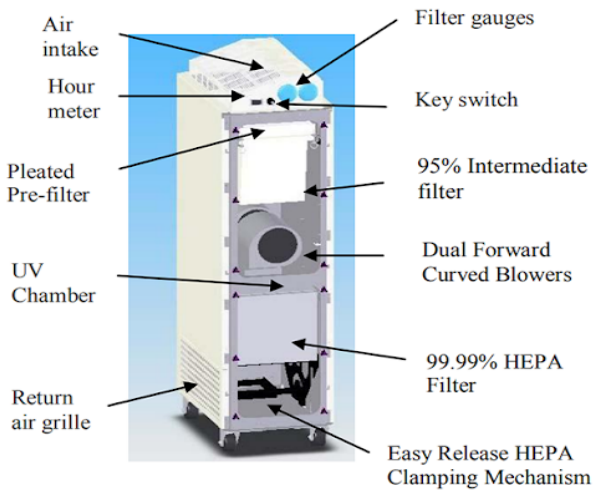
- Proven and effective technology
- Easy and inexpensive to accomplish

CONS

- Could cause strain on motors and reduce airflows due to the added pressure drop associated with the filters.
- Increased energy use

Portable Air Filtration Technology

Another type of filtration option is portable HEPA or ULPA filtered fan units with internal UV lights. These types of units can be located inside large spaces to recirculate filtered and UV treated air. These units can be plugged into regular wall electrical outlets. Variable speed units should be used to mitigate acoustical issues. These units vary from 1000 CFM to 3000 CFM. Based on the occupant concentration and space risk, the number of ACH can be determined. For an open office space, one 1000 CFM unit can serve up to 1000 SF (6 ACH). For large training rooms, one 1000 CFM unit can serve up to 500 SF (12 ACH).



PROS

- Proven and effective technology
- Easy to implement

CONS

- Increased energy use
- Multiple units will be required for large spaces
- These units can be loud (4 to 10 Sones); therefore, acoustical performance shall be carefully reviewed based on the space that the unit will be located.

Increased Ventilation

The CDC 2003 Table notes the theoretical time to remove particles from a room being flushed with clean, HEPA filtered air, assuming perfect mixing/perfect ventilation effectiveness in the space.

Air changes per hour	Minutes required for removal efficiency	
	99%	99.9%
2	138	207
4	69	104
6	46	69
12	23	35
15	18	28
20	14	21
50	6	8
400	<1	1

Effect of Air Change Rates on Particle Removal CDC 2003

Outdoor air ventilation dilutes indoor viral and bacterial contamination. (ASHRAE 2013). Whether achieved by introducing clean fresh air or filtration, increasing a room's air change rate reduces its airborne burden of viruses and microorganisms, thus reducing opportunities for airborne exposures. The following strategies can be implemented to increase air ventilation:

- Enable outside air economizers and increase the minimum outside airflows by overriding outside air dampers position (as much as outside air conditions allow).
- Implement flushing sequences to provide maximum outside air for a few hours before and a few hours after occupancy each day.
- Running variable flow systems as constant volume system at their highest airflow setting that the system heating and cooling capacity can support.

