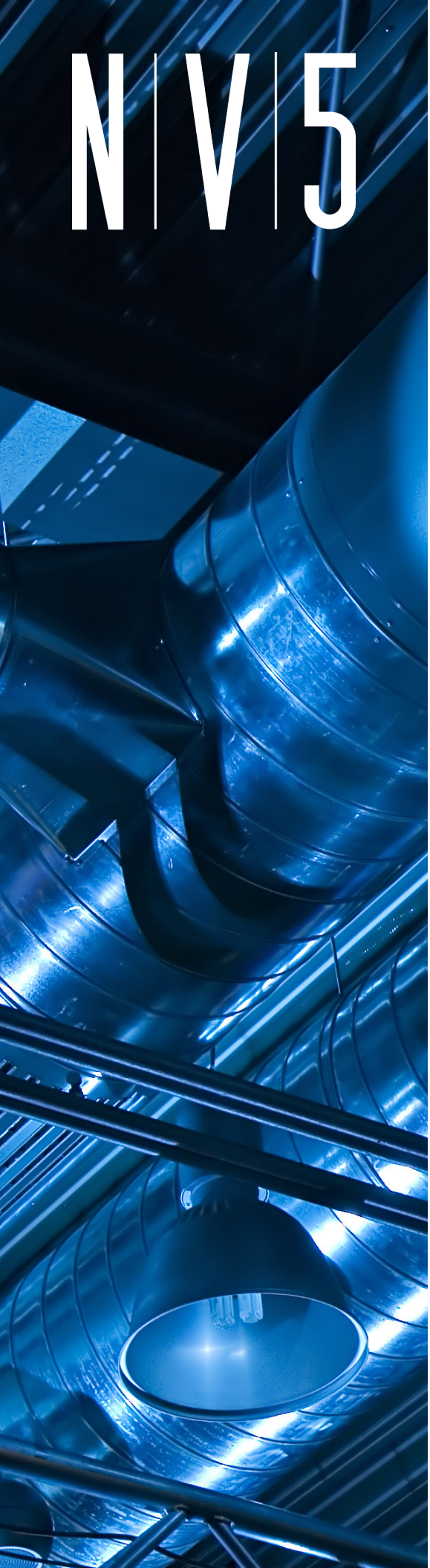

COVID-19

(NOVEL CORONAVIRUS)

AIRSIDE SANITIZATION TECHNOLOGIES FOR SAFER POST-COVID-19 BUILDING OCCUPANCY

The current Coronavirus pandemic (COVID-19) has required people to shelter at home, keeping many offices and buildings vacant and resulting in many building owners and facility managers asking themselves questions such as:

"What cost-effective options are available for modifying my building's air handling systems so they can provide a safer environment for my occupants after this current pandemic is over?"

As it turns out, there are actually many options that can help accomplish this goal. NV5 has looked into this subject as it applies to both commercial buildings as well as healthcare facilities. As always, to be effective, these options need to be applied and tailored for the specific HVAC systems in your building. NV5's team of engineers can help you choose the best option(s) based on the sanitization goals, the specific air handling system capacity, and the duct layout. Also considered will be the constructability of the options that will work to meet the project's goals as well as its life cycle cost analysis (LCCA).

The April 14, 2020, updated ASHRAE* Position Document on Infectious Aerosols and the EPA* website were referenced for the applicable options outlined below.

1. Air Handling Unit Operation: ASHRAE recommends increased outdoor air, longer hours of operation, and humidification (between 40% to 60% RH) as means of protection from virus contagion. In colder climates, a reset (lowering) of the 40% minimum RH based on outdoor air temperature will be needed to prevent condensation on exterior windows.
2. Filtration
   - Air Handling Unit (AHU) Filters. Filtration particulate size ranges are compared to common pollutant particle size ranges. Options for higher efficiency filters can be beneficial as they can remove more and smaller particles.
   - Portable High Efficiency Filtration Units. These ASHRAE recommended High Efficiency Particulate Air (HEPA) filter units can be moved to serve different areas for virus mitigation.
3. Sanitizing the AHU and Air Duct Systems including the rooms served. Four Technologies for microbe mitigation are available. These technologies are:
   - UV Lights (Non-Ducted and Duct Mounted). These CDC* and ASHRAE recommended lights can sanitize the AHU, Ductwork, and Rooms.
   - Dry Hydrogen Peroxide (DHP) Generation. These are installed in the ductwork close to the rooms they sanitize.
   - Bipolar Ionization Generation. These are installed in the ductwork after the AHU and claim to sanitize both the ductwork and the rooms served.
   - Ozone Generation. These are installed in the ductwork after the AHU and claim to sanitize both the ductwork and the rooms served. ASHRAE has strong reservations about ozone's efficiency at the maximum recommended concentration and thus states it shouldn't be used in any occupied spaces.

