



Photos from Pond5.com, left: Mariusz Szczawinski, right: Dinis Tolipov

Healthy Buildings Guide for Small Businesses: A Quick Reference to Improve Indoor Air Quality (Restaurants Excluded)

As Americans, we spend approximately 90% of our lives indoors. Although our buildings and homes provide shelter from whatever Mother Nature brings, the air inside can have pollutant concentrations 2 to 5 times higher than the outdoors.¹ These pollutants come from a variety of sources, including materials used to build and furnish our spaces, the products we stock and sell, byproducts of the services we provide, and occupants and the air we exhale. Indoor air quality is also affected by the amount of ventilation (outside air) we bring in, and the temperature and humidity of our spaces.²

The COVID-19 pandemic brought attention to controlling airborne contaminants, yet it is important to consider the documented benefits of healthy indoor environments at any time – not just during a public health crisis.

America's small businesses vary in size, services, products, ownership style, building mechanical (heating, ventilating, and air conditioning, or HVAC) systems, and more, yet all benefit from healthy indoor spaces for employees and

customers. This guide provides steps small businesses can take, in conjunction with public health guidance, to keep the indoor environment healthy. Small businesses often have unique ownership structures – for instance, the building owner and business owner can be different parties – so this guide addresses both building and business owner action items.

There are many ways to pursue healthy indoor air, including eliminating, minimizing, and/or controlling the contaminants we bring in, as well as removing or diluting any existing contaminants through ventilation, filtration, air cleaning, and/or disinfection. Ultimately, the best results are achieved through a comprehensive approach combining various strategies, including those discussed in this guide. The guidance in this document can be generally applied, but there are more detailed *resources for specific building types and uses, such as schools and healthcare facilities*.³

Where does indoor pollution come from?⁴

There are many sources for airborne contaminants that impact the quality of the indoor air we breathe. **Table 1** seeks to increase awareness of the many sources, some of which may surprise you.

1 U.S. Environmental Protection Agency. 1987. The Total Exposure Assessment Methodology (TEAM) Study: Summary and Analysis. Washington, DC.: U.S. Environmental Protection Agency. EPA/600/6-87/002a.

2 U.S. Department of Labor Occupational Safety and Health Administration. "Indoor Air Quality." Accessed March 3, 2022. <https://www.osha.gov/indoor-air-quality#:~:text=These%20factors%20include%20poor%20ventilation,air%20coming%20into%20the%20building.>

3 ASHRAE. "Coronavirus (COVID-19) Response Resources from ASHRAE and Others." Accessed April 4, 2022. [https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-covid19-infographic-.pdf.](https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-covid19-infographic-.pdf)

4 Green Builder Staff. 2015. "7 Common Indoor Air Pollutants and How to Remove Them." Green Builder Media. Accessed March 3, 2022. <https://www.greenbuildermedia.com/iaq/7-common-air-pollutants-and-how-to-remove-them.>



What can I do?

Small businesses can implement many strategies to keep the indoor environment healthy for employees and customers. The party implementing a strategy will vary because of the diverse ownership structures and landlord-tenant agreements common for small businesses, but there are options for building owners and tenants alike. In general, the following steps are a good starting strategy:

1. Inspect and maintain proper HVAC system operations
2. Identify and control contaminant sources
3. Implement proper filtration
4. Ensure adequate ventilation and airflow to all spaces

5. Educate maintenance and cleaning staff and building occupants about how to maintain healthy indoor air quality
6. Add portable air filtration or air cleaning devices, if desired
7. Add air disinfection systems, if desired.

Pandemic-focused strategies are widely documented,⁵ so the following summary (**Table 2**) expands indoor air quality guidance to include everyday indoor air quality strategies alongside pandemic-focused recommendations.

5 ASHRAE. "Coronavirus (COVID-19) Response Resources from ASHRAE and Others." Accessed March 2, 2022. <https://www.ashrae.org/technical-resources/resources>.

