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VIRUS-FILTERING/ERADICATION TREATMENTS AND THEIR APPLICABILITY TO HVAC SYSTEMS

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Introduction

The current global pandemic is focusing attention on the health of our indoor environments. At Altieri, we are looking even more closely at options available in the design of building systems that will have long-term implications for healthier spaces. The following discussion describes four commercially available treatments that can mitigate the transmission of airborne viruses/disease through building mechanical systems.

Particulate Filtration

By now, everyone is familiar with N95 masks. The reason they have gained popularity in the COVID-19 pandemic is their ability to filter 95% of particles that are at least 300 nm (0.3 micron) in diameter. Most of these respirators also use electrostatic fibers to enhance filter efficiency and reduce pressure drop across the mask filter.[1] Research has shown that the droplet size of sneezes, coughs, and breath vary widely, with coughs and sneezes in the range of 1-2000 micron. Breath, however, produces particles under 1 micron in diameter with some testing showing particles under 0.3 micron.[2]

Particulate filters for HVAC systems work the same way as facemasks. A bank of filter media is placed inside an air handling unit and captures particles as they move through the airstream. The efficiency of the filter is measured by a Minimum Efficiency Reporting Value (MERV) rating, defined by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 52.2.

When it comes to particulate filtration, there is an economic balance between filter efficiency and operating costs. Operating costs include fan energy to move air across filters and actual cost of filters. Retrofitting an existing filter bank with more efficient filters may also increase pressure drop beyond which the existing fan is sized. Typical filter life is 1-3 months, depending on the environmental conditions, before it gets loaded with particles and requires change.

Leadership in Energy and Environmental Design (LEED®) standards maintained by the U.S. Green Building Council recommend a MERV for buildings undergoing certification.[3] Table 1 below indicates MERV ratings and particle size efficiency (PSE) – the ability to capture particles – for particles at 0.3-1.0 micron range.[4][5]

Table 1:

MERV	PSE (%)	Notes
11	20%	LEED Baseline Filtration
13	50%	LEED Enhanced Filtration
16	95%	Considered efficient at capturing airborne viruses. (Same as N95 Mask)
HEPA	99.97%	Come with high pressure drop and require filter bank to be sealed for full efficiency.*

*There are several filters on the market advertised as High Efficiency Particulate Air (HEPA) filters that have not undergone certified test procedures. Beware of products labeled “HEPA Type,” and “up to 99.9% efficiency.” These terms are deceiving and do not come with certification or indicate particle size treated.

Filters are tested at the 0.3-1.0 micron range because this is considered the most difficult particle size to capture. Particles smaller than 0.3 micron are subject to Brownian motion, a physical phenomenon that results in erratic particle motion in the airstream. This motion causes the microscopic particles to impinge on the filter media, thereby increasing filter efficiency in this smaller particle size.

Polarized Particulate Filtration

Polarized particulate filtration builds on particulate filter technology and utilizes an active high DC voltage to create an electrostatic field inside the filter. This field is used to attract particulates to the filter media. Particulate filtration is achieved by a single stage filter that provides MERV 13-15 performance. The filter system is classified as an electronic air cleaner, but it utilizes non-ionizing, non-ozone producing electronic polarization only across the filter media. The filter media itself (without electronic operation) is rated for MERV 13 per ASHRAE 52.2 test. In real world conditions, the system has been tested to achieve MERV 15 performance. The filters have extremely high dust loading capacity at low pressure drops, resulting in much longer replacement periods as compared to typical particulate filters. Typical product life is 2 years, but may vary based on the environment.

Bipolar Ionization

While particulate filtration collects particles in the air, bipolar ionization works by charging the particles in the air to produce positive and negative ions. With bipolar ionization, the molecules in the airstream pass through an ion field damaging virus DNA.[6] Molecules also break down and regroup into more benign gasses, and attract oppositely charged ions, becoming larger and heavier. When the ionized particles combine inside the occupied space, particles subject to Brownian motion that were previously too small to get drawn into the HVAC system will agglomerate with the polarized particles and drop to the surface or get pulled into the HVAC system. The heavier particles then get trapped at the air handling unit filter.

The bipolar ionization equipment can be located inside the air handling unit either upstream of the cooling coil for coil cleaning, or at the discharge plenum for space cleaning. Typical product life is 2 years.

Bipolar ionization systems have also been used as part of ASHRAE 62.1 Indoor Air Quality Procedure by reducing gas phase contaminants to levels equivalent to that required by the ASHRAE's Ventilation Rate Procedure while optimizing the amount of outside air taken into the building. The contaminates targeted by bipolar ionization include carbon dioxide, VOCs, mold, bacteria, and viruses.

High voltage equipment has the adverse effect of producing ozone, and bipolar ionization products also have the potential to create ozone. The ASHRAE Position Document on Filtration and Air Cleaning acknowledges there is little information known of the effects of exposure to low concentrations of ozone, and advises against ozone-producing products even below the threshold values of 10 PPB previously recommended by ASHRAE.[7]

Many products on the market limit the ozone production of the equipment to nearly negligible quantities of ozone. Applicable UL listings for this technology include UL867 (Electrostatic Air Cleaners), which includes ozone test requirements, and UL2008 (Environmental Claim Validation Procedure (ECVP) for Zero Ozone Emissions from Air Cleaners). UL867 allows ozone concentrations of 50 PPB. Owners and designers should note that the concentration limit set by UL867 label is significantly above the ASHRAE threshold. Homework should be done to ensure that the device is not merely meeting the listing, but also limiting ozone production to almost zero. Verification can be provided with the use of a portable ozone detector.

