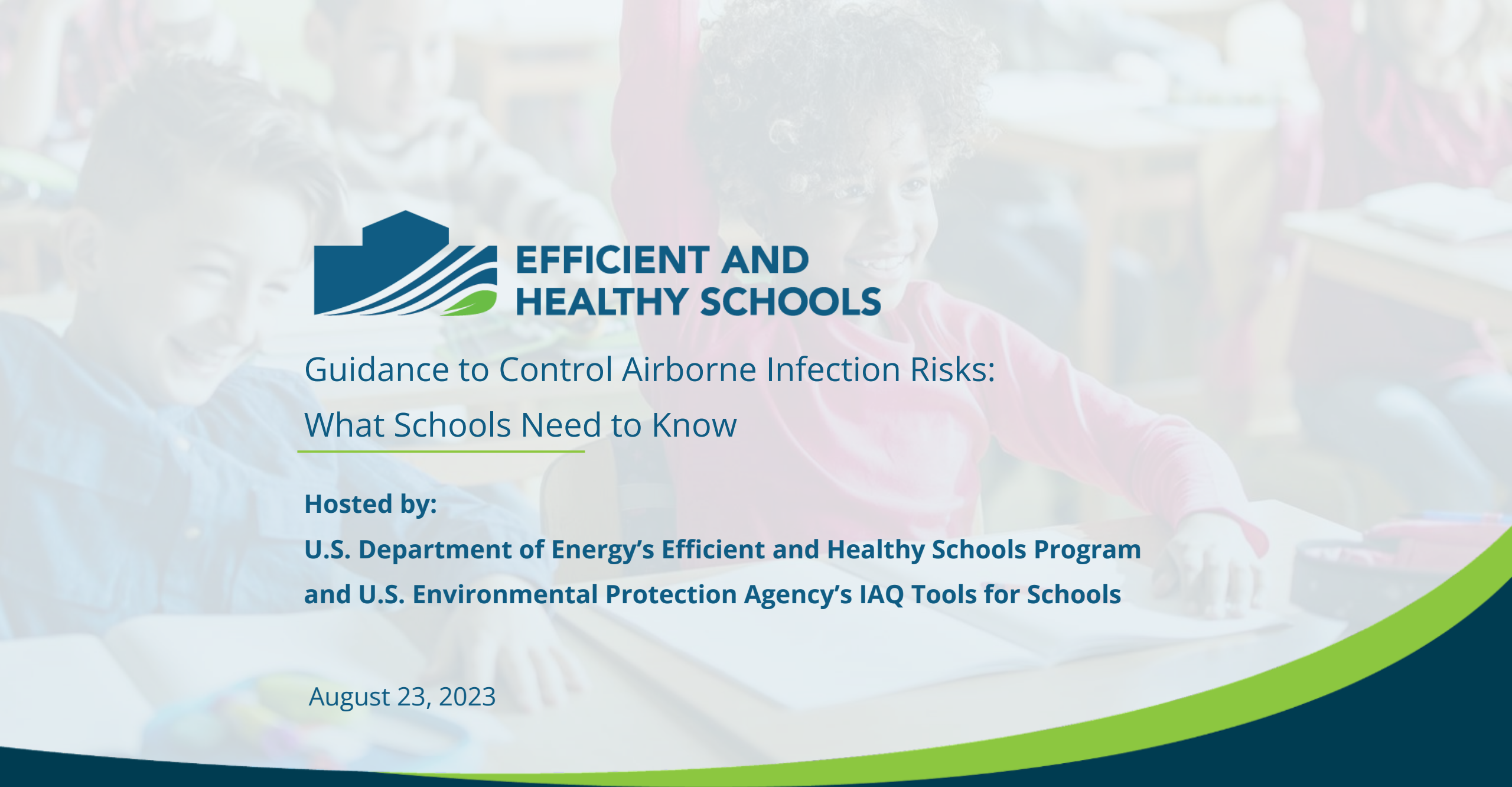


EFFICIENT AND HEALTHY SCHOOLS

Guidance to Control Airborne Infection Risks: What Schools Need to Know

Hosted by:

U.S. Department of Energy's Efficient and Healthy Schools Program and U.S. Environmental Protection Agency's IAQ Tools for Schools

August 23, 2023

Guidance to Control Airborne Infection Risks: What Schools Need to Know

Welcome!

- Webinar is being recorded, and will be posted
- All attendees are muted during this webinar
- Please enter questions into the chat or Q&A at any time, we can answer them at the end
- We will send out the slides and presentation recording shortly after the webinar

Today's Agenda

- EPA IAQ Tools for Schools overview
- Efficient and Healthy Schools Program overview

- **Guidance to Control Airborne Infection Risks:**
  - **Kenneth Mead,** Branch Chief of the Engineering and Physical Hazards Branch within the CDC's National Institute for Occupational Safety and Health (NIOSH)
  - **William Bahnfleth,** ASHRAE Presidential Fellow and Chair of Standard Project Committee 241 – Control of Infectious Aerosols

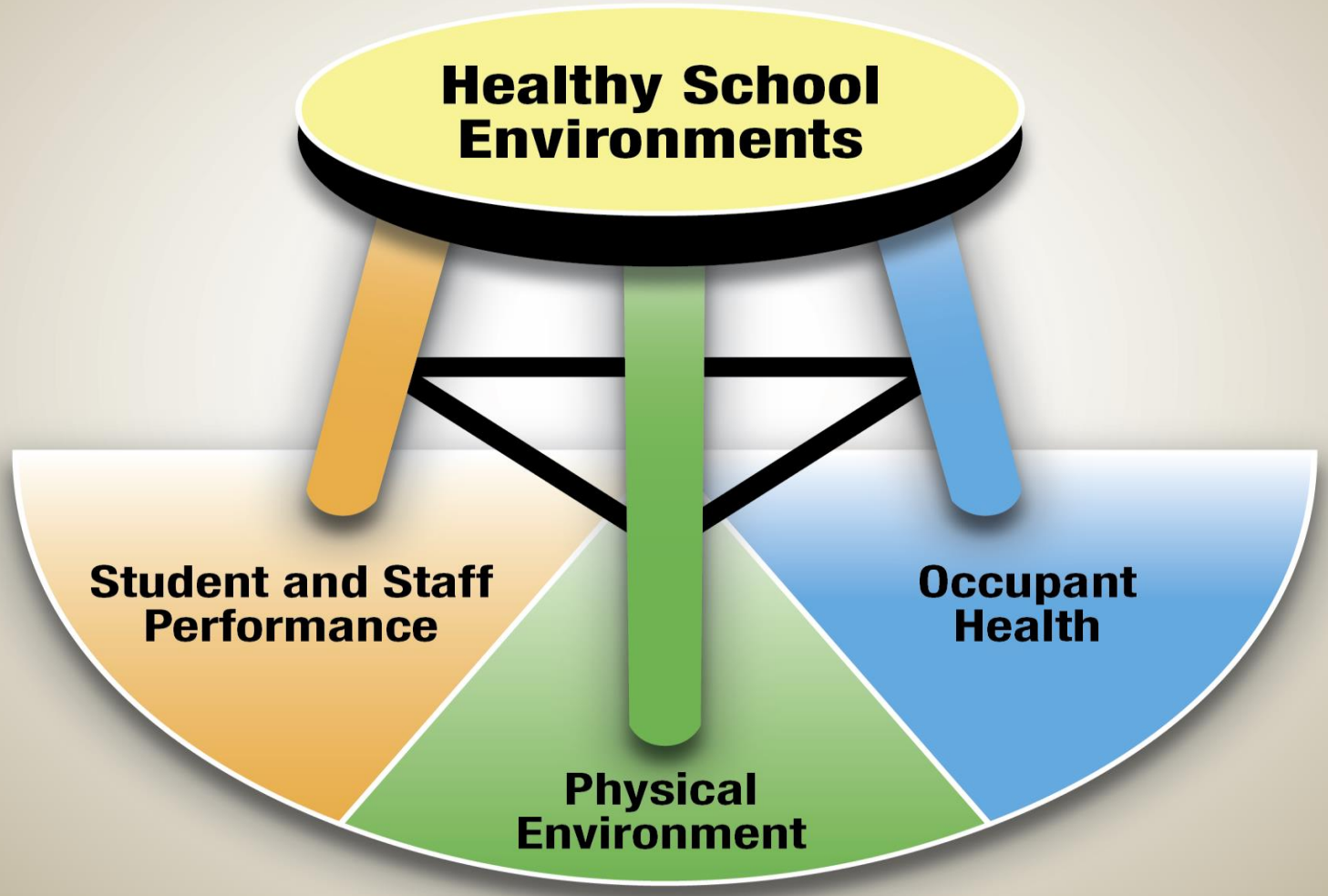
- Q&A. You can also send questions to EHSC@lbl.gov

Guidance to Control Airborne Infection Risks—What Schools Need to Know

August 23, 2023

Sheila Brown,
Indoor Environments Division,
U.S. Environmental Protection Agency (EPA)

