



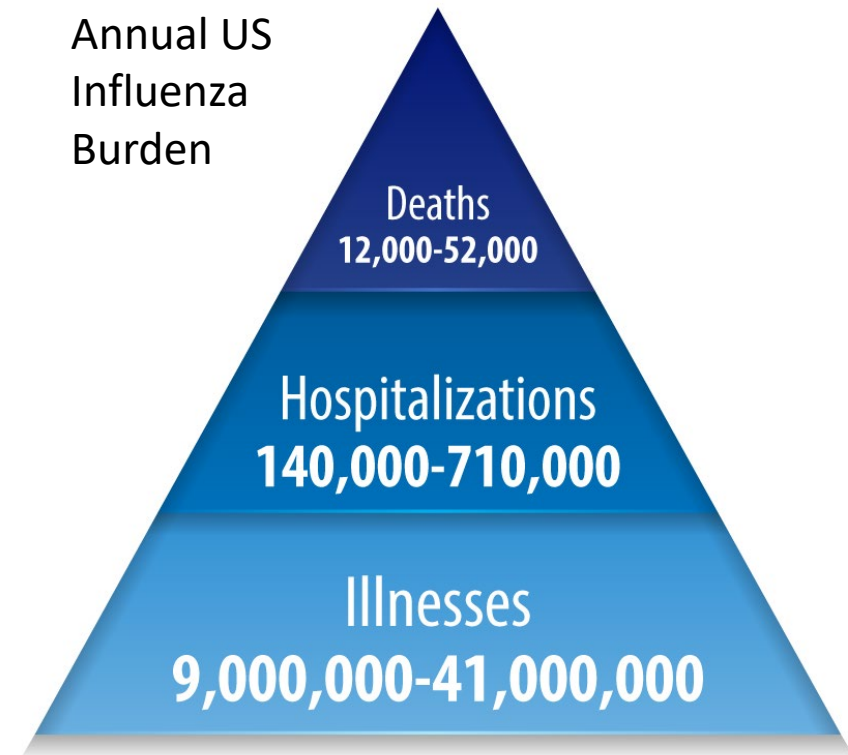
ASHRAE Standard 241 Control of Infectious Aerosols

Using Building Systems to Reduce Airborne Infection Transmission

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COVID-19 is still a concern, but other respiratory infections continue to pose risk

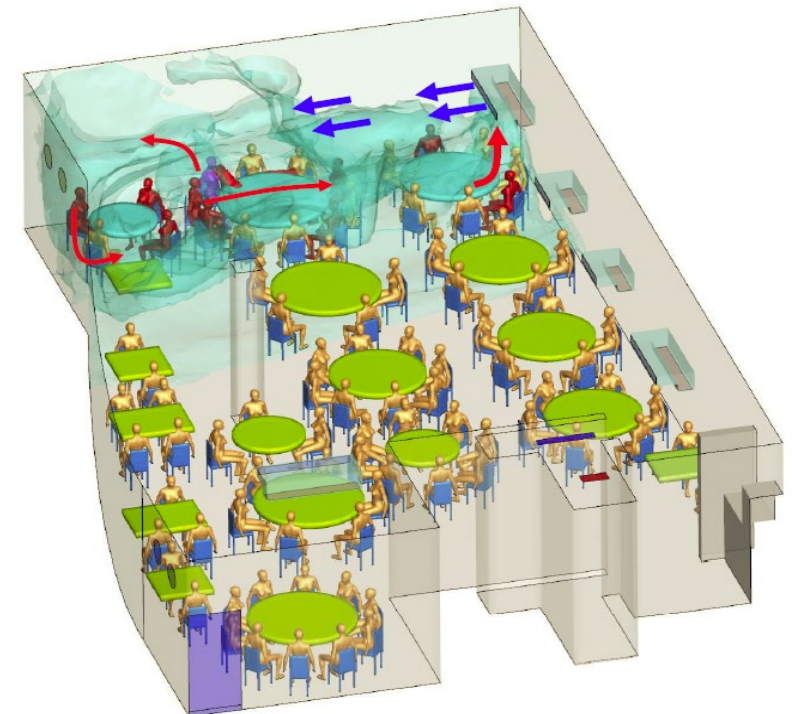
- Diseases that transmit by airborne route (entirely or partially)
 - Chickenpox
 - COVID-19
 - Influenza
 - Measles
 - Pertussis
 - Respiratory Syncytial Virus
 - Tuberculosis



