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A GUIDE FOR BUILDING OWNERS & PROPERTY TEAMS

Indoor Air Quality and COVID-19 Transmission

Indoor air quality (IAQ) has changed from a base contractual obligation focused on comfort to now include tenant safety with both operating and capital cost implications. This white paper will help you understand the risks presented by COVID-19 and provide guidance on air filtration requirements and recommendations. It also outlines ways to improve your current operations to meet tenant comfort and safety requirements while balancing financial and energy impacts.

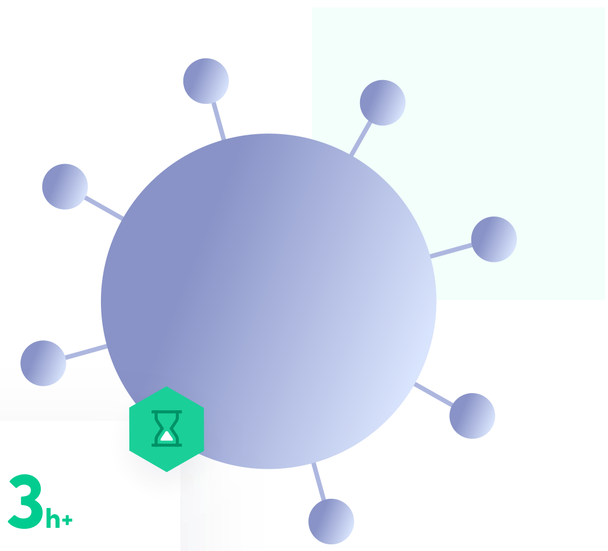
Some of the key questions this paper will answer:

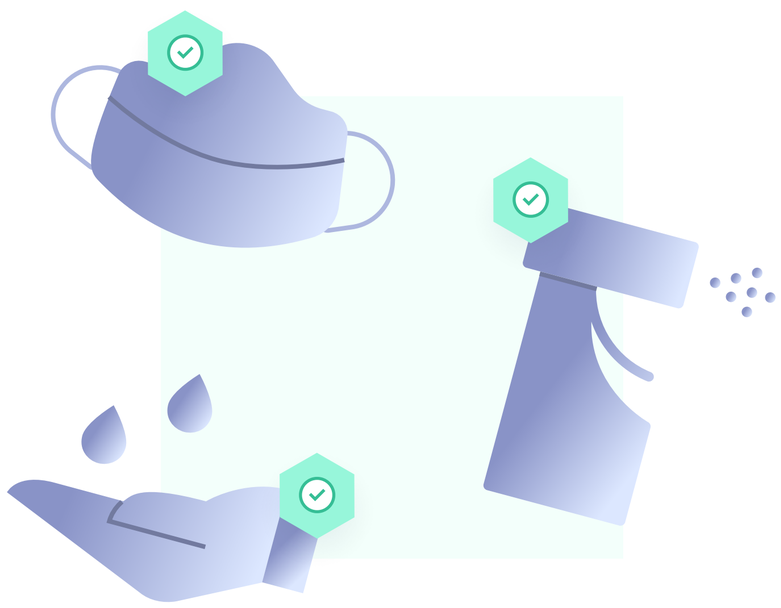
- HOW ARE VIRUSES LIKE COVID-19 ACTUALLY TRANSMITTED?
- WHAT INDOOR AIR QUALITY GUIDELINES AND STANDARDS ARE CURRENTLY IN PLACE?
- WHAT CHANGES DO I NEED TO MAKE TO PROVIDE IMPROVED IAQ TO MY TENANTS?
- WHAT CAN I DO TO HELP MY TENANTS BE CONFIDENT THAT IT IS SAFE TO RETURN TO WORK?
- WHAT DO I NEED TO KNOW ABOUT IAQ AND FILTRATION?

The New Age of Indoor Air Quality

Indoor air quality—and its impact on health—has been a topic of conversation for decades in the commercial real estate market, with a focus on dampness and mold, low ventilation rates, and off-gassing from carpet, furniture, and paint.

However, now the discussion has turned to COVID-19 and its highly contagious transmission via droplets or aerosolized particles when a person talks, coughs, or sneezes. **The virus can live for up to three hours in these forms.**





The six-foot social distancing guideline is generally accepted as proper distancing to remain outside of the “splash zone” for droplets, as they are heavier and fall to surfaces more quickly. However, aerosols are much smaller in size (less than five microns or micrometers), remain airborne for extended periods of time, and can travel much farther. Research has shown these aerosols can travel over 20 feet from a sneeze or cough, and numerous medical experts have said that a high percentage of infections could be attributed to this method of transmission.

The US Center for Disease Control (CDC), World Health Organization (WHO), and other leading health organizations have provided guidance on precautions to help reduce transmission such as face masks, frequent hand washing, and thorough cleaning of surfaces. Those in higher-risk roles are advised to go a step further with personal protective equipment (PPE). However, medical professionals do not have the requisite expertise to provide guidance on how to address IAQ.

