Interim Guidance: Ventilation During the COVID-19 Pandemic

UPDATED October 20, 2020

The following guidance 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. This interim guidance may change as knowledge, community transmission, and availability of PPE and testing change.

AUDIENCE: Non-healthcare organizations (including businesses, companies, offices, schools, faith-based and similar organizations). 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.

Please Note: The ventilation intervention considerations listed below come with a range of initial costs and operating costs which, along with risk assessment parameters such as community incidence rates, facemask compliance and number of occupants in a space, may affect decisions about which interventions to implement. The guidance provided is general in nature and may not be applicable to your specific building or activity**. Always consult** with building engineering or maintenance staff prior to making changes to a mechanical ventilation system. For healthcare organizations, always consult with your (a) infection prevention and control and (b) health and safety support. Be aware that some of the changes may result in increased energy bills or increased wear on ventilation system components.

1. Definitions

Air Changes per Hour (ACH, also called Air Change Rate) is a calculated value which allows standards, guidelines, and comparisons for ventilation to be made for rooms of different dimensions and which have different ventilation systems. Using English units, the formula for ACH is:

ACH = (ventilation rate in CFM x 60 minutes/hour) / room volume in cubic feet

For the purpose of this calculation, only fresh or highly filtered (MERV 13 or greater efficiency) air is used for the ventilation rate; unfiltered or less filtered recirculated air does not count in the ACH calculation.

Air cleaners are standalone devices that move air in a room through a filter. Some filters are capable of removing tiny particles, including virus particles and smoke. Referred to in this document as Portable Air Cleaners (PACs) to differentiate from filters and other devices in HVAC systems which provide air cleaning.

ASHRAE is the American Society for Heating, Refrigeration, and Air-conditioning Engineers. Facilities staff, engineers, and health and safety professionals are familiar with this organization and literature.

CADR or Clean Air Delivery Rate, measures an air cleaner's effectiveness based on room space and the volume of clean air produced per minute. Tested units have three CADR ratings; for COVID-19 purposes the “Dust” CADR rating should be used.

Fans are devices that pull or push air in one direction. Fans can be placed in windows or doorways, they may be “pedestal type” that can be placed anywhere in a room, or they may be attached to ceiling fixtures.

Some fans have switches that allow the user to change the direction of air flow of the fan; fans that do not have such switches must be physically turned to change the direction of air.

HVAC stands for Heating, Ventilation and Air Conditioning system. Also referred to as "Mechanical Ventilation" because of the system's use of fans to move air in and out of rooms, typically through ducts and plenums.

Outside Air refers to clean air drawn from outside the building either by natural or mechanical ventilation. Also referred to as "Fresh Air" or for selected applications "Makeup Air."

PACs are Portable Air Cleaners, devices which can be moved within a building or room to provide air cleaning. PACs are generally sold with some form of highly efficient filter such as a High-Efficiency Particulate Air (HEPA) filter. The portability of PACs allow them to be placed where air cleaning will be most beneficial to room occupants.

Passive ("Natural") ventilation refers to ventilation that is accomplished by opening windows and doors to the outside.

Recirculated Air refers to air which has been drawn from the inside of the building, passed through filters, conditioned, and reintroduced into the building. Unless passed through MERV-13 or greater efficiency filters, recirculated air is not considered when assessing building ventilation for COVID-19 purposes.

2. COVID-19 Basics

COVID-19 is transmitted from person-to-person and may occur in the following scenarios:

- Large droplets from coughing and sneezing are propelled directly into the face, nose, eyes, or mouth of someone nearby, usually within 6 feet. These droplets are sometimes called "ballistic droplets" because they tend to travel in straight lines and are subject to the forces of gravity.
- Small droplets and particles are released when a person breathes, talks, sings, coughs, or sneezes. These small droplets and particles can remain suspended in the air for a period of time and/or move beyond 6 feet on indoor air currents. Other people might inhale these small droplets and particles even if they are further than six feet away. These droplets are sometimes referred to as "aerosols" or "bioaerosols."
- A person touches a surface that is contaminated and then touches a mucus membrane such as their nose, eyes or mouth. Contaminated objects and surfaces are sometimes called "fomites."

