TECHNICAL BRIEF

Guidelines for Ventilation of Buildings Against Infectious Viruses

Introduction

In response to the SARS-CoV-2 pandemic, various organizations have developed guidelines and recommendations to reduce the transmission and impact of infectious viruses. Efforts have expanded scientific knowledge of infectious viruses and provided processes for reducing potential exposure in building environments. The Centers for Disease Control and Prevention (CDC) updated their guidance on "Ventilation in Buildings," and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) published a new standard addressing control of infectious aerosols (ASHRAE Standard 241). The following are highlights of these updates.

CDC Recommendations

CDC's building ventilation guidance includes a summary of important recommendations and frequently asked questions regarding ventilation, filtration, do-it-yourself (DIY) air cleaners, and air treatment options. Ventilation is recognized as a key intervention for maintaining healthy indoor environments by reducing pollutant exposure and protecting occupants from respiratory infections. Key recommendations as summarized below and details of the operational recommendations can be found on CDC's website.

To Improve Air Circulation	To Improve Air Cleanliness
Ensure that the HVAC system meets at least the minimum outdoor air ventilation requirement in design codes.	Upgrade HVAC filters to Minimum Efficiency Reporting Value (MERV) 13 or better.
Increase the introduction of outdoor air.	Inspect HVAC systems regularly.
Use fans to increase the effectiveness of open windows.	Apply portable or built-in high-efficiency particulate air (HEPA) filtration systems.
Adjust HVAC to increase total airflow to occupied spaces. At least 5 air changes per hour (ACH) of clean air is recommended in occupied spaces.	Consider using Ultraviolet Germicidal Irradiation (UVGI or GUV) as a supplemental treatment for inactivating airborne viruses.

ASHRAE Standard

ASHRAE Standard 241 is a consensus-based, code enforceable standard that aims to reduce the risk of infectious aerosol transmission in buildings. It includes requirements for outdoor air systems and air cleaning system design, installation, commissioning, operation, and maintenance that can be applied to multi-family homes, offices, schools, and healthcare facilities. The key concept introduced by ASHRAE 241 is "Equivalent Clean Airflow or ECA," which is "the flow rate of pathogen-free air that, if distributed uniformly within the breathing zone, would have the same effect on infectious aerosol concentration as the sum of actual outdoor airflow, filtered airflow, and inactivation of infectious aerosols." Key elements of the standard are outlined below, and more information can be found on the ASHRAE website.

Target Recommendation	Listed Requirement
Equivalent clean airflow (ECA) per person in breathing zone in infection risk management mode (IRMM)	Minimum ECA ranges 20–90 cfm/person (10–45 L/s/person) depending on occupancy categories.
Clean airflow rate in each ventilation zone	Greater than or equal to the minimum ECA required.
Zone clean air distribution	Assign to well-mixed, natural, cross flow, downflow, upflow.
Air cleaning system	Categorize according to location, discharge orientation, and/or zone air distribution category.
Infectious aerosol removal efficiency (ε_{PR})	Weighted ε_{PR} up to 99% depending on filter specification.
Assessment, planning, and implementation	Create Building Readiness Plan (BRP) to describe the applied controls to achieve the target ECA for infection control. Review BRP annually or as necessary.
Operations and maintenance	Engineering controls shall be operated when the space is occupied in IRMM. Conduct inspection and maintenance of ventilation system equipment and additional engineering controls according to required frequency.

Implications

Supplying effective ventilation with enough clean air in buildings is required for healthy indoor environments. The key takeaway messages from the new guides include:

- **Understand the environment, conditions, facilities, and occupant vulnerabilities.** Specifically, ventilation can have different meanings depending on environmental conditions and people who discuss it. It may include mechanical or nonmechanical (natural) ventilation, as well as filtration through HVAC systems, air cleaners, and air treatment systems. The impact of all these different modalities should be taken into account to accurately estimate the ventilation in the building and to further achieve goals for designing and operating.
- **Apply intervention strategies wisely.** Intervention strategies may include using natural ventilation like opening windows and doors, adding additional HVAC zones to deliver more clean air, increasing ventilation effectiveness by using exhaust fans, adding portable or mounted air cleaners with HEPA filters, and switching HVAC filters to MERV 13 or higher. Multiple strategies can be combined if applicable. Interventions can be as simple as using exhaust fans and DIY air cleaners to involving complex systems that require experienced professionals to install and operate the systems and devices correctly. Consult with professionals if needed.
- **Consider using UVGI to inactivate infectious viruses** when indoor spaces are used for large gatherings, or when the risk of disease transmission is high. Consult with experts for proper selection, implementation, and commission of the system. Be aware of the possibility of introducing other contaminants into the indoor environment.
- **Be aware that reducing the concentrations of indoor airborne viruses does not completely eliminate the risk of disease transmission.** There are cases where a person is very close to the infectious source (or emission source), or overall transmission reduction is less effective for a specific scenario. In these cases, additional precautions or protection may be needed.
- **Monitor indoor air if applicable.** Carbon dioxide (CO_2) monitoring is an informative tool to examine the ventilation efficiency in a given space. Typically, a CO_2 monitor reading below 800 ppm indicates good ventilation. Consider bringing in clean outdoor air or other approaches when CO_2 concentration is high. It should be noted that CO_2 monitoring does not represent the concentration of infectious viruses or airborne particles. A particulate matter sensor can be used for monitoring airborne particle levels. However, the monitor reading may only represent the air concentration in its immediate surroundings and may not be applicable for the entire room or building.
- **Using ventilation and filtration to reduce airborne infectious viruses also applies to general airborne particulate matter that may contain hazardous chemicals, metals, and germs.** In addition to buildings, ventilation and filtration can also be utilized in smaller environments, such as vehicles, buses, subways, and trains.

REFERENCES:

1. CDC. *Community, Work, and School*. Centers for Disease Control and Prevention. https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html (accessed 2023-08-21).
2. *ASHRAE 241-2023* | ASHRAE Store. https://www.techstreet.com/ashrae/standards/ashrae-241-2023?product_id=2567398 (accessed 2023-08-21).

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