Guidance from Industry Experts

Organizations like ASHRAE and BOMA, who do have expertise in IAQ, have provided their own recommendations to address this topic as it relates to the transmission of COVID-19 within buildings.

> "Ventilation and filtration provided by heating, ventilating, and air-conditioning systems can reduce the airborne concentration of SARS-CoV-2 (COVID-19) and thus the risk of transmission through the air."

April 20, 2020.

"ASHRAE Issues Statements on Relationship Between COVID-19 and HVAC in Buildings" statement. [1]

> "Check with your building engineers and HVAC contractor for any other recommended maintenance, changes in maintenance schedules, or filter or system upgrades or changes."

May 1, 2020.

"Getting Back to Work: Preparing Buildings for Re-Entry Amid COVID-19", BOMA International [2]

> "Review HVAC programming to provide flushing two hours before and post occupancies. This includes operating the exhaust fans as well as opening the outside air dampers. For buildings without the capacity to treat large quantities of outside air and when outside air conditions are moderate, open all windows for a minimum of two hours before reoccupation."

May 7, 2020.

"ASHRAE Offers COVID-19 Building Readiness/ Reopening Guidance" [3]

The guidance is that proper, and most likely, upgraded HVAC filtration capabilities are critical to providing a safer environment for tenants and building employees. Additionally, when and where possible, an increase in outdoor air intake is recommended.

How the Virus is Transmitted: A Numbers Game

= Exposure to Virus × Time

It is critical to understand the science behind how viruses are transmitted in order to understand what can be done to help address the challenges with IAQ. Comparative immunologist and Professor of Biology at the University of Massachusetts Dartmouth, Erin Bromage, provides poignant and insightful guidance in her blog post, "The Risks – Know Them – Avoid Them". [4] Summarizing the topic of how viruses are transmitted, we must understand that COVID-19 is a highly contagious, easily transmitted, and potentially asymptomatic infection.

Medical experts estimate that as few as 1,000 COVID-19 particles could spread the infection. We will focus on the airborne transmission for the purposes of this white paper. A cough releases roughly 3,000 droplets at up to 50 miles per hour, and while larger droplets fall, aerosolized droplets can travel across a room in seconds. A sneeze releases around 30,000 droplets at up to 200 miles per hour, some of which can quickly travel across a room. A full-force cough or sneeze can release as many as 200,000,000 virus particles, making it all the more important that infected persons stay home.

COVID-19 Transmission in the Workspace

Professor Bromage also provides a great example of a call center outbreak (Figure 1). A single infected employee came to work on the 11th floor of a building. Over the period of a week, 94 of the 216 employees on that floor became infected. Notice how one side of the office is primarily infected, while there are very few people infected on the other side. This example suggests that being in an enclosed space and sharing the same air for a prolonged period of time markedly increases the chances of exposure and infection.

HVAC systems can contribute significantly to the spread, and conversely the containment, of viral particles.

The likely scenario would be for an asymptomatic person – albeit infected with COVID-19 – to be in the office, breathing and speaking normally. It is estimated that transmission to another person could take as little as 50 minutes when merely sitting near the infected individual, or as little as five minutes when speaking face-to-face, assuming all expelled viral particles are transferred into the other person's lungs – which is, of course, very unlikely. However, air circulation and ventilation flow rates, among other factors, can inhibit transmission significantly.

While a COVID-19 virus particle is approximately 0.125 microns in size, aerosolized droplets produced by humans are usually 0.7 to 10 microns in size. It is a complicated numbers game, but thankfully viral particles in aerosols are often damaged, and thus not all are infectious, and additionally not every aerosol from an infected person will contain viral particles.