Good ventilation is one of the most important ways to control small droplet and particle transmission and can help reduce large droplet transmission.

3. General Considerations

Our understanding of the role that the built environment plays in the transmission of COVID-19 is evolving; recent literature suggests that air currents may carry small droplet and particles well beyond the 6-foot social distancing radius. With the possible exception of hospitals, healthcare facilities, and research facilities, existing ventilation requirements, such as those established in the Building Code and Title 24 were not intended to control exposures to small droplets and particles of hazardous infectious agents such as

COVID-19. Consequently code-compliance should be considered to be the baseline or starting point in creating more protective environments, and ventilation should be maximized to levels as far above code requirements as is feasible particularly for areas where people are unmasked and/or where there is the mixing of unassociated people.

In general, the greater the number of people in an indoor environment, the greater the need for ventilation with outdoor air. Focus efforts on providing fresh air ventilation to the spaces with the highest density of occupants as well as where occupants may be unmasked. Decrease occupancy in areas where outdoor ventilation cannot be increased. Other changes that can be considered in buildings with specific ventilation features include:

3.1 Inspect and maintain local exhaust ventilation in support areas such as laundry or kitchens. Make sure that such ventilation is in balance with the rest of the building so that potentially contaminated air is not drawn in from other areas.

3.2 Ensure restroom and other exhaust fans are functional.

3.3 Keep windows and other sources of natural ventilation open to the greatest extent possible.

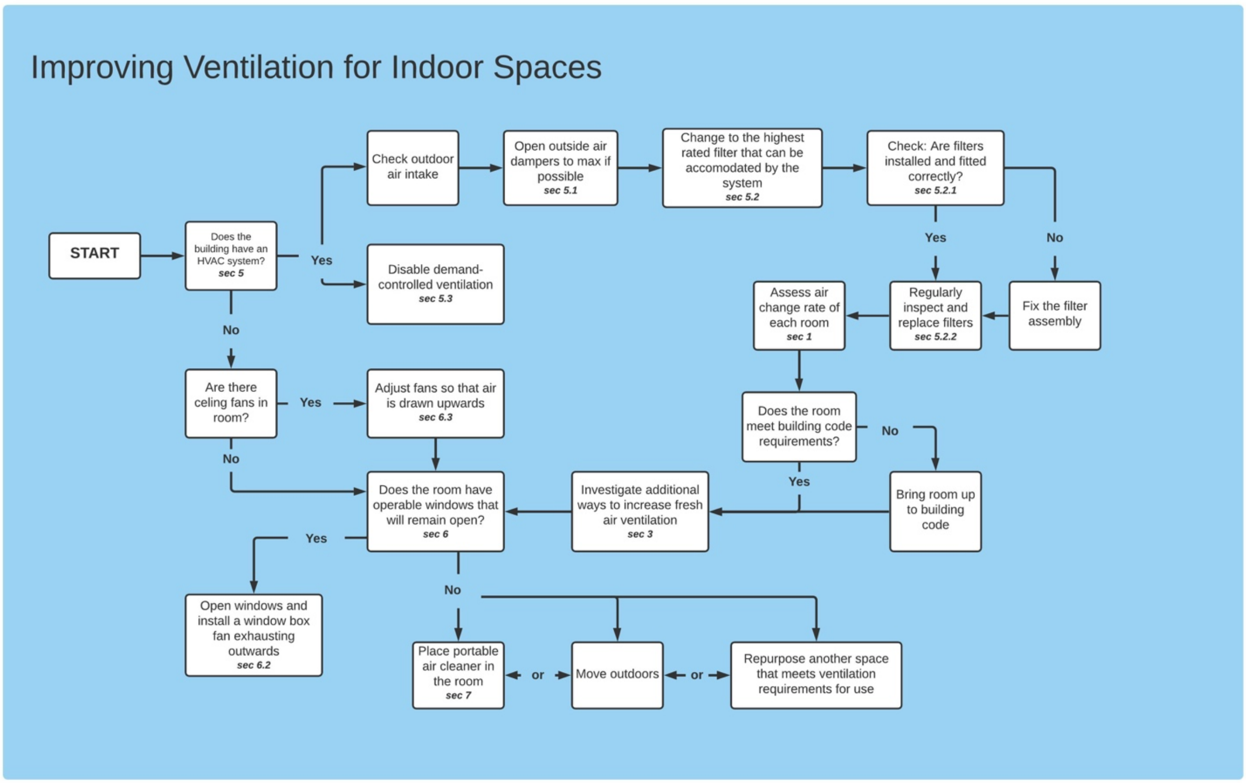
3.4. Consider adding Portable Air Cleaners (PACs) in areas where fresh air ventilation cannot be increased.