The Importance of Indoor Environmental Management in Schools



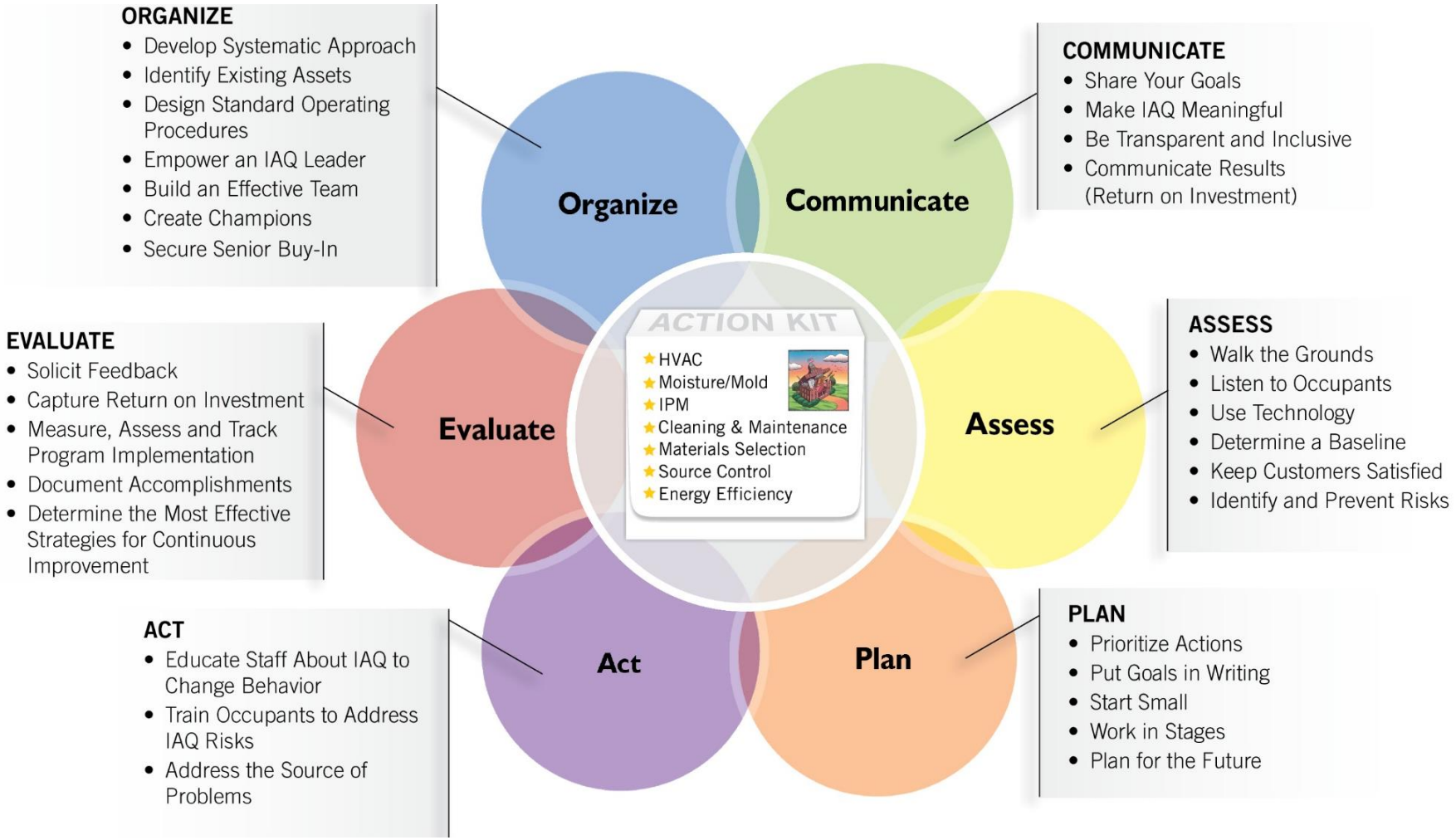
IAQ Tools for Schools Action Kit

What is it? A practical plan for improving your IAQ knowledge using straightforward solutions and individuals already on staff.

The Action Kit includes—

- Reference guides
- Checklists
- Fact sheets
- Sample policies
- Comprehensive IAQ management plans
- The Framework for Effective School IAQ Management
- The Seven Technical Solutions

The Framework for Effective School IAQ Management:
Six Key Drivers



The Framework for Effective School IAQ Management:
Seven Technical Solutions

Quality HVAC
- Inspect HVAC systems regularly
- Establish a maintenance plan
- Change filters regularly and ensure condensate pans are draining
- Provide outdoor air ventilation according to ASHRAE Standards or local code
- Clean air supply diffusers, return registers and outside air intakes
- Keep unit ventilators clear of books, papers and other items

Control of Moisture/Mold
- Conduct routine moisture inspections
- Establish a mold prevention and remediation plan
- Maintain indoor humidity levels between 30% and 60%
- Address moisture problems promptly
- Dry wet areas within 24–48 hours

Strong Integrated Pest Management (IPM)
- Inspect and monitor for pests
- Establish an IPM plan
- Use spot treatments and baits
- Communicate with occupants prior to pesticide use
- Mark indoor and outdoor areas treated with pesticides

Effective Cleaning and Maintenance
- Conduct routine inspections of school environment
- Develop a preventive maintenance plan
- Train cleaning/maintenance staff on protocols
- Ensure material safety data sheets (MSDS) are available to staff
- Clean and remove dust with damp cloth
- Vacuum using high-efficiency filters

Smart Materials Selection
- Maintain products inventory
- Develop low-emitting products purchasing and use policies
- Use only formaldehyde-free materials
- Use only low-toxicity and low-emitting paint
- Select products based on product rating systems
- Use least toxic cleaners possible (only those approved by the district)

Aggressive Source Control
- Conduct regular building walkthrough inspections
- Test for radon; mitigate if necessary
- Implement a hazardous materials plan (use, label, storage and disposal)
- Establish a school chemical management and inventory plan
- Implement smoke-free policies
- Establish an anti-idling school bus policy
- Use walk-off mats at building entrances
- Conduct pollutant-releasing activities when school is unoccupied

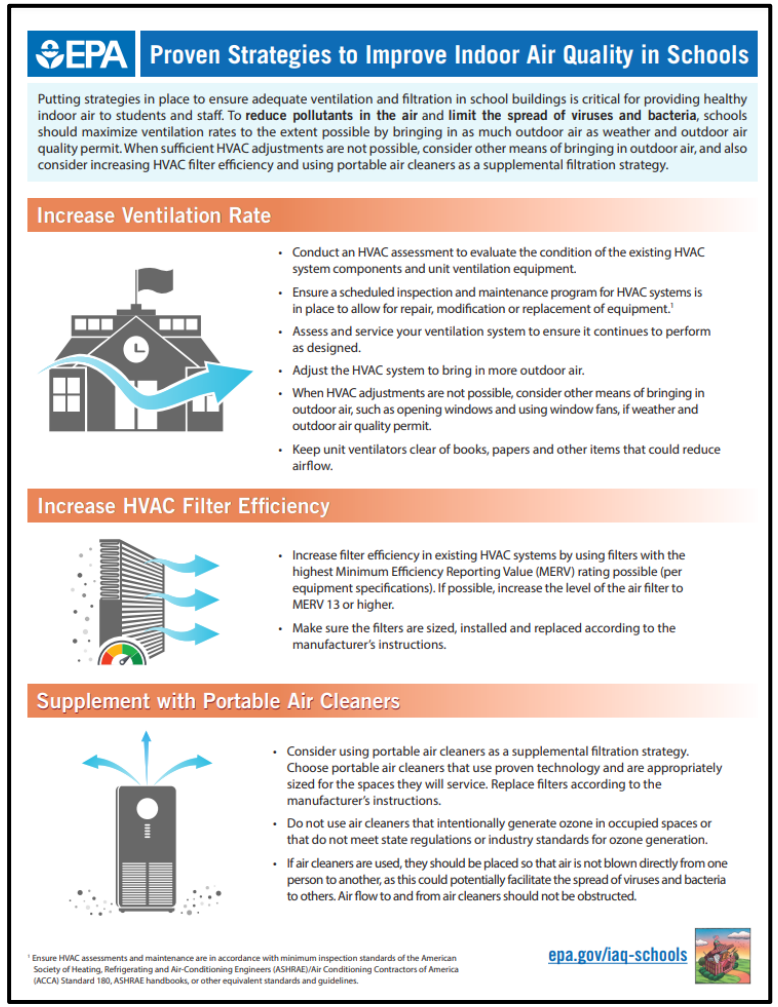
Integrated Energy Management Solutions
- Protect IAQ during energy efficiency upgrades and building renovations
- Conduct regular HVAC maintenance and tune-ups
- Install programmable thermostats
- Consider performing post-construction commissioning for HVAC systems
- Control moisture in building assemblies, mechanical systems and occupied spaces

ACTION KIT

- HVAC
- Moisture/Mold
- IPM
- Cleaning & Maintenance
- Materials Selection
- Source Control
- Energy Efficiency

Proven Strategies to Improve IAQ in Schools Infographic

- Increase ventilation rate
- Increase HVAC filter efficiency
- Supplement with portable air cleaners



Professional Training Webinar Series

Free Online Training!