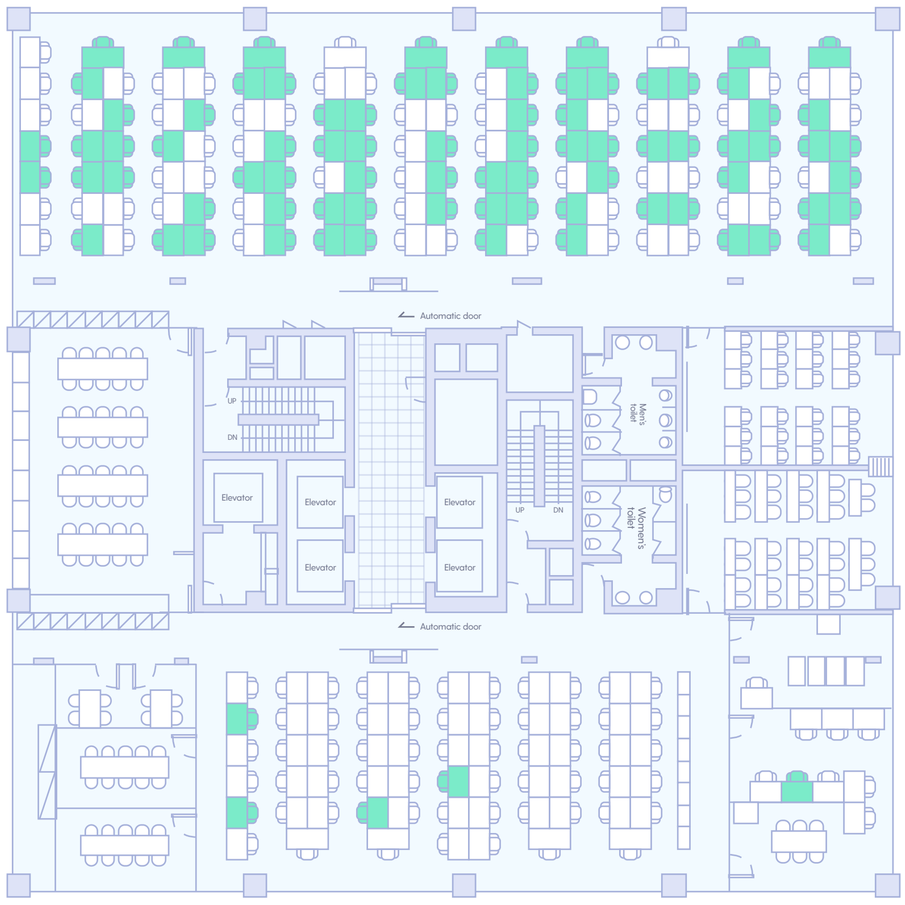
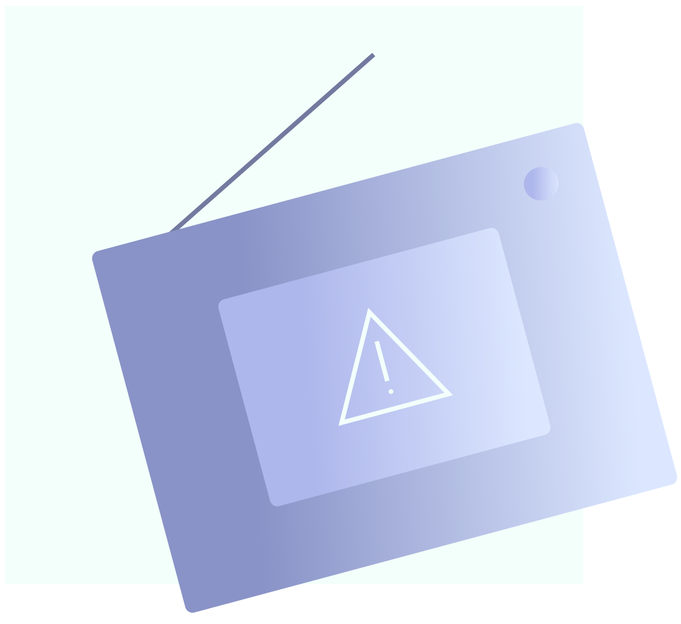


Figure 1.

Seating place of person with confirmed case



Can Air Quality/ Particle Sensors Identify COVID-19?

In short, no. There are many varieties of air quality sensors available and while many commercial buildings have them installed already, they are neither designed, nor are they claimed, to identify COVID-19 particles in the air. Air quality sensors can identify specific gases and contaminants, like CO_2 and radon, but are most commonly used to monitor temperature and humidity.

It is worth noting that researchers are working on developing sensors that could detect bacteria and virus particles in the environment, but they caution that such sensors would not replace established laboratory tests.

