# FAQs: Room Air Exchange Rates ("Air Changes per Hour (ACH)")

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Room ventilation standards and guidance often specifies room ventilation as air exchange rates, commonly referred to as "Air Changes per Hour" or "**ACH**." The following FAQs was developed by the San Francisco Department of Public Health for use by local facilities, and will be posted at www.sfcdcp.org/COVID-Ventilation. These FAQS may change as knowledge, community transmission, and availability of PPE and testing change. Email any ventilation related questions to: dph.doc.ventilation@sfdph.org

**AUDIENCE:** Non-healthcare organizations (including businesses, companies, offices, schools, faith-based and similar organizations) and the general public. Healthcare personnel and first responders need to check with their infection control and safety & health groups for guidance as there are specific hazards or hazardous activities which ventilation systems are set to control. Additional information for healthcare organizations can be found at www.sfcdcp.org/covid19hcp under Health Care Exposures.

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## 1. What is a room air exchange rate and why are they used?

Room air exchange rates are a common method to specify ventilation in a given room or walled-off space. It describes the quantity of ventilation in units of the room volume (length x width x height) and time, typically in hours which is where the term "Air Changes per Hour" comes from. This allows ventilation in rooms of different sizes to be compared with each other and allows guidance to be given using a simple number ("provide 6 ACH") rather than a formula. This is of value:

- For defining how much ventilation is needed based on activities and risks within an area, and
- For calculating how much time is needed when a space is vacated to get entirely fresh air ("purge time").

The CDC makes use of ACH in their 2003 *Guidelines for Environmental Infection Control in Health-Care Facilities* where Table B1 is widely used to estimate the amount of time a room needs to completely clear of a contaminant based on the ACH.

### 1.1. So, a room with an ACH of 6 will take 1 hour and 9 minutes to clean 99.99%?

That is correct – 69 minutes@6 ACH OR 6.9 Air Changes total. This is from the time when contaminant generation ceases (i.e. the infectious patient leaves the room or the Aerosol Generating Procedure is completed); if contamination generation is ongoing, the 69 minute timer keeps on resetting over and over again.

## 2. When should air exchange rates not be used?

Air exchange rates are a theoretical calculation which assumes that air being introduced into a room via the ventilation system completely mixes with the existing air in the room, immediately diluting any contaminants. This is not the case as room shape, locations of ventilation supplies and exhausts, force of air being supplied, and obstacles within the room can all affect mixing. For this reason, **ACH cannot be used to estimate the control or reduction of contaminants as they are being generated**, only after the generation has ceased and the room is being aired out. To control contaminants being generated would require astronomically high air exchange rates. Instead other techniques, most commonly local exhaust ventilation is used to capture contaminants before they enter the room's airspace as whole, and air exchange is used to control any leftover or residual contamination.

### 2.1. So, ACH is an inefficient way to think about decontaminating air, but folks need to understand ACH first and why…right?

That is correct. Additionally, ACH does not work well for rooms which have highly variable occupancy levels.

The value of ACH is that you can avoid more complex standards like "0.5 CFM of fresh air per square foot of floor area" and "15 CFM of fresh air per person", which is how ASHRAE amongst others specifies fresh air ventilation in their standards.

3. How do you calculate Air Changes per Hour (ACH)?

3.1. Basic Formula: The basic formula is:

ACH = (CFM x 60 minutes) / room volume, where
CFM = cubic feet per minute (ft^3/min) of outside air or highly filtered (MERV-13 or greater) air supplied by the ventilation system, and
Room volume is given in cubic feet

*Example: the dimensions of a room are 10'x10'x8'; the ventilation is providing 100 CFM of fresh air*

ACH = (100 CFM x 60 min) / (10x10x8)

ACH = 6,000 cubic feet / 800 cubic feet

ACH = 7.5 (round to 7)

3.2 Ventilation Which Recirculates Part of the Air:

When part of the room's ventilation is being recirculated (normal for commercial buildings) and the recirculated air isn't being run through "highly efficient" (MERV-13 or greater) filters the formula becomes:

ACH = ((CFM x % outside air) x 60) / room volume

*Example: the dimensions of a room are 10'x10'x8'; the ventilation system is providing 100 CFM of air, but only 30% is outside air (the rest is recirculated)*

ACH = ((100 CFM x 30%) x 60) / (10'x10'x8')

ACH = (30 CFM x 60) / 800 cubic feet

ACH = 1,800 cubic feet/ 800 cubic feet

ACH = 2.25 (round to 2)

4. The calculations above make reference to "highly efficient" filters. What are they?

Air filters for ventilation systems tend to have standardized Minimum Efficiency Reporting Values or MERV ratings, a numerical score which indicates how well the filter works when tested with different sizes of particles. Filters used in residential applications may be unrated or have MERV ratings of 9 or less. Commercial buildings typically use filters in the MERV 7-14 range. Only filters with MERV ratings of 13 or above are capable of trapping COVID-19 aerosols, collectively these filters are referred to as "highly efficient".

5. Where do I get the amount of air supply into a room? Where do I get the percentage of outside air in the supply? Where do I find out what type of filter (MERV rating) used in the ventilation system?

People who maintain the ventilation system is the best source of this information. This might include the building (stationary) engineer, facilities manager, or landlord.

6. I only have windows for ventilation. How do I calculate my air exchange rate?

   You cannot calculate your air supply from windows because it will change depending on the direction and force of wind, which windows are kept open, and how much the windows are opened. Rooms which depend on natural ventilation are sometimes assigned arbitrary values such as 1 or 1.5 ACH.