VENTILATION TOOLKIT

FOR THE MITIGATION OF RESPIRATORY INFECTION TRANSMISSION IN RESIDENTIAL CARE FACILITIES

This document is intended to support congregate care facilities (e.g., long-term care facilities, adult foster homes, behavioral health settings) in the implementation of short-term accessible options to improve ventilation for the prevention and control of respiratory pathogens. Concepts may be broadly applicable to other health care settings. Facilities should be aware of relevant regulatory standards for health care settings, including but not limited to, ANSI/ASHRAE/ASHE standards.

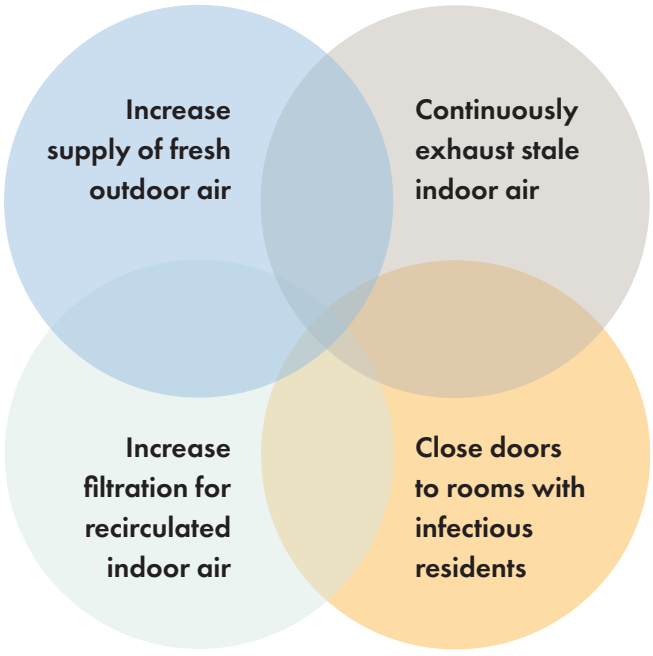
INTRODUCTION

Ventilation refers to how fresh outdoor air is brought in and distributed to occupants of a building. Ventilation can be a powerful tool to maintain a healthy indoor environment. A respiratory virus like SARS-CoV-2 that causes COVID-19 can spread quickly through indoor air. Knowing how ventilation works in your particular facility and how it can be improved is essential to mitigating the risk of infection from any airborne virus.

This toolkit will help you identify how ventilation air moves through your building, and what actions you can take, or ask professionals to take, to lower the risk of spreading respiratory disease.

Each building and ventilation system is different, the specific systems you identify in your facility will lead to particular actions you can take to apply a tailored set of the risk reduction strategies presented in this toolkit.

KEY ACTIONS



Each of the following actions can reduce the risk of spreading respiratory disease through indoor air in buildings, combining them and making improvements to the extent possible in your facility and existing systems will further reduce the risk of infection.

- Increase fresh outdoor air supply to occupied spaces, either through windows and doors or mechanical systems that are capable of bringing in outdoor air.
- Exhaust stale and potentially contaminated indoor air, either through windows and doors, bathroom exhaust fans or mechanical systems that are capable of exchanging indoor and outdoor air.
- Increase the level of filtration for recirculated indoor air, through ducted ventilation system filtration, if available, and portable in-room HEPA filters.
- Close doors to rooms with infectious residents to isolate viral particles for removal via exhaust while limiting transfer to other spaces and occupants in the facility through indoor air.

SURVEY CURRENT SYSTEMS

» Use this section as a checklist as you walk your facility and consider ventilation system types, implementation, and current performance characteristics before moving on to identifying specific optimization and improvement strategies that are relevant for your facility.

» Review the full toolkit before conducting this system survey. Further explanation of everything referenced in this checklist is covered in the following pages, including acronym definitions for terms that may be unfamiliar.