Indoor Air Quality Parameters and Filtration Measures

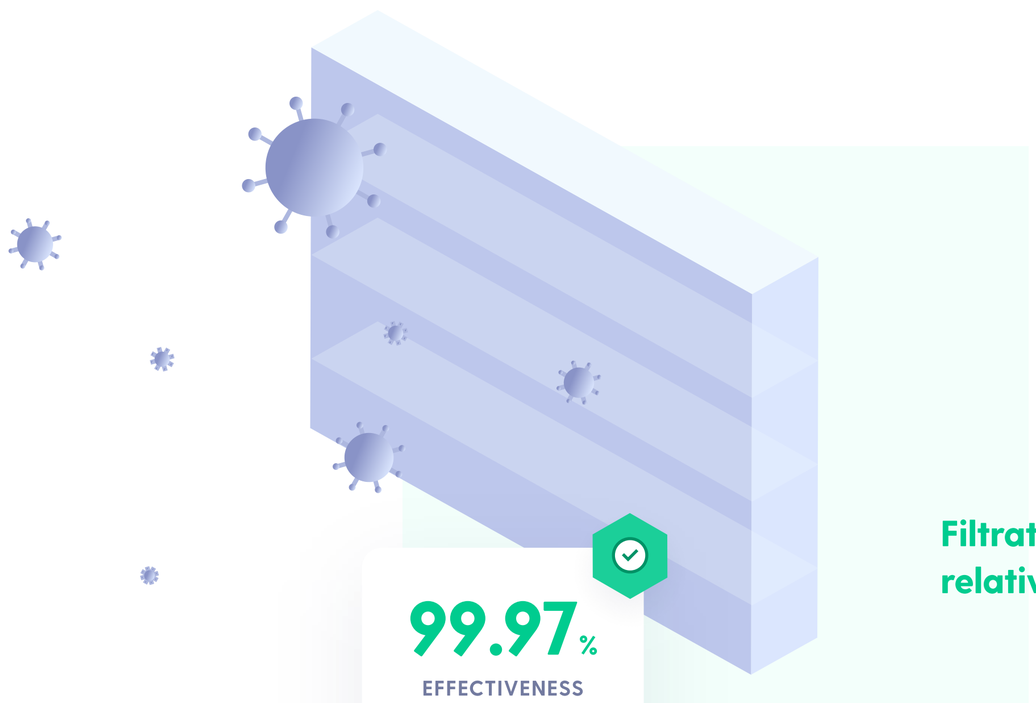
To help us understand the parameters that govern proper IAQ, the International Well Building Institute provides this guide that outlines the characteristics and required conditions to be met for each category (Figure 2).

Particulate matter falls into two categories: 10 micrometers or less and 2.5 micrometers and less in diameter. Recall that aerosolized particulates containing COVID-19 can be smaller than 5 micrometers in size.

CHARACTERISTIC	CONDITIONS TO BE MET
Particulate Matter	10 micrometers or less in diameter: 50 µg/m^3 or 2.5 micrometers or less in diameter: 15 µg/m^3
Carbon Monoxide	Less than 9 ppm
VOCs	Less than 500 µg/m^3
Formaldehyde	Less than 27 ppb
Carbon Dioxide	**About 700 ppm above outdoor air levels** (usually about 1,000 to 1200 ppm) (ASHRAE)
Temperature	**68.5°F to 74°F** (winter); **75°F to 80.5°F** (summer) (ASHRAE)
Humidity	**Below 60%, ideally between 30% and 50%** (EPA)

Figure 2.

***µg/m3 = micrograms per cubic meter**



Filtration System effectiveness relative to the COVID virus:

HEPA (MERV>16) HVAC filters are 99.97% effective to capture particles >= 0.3 microns.

According to ASHRAE Article “Filtration / Disinfection”:

MERV-8 filters are 11% effective in capturing particles > 0.3 microns.

MERV-13 filters are 44% effective in capturing particles > 0.3 microns.

MERV-14 filters are 66% effective in capturing particles > 0.3 microns.

MERV-16 filters are 80% effective in capturing particles > 0.3 microns.

ASHRAE recommends a minimum of MERV-13, but MERV-14 is preferred.

Figure 3 shows the relative efficacy of each filter with respect to particle size based on MERV rating. From this data, MERV-14 filter effectiveness is 50% higher than MERV-13. Manufacturer data indicates MERV-14 filter pressure drop is virtually the same as MERV-13, and in some cases is less than MERV-13. For reference, N-95 masks are 95% effective at capturing particles larger than 0.3 microns in size.

MERV RATING	FILTRATION OF PARTICLES FROM 0.3 TO 1.0 MICRONS	FILTRATION OF PARTICLES FROM 1.0 TO 3.0 MICRONS	FILTRATION OF PARTICLES FROM 3.0 TO 10.0 MICRONS
MERV-16	95%+	95%+	95%+
MERV-15	85%+	95%+	95%+
MERV-14	75%+	90%+	95%+
MERV-13	50%	85-90%	90%+
MERV-12	<20%	80%+	90%+
MERV-11	<20%	65%+	85%+
MERV-10	<20%	50%+	85%+
MERV-9	<20%	<50%	85%+
MERV-8	<20%	<20%	70%+
MERV-7	<20%	<20%	<270%
MERV-6	<20%	<20%	<50%
MERV-5	<20%	<20%	<35%+
MERV-4	<20%	<20%	<20%
MERV-3	<20%	<20%	<20%
MERV-2	<20%	<20%	<20%
MERV-1	<20%	<20%	<20%

Figure 3.

How to Select the Right Filter

The filter rating and the associated increase in filtration efficiency often correlate to a higher price per filter, but these are not the only factors worth consideration. Energy efficiency (how filters affect pressure drop) and useful lifespans of the filters are also critical factors.

It is best to select higher MERV-rated filters that do not significantly increase pressure drop across their filtration mediums. High efficiency, high MERV-rated filters can actually be more energy efficient than lower rated filters. The value of paying $35/filter vs. $10/filter can mean the difference between realizing a measurable payback from improved energy efficiency versus a cost increase.