Table 1. Common Pollutants Affecting Indoor Air Quality*

Pollutants	From
Volatile Organic Compounds (VOCs)	<ul style="list-style-type: none"> • Cleaning products (solvents, chemicals, furniture polish) • Perfumes, hair spray, nail polish remover, cosmetics • Air fresheners, dryer sheets • Ink,^a markers, other art supplies
Formaldehyde (Common VOC)	<ul style="list-style-type: none"> • Off-gassing from common materials: <ul style="list-style-type: none"> – Carpet (also off-gases 4-phenylcyclohexane) – Particleboard and plywood (cabinetry, desks, shelving) – Insulation foams – New clothing (mildew, wrinkle preventer) – Packaging materials
Carbon Monoxide, Carbon Dioxide, and Ozone ^b	<ul style="list-style-type: none"> • Automotive exhaust • Kerosene or gas space heaters, fireplaces, other combustion activities • Leaky furnaces • Occupants • Photochemical reactions with VOCs can create ground-level ozone^c
Particulates ^d	<ul style="list-style-type: none"> • Smoke from cigarettes, cigars, pipes, automotive exhaust, wildfires • Burning candles, kerosene or gas space heaters, and other combustion activities • Printers, copiers^e <ul style="list-style-type: none"> – Toner • Occupants: humans, pets • Dust • Cooking • Paper dust^f <ul style="list-style-type: none"> – Paper production, manufacturing, processing – Mail rooms
Pesticides	<ul style="list-style-type: none"> • Plant or animal pesticide products
Biological Pollutants	<ul style="list-style-type: none"> • Pollen • Dust mites • Fungi/mold spores • Insects • Parasites • Animal/pet hair • Animal or pet droppings, urine • Bacteria and viruses
Radon	<ul style="list-style-type: none"> • Naturally occurring radioactive gas released by soil
Asbestos ^g (Harmful if damaged or disturbed)	<ul style="list-style-type: none"> • Range of old building materials, including insulation, ceiling and floor tiles, products including cement sheets used in roofing and siding

* Many of these substances have exposure limits that should be taken into consideration; visit <https://www.osha.gov/annotated-pels/table-z-1> for more information

a McDonald, Brian C., Joost A. De Gouw, Jessica B. Gilman, Shantanu H. Jathar, Ali Akherati, Christopher D. Cappa, Jose L. Jimenez et al. 2018. "Volatile Chemical Products Emerging as Largest Petrochemical Source of Urban Organic Emissions." *Science* 359(6377): 760-764. <https://www.science.org/doi/10.1126/science.aag0524>.

b U.S. Environmental Protection Agency. "Basic Information about Carbon Monoxide (CO) Outdoor Air Pollution." Accessed March 3, 2022. <https://www.epa.gov/co-pollution/basic-information-about-carbon-monoxide-co-outdoor-air-pollution>.

c U.S. Environmental Protection Agency. "What is Ozone?" Accessed March 3, 2022. <https://www.epa.gov/ozone-pollution-and-your-patients-health/what-ozone>.

d U.S. Environmental Protection Agency. "Indoor Particulate Matter." Accessed March 3, 2022. <https://www.epa.gov/indoor-air-quality-iaq/indoor-particulate-matter>

e American Chemical Society, 2007. "Particle Emissions from Laser Printers Might Pose Health Concern." *ScienceDaily*, August 2, 2020. www.sciencedaily.com/releases/2007/07/070731103629.htm.

f Torén, Kjell, Richard Neitzel, Gerd Sallsten, and Eva Andersson. 2020. "Occupational Exposure to Soft Paper Dust and Mortality." *Occupational and Environmental Medicine* 77 (8): 549-554. <https://doi.org/10.1136/oemed-2019-106394>. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7402447/>

g U.S. Environmental Protection Agency. "Learn About Asbestos." Accessed March 2, 2022. <https://www.epa.gov/asbestos/learn-about-asbestos#find>.

Table 2. Strategies for a Healthy Indoor Environment

Strategy	I am a Building Owner, Landlord, and/or Facility Manager	I am a Business Owner and/or Tenant	Pandemic-Specific Guidance
Choose interior furnishings, including carpet, cabinetry, desks, shelving, and interior paints with low or zero VOC content*	✓	✓	Change interior layout to promote distancing
Educate building and business owners on healthy indoor environments and mitigation techniques	✓	✓	
Stock products with limited VOC content.* This includes products sold and products used in providing services		✓	
Follow proper cleaning methods and use safe cleaning materials ^a	✓	✓	
Ensure HVAC systems are providing at least the minimum required outdoor air ^b to all spaces and meeting appropriate temperature and humidity levels during occupied times, and perform regular HVAC preventative maintenance	✓		
Install highest MERV rated filters feasible for HVAC equipment ^c	✓		Increase central air and other HVAC filtration to MERV 13 or the highest level achievable. If a minimum of MERV 13 cannot be achieved, use other suggested strategies in conjunction to reduce potential spread of COVID-19
Increase outdoor ventilation air above the minimum when conditions and equipment allow. Care should be taken to ensure proper building HVAC functionality	✓		Implement flush sequences, when necessary, between building occupancy periods ^d Open windows and store-front doors to bring in more outside air if physically and environmentally safe. ^e Box fans placed near open windows or doors can increase the flow of outside air
Relocate idling zones, loading zones, and outdoor smoking areas away from building outdoor air intake	✓	✓	
Use properly sized portable air filtration devices with filters targeting specific pollutants for your space ^f		✓	Consider portable air filtration devices with HEPA filters and change filters at manufacturer specified intervals
Repair known cracks and leaks in the building, often around windows and doors	✓		
Hire a professional to examine the building envelope for possible additional leaks; repair leaks if found	✓		