PROS

- Proven and effective technologies
- Easy and inexpensive to accomplish

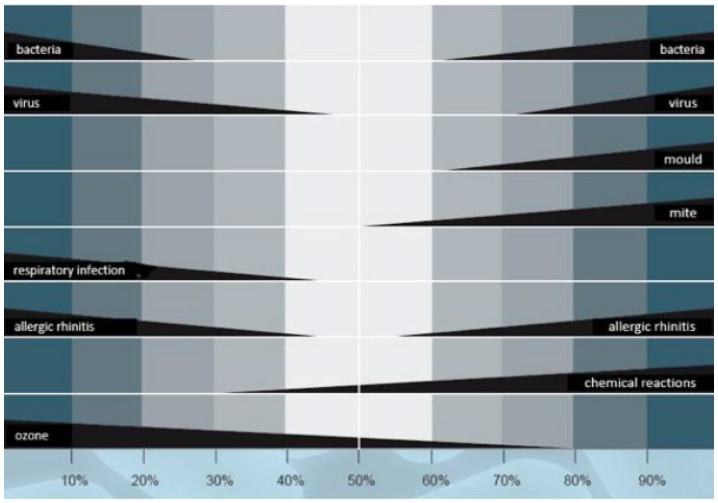
CONS

- Will affect the temperature and humidity of the space
- Increased energy use

Humidity Control

Increasing evidence from various studies indicates that humidity can play a role in the survival of membrane-bound viruses, such as SARS-CoV-2. Previous research has found that at typical indoor temperatures, relative humidity (RH) above 40% is detrimental to the survival of many viruses. Higher indoor RH has been shown to reduce infectious influenza virus in simulated coughs. Based upon studies of other viruses, including CoVs, higher RH also decreases airborne dispersal by maintaining larger droplets that contain viral particles, thus causing them to drop and deposit onto room surfaces more quickly. ASHRAE has recommended in their Position Document on Infectious Aerosols published on April 2020, that the most unfavorable survival rate for viruses and micro-organisms is between 40% and 60% relative humidity (RH). Most air-conditioned buildings are designed for the upper limit of 60%, but not all buildings are humidified to the 40% level; most of the commercial buildings are not humidified. So where feasible, buildings should have humidity capabilities with the 40% setpoint as the goal.

In colder climates, a reset minimum RH based on outdoor air temperature will be required to prevent windows from condensation.



ASHRAE 1985: "Optimal RH Level For Health" = 40%–60%

There are two types of humidifiers; isothermal humidification and adiabatic humidification.

PROS

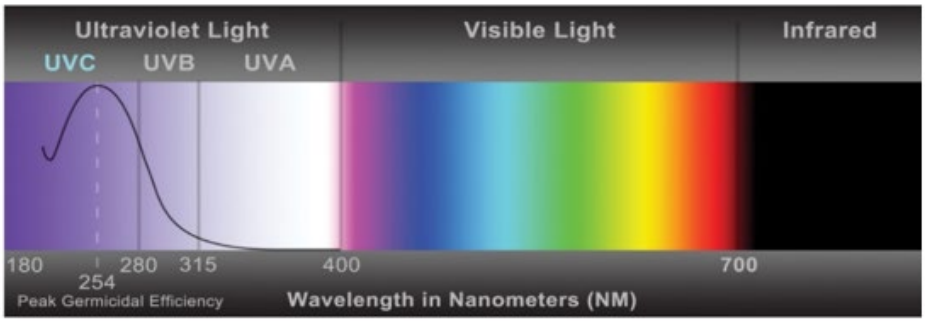
- Isothermal Humidification: Shorter absorption distance, Steam humidifiers use less water than adiabatic humidifiers.
- Adiabatic Humidification: No heat/energy added, Energy Savings, Easy to Install and Retrofit, viable option when Steam or Gas are not available.

CONS

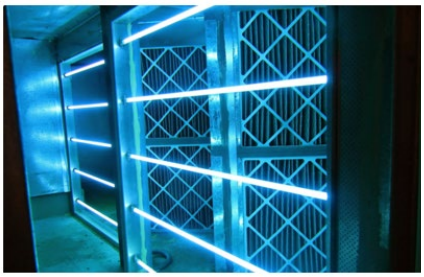
- Isothermal Humidification: Heat/energy added, requires building steam or gas or high electrical load, clean steam is recommended for live steam systems
- Adiabatic Humidification: Longer absorption distance, RO Water is required (smaller portable RO unit's for specific installations should be considered), Preheat of Supply air is required, Compressed air required on air/water systems.

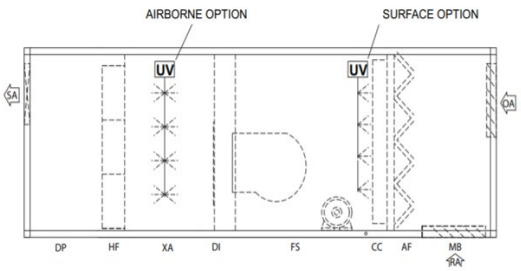
UVGI (Light Systems)

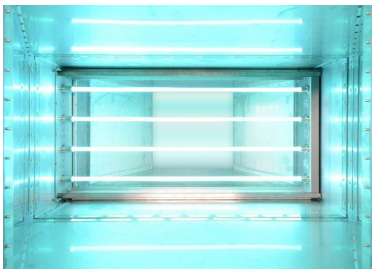
The most effective wavelengths on disinfecting bacteria and viruses in the electromagnetic spectrum is the photobiological ultraviolet (UV) spectral band. The UV band is broken to three smaller bands: UV-A, UV-B and UV-C. UV-C wavelength is from 200 to 280 nanometers (nm) and it appears to be more effective than other two bands on inactivating the viruses similar to SARS-CoV-2, responsible for COVID-19.