ACTIVE OR PASSIVE VENTILATION SYSTEM TYPE

- **Does the facility have a mechanical ventilation system?**
  - **Is it a ducted whole building system or an in-room through-wall system?**
- **Does the facility rely on natural window ventilation?**
  - **Is it being manually operated?**

CHARACTERIZE ACTIVE DUCTED VENTILATION SYSTEM CAPABILITIES

- **Does the facility have a ducted heating and/or cooling system?**
- **Does the ducted system mix air from multiple spaces together?**
- **Does the ducted system have in-line filtration?**
  - **Where are those filters?**
  - **Are they replaced regularly?**
- **Can the in-line filter be upgraded to one that has a MERV rating of MERV 13 or higher?**
- **Can the ducted system be set to run continuously?**
  - **Where are those controls?**
- **Can the airflow rate / fan speed of the ducted system be increased?**
- **Does the ducted system bring in fresh outdoor ventilation air?**
  - **Where does that happen?**
- **Can the ducted system bring in a greater percentage of outside ventilation air?**

OPTIMIZE ACTIVE THROUGH-WALL SYSTEM TO VENTILATE

- Does each space have a through-wall PTAC unit?
  - Is it set to run continuously in ventilation mode?
- Does each space rely on natural window ventilation?
  - Can the windows be opened?
  - Are they currently being opened?
- Who will operate the windows?
  - Will they be left partially open?
  - Will they be intermittently opened and closed?

CHARACTERIZE PASSIVE WINDOW VENTILATION SYSTEM CAPABILITIES

- Can this window inlet be combined with an en suite bathroom exhaust fan outlet?
- Is the bathroom exhaust fan running continuously?
- Can the door to the corridor and other shared spaces remain closed most of the time?

ASSESS IN-ROOM FILTER USE AND PERFORMANCE

- Are there in-room HEPA filters in each space?
  - Can they be added?
- Are the in-room HEPA filters rated for the size of the space they being used in?
  - Can they provide enough CFM of airflow to achieve 5-6 ACH?
- Are the in-room HEPA filters placed in centrally to best circulate filter air in the space?
  - Are there any obstructions in front of the filters?
- Are the in-room HEPA filters being used continuously?
  - Are they on the appropriate fan speed to provide 5-6 ACH for space they are in?
- Is the HEPA filter media being checked and replaced at a regular intervals?
  - Is there a pre-filter?
  - Is it being cleaned at regular intervals?

OPTIMIZE & UPGRADE

- Use this section as a starting point in developing system and facility specific optimization and improvement strategies once you have identified your existing system types and characterized their current performance.
- Keep these four key action areas in mind as you develop a combined set of performance improvement measures to reduce the risk of infection in your facility.
- Reference the remaining sections of the toolkit as you develop your strategies.

INCREASE SUPPLY OF FRESH OUTDOOR AIR

Ducted system:

Increase ratio of outdoor air to recirculated air and run fans continuously

Through-wall system:

Switch from recirculation mode to ventilation mode and run continuously

Operable window ventilation:

Plan when and who will open windows

CONTINUOUSLY EXHAUST STALE INDOOR AIR

Ducted system:

Balance increased ratio of outdoor supply air with system exhaust rate

Through-wall system:

Run bathroom exhaust fan continuously to exhaust air from adjacent spaces

Operable window ventilation:

Run bathroom exhaust fans continuously; open windows on two sides of a room

INCREASE FILTRATION FOR RECIRCULATED INDOOR AIR

Ducted system:

Increase the MERV rating of the inline filter used; increase fan speed to increase the rate of filtration; deploy portable in-room HEPA filters for additional filtration capacity

Through-wall system:

Deploy portable in-room HEPA filters; select unit based on room volume; check and replace filters at regular intervals

Operable window ventilation:

Deploy portable in-room HEPA filters; select unit based on room volume; check and replace filters at regular intervals

CLOSE DOORS TO ROOMS WITH INFECTIOUS RESIDENTS

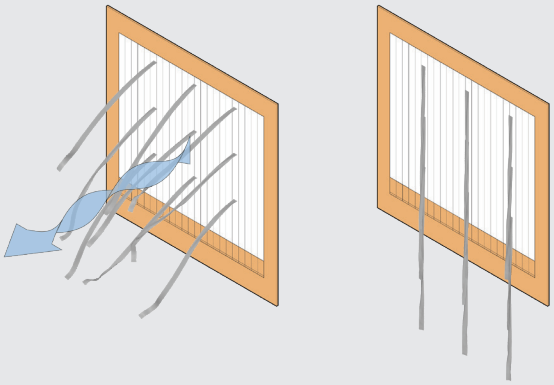
All ventilation system types:

Isolate airborne viral particles to limit transfer to other spaces; allow time for removal via exhaust or filtration

Each building and ventilation system is different. The following pages contain more detail to help you identify how ventilation air moves through your building and how to apply these recommended optimization and upgrade actions with your specific HVAC system type to lower the risk of spreading respiratory disease in your facility.

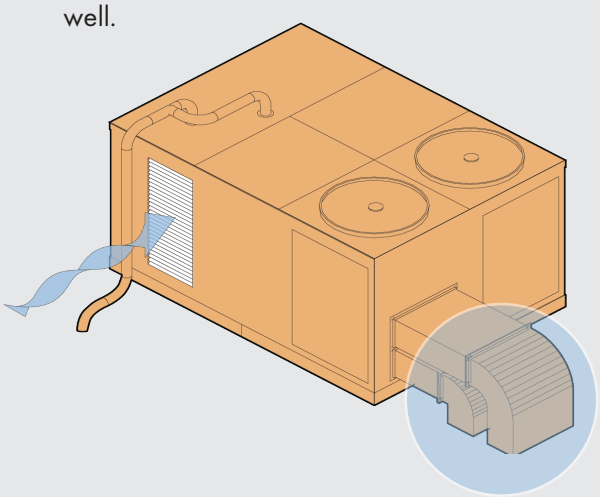
DUCTED SYSTEM TYPES

» Only some types of heating and cooling systems can provide ventilation, and those that can usually have settings that control if and how much fresh outdoor air they provide.



Indoor supply and return grilles indicate a ducted system moves air through your building

» Outdoor equipment can be a simple visible indication of what type of heating and cooling system your facility has, and based on that equipment, whether it can provide ventilation as well.



Packaged rooftop unit with large ducted connections circulates air through your building

Ducted systems: Look for grilles/grates over air ducts on walls, floors and ceilings of each space. If you have a ducted system, there's a chance it has some capability to provide fresh outdoor air and settings could be adjusted and/or the equipment could be modified to increase the amount of fresh outdoor air delivered to each space. It also means there is likely a filter in at least one place in the ducted loop between the heating/cooling equipment and the spaces with ducted supply and return grilles. These filters need to be replaced regularly and they can often be upgraded to provide an increased level of filtration. Ducted systems typically recirculate a large percentage of the air they move around your building. For this reason, ensuring it is providing some percentage of outdoor ventilation air and that recirculated air is being filtered are critical to maintaining healthy indoor air in a building with a ducted heating and cooling system.

Identify air movement and direction: Hold up a piece of yarn, ribbon or tissue to each grille to determine if the system is operating (air is moving or it's not), and whether that grille is an inlet or outlet (air is blowing into or out of the space). Leaving a ribbon tied to a supply grille offers an easy visual check to confirm the system continues to operate over time.

Outdoor equipment: Heating and cooling system types and equipment are numerous and diverse in scale, function and configuration. Some equipment may be hidden away in services spaces indoors, but some equipment is located outdoors so that it can easily exchange heat with ambient outdoor air. A quick walk around your facility near it's perimeter can reveal equipment located there. If you have easy access to the roof, you may find and identify equipment there.