Washable filters typically offer a five-year lifespan and represent considerable return on investment (ROI), even with the added operations and maintenance expense. Subject to consistent maintenance, the cost of a washable filter over its lifetime can be assessed at half the invested value when considering the number of ‘throwaway’ filters required for purchase over the same time period. **Thus, a $50 high-efficiency, washable MERV-14 filter can actually save money due to the operational efficiencies and longer lifecycle, with an ROI of less than one year for a typical building.**

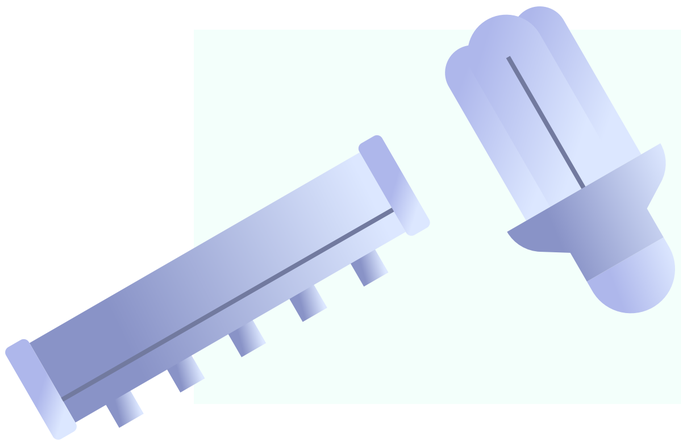
Indoor Air Quality and Filtration Recommendations

Guidance from the US Environmental Protection Agency (EPA) is somewhat dated, as their Building Assessment Survey and Evaluation (BASE) Study is from 2006, and is, in fact, still offered on a CD-ROM. The most comprehensive guidance is the ASHRAE IAQ Guide [5], but at close to 700 pages, it is not very user-friendly for most readers. To summarize, it advises that proper IAQ requires extensive planning that accounts for the building's design, location and climate, among other factors. This is the definitive guide for your HVAC engineers.

The challenge is that even modern offices were not designed to manage airflow to help minimize viral transmission. The predominance of open office tenant space has led to airflows designed to maximize airflow throughout these large spaces for energy efficiency, which compounds this challenge further.

As with any design, overall air quality is determined by the lowest quality parts used in the process. In this excerpt from a New York Times article, March 4, 2020 "Your Building Can Make You Sick or Keep You Well", "[Our] office buildings . . . are chronically under-ventilated. Most buildings use low-grade filters that may capture less than 20 percent of viral particles." [6]

Beyond the use of higher quality filters as noted earlier, in buildings where a dual filtration HVAC system is available, a combination of a MERV-9 filter, which would be adequate for the initial filtration, and a MERV-13 or 14 filter for the secondary filtration is recommended. This combination is both cost effective and efficient for most commercial applications.



A Facility Executive article entitled *Paths to Improved Indoor Air Quality* (dated April 20, 2020) noted similar recommendations for utilizing higher MERV-rated filtration and suggests supplemental filtration strategies using UV and ionization (Figure 4). [7]

UV (ultraviolet) lighting at the mechanical system's cooling coils can remove bacteria, mold spores, and viruses. While this is a more costly option, it will improve the air quality of the entire building vs. a single space with a standalone filter. The ASHRAE handbook, chapter 60.8, recommends 50-100 µW/cm² (microwatts per square centimeter) for coil applications.

UV lighting components range from several hundred to several thousand dollars in cost.

Ionization technology at the main supply air distribution can remove many issues from dust to odors for as little as 1.5 watts of power consumption per linear foot. Ionization bars deliver oxygen molecules into the air to neutralize contaminants. A typical ionization bar can treat up to 20,000 CFM.

Ionization bars and units also range from several hundred to several thousand dollars in cost.

	HEPA FILTER	CARBON FILTER	UV COILS	IONIZATION	HVAC LOAD REDUCTION
PM 10 (Dust, Pollen Wildfires)	✓	✗	✗	✓	✓
PM 2.5 (Cars, Airplanes, Construction)	✓	✗	✗	✓	✓
VOCs (Pesticides, Cleaners, Office Equipment)	✓	✓	✗	–	✓
Ozone (Sunlight Reacting with Emissions)	✓	✓	✗	✗	✓
Carbon Oxides (Fossil Fuel Combustion)	✓	✓	✗	✗	✓
Nitrogen Oxides (Fossil Fuel Combustion)	✓	✓	✗	✗	✓
Sulfur Oxides (Fossil Fuel Combustion)	✓	✓	✗	✗	✓
Bacteria	✓	✗	✓	✓	✗
Mold Spores	✓	✗	✓	✓	✗
Viruses	✗	✗	✓	✓	✗
Odors	✗	✓	✗	✓	✓
Formaldehyde	✗	✗	✗	✗	✓