** All plans and protocols are developed in accordance with protocols from ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers. Inc.), Environmental Protection Agency (EPA), the Centers for Disease Control and Prevention (CDC), World Health Organization (WHO), Occupational Safety and Health Administration (OSHA), and American Industrial Hygiene Association (AIHA).*

AIR HANDLING UNIT OPERATION

ASHRAE recommends increased outdoor airflow (over code minimum) as a means of lowering the concentrations of contaminants in the building. For buildings with CO_2 based outdoor air demand control additional outdoor air can also be accomplished by lowering each room's CO_2 setpoint to 800 ppm. Due to existing heating and cooling capacities, this may need be reset to design outdoor airflow when the outdoor air is near the design heating and cooling temperatures/humidity.

ASHRAE also recommends longer hours of air handling unit operation to maintain building contaminant and microbe dilution and maximum humidity (within limits to avoid mold growth). This can be accomplished with reduced outdoor airflow (OA) volume on cold or hot/humid periods and with the boxes reset to close to their minimum air flows to save of fan energy. They suggest continuous fan operation, but, any increased hours, even 1-2 hours at full OA volume after the building is empty and before occupancy is due to begin, will be beneficial.

Immunobiologists have associated humidity levels with improved immunity to respiratory infections. ASHRAE has recommended in their updated Position Document on Infectious Aerosols (April 14, 2020) that the most unfavorable survival rate for microorganisms 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 with the majority of commercial buildings not having humidification capabilities. So where feasible, buildings should have humidity capabilities with the 40% setpoint as the goal.

In colder climates 40% RH will cause condensation on windows when the outdoor air temperature is cold enough to lower the inside surface temperature below the building's dew point (with 40% RH at 70°F the DP is about 45°F). Since window construction and quality of installation vary by building, there is no way to accurately determine at what outdoor air temperature (OAT) condensation would start. However there will be a need to lower the RH setpoint below 40% RH to avoid condensation below about 35°F OAT down to potentially 10 to 20% RH at 0°F (even lower or no humidification below 0°F). The final setpoint would need to be determined by tuning the setback OAT vs RH curve for each building). Fortunately, for most locations, temperatures below 25°F have relatively few hours of occurrence.

RH above 60% can result in occupant climate dissatisfaction ("clamminess"), and can also lead to mold proliferation indoors. As such, local prevailing climate should be taken into account whenever adjustments to dehumidification and/or temperatures are contemplated.

FILTRATION FOR AIR HANDLING UNITS (AHU)

AHUs contain filters that remove particulate from the airstream. Filters buildings have different efficiencies in filtering different particulate concentrations and sizes. So that filters can be compared with each other, a standard was developed by ASHRAE: Minimum Efficiency Reporting Value also known as the MERV rating. The MERV rating reports a filter's ability to capture larger particles between 3 and 10 microns (µm). MERV ratings of 10 or more may have multiple ratings for smaller particulate sizes of 1 µm or even 0.3 µm as shown in the table below.

MERV Rating	Average Particle Size (µm) / Efficiency
6	3.0 - 10.0 / 35% or less
7	3.0 - 10.0 / 50% or less
8	3.0 - 10.0 / 70% or less
11	1.0 - 3.0 / 65% or less 3.0 - 10.0 / 85% or less
13	0.3 - 1.0 / 50% or less 1.0 - 3.0 / 85% or less
14	0.3 - 1.0 / 75% or less 1.0 - 3.0 / 90% or less
15	0.3 - 1.0 / 85% or less 1.0 - 3.0 / 90% or less
16	0.3 - 1.0 / 95% or less

Source: ASHRAE Standard 52.2-2019

Higher efficiency filters are available that are called "High Efficiency Particulate Air" filters or HEPA filters (as officially defined by the U.S. Dept. of Energy). These are primarily used in clean rooms, hospitals, and pharmaceutical environments. This type of air filter can theoretically remove at least 99.97% of dust, pollen, mold, bacteria, and any airborne particles with a size of 0.3 microns (µm). HEPA filter ratings are similar to MERV but use the European Union (EN 1822) rating system with prefix H (high efficiency) instead of M (MERV). The ratings are:

- H13 HEPA filters are 99.97% efficient at 0.3 µm (sometimes referred to as MERV 17).
- H14 HEPA filters are 99.995% efficient at 0.3 µm (sometimes referred to as MERV 19).

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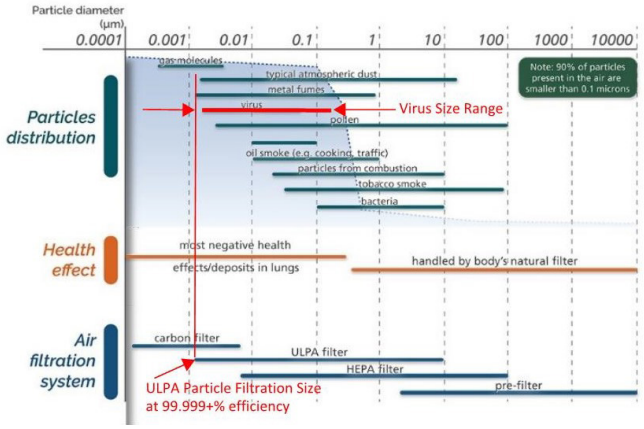
ULPA filters are “Ultra Low Particulate Air” filters. These are an advanced version of HEPA filters that are rated for smaller sized particles and can typically remove at least 99.9995% of dust, pollen, mold, bacteria, as well as viruses with a size of 0.12 microns (µm). ULPA filter ratings also use the European Union (EN 1822) rating system with the prefix U (Ultra high efficiency) instead of H (high efficiency). The ratings are:

- U15 ULPA filters are 99.9995% efficient at 0.12 µm (sometimes referred to as MERV 20).
- U16 ULPA filters are 99.99995% efficient at 0.12 µm.
- U17 ULPA filters are 99.999995% efficient at 0.12 µm.