IAQ Master Class Series

10 technical trainings to build your knowledge base to start, improve or sustain an IAQ management program. Complete all 10 to join the IAQ Master Class.

IAQ Knowledge-to-Action Series

Technical trainings to deepen your IAQ knowledge and build capacity to take immediate action.

Technical Knowledge

- Asthma Triggers
- HVAC Systems
- Moisture and Mold
- Energy Efficiency
- Integrated Pest Management
- Cleaning and Maintenance
- Materials Selection and Source Control

Capacity Building

- Funding and Gaining Buy-In
- Assessment and the IAQ Mobile App
- Staff Training
- Evaluation and Data

Virus Mitigation

www.epa.gov/iaq-schools/ondemand-training-webinars

Efficient and Healthy Schools Program

EFFICIENT AND HEALTHY SCHOOLS

Aims to improve energy performance, reduce carbon emissions, and promote a healthy learning environment in schools.

Engages K-12 schools especially those serving low-income student populations and in rural areas.

Led by the U.S. Department of Energy with technical support from Berkeley Lab and NBI.

https://efficienthealthyschools.lbl.gov/join

Join us to access direct technical assistance

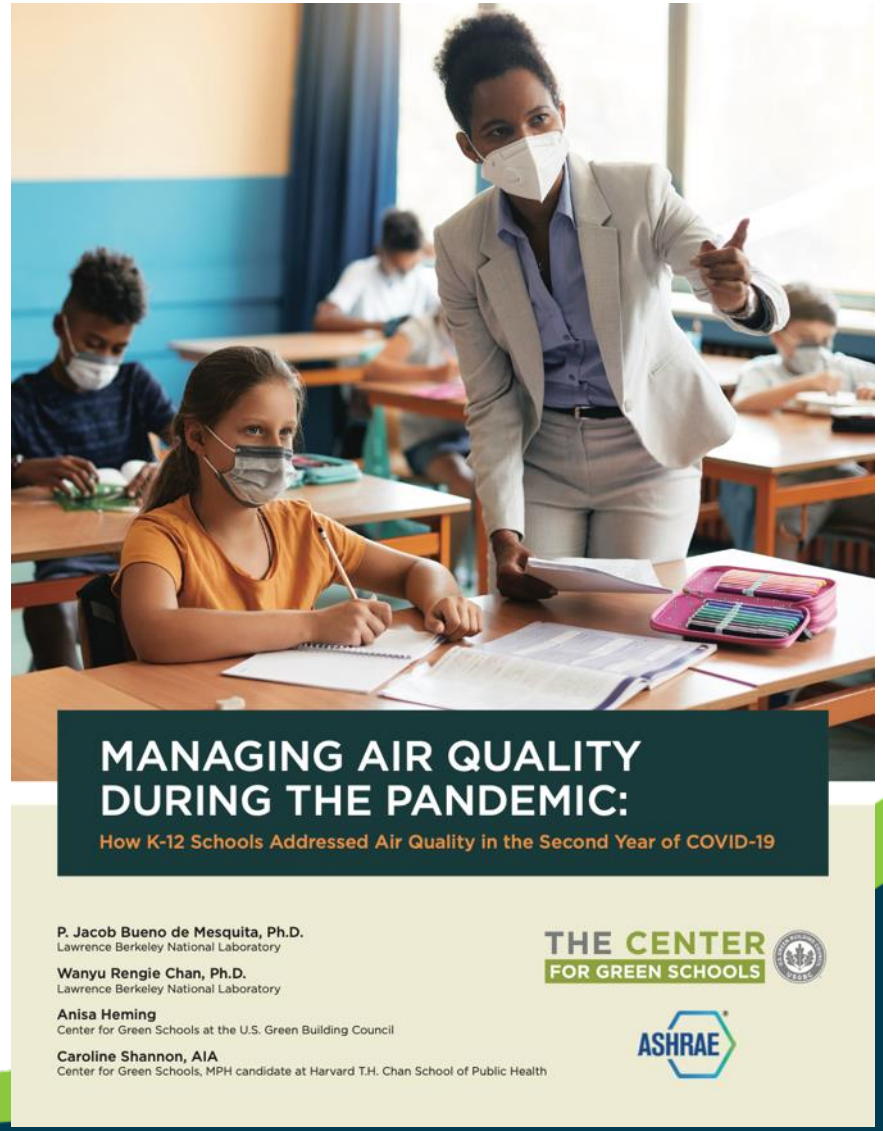
- Technical resources: tools, guides, and case studies
- Building assessment and planning: e.g., energy benchmarking, retrofit measures, ventilation and IAQ
- Connect schools with subject matter experts to talk through strategies
- Signpost funding opportunities

https://www.usgbc.org/resources/managing-air-quality-during-pandemic-how-k-12-schools-addressed-air-quality-second-year

Survey of School Facilities Staff

- What resources or guidance have you used to inform your decisions about which ventilation, filtration, and other building controls to implement in your buildings?

	% Yes
Federal guidance	76
ASHRAE guidance	68
State or local department of public health	67
State Department of Education	63
Consultants or qualified professionals	60
Other school districts	33



CDC COVID-19 Ventilation Guidance Update Briefing

Kenneth R. Mead
Stephen B. Martin, Jr.

August 2023

DISCLAIMERS

- *The findings and conclusions in this discussion are those of the speaker and do not necessarily represent the views of the Centers for Disease Control and Prevention (CDC) or the National Institute for Occupational Safety and Health (NIOSH)*

- *Mention of any company or product does not constitute endorsement by CDC or NIOSH*

- *Citations to websites external to CDC do not constitute CDC or NIOSH endorsement of the sponsoring organizations or their programs or products. Furthermore, CDC is not responsible for the content of these websites.*

Guidance Released May 12, 2023

The Washington Post
Democracy Dies in Darkness

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Opinion | We might be on the verge of an indoor air quality revolution

By Joseph G. Allen
May 15, 2023 at 3:39 p.m. EDT

Source: Washington Post

CDC sets first target for indoor air ventilation to prevent spread of Covid-19

by Brenda Goodman
Published 5:51 PM EDT, Fri May 12, 2023

Source: CNN Health

The Washington Post
Democracy Dies in Darkness

Opinions Editorials Columns Guest opinions Cartoons Submit a guest opinion Today's Opinions newsletter

THE POST'S VIEW

Opinion | The CDC takes a step toward virus-free air in schools and offices

By the Editorial Board
+ Follow
May 15, 2023 at 6:29 p.m. EDT

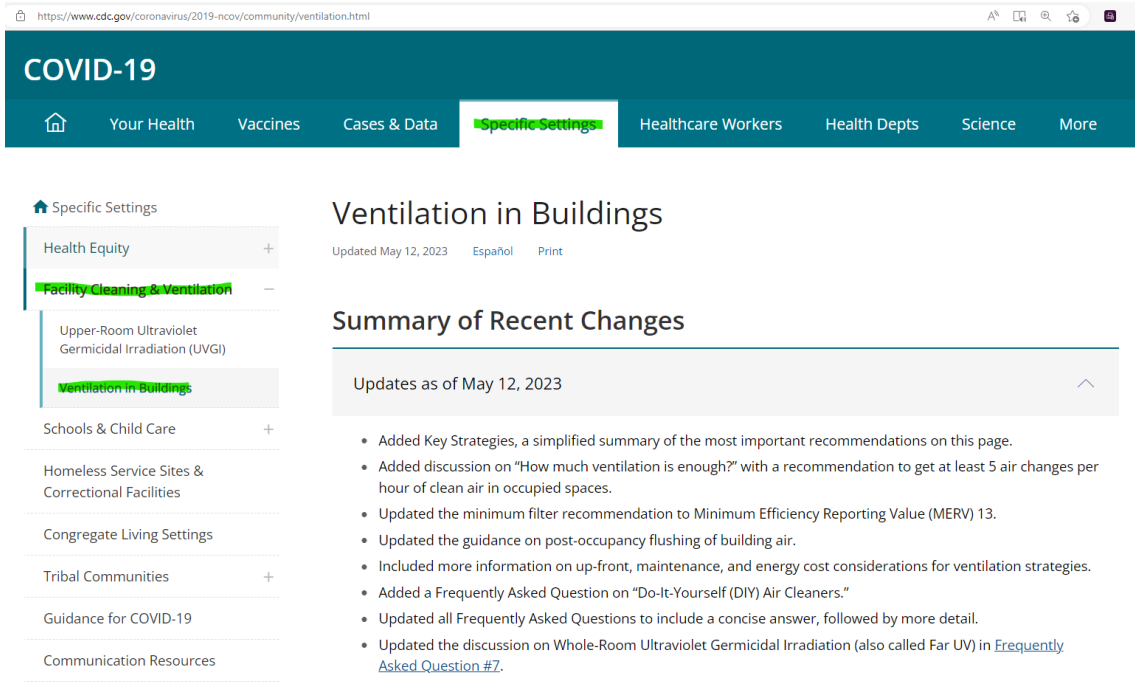
Source: Washington Post

CDC COVID-19 Ventilation Guidance Updates

- Two products:
  - UPDATE - Ventilation in Buildings: https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html
  - NEW - Improving Ventilation in Buildings: https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/improving-ventilation-in-buildings.html *