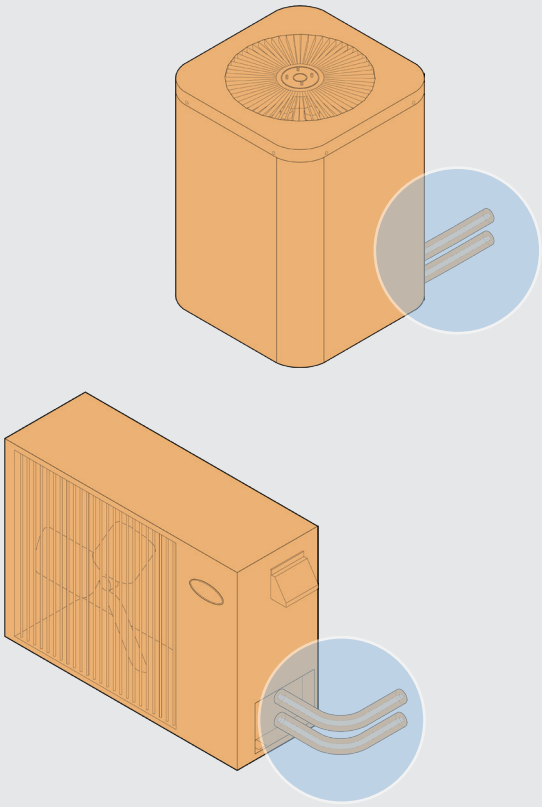
Available satellite imagery is an easy way to get at least some information about whether or not equipment is on the roof and if it's a few large pieces or many small distributed pieces of equipment.

Equipment labels: You don't need to be an engineer to learn something about your systems, just walk over to them. If you find equipment, take a picture of any labels that you can find attached, the internet will do much of the rest of the work for you. In particular, you are looking for a manufacturer name and a model number that will lead you to more information about what kind of equipment it is and if it has ventilation and filtration capabilities or not.

Identify if equipment moves air: Air needs to move through large metal ducts connected directly from the equipment to your building. Typically, this equipment is large and often mounted on a rooftop. If your facility has this type of equipment, dampers to control how much fresh outdoor air is brought in, as well as filters, are often located on and in the equipment itself. They may also be located along the ducted air path. If you find these system components: Note the outdoor air damper position. Note if filters look like they could be obstructing airflow. Note any replacement record. Filters should have a label denoting their Minimum Efficiency Reporting Value, or MERV rating. MERV 13 or greater is preferred but not possible with all systems.

Identify if equipment moves refrigerant: Refrigerant moves through small tubes with insulation around them. If you only see something a few inches in diameter connecting the equipment to your building you have a refrigerant based heat pump system. Typically this equipment is small and you might see multiple similar units in different locations. If your facility has this type of equipment, it is not providing fresh outdoor air or filtration. You'll need to look for these system capabilities elsewhere in your building.

» Without knowing any specifics about the equipment you find outside your building, you can identify if it moves air through your building, or if it moves refrigerant into your building and the air is heated or cooled by the refrigerant somewhere inside.

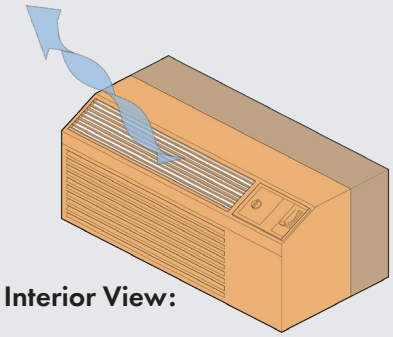


Heat pumps with small insulated tubing connections circulate refrigerant and not air

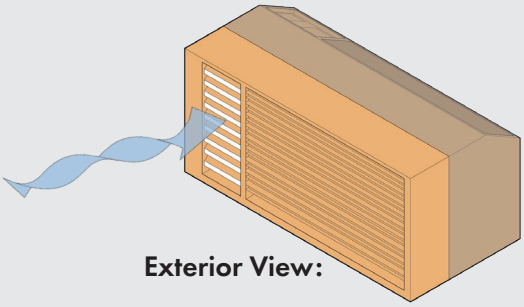
» Even if you see fan blades and can feel air movement at the outdoor equipment, it doesn't necessarily mean it is moving air through your building or providing ventilation. Fans are often used to transfer heat to the outdoor air from a refrigerant based system

IN-ROOM SYSTEM TYPES

» Some heating and cooling systems have equipment that is installed in each room. This distributed approach typically offers occupants some local control of temperature and sometimes ventilation if the equipment is a through-wall unit.