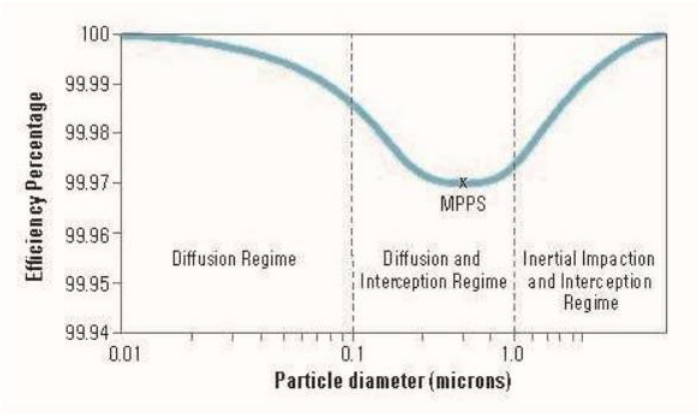
As shown in the following diagram, viruses vary in size between about 0.002 and 0.12 µm. The average coronavirus particle is 0.12 µm with a size range between about 0.002 to 2.5 um.

Particle Sizes and Air Filter Removal Ranges



Source: ESCO Micro Pte. Ltd.

HEPA Filter Particle Size Efficiency Curve



Source: Price Industries

As the chart shows, the extended range of ULPA filters collection covers the 100% of the size range of virus particles and will have 99.9995% removal at the 0.12 µm average corona virus particle size. HEPA filters are rated at 99.97% for 0.3 µm particles (2.5 times the size of the more efficient ULPA filters). But 0.3 um is the particle size that has the lowest efficiency. For smaller particle sizes down to 0.01 um HEPA filter efficiency actually increases to 99.98+% for particles between 0.12 um and 0.01 um (like the ULPE does in the chart down to 0.002 um). Like ULPA filters, smaller particles are filtered by what is called Diffusion. These smaller particles continually bump into each other as they travel through the air, causing for a very chaotic or random zigzagging path. This motion is referred to as Brownian motion which causes these smaller particles to collide with filter media and become trapped.

The highest MERV rated filters can approach levels of HEPA, but only at lower efficiencies than HEPA filters at 0.3 µm particles. As such, they are not typically used to stop virus size particles. A more efficient filtration system in your HVAC system will be beneficial as it can prevent more and smaller particles from getting through than the typical lower MERV rated 3-10 µm size range filters.

Higher efficiency primary or pre-filters can be beneficial in two ways. First, they will allow less particulate accumulation on flat damp surfaces such as cooling coils and drip pans as well as ductwork, which can then help reduce possible microbial growth in these areas. Secondly, higher efficiency primary filters, by collecting more and smaller particles, will extend the life of the HEPA or ULPA filters.

The vast majority of commercial AHUs will not be able to accommodate either HEPA or ULPA filters without potentially extensive modifications. These are final filters and as such should be located on the discharge side of the fan (about 4 to 8 feet of additional length could be needed to fit) with a face velocity of 400 to 500 fpm. When dirty, they will require the fan to have the capacity for up to an additional 2 inches of static pressure (meaning, in most units, at least a larger motor and VFD, and possibly a total fan replacement).

Filter modifications that can be explored are as follows, providing the fan has the capacity for the increased pressure drop:

- All facilities with just MERV 6 to 8 filters in their AHUs or smaller units such as Fan Coil Units, Heat Pump Units, Cabinet Heaters, Fan Powered Boxes, and ducted VRF units could change to MERV 13 filters for AHUs or MERV 8 filters for smaller units at the next filter change.
- All facilities with MERV 8 pre-filters and MERV 12 or less secondary filters in their AHUs could change to MERV 13 to MERV 16 (depending on available space secondary filters at the next filter change.
- Healthcare or cleanroom facilities with HEPA final filters could change to ULPA final filters at the next filter change.