Figure 4. ● Efficient at removing particulates ● Somewhat efficient at removing particulates ● Not efficient at removing particulates

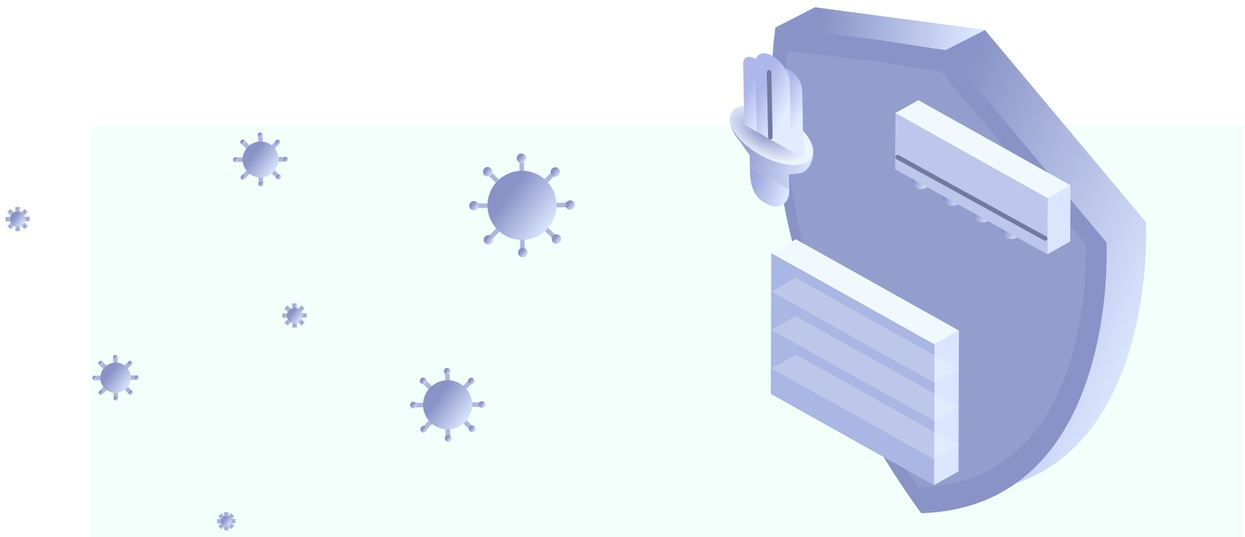
Does Filtration Work?

You probably noticed and wondered, why isn't HEPA filter technology listed as "efficient at removing particulates" for viruses when, by technical specifications, it is 99.97% effective at removing particles >=0.3 microns? The US Federal Trade Commission (FTC) does not allow HEPA filter-based products to claim they can actually remove contaminants from the air – this is a holdover from legal action brought against advertising claims made back in the 1990s.

According to the FTC, the actual effectiveness of an air purifier depends on a variety of factors, including the amount of air that the air purifier processes, the nature of the pollutant, and the rate at which the pollutant is being introduced into the environment.

The truth is, both are correct. No filter that provides even 99.999% filtration can claim to stop all potentially harmful particulates from passing through. Even with the best filtration technology, operating conditions vary, as does climate, maintenance quality and frequency, and other factors. Even poor filters (MERV-6 and below) are better than none, and good filters (MERV-13 and up) are dramatically better at filtering out potentially harmful particles.

A combination of good quality filters, along with supplementary technologies like UV or ionization, and following recommended practices to increase the frequency of outdoor air intake is your best bet at reducing the spread of a virus like COVID-19.



Your job as building owner is not to make exaggerated and legally-exposing claims about the safety of your building. Your job as building owner is to provide the highest comfort and safety for your tenants within your control.

Business Considerations in the New Normal

The current crisis and resulting impact on our economy, combined with the forced and now more generally accepted work-from-home trend, is expected to create headwinds for commercial office real estate, especially in large metro areas. More than ever, it is vital that owners take every possible measure to reduce operating costs while optimizing tenant comfort and safety and pursuing good ESG practices. Reduced operating costs provide owners more flexibility in being aggressive on rents to retain existing tenants and attract new tenants, thereby minimizing the impact of the current market conditions on their returns.

The requirement to safeguard the health of tenants will need to be balanced with costs and sustainability. When business opportunities are constricting, it is paramount to provide differentiation from your competitors, and decision makers that have better insights and analysis to determine which capital investments to make will have the upper hand.