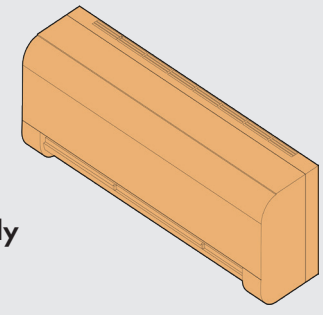


Interior View:



Exterior View:

Packaged terminal air conditioner (PTAC) is a through-wall unit that can provide ventilation



Interior only

Mini-split or ductless heat pump usually mounted high on a wall does not provide ventilation air

Through-wall in-room equipment: If your heating and cooling system is mounted through an outside wall, then there is a good chance it can be set to provide fresh outdoor ventilation air directly to the space it is located in. A packaged terminal air conditioner, or PTAC, is normally installed below a window opening. With one unit installed through the outside wall for each occupied space, this system type is easy to identify from outside the building. These units are a self contained heat pump system and are able to provide heating and cooling to an indoor space by transferring heat to and from the outdoor air, which is why they are designed to be mounted through the exterior wall of a building.

Identify outdoor air control: With access to outdoor air, these systems can be set to allow some portion of the air they are heating or cooling to be ventilation air. Find the controls for the unit, which are usually directly on the unit itself. Look for a setting that toggles between recirculation mode and ventilation mode. The label description may very, but now that you know what it does you can identify it.

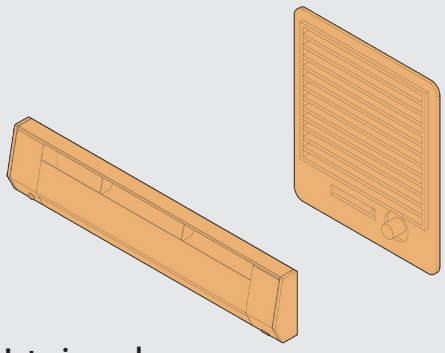
Other in-room heating and cooling equipment: If you have equipment mounted on a wall in each space that heats, cools and circulates air, but find that it isn't a through-wall system, this is likely a mini-split system which is also referred to as a ductless heat pump. These units transfer heat to outdoor air through refrigerant. Because they have no connection to an outdoor air source, they do not provide ventilation.

Identify alternate ventilation source: It's possible that your facility may have a separate ventilation

system. This type of ventilation only system is referred to as a dedicated outdoor air system, or DOAS. If your facility had this system type you would find a small supply and return air grille in the space, as it is only providing ventilation air for occupants and not heating or cooling the space. In addition to grilles being smaller than a ducted system that also heats and cools, it may be set to run intermittently in order to provide a certain amount of ventilation air per hour by only having fans run for a part of that hour. If your facility has this type of dedicated ventilation system, increase the ventilation rate if possible and run it continuously instead of intermittently.

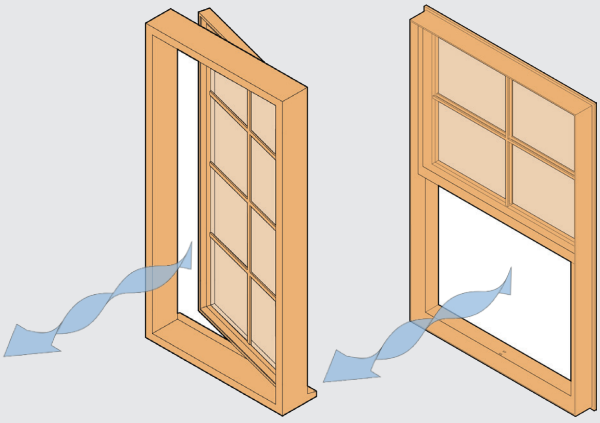
Windows are a natural ventilation source: Many older buildings, especially older residential facilities, were designed with the assumption that occupants would get fresh outdoor natural ventilation air through windows. Older wood windows don't have tight seals and allow for constant ventilation air to be supplied through gaps and cracks. It's possible that old wood windows may have been replaced in your facility. The newer windows are more energy efficient and seal better, eliminating the heat loss and drafts of the old windows. However, typically when old windows are upgraded, and the natural ventilation that occurred through them is eliminated, no alternative mechanical ventilation system is installed. If you have heating only equipment installed in spaces, like electric baseboard radiators or electric in-wall heaters, your original ventilation source is also likely operable windows.

