AIR-CLEANING AND FILTRATION: ADDRESSING THE UNSEEN IN THE "NEW NORMAL"

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The world has changed in the wake of the COVID-19 pandemic. Business leaders are working to understand a "new normal" that may involve profound changes in how they manage and support their people.

For building owners, the need to minimize disease transmission will impact every aspect of the built environment. Many questions have yet to be answered. Will office spaces need to be reconfigured to enhance social distancing? How will occupants access enclosed spaces such as elevators, or common areas such as kitchens and cafeterias? Will buildings require earlier openings and later closings to accommodate rotating workforces?

One thing seems certain: Employees returning to the office will have new expectations for the health and safety of their workplaces.

Fortunately, building owners and engineers can respond effectively to these challenges. By reimagining buildings as barriers to contamination, owners can take steps now to enhance the built environment in ways that will have a meaningful impact on occupant health and well-being. "Our buildings and the people who tend them are our first line of defense for keeping us safe and healthy," says Rachel Gutter, president of International WELL Building Institute, which recently launched the WELL Health-Safety Rating, an evidence-based, third-party verified rating for all building and facility types focused on addressing a post COVID-19 environment.[1]

This white paper provides recommendations and suggested resources for building owners and engineers on how to approach occupant reentry, with a special focus on the optimization of HVAC systems to reduce the transmission of SARS-CoV-2, the novel coronavirus responsible for COVID-19. Specifically, we describe:

- Resources that provide comprehensive guidance for building reentry planning
- Resources and recommendations to enhance building health
- HVAC systems and air-filtration technologies that can be deployed quickly and affordably to refresh existing buildings: What are they? How are they used? What are their strengths and weaknesses?

Buildings have become a first line of defense in reducing the transmission of an unseen but lethal viral threat. HVAC systems play a critical role in this defense. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) concludes that "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."[2] For building owners and engineers, optimizing these systems generally, and through the adoption of specific air-filtration solutions, can effectively reduce the risk of pathogen transmission, improve the health and comfort of occupants, and maintain the profitability and competitiveness of their building operations.

Undertake Comprehensive Planning for Occupant Reentry

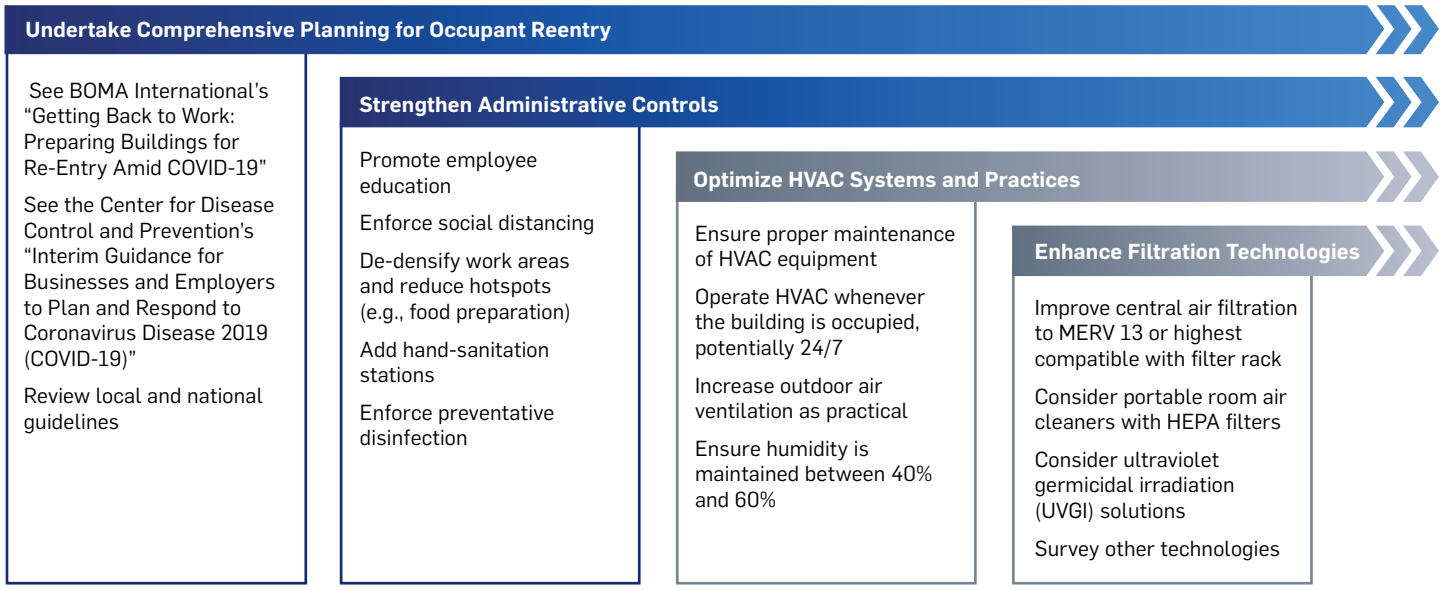
Now is the time for building owners and engineers to undertake comprehensive planning for occupant reentry.