<https://www.cdc.gov/flu/about/burden/index.html>

COVID-19 taught (...reminded) us of how buildings impact airborne transmission

- Catastrophic consequences when buildings can't be occupied safely
- Poorly ventilated buildings increase risk
- Building codes don't address infection risk
- Buildings haven't been designed to adapt to epidemics
- Little regulation of air quality post-occupancy for most buildings leads to lax maintenance



Li, et al. (2020) <https://doi.org/10.1101/2020.04.16.20067728>

ASHRAE Standard 241

Control of Infectious Aerosols

- Origins

- ASHRAE Epidemic Task Force guidance
- Discussions with White House COVID-19 Response Team about need for national standards
- Request to ASHRAE from White House to develop a “national pathogen mitigation standard” on a very aggressive schedule
- ASHRAE board approved development of a consensus standard written in code enforceable language on December 6, 2022
- Project committee began meeting on February 28, 2023
- Standard 241-2023 approved for publication 116 days later on June 24, 2023

Purpose and Scope

- Purpose
 - Requirements for control of infectious aerosols to reduce risk of airborne transmission
 - Occupiable space in existing and new buildings, additions, and major renovations
 - Non-residential, residential, and health care spaces
 - Covers outdoor air and air cleaning system design, installation, commissioning, operation, maintenance
 - Specify *equivalent clean airflow* to be provided in *infection risk management mode*
- Scope
 - Based on reduction of *long range transmission* risk
 - Does not establish overall requirements for acceptable indoor air quality

Overview

- Assess facility – condition and existing equivalent clean air delivered
- Determine target equivalent clean air required by space and system during infection risk management mode
- Determine the need for additional equivalent clean air during infection risk management mode
- Determine the best option for providing required equivalent clean air using outdoor air, particle filtration, and air cleaners tested as required, and operational measures
- Prepare a Building Readiness Plan
- Perform repair and maintenance as needed and required
- Implement upgrades if needed

Infection Risk Management Mode (IRMM)

- The mode of operation in which measures to reduce infectious aerosol exposure documented in a building readiness plan are active
- Decision on IRMM Enable / Disable
 - Public health official
 - Owner
 - Occupant
- Why not all the time?
 - Potential Energy use and cost increase
 - Infection risk and consequences of infection vary over a wide range
- An example of resilience applied to IAQ




Normal

IRMM

Building Readiness Plan (BRP)

- Documents the engineering and non-engineering controls that facility systems will use for the facility to achieve its goals
- Summarizes results of assessment and planning exercises and documents measures to be implemented in IRMM
- Direct descendant of ASHRAE Epidemic Task Force guidance



The image shows the cover of the ASHRAE Epidemic Task Force Building Readiness document. The top section features the ASHRAE logo on the left, the title 'ASHRAE EPIDEMIC TASK FORCE' in large blue letters, and the subtitle 'BUILDING READINESS | Updated 5-17-2022' in smaller orange and blue text. The background is a photograph of a clothing store interior. On the right side, there is a green graphic of a virus particle with a building icon inside it.