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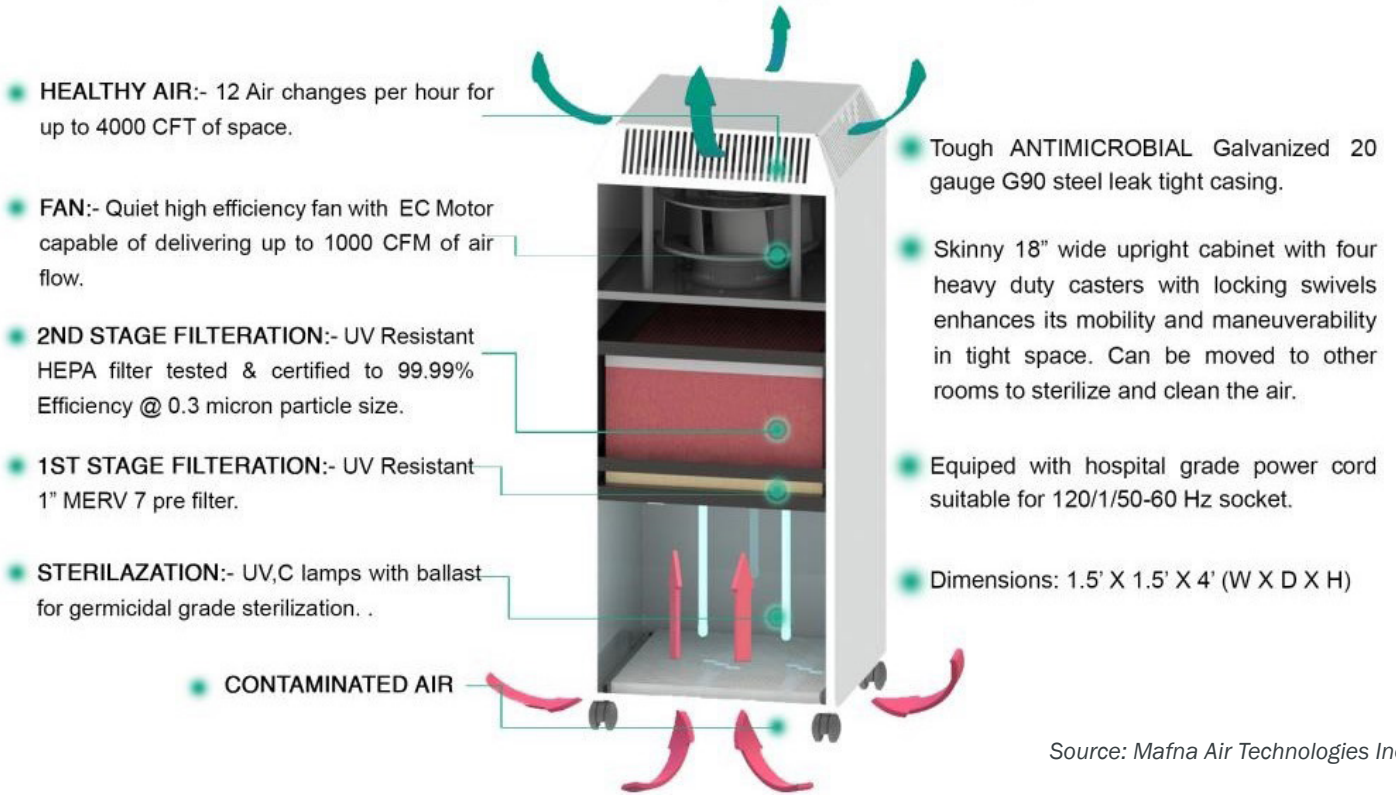
PORTABLE HIGH EFFICIENCY FILTRATION

Another filtration option that is approved by ASHRAE are point of use portable HEPA or ULPA filtered fan units with options for internal UV lights. These can be used in all projects to recirculate the highly filtered and UV treated supply air in areas such as large conference or board rooms (would need some sound treatment or be sized to operate at or below 50% speed), cafes, classrooms, waiting areas, or similar spaces.

Healthcare projects could also use these at nursing stations and in corridors. Another use of these units could be in converting patient rooms into negatively pressurized isolation rooms. This can be done in two ways depending on location. Adding an exhaust unit to filter with a HEPA filter to clean the patient room air and then exhaust the cleaned air safely to the outdoors (commonly referred to as a "negative air machine" (NAM)). This will create a negative pressure in the room (as opposed to adjacent rooms), thus ensuring that contaminants do not spread from the source location.

Another option, if exhaust to outdoors is not feasible, is to use an ULPA filtered fan unit with UV lights to filter the room air and then duct this highly filtered and UV treated air to the adjacent corridor to keep the patient room negatively pressurized relative to the corridor. Care should be taken to periodically test these systems in order to ensure that filters are properly mounted and sealed filters and that user errors do not cause recirculation of contaminants.



Source: Mafna Air Technologies Inc.

SANITIZING AIR HANDLING UNIT AND DUCT SYSTEMS INCLUDING THE ROOMS SERVED

Coronavirus can be spread three ways: 1) Person to person through direct contact, 2) Surface to person through contact and 3) Airborne. Only N95 (or better) respirators can adequately mitigate up close person to person contact, but there are three technologies that can help prevent the spread of the virus by airborne droplets or from people touching infected surfaces. These technologies continuously sanitize the air and surfaces whenever the air handling system is operating.