The Building Owners and Managers Association (BOMA) International has issued a multi-step operating guide, "Getting Back to Work: Preparing Buildings for Re-Entry Amid COVID-19," to ready commercial buildings for the safe return of office tenants, building personnel, visitors, vendors and contractors.[3] This document includes suggested best practices for the safe use and occupancy of elevators, common areas and amenity spaces, shared equipment and supplies, janitorial services, security, signage, emergency preparedness and insurance, as well as legal considerations and additional sources of information. Assemble your team, communicate with stakeholders, assess risk, stay informed and, as BOMA recommends, start now.

In addition to guidance from BOMA, the Centers for Disease Control and Prevention (CDC) offers strategies for reducing transmission of COVID-19 in the workplace.[4] The CDC's focus is on maintaining healthy business operations and a healthy work environment — and on staying nimble. "Employers should plan to respond in a flexible way to varying levels of disease transmission in the community," the CDC recommends, "and be prepared to refine their business response plans as needed."

Both BOMA and CDC emphasize the need to consult with state and local health officials, and both update their guidance on a regular basis as new information and best practices develop.

Optimizing Health and Comfort in the "New Normal" Built Environment



Strengthen Administrative Controls

The built environment is complicated. The risk of pathogen transmission varies by factors such as occupant density, individual accountability for social distancing and hand-washing, the use of appropriate personal protective equipment and disinfectant practices. While there is no guaranteed solution to protecting employee health, planning, responsible choices and vigilance by both building owners and occupants are essential.

The Healthy Buildings Program at the Harvard T. H. Chan School of Public Health offers a "layered" strategy to minimize disease transmission in the workplace.[5] The first layer of defense requires the committed enforcement of work-from-home policies. Once the main workforce is approved for reentry into a building, however, strengthening administrative controls becomes a crucial step in protecting occupant health. Administrative controls may include promoting employee education, enforcing social distancing, de-densifying work areas and reducing food preparation areas and other potential transmission hotspots, adding more hand-sanitation stations and enforcing a rigorous program of preventive disinfection.[6]

For information on this layered approach to building health, the Harvard T.H. Chan School of Public Health offers "The 9 Foundations of a Healthy Building."[7] In addition, the American Society for Microbiology's (ASM) "2019 Novel Coronavirus (COVID-19) Pandemic: Built Environment Considerations to Reduce Transmission" provides up-to-date information on mediation strategies for SARS-CoV-2 transmission based on the most current research on pathogen exchange in the built environment.[8]

Alongside these administrative controls, owners and engineers must also focus on ways to enhance the underlying healthiness of their building's environment. Central to this effort is an emphasis on improving ventilation, air quality, humidity and thermal health. ASHRAE has concluded that a prerequisite to any strategy for the control of infectious disease in the built environment "is a well-designed, installed, commissioned, and maintained HVAC system."[9] Optimization of these systems is a priority in meeting the COVID-19 threat.

Optimize HVAC Systems and Practices

There are several commonsense steps[10] that building owners and engineers can undertake to enhance the effectiveness of their HVAC system in reducing transmission of disease. These steps include the following:

- Operate the HVAC system whenever the building is occupied, including for off-hours cleaning, engineering, security and support staff. If practical, keep the system running 24x7 to ensure optimum building ventilation.
- Increase outdoor air ventilation (using caution in areas with pollution), disable demand-controlled ventilation and open minimum outdoor air dampers as high as 100% if weather and other factors allow. A recent study found that improving ventilation by supplying even minimum levels of outdoor air reduced influenza transmission as much as having half of a building's occupants vaccinated.[11]
- Ensure that humidity is maintained between 40% and 60%, a range that may help to limit the spread and survival of SARS-CoV-2, the ASM reports, "while minimizing the risk of mold growth and maintaining hydrated and intact mucosal barriers of human occupants."
- Review, upgrade and add filtration technologies to improve air quality and reduce the transmission of particles and disease. These steps may include:
  - Improving central air filtration to MERV 13 or the highest compatible with the filter rack, while sealing the edges of the filter to limit bypass
  - Considering the use of portable room air cleaners with HEPA filters
  - Considering the use of ultraviolet germicidal irradiation (UVGI) solutions