Recommendations

In a recent Harvard Business Review (HBR) report entitled *What Makes an Office Building "Healthy"* (dated April 29, 2020), there are several steps that should be taken by building operators to address the health of their buildings [8] (Figure 5). Note that in the Indirect Indicators quadrants at the bottom of the chart, **ventilation is the most practical and immediate factor that can be addressed.**

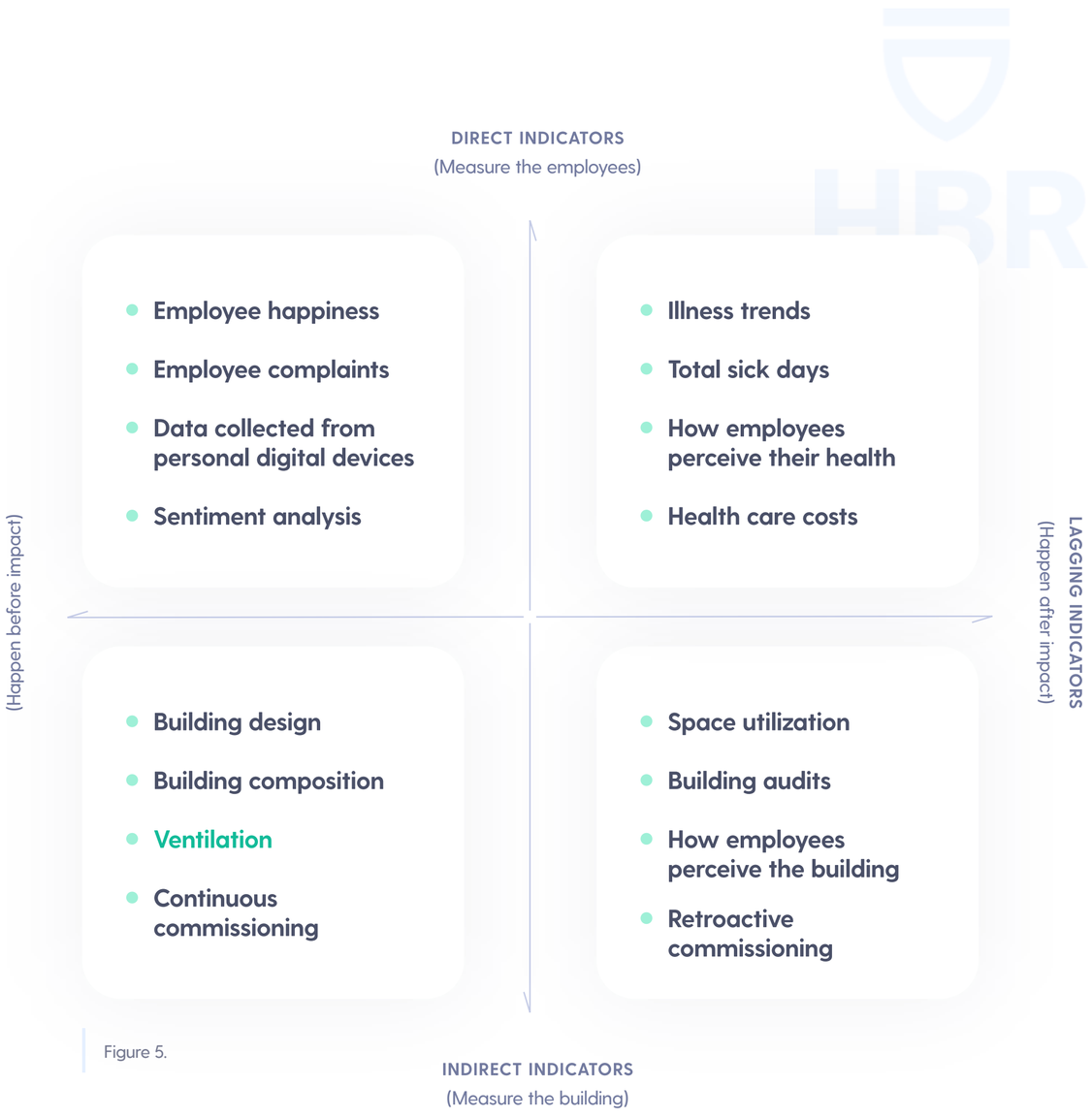


Figure 5.

Utilize MERV-14 filters for single-stage filtration, or MERV-9 at the first stage with MERV-14 second stage when your system is capable. Use of HEPA filters is not recommended, as the added filtration benefit is minimal vs. MERV-14. HEPA filters also cost significantly more than other highly rated MERV filters and may require extensive and costly modifications to the HVAC system to accommodate them.

Use washable filters where possible - while they have a higher initial cost, their long term lifespan (up to five years) provides significant ROI.

Replace or wash filters regularly. Clean filters improve both IAQ and energy efficiency.

Increase outdoor air intake in order to dilute and flush indoor air. Unfortunately, only about 30% of buildings have the necessary CO_2 sensors and variable air volume boxes (VAVs) required to control outdoor air supply on demand as required on a space-by-space basis.

Additional benefits: Retrofitting your building with CO^2 sensors and VAVs can provide significant long-term ROI.