Identify operable windows: Find windows that can be opened. Keep them cracked as possible or open fully when outdoor air temperature is comfortable.



Interior only

Electric resistance heating from baseboard radiators or in-wall heaters do not provide ventilation air or cooling

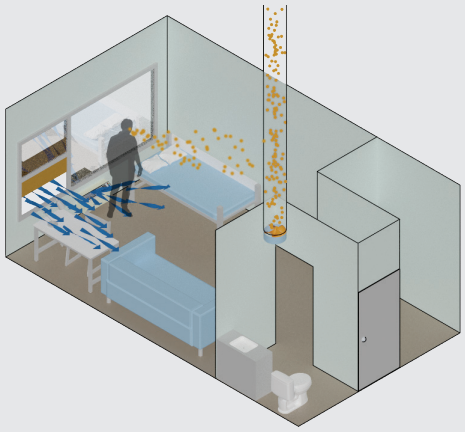


Operable windows provide ventilation air and can control the rate it is being supplied

» Natural ventilation through windows requires manual operation. If leaving windows partially open is not practical for occupant thermal comfort, windows can be opened periodically. Even opening them for a few minutes every hour or a few times a day will benefit occupants.

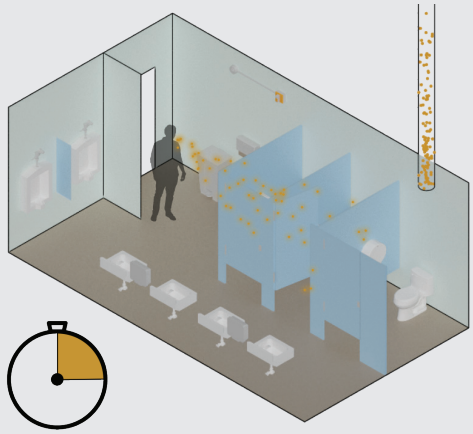
EXHAUST SYSTEMS

» With ventilation air supply established, exhaust, filtration, and isolation are effective strategies that can be used to further reduce the risk of airborne transmission indoors.



Individual en suite bathroom exhaust can be used to draw ventilation air in a window and through the resident's room.

» Exhaust fans remove respiratory aerosols in a space reducing the likelihood they will spread indoors to shared spaces and other occupants.



Shared bathroom and bathing spaces should have continuous exhaust and allow time between users where feasible

Integrated exhaust: If your facility has a ducted mechanical system type that brings in some portion of fresh outdoor ventilation air, it probably also exhausts an equal amount of stale indoor air. For example, a DOAS ventilation-only system has two fans, one pulling fresh air in, and a second pushing stale exhaust air out. Even if the supply fan is set to bring it more air than the exhaust fan removes, your building would be slightly pressurized, and that extra supply air will then exit your building through windows, doors and other gaps and cracks in the building facade.

Standalone exhaust: Bathroom and kitchen spaces typically have a dedicated exhaust fan. These exhaust fans pull air out, and in turn slightly depressurize your building, which pulls air in through windows and doors and other gaps and crack in the building envelope.

Window exhaust: Air can and does move both ways through a window. It depends on wind speed and direction, temperature difference between inside and outside, whether another window is open and where, and whether another system, like an exhaust fan, is causing air to move through that window.

Identify exhaust air path: Consider your facility's mechanical system and whether it provides ventilation air. Look for bathroom exhaust fans and their controls, which might be a simple switch on the wall or may be found elsewhere. Set these exhaust fans to run continuously where possible, and consider where ventilation air is coming in and where the likely air path would be between that inlet and the exhaust fan outlet. If a space is shared, try to allow time between users for exhaust fans to remove airborne contaminants.