Adoption of air-filtration technologies recognizes that the use of outdoor air for ventilation may be limited by extreme weather or by the degree of contaminants in the outdoor air itself. The appropriate filtration technology can provide building owners and engineers with a powerful tool to substantially improve indoor air quality (IAQ). By reducing contaminants in both outdoor air *and* in recirculated indoor air, building owners can reach an optimum balance between IAQ, energy consumption, and occupant safety and comfort. The section below describes some of the most common, affordable and effective of these air-filtration solutions.

Enhance Filtration Technologies

While epidemiologists are still learning how SARS-CoV-2 is spread, current research combined with knowledge of past influenza outbreaks indicates that the virus is most often transmitted through droplets and aerosolized particles. These droplets range in size from .004 to 1.0 microns and can be shared person to person, by contact with infected surfaces and through transfer by air.[12]

HVAC systems use mechanical filters made of porous materials in a variety of densities to trap airborne particles. The effectiveness of any filtration solution depends upon the filter's efficiency (measured by the minimum efficiency reporting value, or MERV), the number and location of filters used in series, the rate of airflow and the size of the particles intended to be trapped. Some filters may be capable of capturing a combination of particles, gases or airborne biological contaminants, though the most common air-filtering solutions involve the use of several types of filters working in series. MERV ratings provide a scale for ranking filters designed to capture particles ranging in size from 10 microns to as small as .3 microns.

One standardized measure, PM2.5, refers to particles smaller than 2.5 microns, believed to have a significant adverse impact on chronic health. "PM2.5 is also the most straightforward contaminant to remove from indoor environments through filtration," ASHRAE's Rick Karg says.[13] ASHRAE recommends MERV 13 or higher to capture these ultrafine particles. Additional research indicates that MERV 16 filters are able to remove about 95% of PM2.5 particles.[14]

Most residential and commercial buildings utilize filters up to MERV 12, while clean rooms, surgery suites, isolation wards and other medical, industrial and commercial high-risk facilities use MERV 13 rated filters or higher. High-efficiency particulate air (HEPA) filters have MERV values of 17 to 20, with MERV 17 HEPA filters able to remove 99.97% of particles down to .3 microns in size.

Filtration Technology[15]	Applications	Methodology	Advantages and Limitations in Addressing SARS-CoV-2 Virus Capture
Media filters (MERV 1-16)	Residential, many commercial and industrial	Captures particulates	+ Simple installation + MERV 16 and higher effective against PM2.5 – Largely ineffective against particles the size of SARS-CoV-2
HEPA filters (MERV 17-20)	Clean rooms, surgery suites, isolation ward, high-risk facilities	Captures particulates	+ Effective against particles that carry SARS-CoV-2 – May increase energy use – May require HVAC system modifications
UVGI (GUV) and media filters	Commercial buildings, healthcare, residential	Degrades and inactivates virus, captures particulates	+ Ideal for augmenting HEPA filtration systems – May require HVAC system modifications

A review of air-filtration efficiencies suggests that even the highest-rated filters are incapable of capturing particles the size of the COVID-19 virus. However, the ASM notes that "viruses are rarely observed as individual particles, but instead are expelled from the body already combined with water, proteins, salts, and other components." To date, ASM reports, "SARS-CoV-2 has been observed in aerosolized particles in a spectrum of sizes including 0.25 to 0.5" microns.[16] Consequently, the deployment of highly rated MERV and HEPA filters can play a substantial role in capturing particles infected by SARS-CoV-2 and reducing the risk of disease transmission throughout the built environment.

Many buildings use inexpensive filters designed to capture less than 20% of virus-sized particles.[17] Depending upon the age and type of HVAC installation, high-efficiency filters may represent a quick and affordable retrofit. Building owners should rely on expert engineering advice when making this decision.