* Compounds have exposure limits that should be taken into consideration; visit <https://www.osha.gov/annotated-pels/table-z-1> for more information

a American Lung Association. "Cleaning Supplies and Household Chemicals." Accessed March 2, 2022. <https://www.lung.org/clean-air/at-home/indoor-air-pollutants/cleaning-supplies-household-chem>.

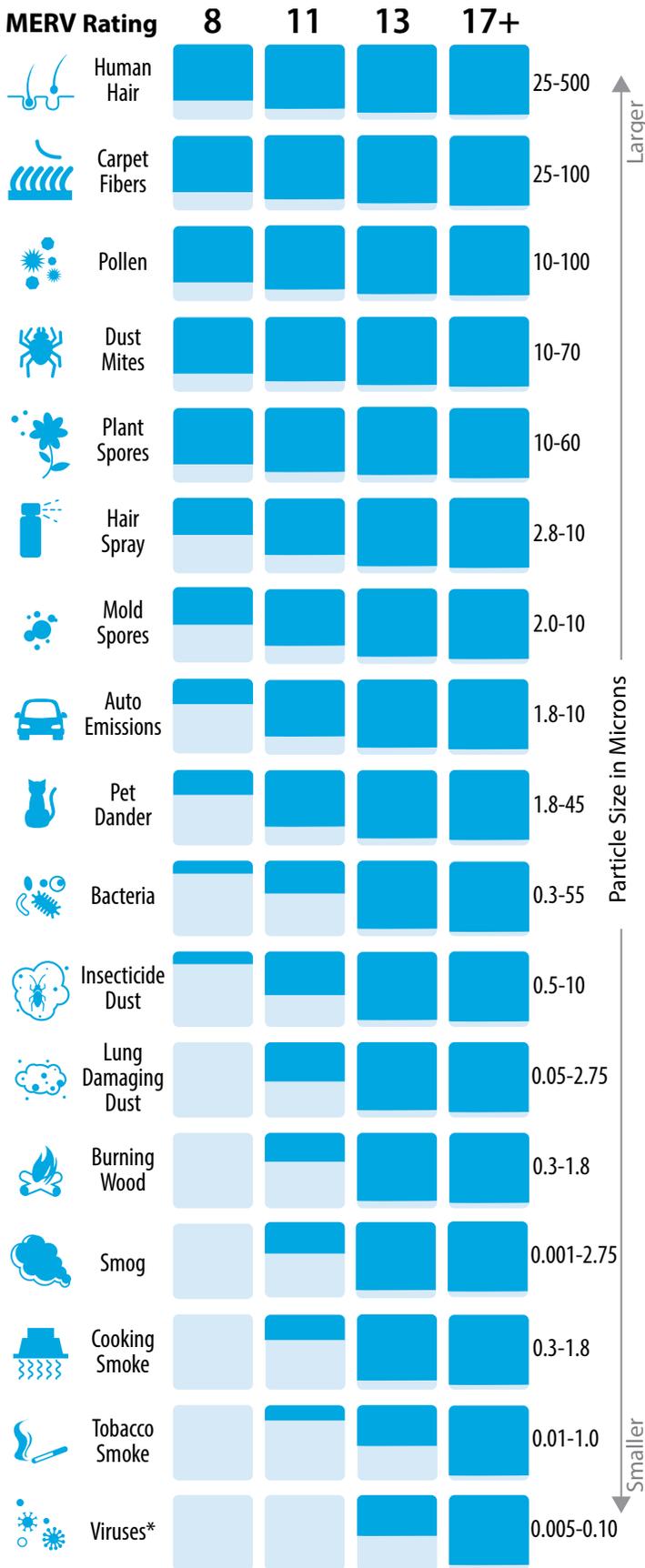
b ASHRAE. "Standards 62.1 & 62.2." Accessed March 2, 2022. 62.1, <https://www.ashrae.org/technical-resources/bookstore/standards-62-1-62-2>.

c See further details on filter ratings and pollutants in **Figure 1**

d ASHRAE. "Core Recommendations for Reducing Airborne Infectious Aerosol Exposure." Accessed March 2, 2022. <https://www.ashrae.org/file%20library/technical%20resources/covid-19/core-recommendations-for-reducing-airborne-infectious-aerosol-exposure.pdf>.

e Visit airnow.gov to check the air quality in your area

f See further details on portable air filtration devices and filter selection considerations in **Table 3** and **Figure 1**



How should I adjust my HVAC system?