CDC COVID-19 Ventilation Guidance Updates

- Ventilation in Buildings: https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html



- Last Update June 2, 2021

- Since the last update:
  - Feedback continued to accumulate
    - External partners in/out of government
    - Incoming questions to CDC/Info and other activities within the CDC COVID-19 response
  - New and evolving guidance from external sources
  - Evolving knowledge on the science of transmission and intervention strategies

CDC COVID-19 Ventilation Guidance Updates

Ventilation in Buildings:
https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html

Summary of Changes:

- Defined what the term “ventilation” means on the page.
- Added discussion on “How much ventilation is enough?” with a recommendation to get at least 5 air changes per hour of clean air in occupied spaces.
- Updated the minimum filter recommendation to Minimum Efficiency Reporting Value (MERV) 13.
- Updated the guidance on post-occupancy flushing of building air.
- Increased emphases on system inspection, performance verification and code compliance as a foundational starting point prior to invoking additional ventilation interventions

CDC COVID-19 Ventilation Guidance Updates

Ventilation in Buildings:
https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html

Summary of Changes (continued):

- Included more information on up-front, maintenance, and energy cost considerations for ventilation strategies.
- Added a Frequently Asked Question on “Do-It-Yourself (DIY) Air Cleaners.”
- Updated all Frequently Asked Questions to include a concise answer, followed by more detail.
- Updated the discussion on Whole-Room Ultraviolet Germicidal Irradiation (also called Far UV) in a Frequently Asked Question.
- Incorporated editorial tweaks in response to external feedback.

Guidance Objective: Use Improved ventilation to reduce potential infectious aerosol concentrations within occupied indoor spaces

Toxicology Refresher (from an engineer!)

- Dose:
  - Airborne Dose = Airborne concentration x time x inhalation rate
  - Surface Contamination (from Infectious Aerosols):
    - *f(x):* {concentration, settling rates, and time between cleanings}
  - Common variables: **Concentration** & Time

- Time is largely an administrative variable, addressed using administrative controls

- **Concentration** is the variable we can focus on controlling through the use of improved building ventilation

Ventilation

Definition: Ventilation is a term with different meanings to different people. For the purpose of our webpage, “ventilation” includes:

- Indoor air movement and dilution of viral particles through mechanical or nonmechanical (also called natural) means.
- Filtration through central heating, ventilation and air conditioning (HVAC) systems and/or in-room air cleaners (portable or permanently mounted).*
- Air treatment with Ultraviolet Germicidal Irradiation (UVGI) systems (also called Germicidal Ultraviolet or GUV).*

* These air cleaning techniques are sometimes referred to as “equivalent ventilation.” They are not a substitute for meeting minimum outdoor air delivery requirements that may be specified in national, state, and local building codes.

How Much Ventilation Is Enough?

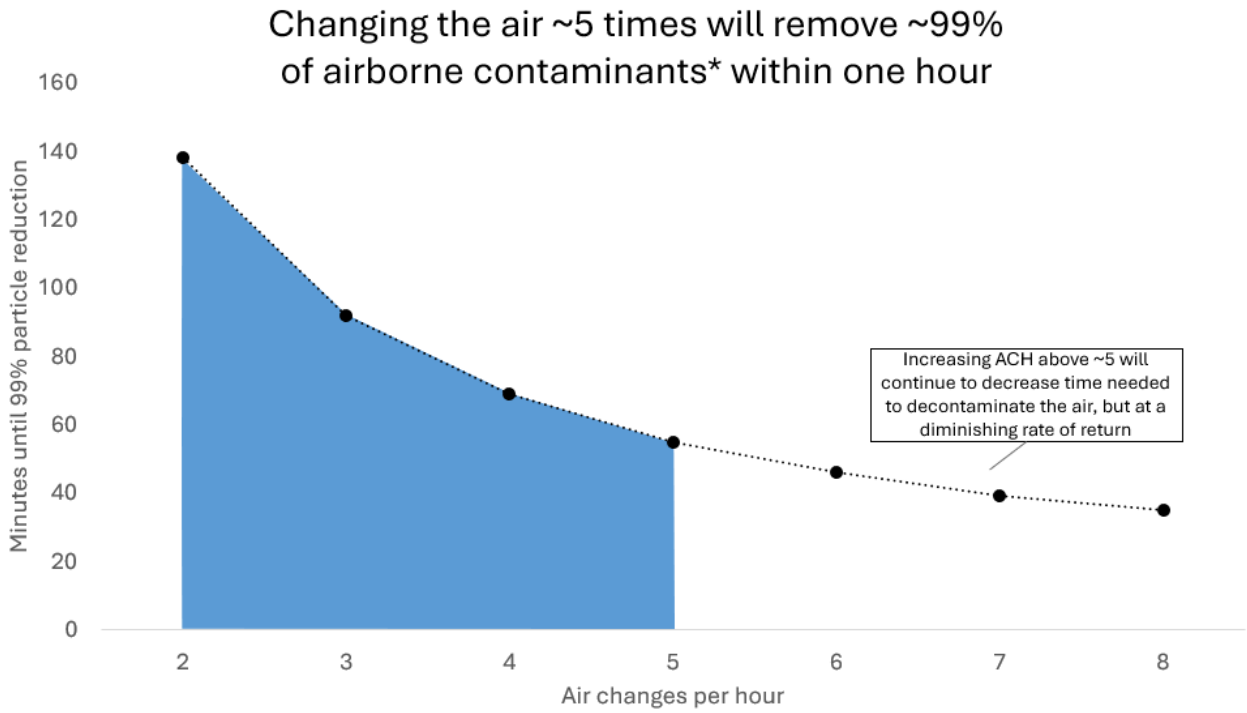
Aim for 5 Air Changes per Hour (ACH)

- When possible, aim for 5 or more air changes per hour (ACH) of clean air to help reduce the number of germs in the air. This can be achieved through any combination of central ventilation system, natural ventilation, or additional devices that provide equivalent ACH to your existing ventilation.
- While there is insufficient science to identify an optimum ventilation strategy for all spaces, 5 ACH is what portable air cleaners provide (as eACH) when properly sized following the Environmental Protection Agency's guidance on the selection of portable air cleaners.

How Much Ventilation Is Enough?

Aim for 5 Air Changes per Hour (ACH) (continued)

- Five ACH will not guarantee totally safe air in any space, but it reduces the risk of exposure to germs and other harmful air contaminants.
- Rather than a hard-and-fast rule, the 5 ACH target provides a rough guide to air change levels likely to be helpful in reducing infectious particles.



Important Caveats:

- Assumes perfect mixing
- Assumes source has stopped

How Much Ventilation Is Enough?

Aim for 5 Air Changes per Hour (ACH) (continued)

- Large volume spaces with very few occupants (e.g., a warehouse) may not require 5 ACH and spaces with high occupancy or higher-risk occupants may need higher than 5 ACH.
- While ACH levels higher than 5 (e.g., those used in airborne infection isolation rooms in hospitals) may reduce infectious aerosols further, the potential benefits of increased ventilation should be balanced with the additional upfront, periodic maintenance, and energy costs that may be incurred.
- A Lancet Commission Report that draws on available scientific evidence proposes ACH levels of 4 as “Good,” 6 as “Better,” and >6 as “Best,” underscoring that ACH (to include eACH) represents a continuum.

MERV 13 Filters

- Upgrade central HVAC filter efficiency to a Minimum Efficiency Reporting Value (MERV)-13 or better.
- When compatible with your HVAC system, increased filtration efficiency is especially helpful when enhanced outdoor air delivery options are limited.

Source: Getty Images

Post-Occupancy Flushing

In non-residential settings where an infectious source was not known to have been present, run the HVAC system at maximum outside airflow for 2 hours, or until the building has achieved at least 3 clean air changes, after the building is no longer occupied.

Increased Emphasis on System Inspection, Performance Verification, and Code Compliance

If you do nothing else, ensure existing HVAC systems are providing at least the minimum outdoor air ventilation requirement in accordance with ventilation design codes.

- Applicable codes are based on the year of building construction or latest renovation and intended building occupancy.
- Preferably, upgrade HVAC system performance to meet current ventilation code requirements at current occupancy levels.**
- This will develop a strong and lasting baseline upon which further interventions can be implemented.

More Detail on Up-front, Maintenance, and Energy Cost Considerations

Intervention Strategy	Up-front Cost	Ongoing Daily Interaction	Ongoing Maintenance Requirements	Incremental Energy Usage
Opening windows	No	Yes	No	Varies, depending on ambient outdoor conditions.
Expanded operation of dedicated exhaust ventilation	No	No	Periodic preventive maintenance	Varies, depending on exhaust system capacity and ambient outdoor conditions.
Repositioning HVAC outdoor air dampers	No	No	Periodic preventive maintenance	Varies, depending on HVAC system capacity and ambient outdoor conditions.
Switching thermostats from “Auto” to “On” or adjusting building HVAC control systems to disable demand-controlled ventilation (DCV)	No	No	Periodic preventive maintenance	Varies, depending upon fan energy consumption

Note: This is not the complete table. It is a sample for illustration purposes only.

