National Institute of Environmental Health Sciences
Worker Training Program

Selection and Use of Portable Air Cleaners

to Protect Workers from Exposure to SARS-CoV-2

This fact sheet provides guidance to help employers, building operators, and union officials select and use portable air cleaners to remove virus-contaminated air in indoor spaces.

Overview

Ventilation and filtration are important to prevent transmission of COVID-19. SARS-CoV-2, the virus that causes COVID-19, is mainly spread through inhalation of virus-contaminated air when an infected person speaks, laughs, coughs, sings, or sneezes. Physical distancing alone will not prevent the build-up of viral particles in a room or workspace (Figure 1).

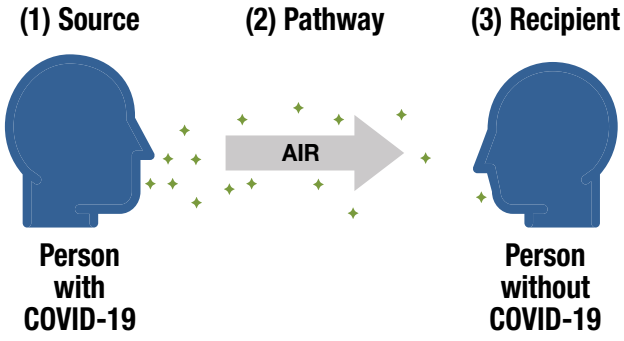

Figure 1. For transmission to occur via tiny airborne particles, three things are necessary: source, pathway, and recipient.[1]

Approximately 40% of people who are infectious are asymptomatic (no symptoms) or presymptomatic (before symptoms begin) and may contaminate air unknowingly. Work settings with inadequate ventilation and/or those that require people to be close together for extended periods of time, increase the risk of COVID-19 transmission. The illustration at right outlines the recommended steps to improve ventilation in buildings (Figure 2).

The Centers for Disease Control and Prevention defines close contact as within 6 feet of a person for 15 minutes or more during a 24-hour period. Wearing a cloth or surgical mask, while helpful, cannot be relied upon to prevent the spread of COVID-19.

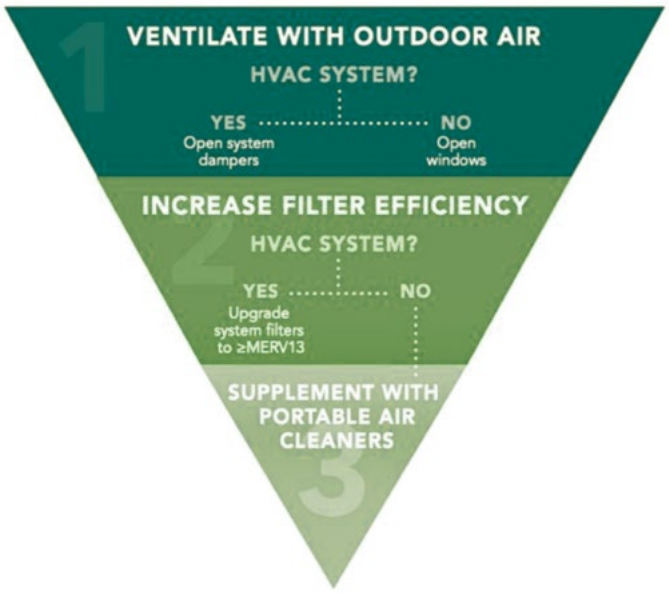

Figure 2. Illustration of the order in which to consider improvements to ventilation in buildings.[2]

1 Based on an image from the Center for Infectious Disease Research and Policy. https://www.cidrap.umn.edu/covid-19/preparedness-and-response/protecting-essential-workers

2 Source, Jones et al, 2020. Schools for Health, Risk Reduction Strategies for Reopening Schools. Harvard Healthy Buildings Program.