Why is sanitizing the ducts and/or rooms served by them important? Because duct systems typically recirculate large volumes of indoor air from the entire building area served and mix this air with a smaller volume of outdoor air. The ducts then transport the return air system generated microorganisms to each room served and therefore to each person in those rooms. There is little conclusive evidence of airborne virus transmission through enclosed duct systems, however; molds and bacteria (specifically Legionella) can be distributed through central duct systems and can have deleterious effects on human health.

There are four technologies that claim to reduce microbial colonies, bacteria and viruses by over 99% (flu viruses, coronaviruses and staph) in air handling units (AHU) and/or their duct systems. The first two systems are high intensity Ultra Violet Germicidal Irradiation (UVGI) lights using the UVC spectrum between 253 and 255 nanometer wavelengths that have a proven track record in microbe mitigation (without generating

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any ozone) and Dry Hydrogen Peroxide (DHP). The difference between the two is that UV lights can be installed in the AHU and in the duct system adjacent to the AHU while the DHP system is installed in the ducts within 20 feet of each diffuser for the spaces served. As such, while DHP only sanitizes the end of the duct system, it claims to fully sanitize all of the spaces it serves. These technologies can be used with small units such as Fan Coil Units, Heat Pump Units, Fan Powered and VAV Boxes, and ducted Variable Refrigerant Flow systems.

The last two systems: Bipolar Ionization (BPI) and Ozone Generation, are also central systems that sanitize the entire supply air ductwork starting at the AHU discharge with a central generator or multiple generators depending on the supply air duct layout. They both also claim to sanitize the rooms served by the duct system.

Unlike the simple on/off control of UVC lights, some oxidizing systems may need to be controlled by sensors that limit the generator output to keep the oxidant concentration in all rooms to safe levels for occupied buildings.

UV LIGHTS (NON-DUCTED)

Most projects can add ASHRAE approved high intensity UVC lights in the AHU cooling coil and drain pan section, set-up to keep both the cooling coils and drain pans clean of microbial growth. These should be sized for a 99.9% Coronavirus kill rate at the end of the UVC bulbs life. These will only kill microbes on the coils and drain pan, not in the airstream due to the short contact time.

Healthcare projects with downstream final HEPA or ULPA filters can also use high intensity UVC lights at the inlet of the filters to kill collected microbes (providing the filter material is compatible with UV). These should be sized for a 99.9% kill rate at the end of the UVC bulb's life.

Commercial and healthcare projects could also use ASHRAE approved upper wall mounted UV lights in common areas such as conference or board rooms, cafes, waiting areas, or similar spaces. These shine UVC light along

Source: Cure UV

the upper wall and ceiling areas to create a kill zone for microbes. The kill rate of microorganisms can be 90% or higher when used with a low speed ceiling fan slowly moving room air vertically into the ceiling kill zone. The ceilings and walls should not be reflective for occupant safety. TVs and monitors (due to potential reflection) should not be mounted within 4 feet of the ceiling and all components in the kill zone should be UV Resistant

UVC lights are safer than UV light wavelengths that were previously since non-UVC light could cause permanent sight as well as skin damage. UVC light is typically stopped by glass and many plastics but can cause temporary eye discomfort and sunburn with short-term direct exposure for no more than 4 to 5 minutes. Longer direct exposures can lead to more and longer discomfort, or worse.

UV lights work well in all these locations since the surfaces where the microbial growth can collect will have continuous exposure to the UV lights and the air velocity is 450 fpm or less. The lower the velocity the longer microbes are exposed to the UV lights and the higher the kill rate. These lights are unlikely to provide protection against close contact or person to person transmission.

A downside to UV lighting is the maintenance cost for replacing the bulbs as the bulb life is typically 1 year.

UV LIGHTS (DUCT MOUNTED)

Duct mounted high intensity Ultraviolet Germicidal Irradiation (UVGI) lights should be sized to reduce flu viruses by 90% and Coronavirus by 99.9% at the end of the UVC bulbs life. The application challenge is to ensure the targeted organisms are exposed to sufficient UV dose in the available space and time of UV exposure. Multiple parallel UV lights are mounted longitudinally in the duct (as shown in the picture below). The location(s) and number and lengths of the lights will depend on the duct layout, air velocity and desired kill percentage. Multiple sections in series could be needed in higher velocity ducts (over 1500 fpm).

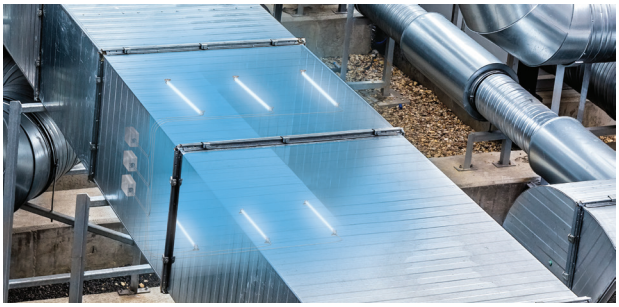

Photo courtesy of UltraViolet Devices Inc

These can be used before or after air handling units in the ducts to sanitize the air before it gets to the rooms. The CDC, EPA, and ASHRAE all recommend the use of duct mount UVGI to minimize the spread of airborne microorganisms in air ducts.