New FAQ on DIY Air Cleaners

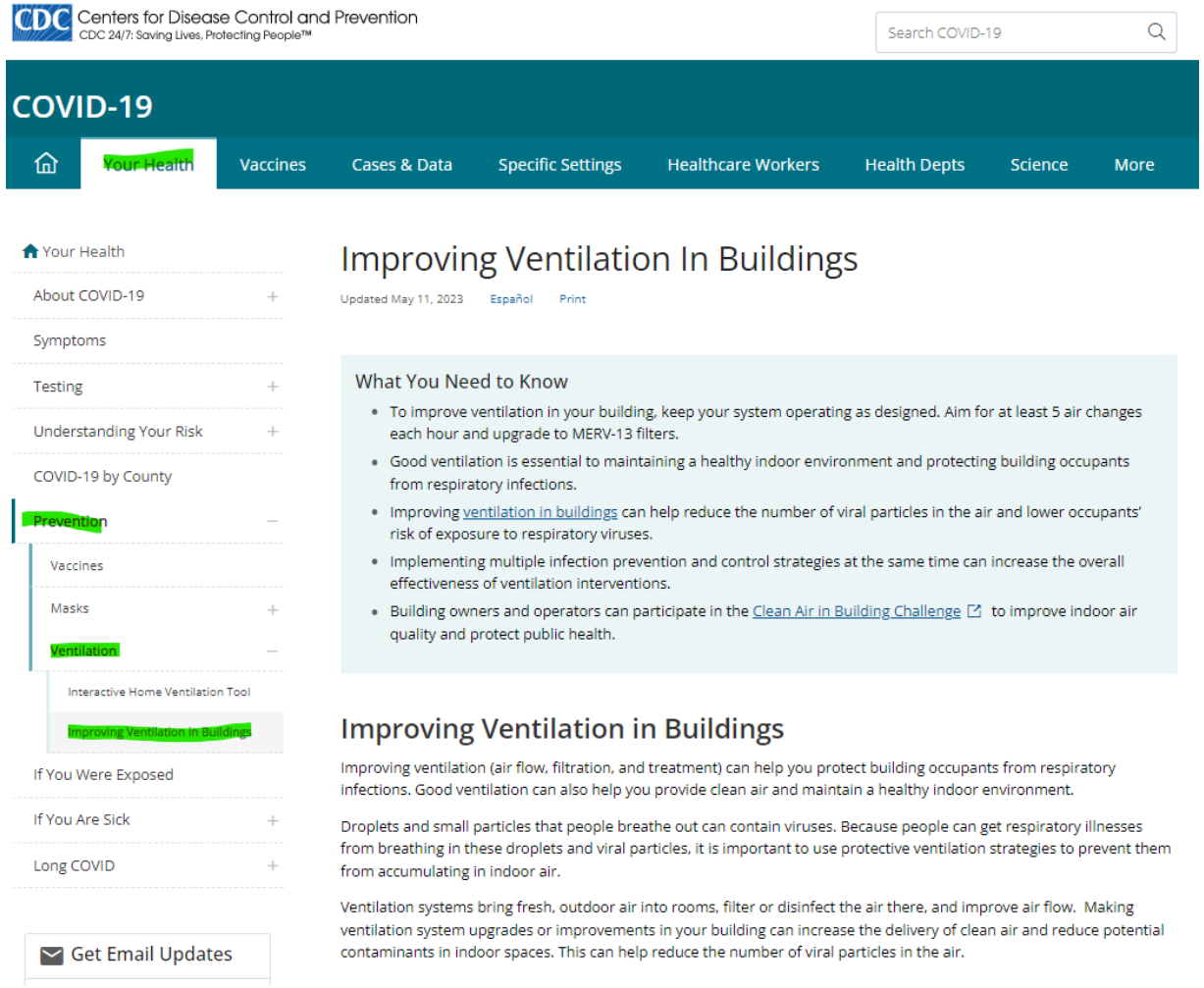
Are do-it-yourself (DIY) air cleaners effective at reducing the risk of COVID-19 transmission indoors? How do they compare to commercially-available products?

Yes, when built and used correctly, they can be a protective temporary intervention.

- Adding filtration and air movement to a space is generally better than doing nothing when it comes to reducing potential risks from viral particles in the air. Well-constructed do-it-yourself (DIY) air cleaners can serve this purpose. When constructed with great attention to detail, DIY air cleaners have been shown to be effective. Their effectiveness and safety have been supported by the U.S. Environmental Protection Agency (EPA) to reduce wildfire smoke indoors. The particle sizes associated with wildfire smoke include the 1 – 3 micrometer (µm) particles associated with human-generated viral particles, like those that cause COVID-19. Thus, DIY air cleaners can help reduce exposure to those airborne viral particles.
- DIY air cleaners are appropriate during emergencies, for short-term use, or when obtaining commercially-available air cleaners, for whatever reason, is not possible.
- However, DIY air cleaners should not be used as a permanent, long-term solution for in-room air cleaning. Commercially-available portable air cleaners with high-efficiency particulate air (HEPA) filters are preferred and should be used whenever possible. These units have an established Clean Air Delivery Rate (CADR), which is an established standard defined by the Association of Home Appliance Manufacturers (AHAM).

CDC COVID-19 Ventilation Guidance Updates

Improving Ventilation in Buildings: https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/improving-ventilation-in-buildings.html



CDC COVID-19 Ventilation Guidance Updates

Improving Ventilation in Buildings:

Description

- Approximately 2-page document with text, graphics and inserts
- Located in different ("Prevent Getting Sick") section of CDC COVID web guidance, but still links back to main *Ventilation In Buildings* webpage
- Intended for use by lay audience as a tool for understanding ventilation improvement options
- Can help building occupants identify what questions to ask of their building owners/managers
- Serves as a simplified summary for those who want to incorporate ventilation interventions in their messaging

CDC COVID-19 Ventilation Guidance Updates

Summary List of Actions

- Know how your building's HVAC systems work, ensure that it operates as it should and gets regular maintenance. Consider improving or upgrading older systems.
- Increase air filtration in your HVAC system. Use MERV 13 or higher filters that fit well within the filter rack.
- Use air cleaners (also called air purifiers) with high-efficiency filters. Select a device that is appropriate for the size of your space.
- Aim for at least 5 air changes per hour (ACH).

CDC COVID-19 Ventilation Guidance Updates

Summary List of Actions (continued)

- Bring fresh, outdoor air into rooms by opening windows and doors.
- Turn on exhaust fans and use other fans to improve air flow.
- Turn your thermostat to the "ON" position instead of "AUTO" whenever the room is occupied.
- Consider installing a UV air treatment system to “kill” viral particles in the indoor air. (Note this is an energy efficient way to boost a room’s ACH).
- Use portable carbon dioxide (CO_2) monitors to determine how fresh or stale the air is in rooms. Readings higher than 800 ppm may suggest that you may need to bring in more fresh air.

CDC COVID-19 Ventilation Guidance Updates

Related Comments

- Ventilation guidance is not compatible with a one-size-fits-all approach
  - Both the main ventilation page and the plain-language document are sprinkled with persistent caveats indicating that a particular recommendation may not be a good fit for all scenarios
- ASHRAE (professional engineering association who writes ventilation standards) recently developed a new standard on ventilation design and operation to protect against infectious aerosol exposures within indoor environments (Standard 241)
  - Published July 2023
  - Applicable to indoor environments during periods of higher exposure risk to infectious aerosols
  - Some aspects of ASHRAE 241 could impact future changes to CDC ventilation guidance
  - Pursuing methodology for performance validation of emerging technologies
  - Although scope and purpose are different, CDC guidance envisioned as a contributor to the discussion on importance of ventilation which will hopefully fuel adoption of new ASHRAE standard
- Significant research in/out of CDC and government could impact future guidance.

CDC COVID-19 Ventilation Guidance Updates

Future Plans?

- Transition to “evergreen” version of the webpages that are applicable to infectious aerosols in general.