Consider using portable air cleaners (Figure 3) to supplement heating, ventilation, and air conditioning (HVAC) system ventilation and filtration, especially in buildings or spaces where adequate ventilation is difficult to achieve. Directing the airflow so that it does not blow directly from one person to another reduces the potential for inhalation of virus-contaminated air.

Figure 3. Example of a portable air cleaner.[3]

What Are Air Cleaners and HVAC Filters?

Air cleaners and HVAC filters are designed to capture pollutants that pass through them out of the air. When used properly, air cleaners and HVAC filters can help reduce the spread of airborne viruses in a building or enclosed space. Portable air cleaners may be particularly helpful when additional ventilation with outdoor air is not possible, or when it compromises indoor temperature or humidity, or when outdoor air pollution is high.

When used along with other protective measures, filtration can be part of a workplace COVID-19 exposure control plan to reduce the potential for inhalation of the SARS-CoV-2 virus indoors.

3 Source: www.rabbitair.com

Caution: The use of air cleaners is a ventilation intervention that provides one layer of protection against COVID-19 transmission. By itself, air cleaning or filtration is not enough to protect people from exposure to the virus that causes COVID-19.

How Can I Tell If an Air Cleaner Will Be Effective?

For an air cleaner to be effective in removing viruses from the air, it must be able to remove small, microscopic airborne particles (in the size range of 0.3 -1 µm[4]). Manufacturers of air cleaners report this capability in several ways such as:

- Documenting particle removal efficiency for specific particle sizes (e.g., removes 99.9% of particles as small as 0.3 µm).
- Use of High Efficiency Particulate Air (HEPA) filters.
- Use of the Clean Air Delivery Rate (CADR) rating system to rate air cleaner performance.

Key Steps to Select Portable Air Cleaners

1. Determine what type of ventilation system is used in the building.
2. Calculate cubic footage of the space(s) where the air cleaners will be used.
3. Determine the capability and number of air cleaners needed for the workspace.
4. Identify price and value based on ongoing filter replacement, maintenance, and upkeep.

4 µm is the symbol for micrometer. A micrometer is one millionth of a meter, invisible to the human eye.

Determine Type of Ventilation System Used in the Building

The first step is to determine if the building has **mechanical** and/or **natural ventilation** systems. With a **mechanical ventilation system**, outdoor air will be drawn into the building with a fan. That outdoor air will be heated or cooled, filtered, and then distributed to the occupied spaces through supply vents called diffusers (Figure 4). In most ventilation systems, air is recycled through exhaust or return vents where a portion of the air is exhausted to the outside and a portion is combined with outside air and recycled. Some systems only supply enough air to meet outdoor air requirements and do not recirculate. Some mechanical systems have economizers that recycle 100% of the air to save on energy costs by reducing heating or cooling of outside air. Recycled air that is not properly filtered is more likely to be contaminated. **Avoid recycling unfiltered air.**

Unit ventilators provide outside air, filtration, and exhaust for a single room only. In general, they are not capable of increasing ventilation and filtration to the recommended levels.

Natural ventilation is when outside air comes in through open windows and doors and there is no specific equipment to move and filter air in and out of the building.

See the checklist at the end of this document (Appendix) to learn more about your building's ventilation systems.

Figure 4. Typical supply air vent (diffuser).

The Bottom Line: If feasible, increase outside air and filtration in the building's mechanical ventilation system. If that is not feasible, consider using portable air cleaning units.

Do not use air cleaners that generate ozone in occupied spaces.

- **Some products sold as air cleaners generate ozone. These products are not safe to use when people are present because ozone can irritate breathing.**
- **Ozone generated by commercially available air cleaners in indoor spaces does not effectively remove viruses, bacteria, mold, or other biological pollutants.**

How Do I Select A Portable Air Cleaner?