General Information

- [Building Readiness Intent](#)
- [Building Readiness Team](#)
- [Building Readiness Plan](#)

Epidemic Conditions in Place (ECiP)

- [Systems Evaluation](#)
- [Building Automation Systems \(BAS\)](#)
- [Ventilation per Code / Design](#)
- [Increased Ventilation above Code](#)
- [Increased Ventilation Control](#)
- [Building and Space Pressure](#)
- [Flushing Between Occupied Periods](#)
- [Equivalent Outdoor Air](#)
- [Upgrading and Improving Filtration](#)
- [Filter Droplet Nuclei Efficiency / Particle Size Expectations](#)
- [Energy Savings Considerations](#)
- [Exhaust Air Re-entrainment](#)
- [Energy Recovery Ventilation Systems Operation Considerations](#)
- [UVGI Systems](#)
- [Domestic Water & Plumbing Systems](#)
- [Maintenance Checks](#)
- [Shutdown a Building Temporarily-FAQ](#)
- [System Manual](#)
- [Reopening During Epidemic Conditions in Place](#)

Post-Epidemic Conditions in Place (P-ECiP)

- [P-ECiP: Prior to Occupying](#)
- [P-ECiP: Operational Considerations once Occupied](#)
- [P-ECiP: Ventilation](#)
- [P-ECiP: Filtration](#)
- [P-ECiP: Building Maintenance Program](#)
- [P-ECiP: Systems Manual](#)

Additional Information

- [Acknowledgements](#)
- [References](#)
- [Disclaimer](#)

Information in this document is provided as a service to the public. While every effort is made to provide accurate and reliable information, this is advisory, is provided for informational purposes only, and may represent only one person's view. They are not intended and should not be relied upon as official statements of ASHRAE.

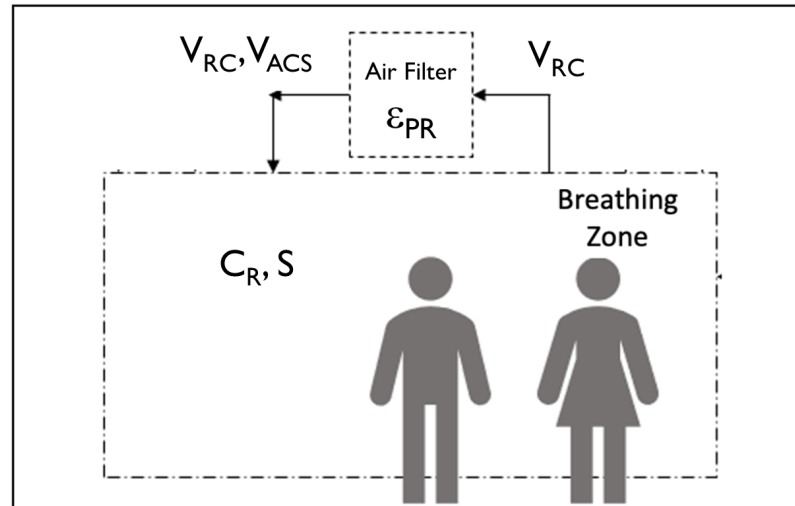
Equivalent Clean Airflow (ECA)

- 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
- Concept on which the entire standard depends
 - Determine ECA for infection risk mitigation (ECA_i)
 - Determine total ECA for spaces, systems (V_{ECA_i})
 - Analyze options to reach target in IRMM
- Also adopted from Epidemic Task Force guidance (same as *equivalent outdoor air*)