Ways to achieve min 5 ACH of clean air

Example: 20’x30’x9’ school classroom with 20 students and 1 teacher

Ways to achieve min 5 ACH of clean air

To calculate the ACH (or eACH):

1. Determine (or measure) the airflow through the system in cubic feet per minute (cfm).
2. Determine the area of the room = length (ft) x width (ft)
3. Determine the height of the room (ft).
4. Calculate ACH:

$$\text{ACH} = \frac{\text{cfm} \times 60}{\text{Area} \times \text{Height}}$$

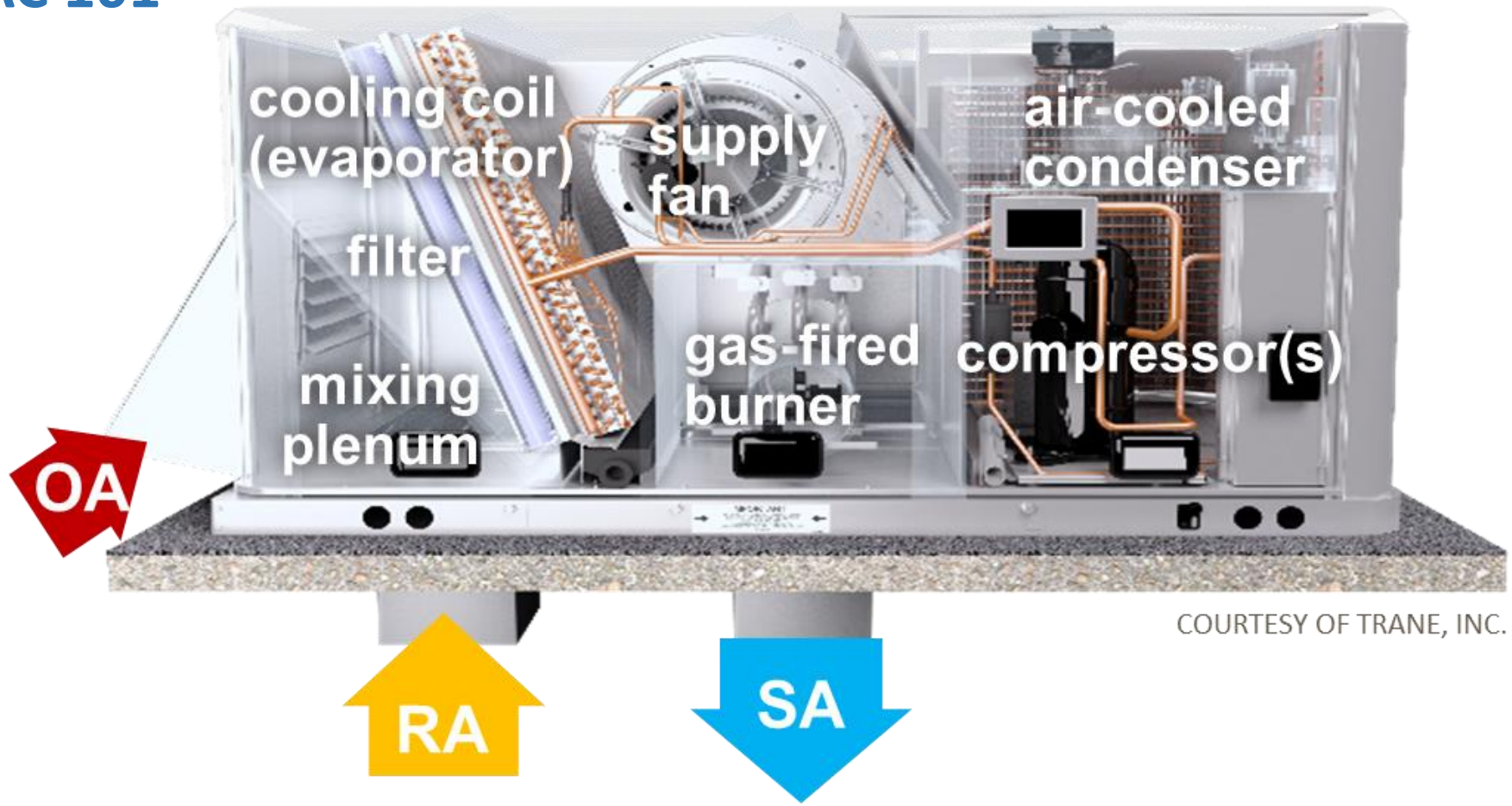
5. When multiple strategies are used, repeat the ACH calculation for each system then add together for a total ACH value (which could be compared to the minimum 5 ACH recommendation).

Note: See FAQ #2 and FAQ #5 for examples on how the ACH calculation may be applied.

From: Ventilation in Buildings | CDC

Ways to achieve min 5 ACH of clean air (continued)

HVAC 101



COURTESY OF TRANE, INC.

Ways to achieve min 5 ACH of clean air (continued)

Example: 20'x30'x9' school classroom with 20 students and 1 teacher:

- Outdoor air delivery based on ASHRAE standard STD 62.1 is 282 cfm
- Total air delivery to meet tempering requirements is 400 cfm
- Air filtration has been upgraded to MERV 13 (85% efficient at 1.0 micron*)
  *See FAQ # 3 at CDC's Ventilation in Buildings | CDC webpage
- Room Area = 20' x 30' = 600 sq-ft
- Clean ACH from outdoor air = Q_{cfm} x 60/(Room area x height) =
  = 282 ft^3/m x 60 (m/hr)/(600 ft^2 x 9 ft) = 3.13 = **3 ACH**
- Return air portion of total air delivery = 400-282=118 cfm
- Clean air "credit" in the filtered return air portion = 118 x 0.85 = 100.3 cfm
- Clean air ACH from filtered return air = 100.3 x 60/5400 = 1.11 = **1 ACH**

Resulting "Clean" ACH = ACH_{OA} + ACH_{RA}= 3 + 1 = 4 ACH

Continued….

Ways to achieve min 5 ACH of clean air (continued)

continued…..

Comment: We need about 100 more cfm of clean air in order to meet the minimum 5 ACH target. To account for mixing inefficiencies and since classrooms are a little more crowded than many other indoor spaces, we might choose to meet and moderately exceed this value by:

- Use of a portable or ceiling-mounted HEPA air cleaners
- Use of a window fan of known flow rate in exhaust orientation in window, while other windows are opened slightly to allow increased incoming air
- Evaluating to see if HVAC system is capable of providing a higher total air flow rate

Questions?

- Kenneth R. Mead (kcm3@cdc.gov)
- Stephen B. Martin, Jr. (stm9@cdc.gov)

PennState College of Engineering | ARCHITECTURAL ENGINEERING

ASHRAE

Using Building Systems to Reduce Airborne Infection Transmission – ASHRAE's Perspective

William Bahnfleth, PhD, PE

Professor of Architectural Engineering

Chair, ASHRAE SSPC 241

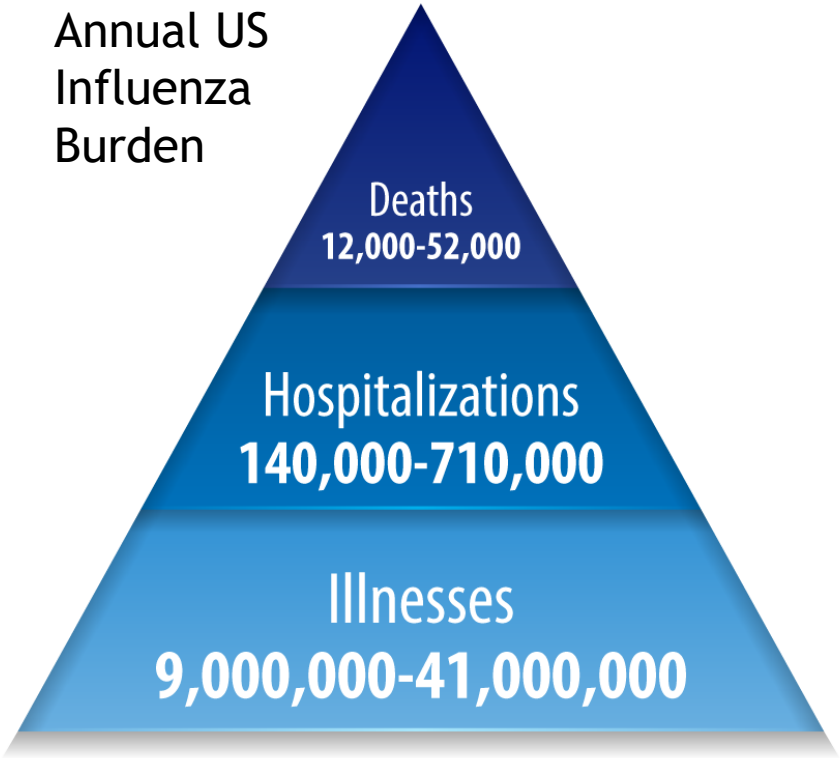
What is distinctive about school buildings?