Consider the following characteristics when selecting a portable air cleaner:

1. Select a unit that **DOES NOT** include ultraviolet irradiation, ozone generators, or other disinfection features. These extra features may pose a health hazard to building occupants and provide little added benefit to air cleaning.
2. Consider the noise rating and whether it will disrupt activities in the room.
3. Select a unit that uses a **HEPA filter**. A HEPA filter will remove at least 99.97% of sub-micron particles.
4. Select the correct size of portable air cleaner based on the room size by calculating the necessary cubic feet per minute required to achieve the desired air exchange rate for the individual room. The portable air cleaner will have information on the label (Figure 5) or in the user manual describing its capabilities. Unfortunately, there is not a standard approach to labeling these devices and often the labeling is inaccurate or misleading.

a. Calculate the cubic feet of the room by multiplying the width, length, and height of the room in feet. Calculation: Width x Length x Height = Cubic Feet

b. Calculate the necessary cubic feet per minute (CFM) for the space where the portable air cleaner will be used. For most buildings, a minimum of 5-6 air changes per hour (ACH) of additional air cleaning is desired. One ACH means that in one hour, a volume of air has been introduced to the space that is equivalent to the volume of the space. This does not mean all the air in the room has actually been replaced due to inefficient air mixing. It takes many air changes to completely replace all the air in a room.

Providing 5-6 ACH is recommended as it will replace about 99% of the volume of air in an indoor space with fresh filtered or outdoor air every 45 – 60 minutes.

i. **Cubic Feet per Minute (CFM) Calculation:** Multiply 5 ACH with the cubic feet of the room, then divide this number by 60.

Calculate CFM for a room

$$\text{CFM} = \frac{5 \text{ ACH} \times \text{Width} \times \text{Length} \times \text{Height}}{60}$$

ii. Consider increasing the required CFM by 10% to account for variability between specified and actual performance.

iii. Select an air cleaner based on your calculated CFM requirement.

c. Many air cleaners only indicate their capabilities based on square feet. Their ratings are based on 8-foot ceilings. In areas with higher ceilings, the rating for these units should be adjusted downward. If you have an area that is larger than any available product will serve, use multiple air cleaners.

d. A recommended standard for rating the effectiveness of air cleaners is the use of a **Clean Air Delivery Rate (CADR)**, expressed in CFM (Table 1). For manufacturers that use this standard, three CADR numbers are given on the label, one for smoke, dust, and pollen. The smoke particles are the smallest, so that CADR number applies best to viral particles related to COVID-19. A portable air cleaner with a smoke CADR of 30 CFM can be interpreted as equivalent to an additional 30 CFM of fresh outdoor air ventilation. The larger the CADR the greater amount of air the unit will clean. The CADR is determined at the highest fan speed (if the fan speed is adjustable). Keep in mind that the CADR assumes good room air mixing, which is not typical.

Warning: operating the air cleaner at lower fan speeds will greatly reduce their ability to clean air.

Figure 5. Example of a label from a portable air cleaner.[5] Note: this label uses square feet, assuming an 8 foot ceiling. In rooms with ceiling greater than 8 feet, the calculation needs to be adjusted downward or multiple air cleaners should be used.

5 Source: HVAC filtration for controlling infectious airborne disease transmission in indoor environments: Predicting risk reductions and operational costs Parham Azimi, Brent Stephens, Build Environ . 2013 Dec;70:150-160. doi: 10.1016/j.buildenv.2013.08.025. Epub 2013 Sep 4.

Portable Air Cleaner Sizing for Particle Removal						
Room area (square feet)	100	200	300	400	500	600
Minimum CADR (cfm)	65	130	195	260	325	390

Table 1. This chart is for estimation purposes. The CADRs are calculated based on an 8-foot ceiling. If you have higher ceilings, you may want to select a portable air cleaner with a higher CADR. This chart only applies to air cleaners with HEPA filters.[6]

If the outdoor air ventilation rate is not reliably known, a simple rule of thumb for sizing a portable unit for a room of 500 square feet and 8-foot ceiling height is to select a portable unit with CADR of 325 CFM. This portable unit can provide a supplemental 5 ACH in the room.