HVAC mounted (AHU or duct mounted), high output UVC emitters can provide disinfection in recirculating central air handling systems. UV systems installed in air handlers are proven to control biofouling of cooling coils. However, 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. Systems must be specified and 3rd party tested for zero ozone generation. UVC lights provided for coil disinfection are constantly shining on the **coil surface**, so a lower UV dose / intensity is required from the light to prevent bacteria/growth from developing within the coil. UVC lights provided for **airborne/airstream** disinfection must provide a significantly higher UV dose / intensity due to how fast the airstream moves across the light. Resonance time and power output is critical to disabling viruses.

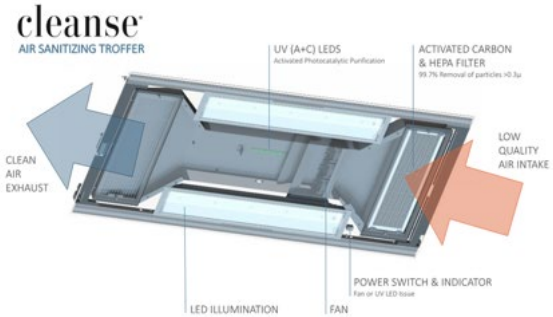




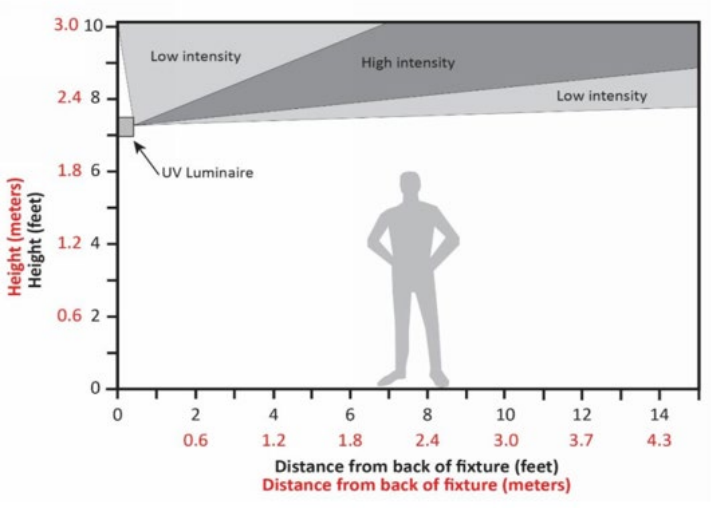


Germicidal ultraviolet (GUV) disinfection is the primary means of safe and highly effective air disinfection, provided it is planned, installed, commissioned, and maintained. There are four primary ways to use this method to disinfect the spaces or air using electrical lighting fixtures.

- The first method is upper-room GUV fixtures with air mixing for controlling airborne pathogens in an occupied space. In this method, the UV-C light is not visible.



- The second method of upper-room GUV technology utilizes open, wall mounted fixtures. The fixtures are located above occupant's heads and aimed upward above seven feet high. This approach disinfects large volumes of room air; however, this method requires higher rates of ventilation and air movement.



- The third Method employs direct, overhead GUV lighting fixtures to disinfect air and surfaces in unoccupied and locked rooms. The control system for these fixtures includes occupancy sensor, smart time clock, and interlock to the access doors to shut down the UVC lights as soon as the space becomes occupied.

Finally, the fourth method for the use of UV-C technology is in ongoing development for entry sanitizing gates and booths to the facilities and commercial spaces. This UVC lighting based technology, along with disinfecting air curtains to control airborne, is one of the most advanced technology.

PROS

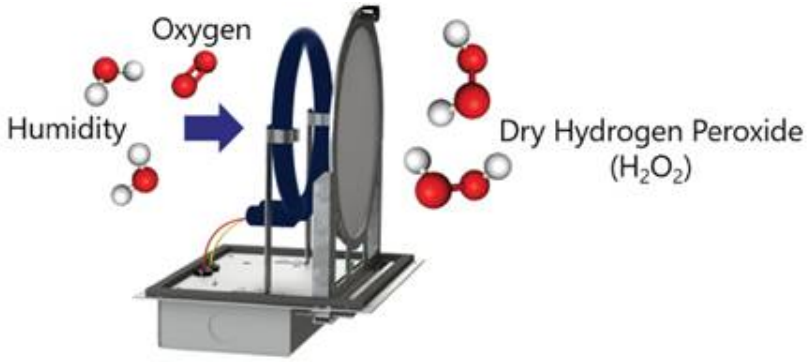
- UV-C lighting is proven and effective technology

CONS

- Few studies exist with 3rd party testing of airstream virus mitigation.
- Longer time and higher doses of virus exposure is required to improve effectiveness.
- Increased energy use
- The life of UVC light bulbs is around 2 years, and requires replacement at approximately this duration.