- Architectural and mechanical diversity
  - Age
  - HVAC system types, including natural ventilation
  - Maintenance
- Space types
  - Moderate to high occupant density
  - Congregate spaces – cafeteria, gymnasium, auditorium
  - Spaces with high aerosol generating activities – choir, band and orchestra rooms
- Highly variable economic circumstances – public, tribal, private
- *As buildings*, commonalities than differences with other public buildings
- Operationally – need to be available and safe

Covid is less acute, but respiratory infections are still a major risk

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

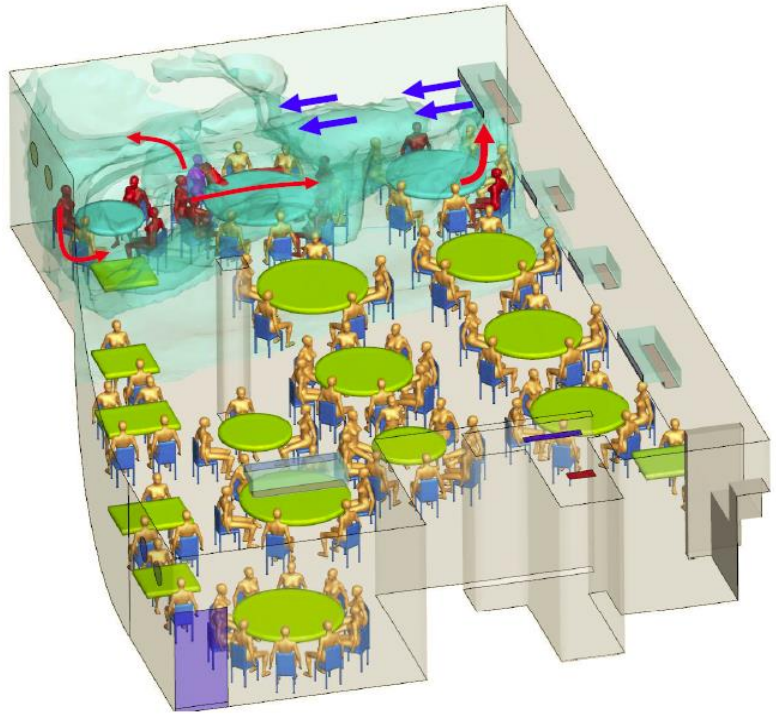
Annual US Influenza Burden



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

Covid taught (…reminded) us of how buildings impact airborne transmission

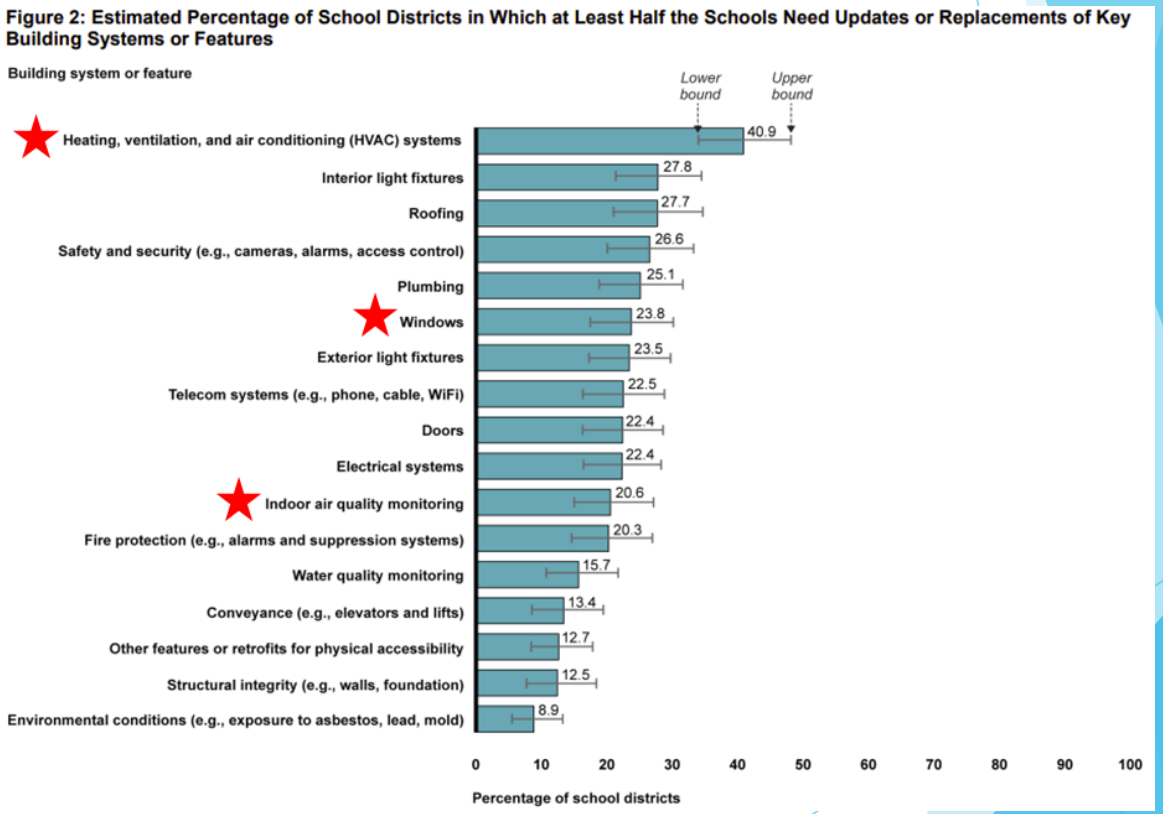
- Catastrophic consequences when buildings can't be occupied safely
- Poorly ventilated buildings increase risk
- Building codes don't address infection risk
- Buildings haven't been designed to adapt to epidemics
- Little regulation of air quality post-occupancy for most buildings leads to lax maintenance



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

School maintenance was a problem before Covid

- General Accountability Office study on condition of US schools (June 2020)
- Maintenance or replacement needs
  - HVAC - #1
  - Windows - #6
  - IAQ monitoring #11
- Poor maintenance impacts IAQ and energy use, increases infection risk



https://www.gao.gov/assets/710/707374.pdf

ASHRAE Standard 241
Control of Infectious Aerosols

- Origins
  - ASHRAE Epidemic Task Force guidance
  - Discussions with White House Covid 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
- Determine need for additional equivalent clean air
- 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 to document assessment and decisions
- Perform repair and maintenance as needed and required
- Implement upgrades if needed

Air Cleaning

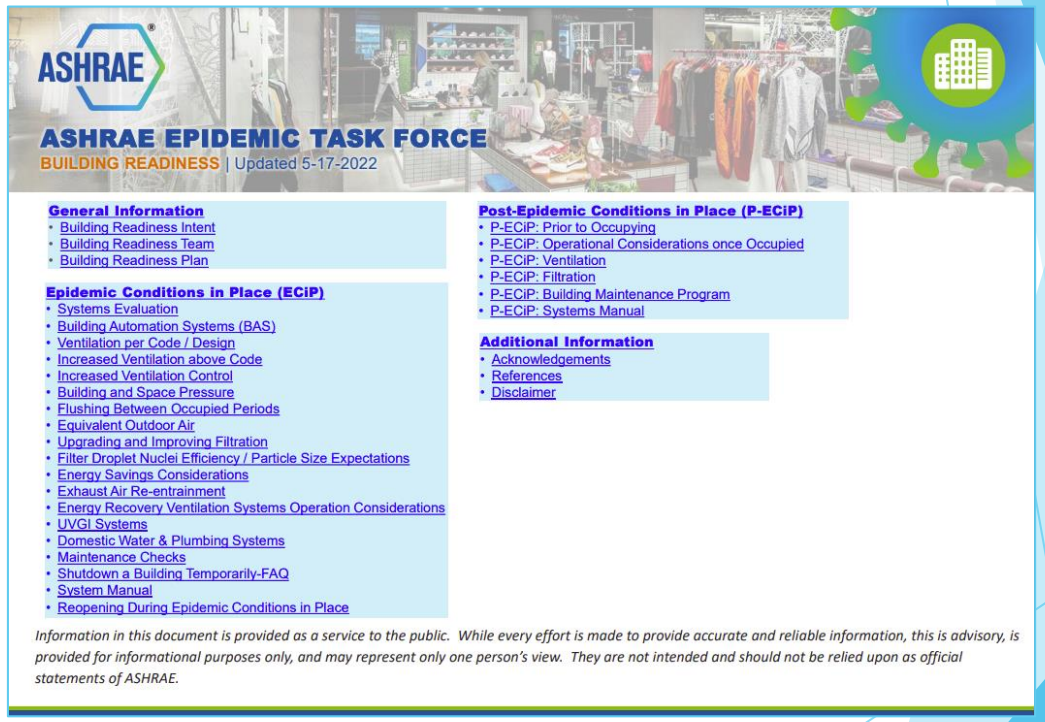
- Reducing infectious aerosol concentration through capture and removal or inactivation
- Air cleaning technologies
  - Mechanical filters (including electret media)
  - Germicidal ultraviolet light
  - Reactive species – ionizers, photocatalytic oxidation, other oxidants
- Mention of specific technologies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

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

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



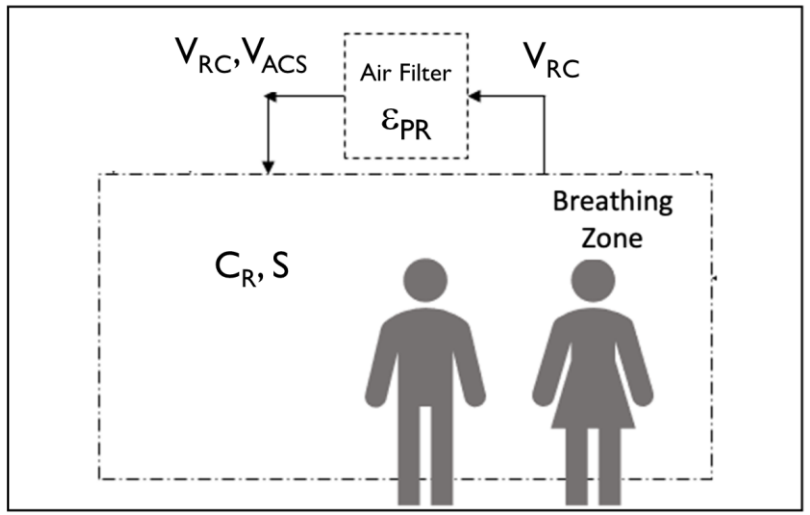
Equivalent Clean Airflow (ECA)