These are mounted close to the AHU and disinfect contaminated air before air enters any rooms served by the AHU.

The UV lights are on whenever the AHU is operating. Unlike the three other ducted microbial mitigation systems, UVGI is considered safer since it does not need any controls to limit output, as it is non-toxic. In large duct systems with some rooms hundreds of feet away from the generator and other rooms with 30 feet, room concentration sensing could be difficult to control to keep all rooms within limited minimum and maximum concentration ranges. One downside is the cost to replace UVGI bulbs which typically last 1 year.

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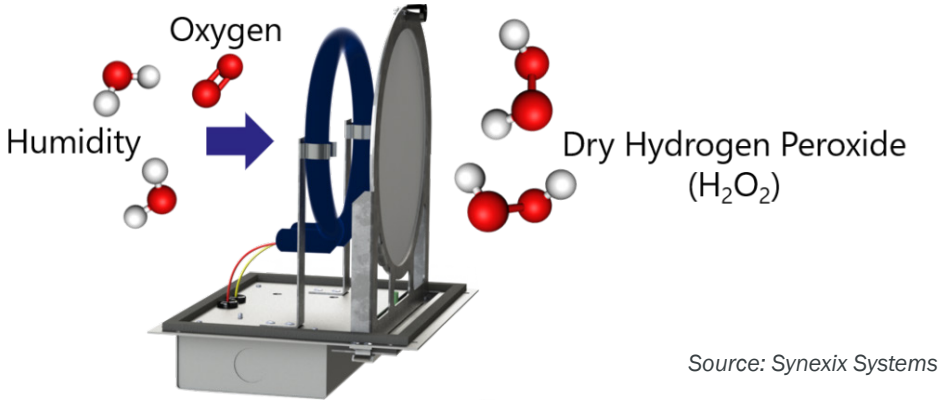
DRY HYDROGEN PEROXIDE

The third technology, Dry Hydrogen Peroxide (DHP) Generation, is more of a distributed system and can't be centrally located, as the generators need to be located close to the rooms served and thus sanitize not only the ducts near the diffusers to the rooms, but also the rooms themselves. Do not confuse DHP with gaseous Hydrogen Peroxide that has been used for over 50 years to sanitize critical areas such as animal facilities. The limitation of gaseous Hydrogen Peroxide has been that the room couldn't be occupied while it was being sanitized. This is not a problem with DHP technology which has been around for over 10 years and has proven to be a safe system to use while the building is fully occupied. It can be used for all types of buildings where only certain areas would need continuous sanitization, such as conference or board rooms, waiting rooms, cafes, etc. For healthcare facilities, additional areas that could be sanitized would be isolation rooms, common corridors, nursing stations, ER, and other areas where continuous sanitization would be very important.

This technology has not been commented on by ASHRAE. Using DHP, this microbial reduction technology allows for the natural and continuous reduction of microbial contamination in the air as well as on surfaces within occupied spaces, even in out of reach areas. The technology is available in portable devices for spaces with a low volume of supply air. There is also a duct mounted system that can fit into existing ductwork with adaptors. These devices are located in the duct no more than 20 feet from the diffusers of the rooms being served and once powered, will work whenever the associated air handling unit is operating.

The critical differentiator of DHP from other forms of hydrogen peroxide is that DHP can be safely delivered in occupied spaces at between 5 and 25 ppb, well below the 1,000 ppb OSHA TWA for 8 hour exposure. DHP when located close to the area being served is effective for reducing contaminants such as viruses, bacteria, mold, and even volatile organic compounds (odors).

All microbes require water from the environment to survive. Hydrogen peroxide molecules (H_2O_2) are structured similarly to water (H_2O). By encompassing all rooms and enclosed spaces served with low levels of DHP, it can reach all locations where microbes can be located. Once attached, the microbe breaks down naturally.



Source: Synexix Systems

Dry Hydrogen Peroxide (DHP) Technology is designed to provide prophylactic mitigation of broad-spectrum pathogens including viruses, bacteria, and fungi from the moment they are introduced, even if their introduction is unrecognized by a facility. Although no longer capable of pathogenic infection, affected fungi can still cause allergic response. The catalysts (discharge screens) requires quarterly (four/year) replacement involving ceiling tile removal and replacement through duct access doors.

DHP PERFORMANCE TABLE

Germ	Microbial Load (Organisms per Square Inch)	Test Time (Hours)	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%