DHP (Dry Hydrogen Peroxide)

Dry hydrogen peroxide or DHP, a non-aqueous gas, has been used for environmental disinfection in fields such as agriculture, biodefense/government, and sports for some time and is increasingly gaining attention in the healthcare community because of its ability to meet some of the aforementioned microbial reduction challenges.



The biocidal activity of hydrogen peroxide in any form – liquid, vapor, dry gas – is rooted in the fact that microbes require water and have electrostatically charged points on their cells designed to attract water molecules from the environment. Hydrogen peroxide molecules are very similar to water molecules and are also attracted to these charged points; however, unlike water molecules, hydrogen peroxide attacks microbes and disrupts their cell membrane. Because hydrogen peroxide will compete with water molecules for access to these points on a microbe's cell wall, higher concentrations of hydrogen peroxide are needed to effectively disinfect when in the presence of water.

DHP PERFORMANCE

Germ	Microbial Load (Organisms/Sq.In.)	Test Time (hr)	Reduction vs. Control
H1N1 (flu virus)	1,120,000	1	99.80%
MRSA (staph)	100,000	6	99.53%
MRSA*	562,000	6	95.15%
Black Mold (vegetative)	22,000	6	86%
C-Diff (spores)	3,780,000	72	51%

PROS

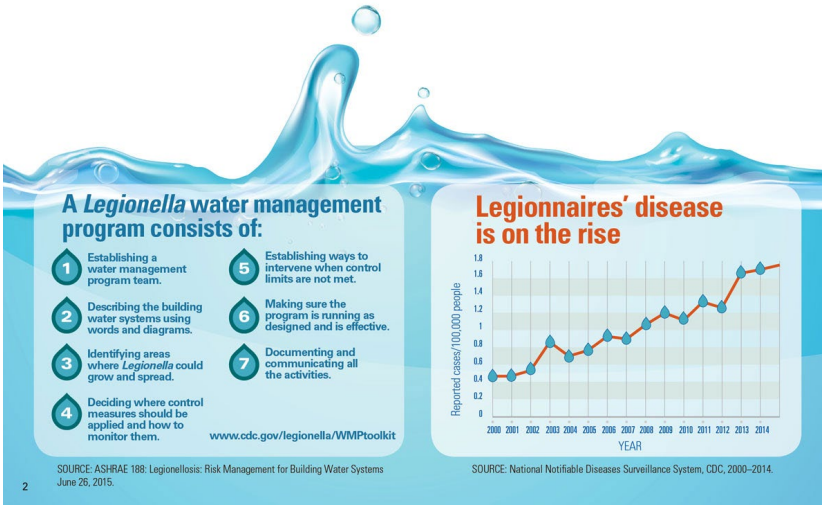
- Proven technology in agriculture and healthcare during unoccupied periods

CONS

- DHP is not commented or recommended by ASHRAE for use in occupied buildings. RWS believes that there is not enough proven data, case studies or installations of this technology in occupied spaces at this point; therefore, we recommend considering this technology for future installation when more data becomes available.

Plumbing Systems

Stagnant water in the piping system leads to increased risk of Legionnaires' disease and other water-born illnesses. Prior to re-occupying, previously vacant buildings plumbing systems need to be made ready in order to avoid risks to the occupants.



The following steps are recommended:

- Develop a water management plan (WMP) for your water system: ASHRAE 188-2018
- Flush the water system through to all use points, replacing all stagnant water with fresh water
- Replenish trap seals at floor drains and other receptors, flushing the water system replenishes fixture trap seals
- Replace water filters
- Operate water heaters at the highest temperature possible with mixing valves to protect against scalding
- Disinfect water features and landscape irrigation systems
- Cooling towers shall be cleaned and maintained
- Fixtures should be replaced to hands-free / touch free to minimize surface contact and risk of spreading viruses.