A second effective solution to improving air quality and reducing the transition of COVID-19 is ultraviolet germicidal irradiation (or UVGI, sometimes shortened to germicidal UV, or GUV), which works by degrading and inactivating bacteria, mold spores, fungi and viruses. The typical source of ultraviolet disinfection is a low-pressure mercury vapor lamp which provides radiant energy in the spectral band known as UV-C, from 200 to 280 nanometers. One study has demonstrated that 10 minutes of UV-C light inactivated 99.999% of CoVs tested, including SARS-CoV-2.[18]

Researchers at the Illuminating Engineering Society have concluded that GUV "can be most effectively used to disinfect air in the upper room [air above 7 feet] where ceiling height permits." Medical facilities have also employed GUV in mobile units, and in HVAC air-handling units to reduce mold growth on cooling coils.[19] UV germicidal emitters may also be installed on the supply side of an HVAC system downstream from the cooling coil and above the drain pan for effective biofilm and microbial control.[20]

UVG is an effective but specialized solution used to enhance a fully optimized HVAC system.

Conclusion

Experts believe that the effects of COVID-19 will be long-lasting. "Exactly how long remains to be seen," epidemiologist Marc Lipsitch says, but "it's not a matter of getting past the peak, as some people seem to believe."[21] Building owners and HVAC engineers should take steps now to ready their buildings for occupant reentry, and to create the platform for a healthy, sustainable environment.

Adoption of a layered strategy reflects the complexity of the built environment and relies on both building owners and occupants to contribute to one another's health and well-being. Important to this strategy is a review and possible refresh of a building's HVAC system, including the addition of air-filtration solutions. "There's just no reason anymore to economize on airflow and filtration," Harvard Business School's John Macomber says. "It's a cheap way to help people be healthier."[22] In the new normal, a healthy building will be the minimum acceptable for building owners to remain competitive.

Mechanical filtration, UVGI and other air filtration technologies that building owners may wish to investigate, including electronic particle air cleaners, sorbent air cleaners and air cleaners using photocatalytic oxidation, are described in the "ASHRAE Position Document on Filtration and Air Cleaning."[23] Carrier has also summarized solutions and best practices in its Carrier Engineering Newsletter, "Meeting IAQ Needs with Enhanced Filtration."

Engineers are key to optimizing HVAC systems that reduce disease transmission while optimizing energy consumption and occupant comfort. Carrier experts are available to consult on these important decisions.[24]

Suggested Additional Resources

"Getting Back to Work: Preparing Buildings for Re-Entry Amid COVID-19," BOMA International, April 28, 2020, https://www.boma.org/BOMA/Research-Resources/3-BOMA-Spaces/Newsroom/Press_Room/2020/Getting_Back_to_Work.aspx

"Interim Guidance for Businesses and Employers to Plan and Respond to Coronavirus Disease 2019 (COVID-19)," Centers for Disease Control and Prevention, March 21, 2020, https://www.cdc.gov/coronavirus/2019-ncov/community/guidance-business-response.html

"The 9 Foundations of a Healthy Building," Harvard T.H. Chan School of Public Health, 2020, https://dev.forhealth.org/

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Lawrence J. Schoen, "Guidance for Building Operations During the COVID-19 Pandemic," *ASHRAE Journal Newsletter*, March 20, 2020, https://www.ashrae.org/news/ashraejournal/guidance-for-building-operations-during-the-covid-19-pandemic

"ASHRAE Position Document on Airborne Infectious Diseases," Approved by ASHRAE Board of Directors January 19, 2014, Reaffirmed by Technology Council February 5, 2020, Expires August 5, 2020, ASHRAE, Atlanta, GA, https://www.ashrae.org/file%20library/about/position%20documents/airborne-infectious-diseases.pdf

"How to Operate and Use Building Services in Order to Prevent the Spread of the Coronavirus Disease (COVID-19) virus (SARS-CoV-2) in Workplaces," REHVA COVID-19 Guidance Document, April 3, 2020, https://www.rehva.eu/fileadmin/user_upload/REHVA_COVID-19_guidance_document_ver2_20200403_1.pdf

"Meeting IAQ Needs With Enhanced Filtration: A Review of ASHRAE Standards Related to Building Air Quality," *Carrier Engineering Newsletter*, Volume 5, Issue 1, Carrier Corporation 2017, https://www.shareddocs.com/hvac/docs/1001/Public/0E/ENG_NEWS_5_1_1.pdf

"ASHRAE Position Document on Filtration and Air Cleaning," Approved by ASHRAE Board of Directors January 29, 2015, Reaffirmed by Technology Council January 13, 2018, https://www.ashrae.org/file%20library/about/position%20documents/filtration-and-air-cleaning-pd.pdf

"IES Committee Report: Germicidal Ultraviolet (GUV) – Frequently Asked Questions," IES Photobiology Committee, Illuminating Engineering Society, 2020, Web May 14, 2020, https://media.ies.org/docs/standards/IES%20CR-2-20-V1a-20200507.pdf

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