The Clean Air Delivery Rate (CADR) ratings for portable units are specific to three pollutants (tobacco smoke, dust, or pollen) and an air cleaner will receive a rating for each of these pollutants. The efficiency of the device is based on the difference between pollutant concentrations in a test chamber with and without air cleaner use. These efficiencies are then translated to CADR ratings which describe efficiencies at various room sizes.

6 Source EPA Guide to Air Cleaners in the Home, 2nd Edition.

Other Important Considerations Regarding Portable Air Cleaners

Use and Room Configuration

- Consider the location of furniture and people in the room and the placement of units relative to room layout. The goal is to get as much of the room air as possible to flow through the HEPA filter as this is what is cleaning the air which is then returned to the room. Obstructions and distance can interfere with drawing the air into the unit.
- DO NOT place air cleaners next to corners, doorways, curtains, walls, or furniture. Preferably they should be about 3 feet away from obstructions.
- While open windows are a ventilation improvement option during the COVID-19 pandemic, air cleaners should be placed away from open windows to provide the maximum protective benefit (i.e., the units should filter air from inside the room, not air directly from outdoors).
- In a large room, use more than one portable air cleaner with a HEPA filter to promote better mixing and overall air cleaning.
- If feasible, air cleaners should remain on and maximized in the space 2 hours before and after occupancy.

Maintenance

- Schedule preventive maintenance for the units.
- Ensure a sufficient supply of the correct filters needed for change-out of both the pre-filter and HEPA filter.
- Follow the manufacturer maintenance and filter change requirements.
- Ensure staff are aware of these requirements.
- Ensure good fit of filters in the frame and no leakage of air around the filter unit.

Cost

- Portable air cleaners range in cost from about $150 to $2,000 depending on their size and features.
- One handy feature is a shut off timer that allows the unit to shut down and turn on at set times.
- The average annual electricity costs for running portable HEPA air cleaners 100% of the time are just under $200 per year, with individual units ranging from just over $100 to nearly $250 per year. The cost of replacement filters should also be considered in estimating overall annual cost.

Appendix

How Do I Learn More About My Building's HVAC System?

To learn about your building's HVAC system, meet with building managers, maintenance personnel, landlords, or an HVAC contractor. Ask them about the specific design, operation, and maintenance of your building's systems. The best approach includes an inspection so that you can see how things work. A simple test is holding a tissue near air supply and exhaust vents to see if air is moving or not. Also look to see if vents have been covered or blocked. This may occur when buildings are renovated.

Be sure to ask the following questions:

- Does the building have a mechanical or natural ventilation system? If natural, then skip the rest of the questions below and consider using portable air cleaners. If mechanical find out the following:
- How do the systems work?
- How many air changes per hour of outside air is brought into the building or produced by filters in the HVAC equipment?
- Where does the outside air enter the building?
- What is the MERV[7] rating of the filter used in this building? MERV = minimum efficiency reporting value. Experts recommend a MERV rating of 13 or higher for control of COVID-19 if the building systems can function with that level of filtration. Filters with a MERV of 13 and above are required to demonstrate at least 50% removal efficiency for the smallest particles tested.
- How often are the filters changed?
- How is the filtered air distributed to the occupied spaces?
- Does the system have economizers?
- Are supply and exhaust returns all functioning properly?
- When was the system last tested and balanced to ensure it is working as designed?
- Have renovations changed conditions in some of the rooms?
- How many zones and thermostats are used by the HVAC system? Warning: often setting a thermostat to "automatic", causes the fan bringing in outside air to only function when the system requires heating or cooling. Setting the fan to the "on" position will avoid this problem

For more information: https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html

7 The MERV is an output of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard Test 52.2. This test method assigns the filter with a number (from 1 to 16) based on a performance test comparing concentrations of particles sized between 0.3 and 10 µm, upstream and downstream of the filter. The MERV for each filter corresponds to the particle removal efficiency of the filter, based on the specific size category of particles tested.

References and Resources

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