Source: Synexis

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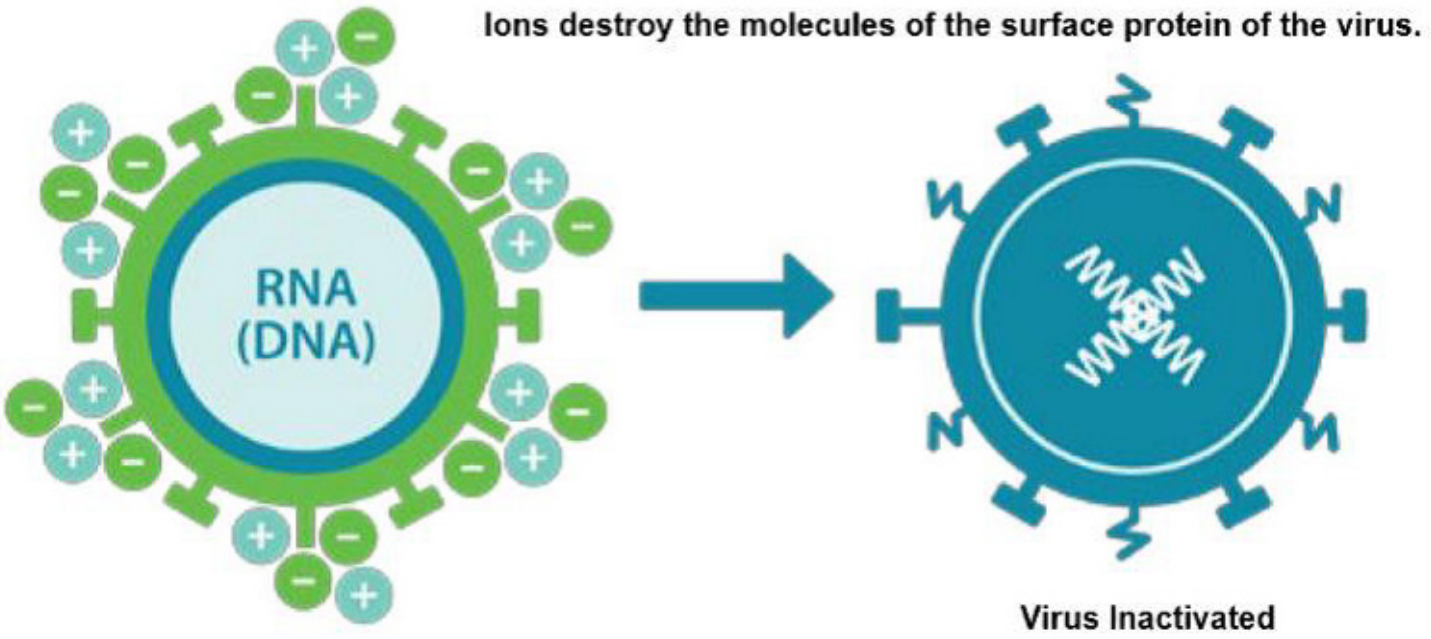
BIPOLAR IONIZATION GENERATION

Bipolar Ionization (BPI) technology for duct mounting has been around for a couple of decades. The process claims to inactivate viruses as well as bacteria, mold spores and other microorganisms. BPI generation is an active indoor air purification system, which works by generating bipolar ions that are then carried into occupied spaces via the duct systems. The system attempts to sanitize the air by saturating the space people occupy with negative and positive ions thus providing continuous disinfection to the air and surfaces. There are different ways to generate the ions. One method is to use tubes (not UV type). These tubes will need replacement every two years.

BPI can also be used in AHUs to keep the cooling coils disinfected (like UV lights). However, the generator would be located between the filters and the cooling coil, rather than after the cooling coils like UV lights. The mechanisms used to inhibit infection by viruses (and similar microorganisms), airborne and on surfaces are reportedly as follows:

- Positive and negative ions surround the surface membrane of the airborne virus.
- Through a chemical reaction occurring on the virus membrane surface, ions are transformed into highly reactive OH groups called hydroxyl radicals. Hydroxyl radicals steal hydrogen from the spine-like proteins that protrude from the surface of the virus membrane, opening holes in the membrane.
- The ions destroy the virus surface structure, its envelopes and spikes, on a molecular level. As a result, the virus cannot infect even if it enters the body.

BPI also claims to improve air cleanliness by agglomerating particles, dust, and allergens into larger particles where they are more efficiently trapped by air system filters and/or drop to the floor out of our breathing zone. Notably, these particles can still be picked up by touching these surfaces. There is also an effect on gaseous contaminants, volatile organic compounds which are hydrocarbon chains. The ions in a gas phase process break down these chains into carbon dioxide and water vapor.



Source: AtmosAir Solutions

Unfortunately, ASHRAE states in their recently updated Position Document on Infectious Aerosols (April 14, 2020) that "Bipolar Ionization Systems have been documented to range from relatively ineffective to very effective in reducing airborne particles. Systems have been evaluated to either show benefits or no benefits for acute health symptoms. A convincing body of scientifically-rigorous, peer-reviewed studies does not currently exist on this emerging technology; so manufacturer data should be carefully considered."

Some BPI manufacturers state that they have documented 3rd party studies and that ASHRAE will be looking into these in the future.