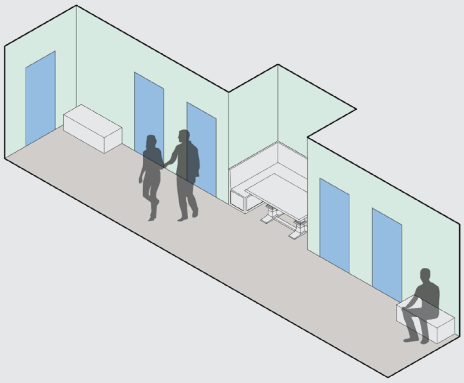
IN-ROOM FILTRATION

Recirculating systems: If ducted systems are providing heating and cooling, they typically rely on recirculating the majority of the air you feel coming out of the supply grille. This recirculated air is typically a combination of air from a group of multiple spaces in a building or even the whole building, mixed together and then heated or cooled before being returned back to the same group of spaces. This is why improved in-line filtration can reduce the risk of transmission from one space to another that both share a ducted heating and cooling system.

In-room systems: heating and cooling equipment located in the space itself means there is no intended mixing of air from elsewhere in the building in order to accomplish the air heating or cooling task. This is a benefit to reduce transmission between spaces, however, these in-room systems typically lack ventilation air which allows indoor concentrations of contaminants like viral particles to rise if the air in the space stays in the space.

Portable HEPA filtration: In all cases, adding and operating in-room filtration will reduce the risk of airborne transmission indoors. High Efficiency Particulate Air, or HEPA, filters are the replaceable filter media in these portable units and they are rated to remove nearly all of even very small viral and non-viral particles from air that passes through the filter. The other component to these units is a fan. The higher the fan speed setting, the more air that moves across the filter, and the quicker and more often the air within the space is circulated through the unit and back to the room. Selecting the optimal unit should be done based on the size of the space and the unit specifications.

» Keeping doors between resident rooms and common spaces closed as much as possible will help isolate the exhaust air path for each space and also isolate in-room filtration effectiveness if portable HEPA filters are being used.



Closing doors between spaces when possible will help isolate air volumes and air paths

In-room portable HEPA filters remove particles and circulates air within the space it is located

IN-ROOM FILTRATION

Room Volume (ft^3)	=	Room Length (ft)	×	Room Width (ft)	×	Room Height (ft)

Calculate the room volume for each space you intend to place an in-room HEPA filter

5 - 6 ACH = Recommended HEPA airflow rate

Minimum Filter (CFM)	=	Room Volume (ft^3)	×	5 (ACH)	÷	60 (min/hr)

Calculate the minimum CFM rating for a HEPA filter sized to achieve 5 ACH in each space

» An in-room HEPA filter that is rated above the minimum recommended CFM value for your space volume on it's highest fan speed setting, may be able to be run on a slower and quieter setting. Also, because the HEPA filter media is sized for higher airflow rates, it may not need to be replaced as frequently when run at lower fan speeds, as long as that fan speed provides 5-6 ACH in your space.

Identify space parameters: One way that in-room filters are rated is by the volume of air they can move on their highest fan speed setting past the HEPA filter in a certain amount of time. This airflow metric is typically expressed in cubic feet per minute, or CFM. Once you measure the space you intend to install an in-room filter in you'll be able to make a calculation of the minimum airflow rate in CFM the unit you select should be capable of providing. Measure the length, width, and height of the space in feet. Multiplying these together gives you the volume of the space in cubic feet.

Recommended filtration airflow rate: The minimum recommended airflow rate for in-room filtration is expressed as the number of times the equivalent of one full air volume of the space can pass through the filter in one hour. 5-6 air changes per hour, or ACH, is recommended for most space types.

Calculate minimum airflow in CFM: Simply take the volume of your space in cubic feet multiplied by the recommended 5 air changes in one hour, then divide by the 60 minutes that make up and hour. The result is the minimum CFM any in-room filter unit should be rated to provide. For large spaces, use more than one in-room filter.

Caution: Manufactures use various methods to market the performance of their products. Make sure it has a HEPA filter and no other type of air cleaning technology, many of these additional features can be harmful to occupants. If only the square footage the unit is suggested for is listed, an 8 foot ceiling height was assumed. If your ceiling is higher, the suggested floor area should be adjusted down. Watch out for

missing, mixed or misleading units following numerical performance values.