Small business HVAC systems vary, so strategies that can be implemented successfully will vary as well; however, there are effective options for all system types.

Filters are an effective way to capture particles you'd like removed from the air. **Figure 1** helps guide filter selection for various airborne pollutants. Generally, higher MERV filter ratings provide more effective source removal; however, not all HVAC systems can fit or handle all MERV-rated filters.

Where HVAC systems are unable to function properly or physically fit filters with preferred MERV ratings, other strategies can be considered, such as in-room air filtration devices, increased outdoor air, or others. Keep in mind, the person responsible for implementing these strategies will depend on the ownership structure and/or landlord-tenant agreements established. If there are questions, consult with an HVAC expert to ensure proper HVAC system operation and proper implementation of improvement measures.

■ Average Removed in %
■ Average Not Removed in %

8 MERV Rating

Up to 70% of 3.0 to 10 Microns
 Up to 20% of 1.0 to 3.0 Microns
 N/A for 0.3 to 1.0 Microns
 Commercial Buildings,
 Industrial Workplace,
 & Paint Booth Inlet

11 MERV Rating

Up to 85% of 3.0 to 10 Microns
 Up to 20% of 1.0 to 3.0 Microns
 Up to 20% of 0.3 to 1.0 Microns
 Better Commercial Buildings

13 MERV Rating

Up to 90% of 3.0 to 10 Microns
 Up to 85% of 1.0 to 3.0 Microns
 Up to 50% of 0.30 to 1.0 Microns
 Superior Commercial Buildings

17+ MERV Rating

Up to 95% of 3.0 to 10 Microns
 Up to 95% of 1.0 to 3.0 Microns
 Up to 95% of 0.3 to 1.0 Microns
 Clean Rooms, Pharmaceutical,
 & Carcinogenic Materials

Activated Carbon Filters

Can help remove gaseous contaminants.

* The virus that causes COVID-19 (the SARS-CoV-2 virus) is 0.125 microns in size and often in virus carriers that are much larger, like saliva and water droplets. A minimum MERV 13 filter is recommended to capture SARS-CoV-2 attached to these carrier droplets to reduce potential spread of COVID-19.

Figure 1. MERV filters remove particulates out of the air; other methods are needed to remove gases and volatile organic compounds

Spotlight On: Portable Air Filtration Devices

Portable air filtration may be a new idea to you, and it can be helpful to know more about your options before making a purchase. Portable filters reduce contaminants in the air and can be useful supplements to other strategies, like increased ventilation and filtration on main HVAC equipment, and public health guidance.

Table 3. Portable Air Filtration Considerations

When considering portable air filtration, you'll want to think about: ^{a,b}	
What do I want removed?	Virus particles can be filtered, as can pollutants like smoke and mold spores.
What do I look for?	Viruses and smoke, for example, are captured by products that filter particles 0.1-1 microns in size, are a HEPA unit, or have a high Clean Air Delivery Rate (CADR) for smoke. Look for a filter that will capture what you'd like to remove from your air; use the filters listed in Figure 1 for guidance.
How big is my space?	Measure your square footage and ceiling height.
How is my space arranged?	Find available outlets, area for the air cleaner, and clear exit paths.
Do I have an open place?	Portable air filtration devices must have sufficient space around air intake and exhaust and should not blow air directly from one person to another.
What size do I need?	Many products have a suggested room size in the product description. Multiple units can also be used for larger areas.
How loud can it be?	Look at the noise rating on the product and compare it to example decibel ratings and sounds. ^c

- a U.S. Environmental Protection Agency. "Air Cleaners and Air Filters in the Home." Accessed March 3, 2022. <https://www.epa.gov/indoor-air-quality-iaq/air-cleaners-and-air-filters-home>.
- b ASHRAE. 2021. "In-Room Air Cleaner Guidance for Reducing COVID-19 in Air in Your Space/Room." ASHRAE. <https://www.ashrae.org/file%20library/technical%20resources/covid-19/in-room-air-cleaner-guidance-for-reducing-covid-19-in-air-in-your-space-or-room.pdf>
- c Compare the device's decibels to information from the Centers for Disease Control and Prevention: https://www.cdc.gov/nceh/hearing_loss/what_noises_cause_hearing_loss.html

Special Considerations^{7, 8}

Activated Carbon Filters⁶

Some air contaminants are in gas form, making it impossible for traditional filters to capture them. It's beneficial to use multiple types of filters in your space to capture all pollutants you're concerned about. Chemical filters, such as activated carbon, can help remove gaseous contaminants – like odors and volatile organic compounds – from your air.