CAUTION: Increasing the outdoor air intake can negatively impact temperature and humidity conditions, affecting the performance of your HVAC system and associated energy consumption.

Evaluate the additional utilization of UV and, especially, ionization filtration as low energy cost solutions for removing viruses from the air.

> Additional considerations: The use of ionization for air filtration is a relatively new convention and shows compelling promise. However, it currently lacks widespread industry acceptance, perhaps due in part to the lack of extensive peer-reviewed studies to substantiate its impact.

Recognizing that elevators are generally known for having poor air circulation, some basic considerations are advised. If your elevator programming allows, set them to return to a vacant or less occupied floor and for the doors to remain open to help circulate normally stagnant air from the elevator carriage. Add elevator fans to circulate air where possible.

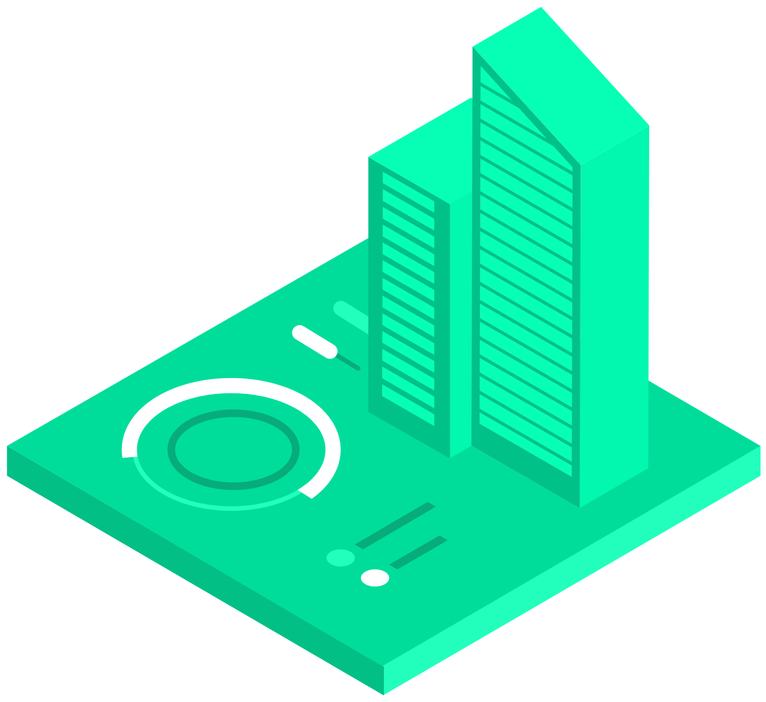
For cleaning, maintenance, and engineering staff that are going to be in situations where they are likely to encounter concentrations of aerosolized particles, use an N-95 mask.

If your building is still in the design phase, not yet fully constructed, or operational, but as a potential retro-commissioning project, have your engineers consider modifying the airflow in the building and throughout the tenant spaces. Similar to how hospitals design rooms to optimize the flow of clean vs. unclean air, offices should evaluate air flow design to minimize the practice of moving large volumes of air from one end of a large space to the other. Reducing the distance covered from the output to return airflow can help minimize the spread of infection in enclosed spaces.

Engage with your tenants in a dialog about the safety of the air they breathe in the building. Provide a detailed report about what changes, safety measures, and investments you have taken or made and will continue to take or make to safeguard indoor air quality for them. Make it clear that you intend to meet and exceed regulatory guidelines and standards that most certainly will change in the coming months.

Conclusion and Next Steps

In the new age of COVID-19, building owners and property teams need to be able to provide the IAQ required in order to support, retain, and attract tenants. They also need to contain costs while ensuring occupancy remains high. There are thousands of factors that impact the performance of your building, from its design and utilization to the impact of the climate. You need to be able to evaluate and optimize for all of these to ensure the optimal tenant experience while maximizing investment returns.



Bractlet provides a unique solution to help building owners and property teams optimize building performance and make better investment decisions. Bractlet utilizes proprietary power meters combined with data from your existing building automation system (BAS) to deliver real-time, dynamic simulations of thousands of possible business decisions.

By creating a digital twin of your building based on the nuances of its design and utilization and taking into account prevailing environmental conditions, Bractlet provides a holistic, physics-based tool for evaluating actual performance vs. design capabilities and industry benchmarks, and then identifies opportunities for improvement.

Sources

1	ASHRAE	https://bit.ly/301fzy8	5	ASHRAE	https://bit.ly/2MvhDpX
2	BOMA	https://bit.ly/2ABPURO	6	NY TIMES	https://bit.ly/3dFV0eo
3	ASHRAE	https://bit.ly/2XYsRbY	7	FACILITY EXECUTIVE	https://bit.ly/3gL7402
4	ERIN BROMAGE	https://bit.ly/2AwbabU	8	HARVARD BUSINESS REVIEW	https://bit.ly/2yZ38rz

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