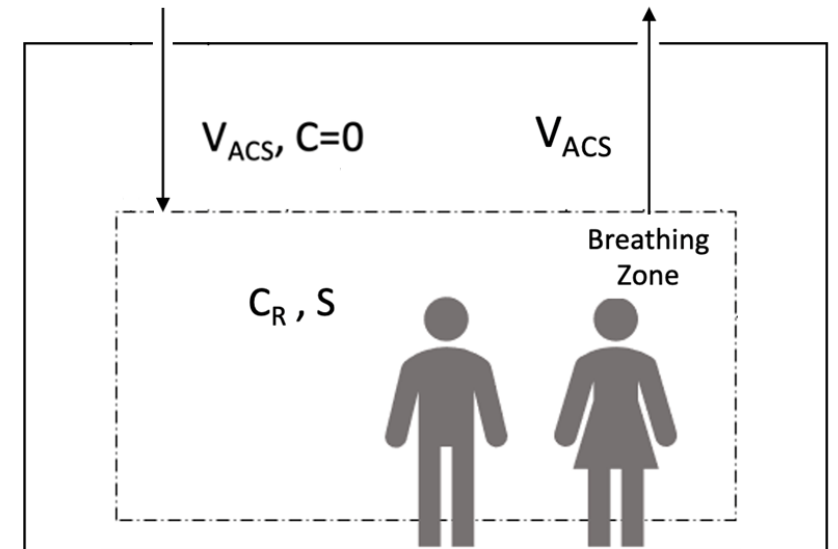
Equivalent clean air flow for an air filter

- V_{RC} – Actual recirculated flow through air cleaner
- V_{ACS} – Equivalent clean airflow of air cleaner
- ϵ_{PR} – Filter single-pass efficiency [%]
- C – Infectious aerosol concentration
- C_R – Concentration in space

Actual air cleaning system



Equivalent dilution process




Can show (with a little math...) that:

$$V_{ACS} = \frac{\epsilon_{PR}}{100} \times V_{RC}$$


ECAi depends on space type,
number of people, activity

$$V_{ECAi} = ECAi \times P_{Z, IRMM}$$

or



Design occupancy



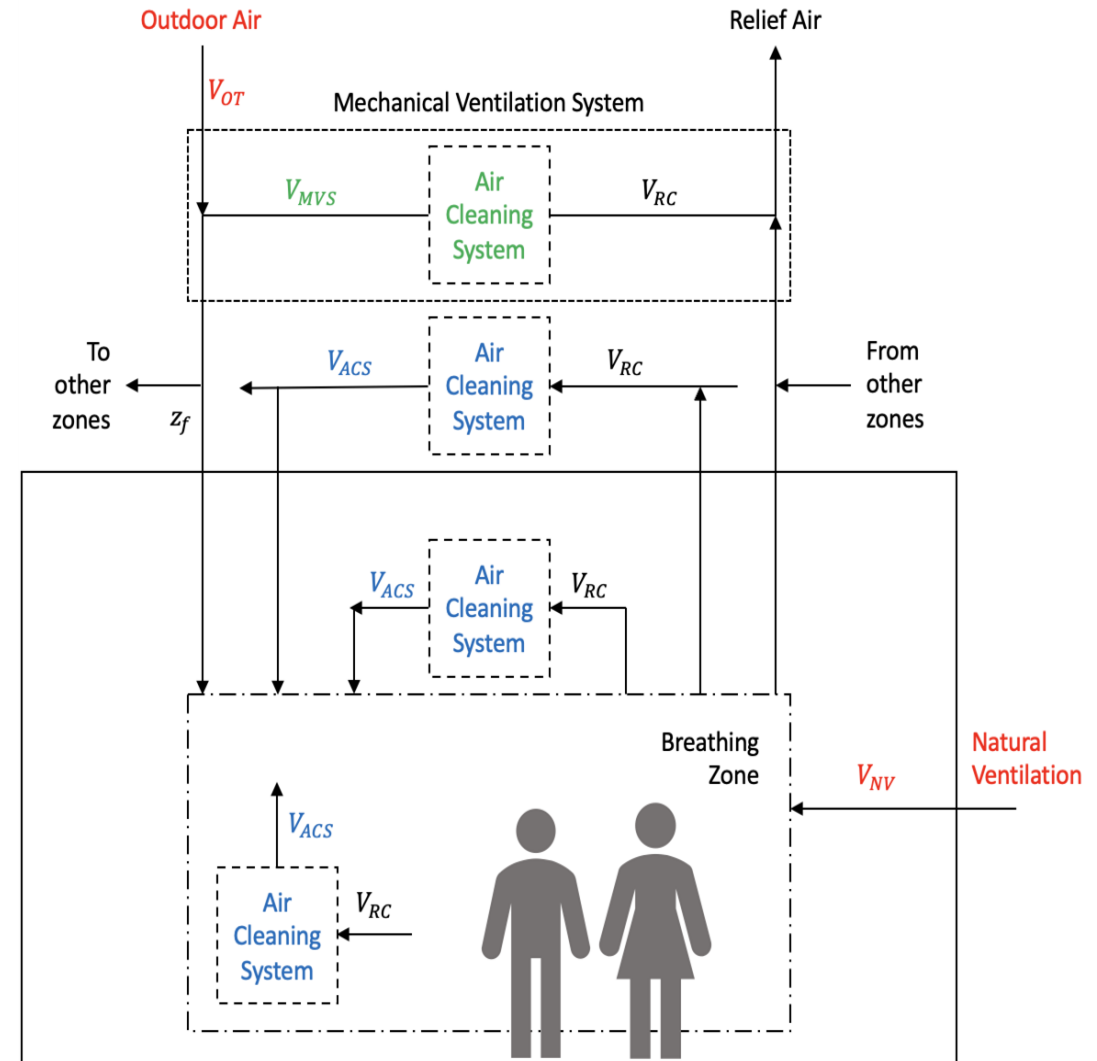
IRMM
occupancy

Double table ECAi for high vocalization spaces

Occupancy Category	ECAi	
	cfm/person	L/s/person
Correctional Facilities		
Cell	30	15
Dayroom	40	20
Commercial/Retail		
Food and beverage facilities	60	30
Gym	80	40
Office	30	15
Retail	40	20
Transportation waiting	60	30
Educational Facilities		
Classroom	40	20
Lecture hall	50	25
Industrial		
Manufacturing	50	25
Sorting, packing, light assembly	20	10
Warehouse	20	10
Health Care		
Exam room	40	20
Group treatment area	70	35
Patient room	70	35
Resident room	50	25
Waiting room	90	45
Public Assembly/Sports and Entertainment		
Auditorium	50	25
Place of religious worship	50	25
Museum	60	30
Convention	60	30
Spectator area	50	25
Lobbies	50	25
Residential		
Common space	50	25
Dwelling unit	30	15

Meeting the VECAi target

- VECAi requirement can be met by
 - **Outdoor airflow** – mechanical/natural
 - ECA from **multi-zone air cleaning systems**
 - ECA from **in-room air cleaning systems**
- Approach allows maximum flexibility to user
- Limitations on compliance
 - Must have prerequisite minimum outdoor air
 - To receive credit toward meeting requirements, mechanical filters must be MERV-A 11 or higher or equivalent
 - MERV 11 acceptable until 1/1/2025



Air Cleaning

- Reducing infectious aerosol concentration through capture and removal or inactivation
- Air cleaning technologies
 - Mechanical filters (including electret media)
 - Germicidal ultraviolet light
 - Reactive species – ionizers, photocatalytic oxidation, other oxidants
- Mention of specific technologies in the standard is not endorsement!



Air Cleaning System Effectiveness and Safety

- Lack of information and standards related to air cleaning systems was a major problem during the COVID-19 pandemic:
 - Effectiveness – ability to remove or inactivate infectious aerosols
 - Safety – adverse effects of direct exposure (UV-C, oxidants), secondary contaminants (particles, ozone)
- Standard 241 establishes minimum requirements for effectiveness and safety testing in Normative Appendix A - Determining air cleaning system effectiveness and safety (does not apply to mechanical filters tested by ASHRAE 52.2 or comparable standard)
- Goal is a level playing field for all technologies