Sorbent-Based Air Cleaning⁷

Sorbent-based air cleaning technologies are also designed to capture many of the gaseous pollutants found in indoor spaces – including carbon monoxide, carbon dioxide, ozone, formaldehyde, and volatile organic compounds.

Air Disinfection Systems⁸

Ultraviolet germicidal irradiation (UVGI) systems are one type of air disinfection technology that uses light to inactivate microorganisms. The effectiveness of these systems to disinfect air and/or surfaces has been demonstrated, and they can be used to avoid bacterial and fungal build up on wet coil surfaces in central HVAC systems. Consult with a UVGI expert when considering these systems.

6 ASHRAE. 2018. ASHRAE Position Document on Filtration and Air Cleaning. Atlanta, GA. <https://www.ashrae.org/file%20library/about/position%20documents/filtration-and-air-cleaning-pdf-feb.2.2021.pdf>.

7 enVerid. "Sorbent Ventilation Technology." Accessed March 4, 2022. <https://enverid.com/products/sorbent-ventilation-technology/>.

8 ASHRAE. "Filtration/Disinfection." Accessed March 2, 2022. <https://www.ashrae.org/technical-resources/filtration-disinfection>.

Monitoring Indoor Air Quality

This guide details ways to improve indoor air quality in small businesses. If you are interested in monitoring your indoor air quality, consider the following:

- CO₂ monitoring is common and can be an indicator of indoor air quality changes linked to occupant activity
- Indoor air quality monitors measuring total VOCs, particulate matter (PM_{2.5} and PM₁₀), and formaldehyde are available and range in quality and accuracy; these should not replace accurate monitoring when required
- Occupants can be indirect indicators of air quality, and any expressed dissatisfaction⁹ should be promptly assessed.

Energy Use Implications

Your energy use and bill may be affected as you change how you manage your indoor air quality. Below are generalized energy impacts of the previously discussed strategies:

- Many commercial buildings use MERV 8 filters in central HVAC system equipment. Switching to a MERV 13 filter may increase average total energy consumed by an estimated 1%.¹⁰ MERV 18 filters would have a higher, likely proportional energy increase.
- Increasing outdoor ventilation air can have a more significant impact on a building's energy use, depending on the difference between the increase and normal operating conditions. As an example, it

is estimated energy consumption would increase 20-25% annually⁹ if all eligible commercial buildings in the U.S. increased ventilation air to 100%.

- Most portable air filtration devices draw between 30 and 90 watts of power during maximum fan speed operation. On the lower end, this is about the same power draw as a cell phone charger. Running a device 24 hours a day would likely increase energy costs \$150-\$250 per year for a 5,000 square foot business, based on most electricity rates.¹¹

It is important to note that each business and building is unique, and specific changes in energy use may look slightly different from the general guidance provided here.

Conclusion

Small businesses are unique in that there may be separate parties controlling the overall building HVAC system and the business operations within each space, but business owners *and* tenants have options in the pursuit of healthier indoor environments, even if they don't control the HVAC system. *Utilizing multiple strategies from this guide in combination with public health guidance can improve small business air quality during business as usual and during a virus event.*

Want to Learn More?

The Better Buildings Alliance Space Conditioning Technology Research Team creates commercial building heating, cooling, and ventilating resources. To join the email distribution list and receive updates on new materials, contact this email address:

BBA.spaceconditioning@nrel.gov.

⁹ ASHRAE. "Standards 62.1 & 62.2." Accessed March 2, 2022. 62.1, <https://www.ashrae.org/technical-resources/bookstore/standards-62-1-62-2>.

¹⁰ CaraDonna, Chris, and Kim Trenbath. 2022. "U.S. Commercial Building Stock Analysis of COVID-19 Mitigation Strategies." Presented at COBEE, Concordia University, Montreal, July 2022. National Renewable Energy Lab, Golden, CO.

¹¹ U.S. Department of Energy. "Estimating Appliance and Home Electronic Energy Use." Accessed March 4, 2022. <https://www.energy.gov/energysaver/estimating-appliance-and-home-electronic-energy-use>.



Photo from Pond5.com, Bunlue Nantaprom