To help you in improving your building’s ventilation, some of the following parties may be able to assist:

- Facilities (“Stationary”) Engineers
- Building Maintenance and Repair Staff
- Mechanical Engineers
- Mechanical (HVAC) Contractors
- General Contractors
- Architects and/or
- Indoor Air Quality or Industrial Hygiene Consultants

4. “Decision Tree” for Improving Ventilation for COVID-19

The following “Decision Tree” is based on a Yale University School of Public Health drawing which is part of their guidance for improving ventilation in schools for COVID-19. Section references in the Decision Tree refer to specific sections of this document.



Schools and other interested parties are encouraged to read the Yale School of Public Health’s web page Ventilation Key to Reducing Risk, part of Yale’s Public Health Guidance for Reopening Schools in 2020.

5. Improving Mechanical Ventilation

Consider mechanical ventilation system upgrades or improvements and other steps to: 1) increase the delivery of clean air and 2) remove or dilute concentrations of COVID-19 or other contaminants in the building air. Obtain consultation from experienced HVAC professionals when considering changes to HVAC systems and equipment. Some of the recommendations below are based on ASHRAE’s Guidance for Building Operations During the COVID-19 Pandemic . Review additional ASHRAE guidelines for schools and universities for further information on ventilation recommendations for different types of buildings and building readiness for occupancy. Not all steps are applicable for all scenarios.

5.1 Further open outdoor air dampers and close recirculation dampers (“economizers”) to reduce or eliminate air recirculation. In mild weather, this will not affect thermal comfort or humidity, but in cold, hot, or humid weather this may result in changes to indoor air and result in building occupant discomfort.

5.2. Improve central air filtration to as high as possible without significantly diminishing design airflow. Target air filtration should be MERV 13 or greater.

5.2.1 Inspect filter housings and racks to ensure appropriate filter fit and check for ways to minimize filter bypass.

5.2.2 Clean, or replace filters, and check filters to ensure they are appropriately installed, seated, and functioning. Note that during air quality events like wildfire smoke, higher efficiency filters will load faster and will need closer monitoring.

5.3 Disable “demand controls” on ventilation systems so that fans operate continuously, independently of heating or cooling needs.

5.3.1 If HVAC systems operate on day/night or other pre-programmed cycles, consider running the HVAC system at maximum outside airflow for 1-2 hours before the building opens and for 2-3 hours after the building is closed.

5.4 Generate clean-to-less-clean air movement by adjusting the settings of supply and exhaust air diffusers and/or dampers in higher risk areas, so that potentially contaminated air is moved away from occupants or guests.

6. Improving Passive Ventilation

Consider implementing any of the following to improve the supply of outside air into a space, using caution on poor air quality days:

6.1 When weather conditions allow, increase fresh outdoor air by opening windows and doors. Do not open windows and doors if doing so poses a safety or health risk (e.g., risk of falling, triggering asthma symptoms) to anyone using the facility.

6.2 Use fans to increase the effectiveness of open windows. Position fans securely and carefully in or near windows. Take care with electrical cords; look out for tripping or wet conditions which can create electrocution hazards. Position fans to minimize air blowing from one person to another. Window fans placed in exhaust mode can help draw fresh air into a room via other open windows and doors without generating strong room air currents. NOTE: For buildings with both operable windows and mechanical ventilation systems, the interactions between the two needs to be carefully considered.