Assessment, planning, and implementation

- Builds on ASHRAE Epidemic Task Force Building Readiness guidance
- Applies commissioning practices to infection risk mitigation systems
- Requirements for developing the Building Readiness Plan
- Assessment of existing V_{ECAi} to determine need for additional controls
- Supporting information
 - Tracer particle test procedure for determining $VECAi$ in-place (appendix)
 - Checklists for assessment and commissioning (appendix)
 - Building Readiness Plan template (appendix)
 - Equivalent clean air calculator (download at [ashrae.org/241-2023](https://www.ashrae.org/241-2023))
 - Guidance on assessing energy recovery ventilators (download)
 - Guidance on preventing re-entry of contaminated air (download)

Operations

(Does not apply to occupancies covered by ASHRAE Standard 62.2)

- BRP on site, accessible, current
- Essential supplies stocked
- Operating modes defined:
 - Normal – occupied/unoccupied
 - IRMM – occupied/unoccupied
 - Temporary shutdown
- Temperature and humidity – maintain design set points when occupied
- Operating schedules
 - On for all occupied hours
 - No on-off control of HVAC fans
- Flushing not required between occupancy periods
- Operator training
- Occupant communication

Maintenance

- Maintenance tasks and frequencies for all occupancies and system types follow ASHRAE/ACCA Standard 180 plus additional requirements
→
- Frequency of some checks increased for IRMM

Table 9-2 Minimum Maintenance Activity and Frequency for Additional Engineering Controls and Associated Components While in Use

Engineering Control	Inspection/Maintenance Task	Frequency
In-room air cleaners	<p>Verify unit is in appropriate location and operating as intended per the <i>BRP</i>. Confirm that the air cleaner is operating at the speed or setting assumed in the V_{ECAi} calculation.</p> <p>Maintain systems and equipment and verify performance per manufacturer's instructions.</p> <p>Visually inspect intake for debris and clean as necessary.</p>	Monthly
Ultraviolet (UV) germicidal irradiation	<p>Maintain systems and verify performance and safety per manufacturer's instructions and in accordance with ANSI/IES RP-44-21¹¹ and ANSI/IES RP-27.1.22²⁰ or equivalent.</p> <p>Adjust, clean, and replace equipment as needed.</p>	Assess quarterly or per manufacturer's recommended interval
All air cleaning systems and equipment (including in-room, in-duct, and UV air cleaners)	<p>Maintain systems and equipment and verify performance per manufacturer's instructions.</p> <p>Adjust, clean, and replace equipment as needed.</p> <p>If equipment cannot be repaired, remove equipment from service and use a substitute engineering control to maintain V_{ECAi} in occupied space.</p>	Assess quarterly or per manufacturer's recommended interval
Separation space	The designated temporary separation areas shall be tested for negative pressure whenever an infected individual is present.	As used

Additional requirements for dwelling units

- For Systems and Spaces with vulnerable or infected occupants
 - Block HVAC systems serving multiple units to separation space
 - Infected occupant – fully enclosed separation area
 - Provide separation area VECAi based on health-care patient room ECAi
 - Rest of space treated as Dwelling
 - Vulnerable occupant – fully enclosed separation area
 - Provide VECAi based on health-care patient room ECAi throughout dwelling
- Lids on toilets
- Water in plumbing traps

Future

- Enhancements
 - Performance path
 - Energy use impacts
 - Add more space types
 - Expand air distribution content
 - Update air cleaner testing
 - Support for users
- Continuous maintenance
 - Interpretations
 - Change proposals
- Communication/education
- Adoption

“(T)his effort to try to improve indoor air quality, reduce the burden of respiratory pathogens – yes, it's been something we have been talking about at the White House – yes, a lot of experts have been talking about it. Talking is good. Talking is important, but what ASHRAE did over the last six months in building out the standards, the 241 standards, that just got approved on Saturday, fundamentally changes the game.

It is one of the most important public health interventions I have seen in years, if not decades.”

Dr. Ashish Jha
Coordinator, White House COVID-19 Response Team
Remarks at ASHRAE Annual Conference, June 26, 2023