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OZONE GENERATION

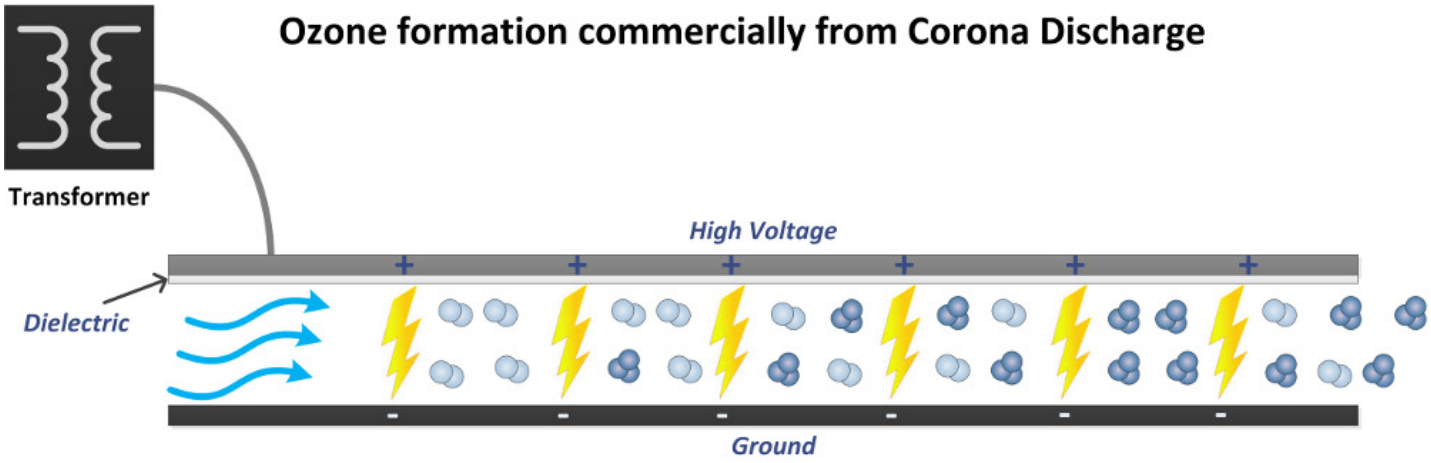
Ozone is enriched oxygen (O_3). The benefits of using ozone for sanitizing a building are due to its oxidizing and germicidal properties. Ozone kills micro-organisms by breaking down their protein structure. It neutralizes bacteria, viruses, molds, fungi, yeasts, mildew, amoebae and algae, including pathogenic and non-pathogenic germs.

Ozone also deodorizes many organic and inorganic odors, both gases and small particulate. It does this by a process of oxidation, permanently converting the odor into water vapor, and other compounds such as carbon dioxide. It also leaves no chemical residue as ozone and will eventually decompose back into oxygen. Since it is generated on site, the safety problems associated with liquid disinfectant storage, handling and transportation are nullified.

Ozone generators are available for installation as an integral part of the duct system on a permanent basis. By injecting the correct ozone concentration, they destroy microorganisms and odors, both in the duct system as well as in the space/room served by the duct system.

What is the correct concentration of ozone? ASHRAE recommends 10 ppb (maximum) for occupied spaces. However, ASHRAE and the EPA both state that to be effective, the ozone level would need to be well above the "public health standards" limit and thus they do not recommend that ozone be added to any occupied buildings.

The most common method of producing ozone commercially and industrially is electrical discharge, or corona discharge. A corona discharge is simply a diffused spark through a dielectric to spread out the electrical discharge to a large area for maximum efficiency. Corona discharge ozone generators typically use: a corona cell using a dielectric material which may be glass, ceramic, or quartz; high voltage transformer to increase voltage of the electrical discharge; and a power supply to regulate power to transformer. Advantages of corona discharge ozone generators are scalable to create large amounts of ozone, cost effective for long term operation, and low maintenance.



Ozone is formed via an electrical discharge that is diffused over an area using a dielectric to create a corona discharge. Oxygen passed through this corona discharge is converted to ozone.

Source: Oxidation Technologies, LLC

Unfortunately, ASHRAE states in their recently update Position Document on Infectious Aerosols (April 14, 2020) that Ozone is harmful for health and exposure to ozone creates risk for a variety of symptoms and diseases associated with the respiratory tract. ASHRAE's Environmental Health Committee issued an emerging issue brief suggesting "safe ozone levels would be lower than 10 ppb" and that "the introduction of ozone to indoor spaces should be reduced to as low as reasonably achievable (ALARA) levels." It should only be considered for disinfection on unoccupied spaces, and it should never be used in occupied spaces. Available scientific evidence shows that, at concentrations that do not exceed public health standards, ozone is generally ineffective in controlling indoor air pollution. The EPA states on their website article Ozone Genera- tors that are Sold as Air Cleaners that: "If used at concentrations that do not exceed public health standards, ozone applied to indoor air does not effectively remove viruses, bacteria, mold, or other biological pollutants. Some data suggests that low levels of ozone may reduce airborne concentrations and inhibit the growth of some biological organisms while ozone is present, but ozone concentrations would have to be 5 - 10 times higher than public health standards allow before the ozone could decontaminate the air sufficiently to prevent survival and regeneration of the organisms once the ozone is removed."

As a firm that specializes in HVAC system design, we are here to help determine what cost-effective options are available for modifying your building's air handling systems so they can provide a more sterile environment for your occupants.

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