6.3 For rooms with high ceilings, ceiling fans may help dilute potentially contaminated air with cleaner air in the higher parts of the room. Use of such fans do not bring additional fresh air into the room and **is considered to be supplemental** to fresh air ventilation. Set ceiling fans to draw air upwards. If the ceiling fans do not have a directional switch consider rotating fan blades counterclockwise so that air is drawn upward in the room. Pushing air downwards **increases the risk** of air blowing from person to person.

7. Portable Air Cleaners (“HEPA Air Filters”)

Portable Air Cleaners (PACs) can be considered in rooms and areas where mechanical and passive ventilation cannot be improved. PACs come in a range of sizes, features, and prices and higher-priced units may not necessarily provide greater improvements to air quality. Depending on the quantity, quality and condition of existing ventilation, PACs providing 2-5 additional ACH may be needed. At the minimum:

7.1 Purchase PACs which are certified for ozone emissions and electrical safety by the California Air Resources Board (CARB).

7.2 Ensure PACs are appropriately sized for the room or area they are deployed in. One method for selecting the appropriate size unit is the Association of Home Appliance Manufacturer's (AHAM) Clean Air Delivery Rate (CADR). The authors of the CADR standard suggest that a unit should have a CADR at least 2/3 of the room's floor area (in square feet), with adjustments made if the room's ceiling is more than eight feet in height. If this method is used, the unit's CADRs for Dust should be used. A list of all units with CADR ratings (with the rating values) can be found on AHAM's "Verifide" website.

7.3 For more in-depth help determining the correct size of PACs for COVID-19, Harvard University and the University of Colorado, Boulder have jointly developed a spreadsheet for identifying the correct PAC, using the CADR. If using this spreadsheet please note that the PACs listed on the third tab are examples rather than the sole units that can be used or verified/endorsed manufacturers and models, and that you can input the CADR (use the Dust value) for any unit on the second tab of the spreadsheet.

7.4 Manufacturer's specifications, CADR values, and the Harvard/CU spreadsheet all base their estimates on the PAC operating at maximum fan speed. Reducing fan speed may reduce the noise generated by the unit but will also decrease the amount of air filtration the unit will provide.

7.5 Supplemental technologies such as ultraviolet lights, and ion/"free-radical" generators in PACs have not been independently or systematically assessed for effectiveness against COVID-19. Harvard and Colorado University Boulder explicitly state "Avoid add-ons (e.g., ionizers, ultraviolet lights)."; the Consumer's Union ("Consumer's Reports") takes a similar position for PACs in general, not just for COVID-19.

7.6 For effective air cleaning, PACs should be placed towards the center of where people sit or gather, with unit exhaust directed so that it will not blow air from person to person. Placing air filtration units in unused corners of rooms or beneath tables will not effectively clean the air. Do not create a tripping hazard with the PAC or associated electrical cords.

7.7 Low-cost air cleaners can be constructed by fitting a 20"x 20" MERV-13 air filter to the intake (suction) side of a 20" box fan.

7.7.1 Completely taping the edges of the filter to the fan housing will reduce leakage and increase effectiveness.

7.7.2 The additional resistance of the filter may cause the fan motor to overheat. Never leave the fan running when the room is unattended. Shut the fan down if any unusual odors or noises are detected.

7.7.3 Fan noise will increase with the filter in place. Reducing fan speeds to control noise may significantly impact the amount of air cleaning.

7.8 Commercial/Industrial and Healthcare (C/I&H) "HEPA Air Filters" can be used and are particularly well-suited for larger rooms and areas:

7.8.1 Commercial/Industrial units, sometimes referred to as "Negative Air Machines (NAMs)" or "hogs," may already be available in larger facilities; check with Facilities/Maintenance personnel who may also be able to order them through their equipment suppliers. Healthcare units refer to those purchased from healthcare and hospital suppliers; consumer channel units which the vendors advertise as providing "hospital grade" filtration should be treated as being PACs.