Common rating standard: Clean Air Delivery Rate, or CADR, is a rating system used for portable air cleaners including those that don't incorporate a HEPA filter and those that employ additional features beyond filtration. CADR is most commonly expressed in CFM and three different numbers are provided and labeled smoke, dust, and pollen. Since smoke has the smallest particle size, this is the number to compare across units for performance. The unit CADR for smoke should be higher than the minimum CFM value you calculated for 5 ACH in your particular space.

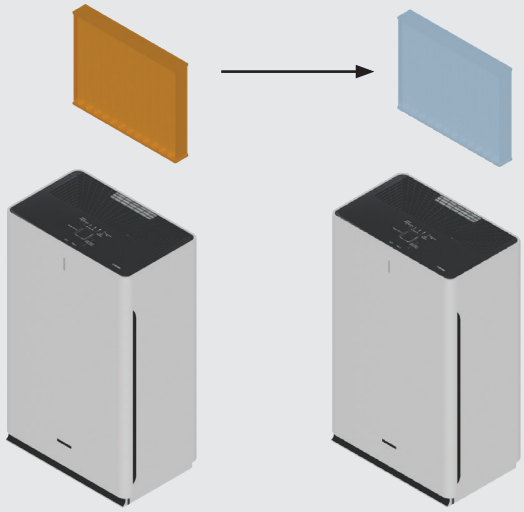
Maintenance: Just like the filters in your ducted HVAC system, in-room filters need to be replaced at a regular interval which will depend on the use case and size of the filter. Take replacement filter cost into account when selecting an in-room HEPA filter.

Noise: If the portable in-room filter gets turned off, turned down, unplugged or moved it will be less effective. Testing data should be available and reported for the level of sound produced when the unit is running at each fan speed and will be reported in decibels, or dB, with lower dB readings being quieter.

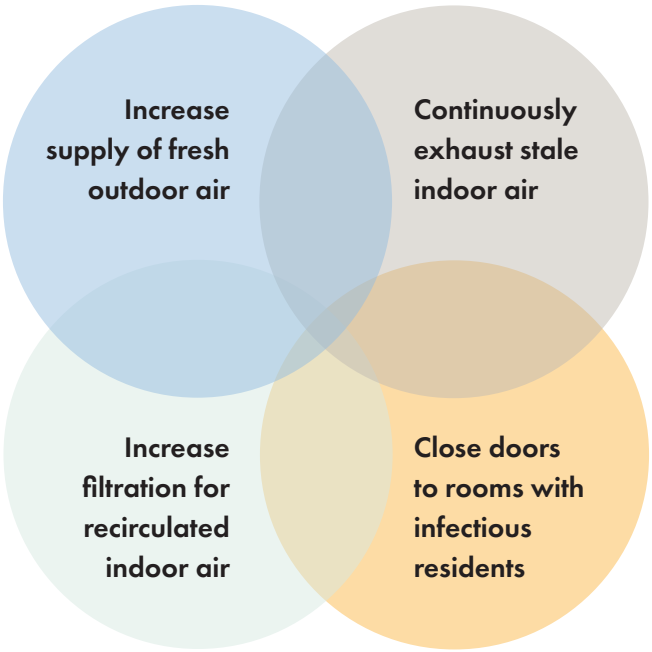
Placement: Consider the size of the unit and where it might be placed in your space amongst furniture, space, use and power source location constraints. An in-room filter placed in a corner or behind an obstruction will be less effective that one that can freely circulate as much air in the space as possible.

In-room HEPA filter sizing estimates using CADR	
Room Volume (ft^3)	**Minimum CADR (CFM)**
800 ft^3	65 cfm
1600 ft^3	130 cfm
2400 ft^3	195 cfm
3200 ft^3	260 cfm
4000 ft^3	325 cfm

» Many portable in-room HEPA filters have a pre-filter in front of the HEPA filter media. This filter stops dust and larger particles. It can also be cleaned by vacuuming, sometimes washed, or inexpensively replaced. A unit with a pre-filter is recommended and will allow for longer time intervals between replacing the more expensive HEPA filter media.



In-room portable HEPA filters require regular filter replacement to maintain effective airflow



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