- 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 (ECAi)
  - Determine total ECA for spaces, systems (V_{ECAi})
  - Analyze options to reach target in IRMM
- Also adopted from Epidemic Task Force guidance (same as *equivalent outdoor air*)

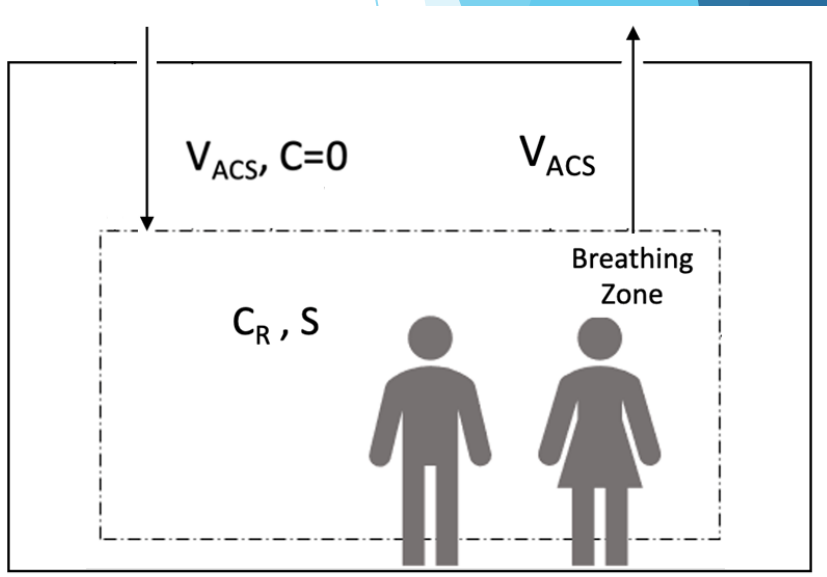
Equivalent clean air flow for an air filter

- 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



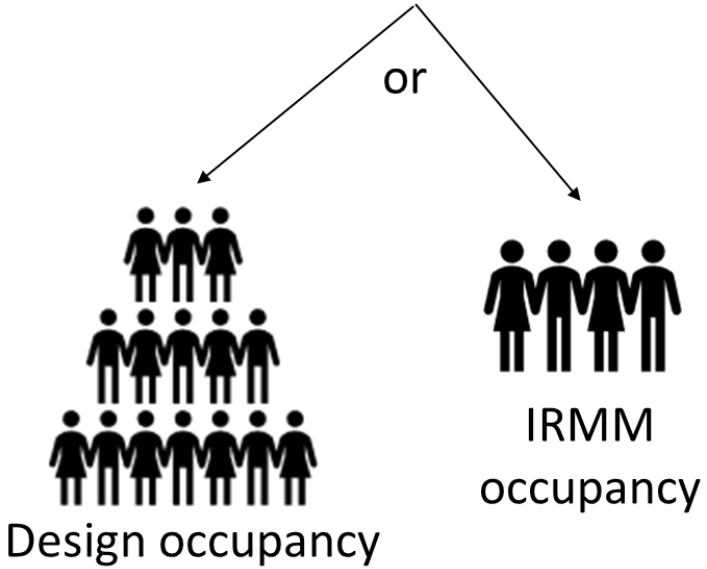
Equivalent dilution



Can show (with a little math…) that: $V_{ACS} = \frac{\varepsilon_{PR}}{100} \times V_{RC}$

ECAi depends on space type, number of people, activity

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

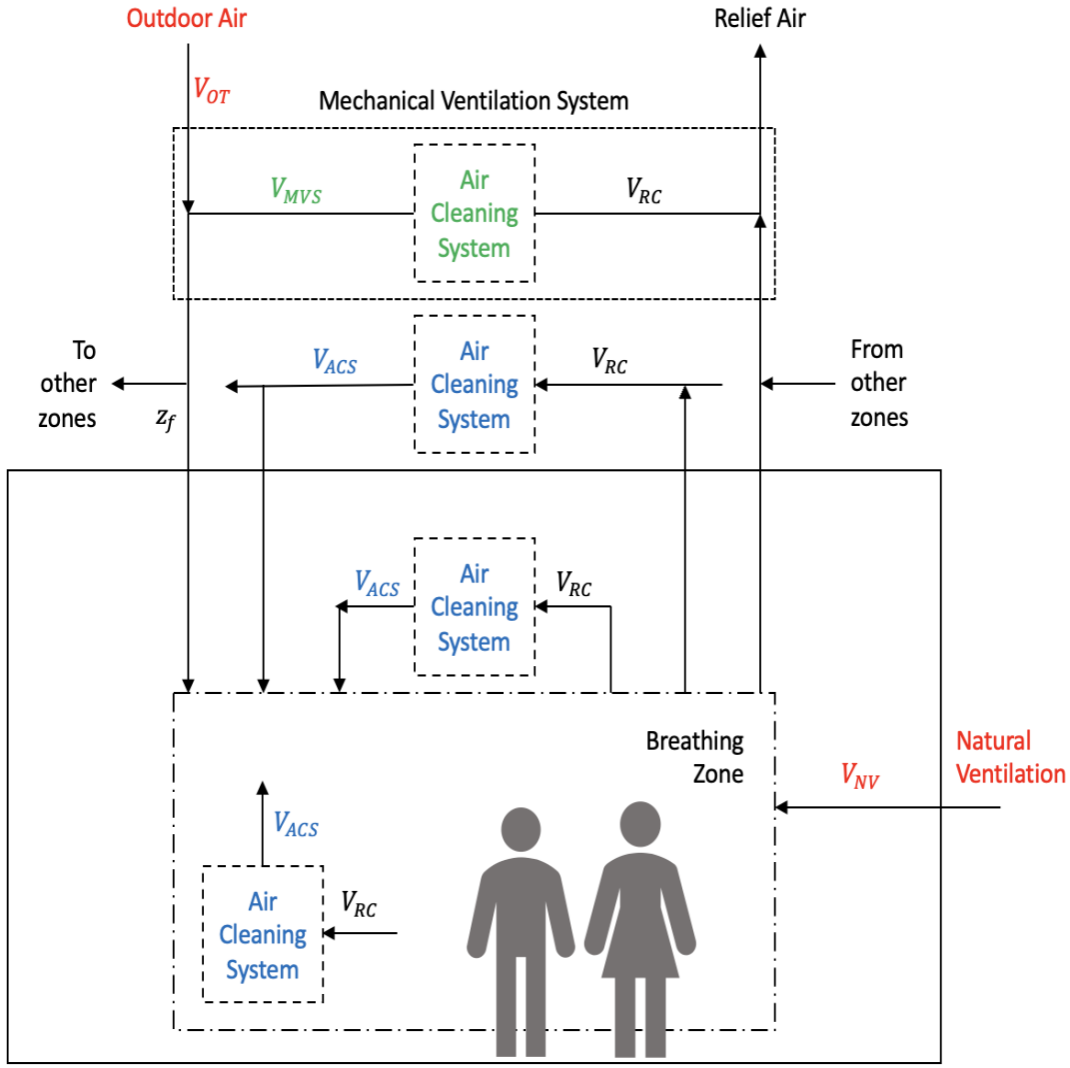


Double table ECAi for high vocalization spaces

Occupancy Category	ECAi cfm/person	ECAi 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 System Effectiveness and Safety

- Lack of information and standards related to air cleaning systems was a major problem during the Covid 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)
  - 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	Verify unit is in appropriate location and operating as intended per the *BRP*. Confirm that the air cleaner is operating at the speed or setting assumed in the V_{ECAi} calculation. Maintain systems and equipment and verify performance per manufacturer's instructions. Visually inspect intake for debris and clean as necessary.	Monthly
Ultraviolet (UV) germicidal irradiation	Maintain systems and verify performance and safety per manufacturer's instructions and in accordance with ANSI/IES RP-44-21 [11] and ANSI/IES RP-27.1.22 [20] or equivalent. Adjust, clean, and replace equipment as needed.	Assess quarterly or per manufacturer's recommended interval
All air cleaning systems and equipment (including in-room, in-duct, and UV air cleaners)	Maintain systems and equipment and verify performance per manufacturer's instructions. Adjust, clean, and replace equipment as needed. If equipment cannot be repaired, remove equipment from service and use a substitute engineering control to maintain V_{ECAi} in occupied space.	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

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

Thank you!

Bill Bahnfleth

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Thank you for attending!

Q&A

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