Ultraviolet Germicidal Irradiation (UVGI)

Ultraviolet light, specifically UVC light, has historically been used in the healthcare industry to irradiate and damage the DNA of viruses.[8] UVC lights can be located either in the upper portion of the occupied space or inside the HVAC system. We focus here on the application of the light within the HVAC system.

Wavelength selection is important. High wavelengths found in UVA and UVB light are the most damaging and can cause skin cancer. Low wavelengths are less damaging, but produce ozone below 240 nm. For the purpose of this discussion, we focus on UVC 245 nm which is outside of the ozone producing spectrum. UVGI disinfection rate is a function of several factors, including dosage, air velocity, temperature, relative humidity, exposure time, and lamp life. Lamp output is dependent on mercury vapor pressure within the lamp and is affected by both air velocity and air temperature. If the pressure gets too low or too high due to temperature, the lamp cannot produce full UV radiation. Air velocity is a factor because it can lower vapor pressure due to windchill. Lamp aging also plays a factor in effectiveness with reduced outputs when nearing end of life.

The lamp location inside the HVAC unit is similar to that of bipolar ionization. Lamps can be located either upstream or downstream of the cooling coil. Locating the lamp upstream of the cooling coil requires fewer lamps for disinfection due to the moderate air temperature. Locating the lamp downstream of the coil can keep the coil and drain pan clean, but the lower temperature requires more lamps to provide the same output. Lamps located in the air handling unit can degenerate components in the light path including filters and door seals. Another location for UVC lamps is in the supply air duct. Temperature and windchill are still a factor, so the ducts should be sized to minimize air velocity, but air handling unit components would be protected.

Extreme caution must be exercised to avoid eye and skin exposure to UVC. Signage should be installed at the equipment location, and proper protective gear should be worn. Lamps should also be visually inspected regularly for dirt or dust and cleaned when dirty to optimize performance. The best way to measure lamp output is with a UVC light intensity meter. Blue light does not equal UVC light. Lamps should be replaced annually. Care should be taken with lamp disposal due to mercury content.[9]

Combining Technologies

HVAC systems are not limited to one indoor air quality treatment or technology. Systems can benefit from combined filtration including particulate filtration paired with bipolar ionization or particulate filtration paired with UVGI. Each facility has different needs, and there are different treatments to get to the end goals of filtration, efficiency, and maintenance criteria.

Conclusion

Building mechanical systems can increase indoor air quality and reduce the spread of viruses. Particulate filtration and polarized particulate filtration work by trapping the virus and preventing it from recirculating into the space. Bipolar ionization and UVGI work by damaging or killing the virus in the HVAC system. These technologies increase indoor air quality without increasing ventilation rates and the incurrence of associated energy costs. Altieri can help guide building owners to an individualized treatment to best suit the needs of each building.

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References:

[1] Effect of Particle Size on Performance of an N95 Filtering Facepiece Respirator and a Surgical Mask at Various Breathing Conditions. Aerosol Sci Technol. 2013;47(11):1180-1187. doi: 10.1080/02786826.2013.829209. Epub 2013 Aug 20.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6756464/

[**2] Characterizations of particle size distribution of the droplets exhaled by sneeze.** J R Soc Interface. 2013 Sep 11;10(88):20130560. doi: 10.1098/rsif.2013.0560. Print 2013 Nov 6.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3785820/

[3] LEED® Reference Guide for Building Design and Construction Version 4.

[4] National Air Filtration Association. Understanding MERV
https://www.nafahq.org/understanding-merv-nafa-users-guide-to-ansi-ashrae-52-2/

[5] United States Environmental Protection Agency
https://www.epa.gov/indoor-air-quality-iaq/what-merv-rating-1

[6] Cleaning Indoor Air using AtmosAir Bi-Polar Ionization Technology. Dr. Philip M. Tierno Jr., Professor of Microbiology and Pathology, New York University School of Medicine, April 2017.
http://atmosair.com/wp-content/uploads/2017/04/Cleaning-Indoor-Air-Using-AtmosAir-Bi-Polar-Ionization-Technology_Dr.-Philip-Tierno-Jr_NYU-Professor_2017.pdf

[7] ASHRAE Position Document on Filtration and Air Cleaning. Reaffirmed by Technology Council January 13, 2018
https://www.ashrae.org/File%20Library/About/Position%20Documents/Filtration-and-Air-Cleaning-PD.PDF

[8] A history of Ultraviolet Germicidal Irradiation for Air Disinfection, Nicholas G Reed
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2789813/

[9] 2016 ASHRAE Handbook – HVAC Systems and Equipment
https://www.ashrae.org/file%20library/technical%20resources/covid-19/i-p_s16_ch17.pdf