7.8.2 C/I&H units typically do not have CADR ratings. Instead the manufacturer's rated airflow (in CFM) is incorporated into the Air Changes per Hour calculation provided in the Definitions section. Depending on the fresh air ventilation in the room ACHs of 2.5-6 are needed, with lower values working for well-ventilated rooms and 4-6 for rooms with marginally ventilated rooms. When calculating ACH from C/I&H units it is not uncommon to derate manufacturer's airflows by 10-25% to account for unit wear and filter conditions.

7.8.3 C/I&H units commonly have flanged exhaust ports intended for connection to temporary ductwork used during construction and renovation. Exhaust ports may need to be fitted with some form of diffuser to slow exhaust airflow and prevent air from being blown from one person to another.

7.8.4 The power draw of C/I&H units typically limit them to one large-capacity (2000 CFM) unit per 20 Amp circuit. Overloading circuits can trip breakers and create fire hazards. Even when circuits are found to support more than one C/I&H unit this may change over time as filters load and components wear.

8. Determining Ventilation Effectiveness

8.1 Small pieces of ribbon or tissue paper can be affixed to ventilation supply registers to verify that the system is operating.

8.2 A lightweight (down) feather, on the end of a stick or dowel can be used to trace air currents such as from fans or PACs, to verify that air is not being blown from person to person.

8.3 Commercial "ventilation smoke tracers" are sold to evaluate air currents but **must be used with extreme caution**. Many of the products use titanium tetrachloride, stannic oxychloride, or sulfuric acid fume which are severe respiratory tract irritants. Smoke candles create too much smoke for indoor use under normal circumstances.

8.4 Low cost carbon dioxide, CO_2, (<u>not</u> carbon monoxide, CO) monitors are commercially available. Increases in carbon dioxide levels over outdoor levels (typically 350-450 parts per million (ppm)) when a space is occupied may indicate that ventilation is not keeping up with room occupant's breathing which has 4-5% (40,000-50,000 ppm) of carbon dioxide.

8.4.1 Although 700 ppm above background levels is the common value used to assess indoor air quality, lower increases (200-400 ppm above background) may be more appropriate to assess fresh-air supply for COVID-19.

8.4.2 Measurements should be taken at multiple locations within a room or space and repeated periodically during the time the room or space is occupied.

8.4.3 If PACs are being used CO_2 measurements need to be assessed with extra caution as PACs do not filter or remove CO_2 from the air. In such circumstances CO_2 differences in measurements at different locations may still help identify "dead spots" within rooms where air mixing or exchange is not occurring and when inadequate amounts of outside air are being provided.

Resources

San Francisco Department of Public Health (SFDPH)

- www.sfcdcp.org/covid19

Centers for Disease Control

- Operating schools during COVID-19: CDC's Considerations
- Wildfire Smoke and COVID-19: Frequently Asked Questions and Resources for Air Resource Advisors and Other Environmental Health Professionals

AIHA (formerly the American Industrial Hygiene Association)

- Reducing the Risk of COVID-19 Using Engineering Controls

American Conference of Governmental Industrial Hygienists

- White Paper on Ventilation for Industrial Settings during the COVID-19 Pandemic

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)

- Guidance for Building Operations During the COVID-19 Pandemic
- ASHRAE Resources Available to Address COVID-19 Concerns
- ASHRAE Reopening Schools and Universities C19 Guidance
- Standard 62.1-2019 Ventilation for Acceptable Indoor Air Quality
  (note – this is a for-fee document. ASHRAE provides free web-access to a read-only version from the linked web page; look for Standard 62.1-2019)

Association of Home Appliance Manufacturers

- Directory of Certified Portable Air Cleaners
- Information Regarding Portable Air Cleaner Testing

Environmental Protection Agency (EPA)

- Ventilation and COVID-19
- Indoor Air in Homes and COVID-19

Harvard University School of Public Health and University Colorado, Boulder School of Engineering

- Harvard-CU Boulder Portable Air Cleaner Calculator for Schools

World Health Organization

- Q&A: Ventilation and air conditioning in public spaces and buildings and COVID-19

Yale University School of Public Health

- Reopening Schools - Ventilation Key to Reducing Risk