CDC COVID-19 Ventilation Guidance

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CDC COVID-19 Ventilation Guidance Updates Released May 12, 2023

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

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: CNN Health

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: Washington Post

CDC COVID-19 Ventilation Guidance Updates

Objective: Use improved ventilation to reduce potential infectious aerosol concentrations within occupied indoor spaces.

Toxicology Refresher (from an engineer!)

- Dose of infectious aerosols:
  - Airborne dose: function of the concentration, time, and inhalation rate
  - Surface contamination: function of concentration, settling rates, and time between cleanings
  - Common variables: **concentration** and time

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

- **Concentration** is the variable we can help control through the use of improved building ventilation.

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.

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)

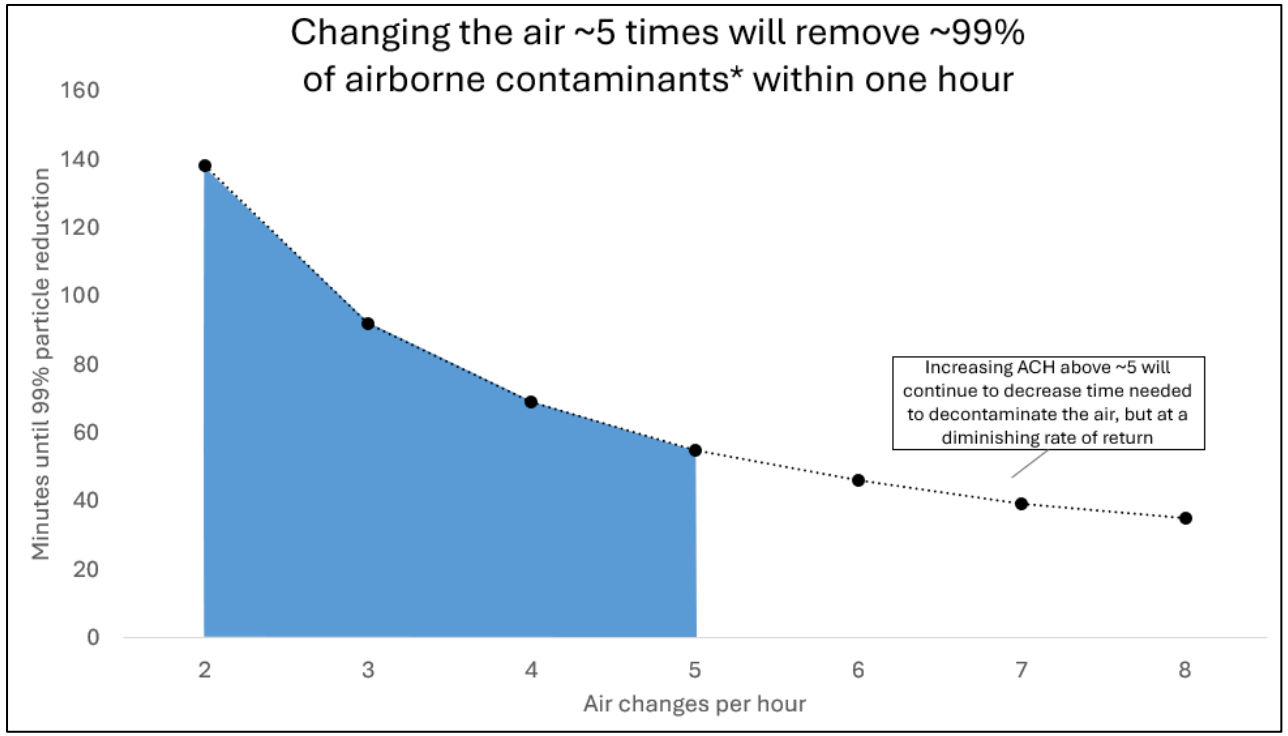
- When possible, aim for 5 or more air changes per hour (ACH) of clean air to help reduce the number of germs in the air. This can be achieved through any combination of central ventilation system, natural ventilation, or additional devices that provide equivalent ACH to your existing ventilation.
- 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.

https://www.epa.gov/sites/default/files/2018-07/documents/guide_to_air_cleaners_in_the_home_2nd_edition.pdf

How Much Ventilation Is Enough?

Aim for 5 Air Changes per Hour (ACH)

- 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).

Updated Discussion on UVGI

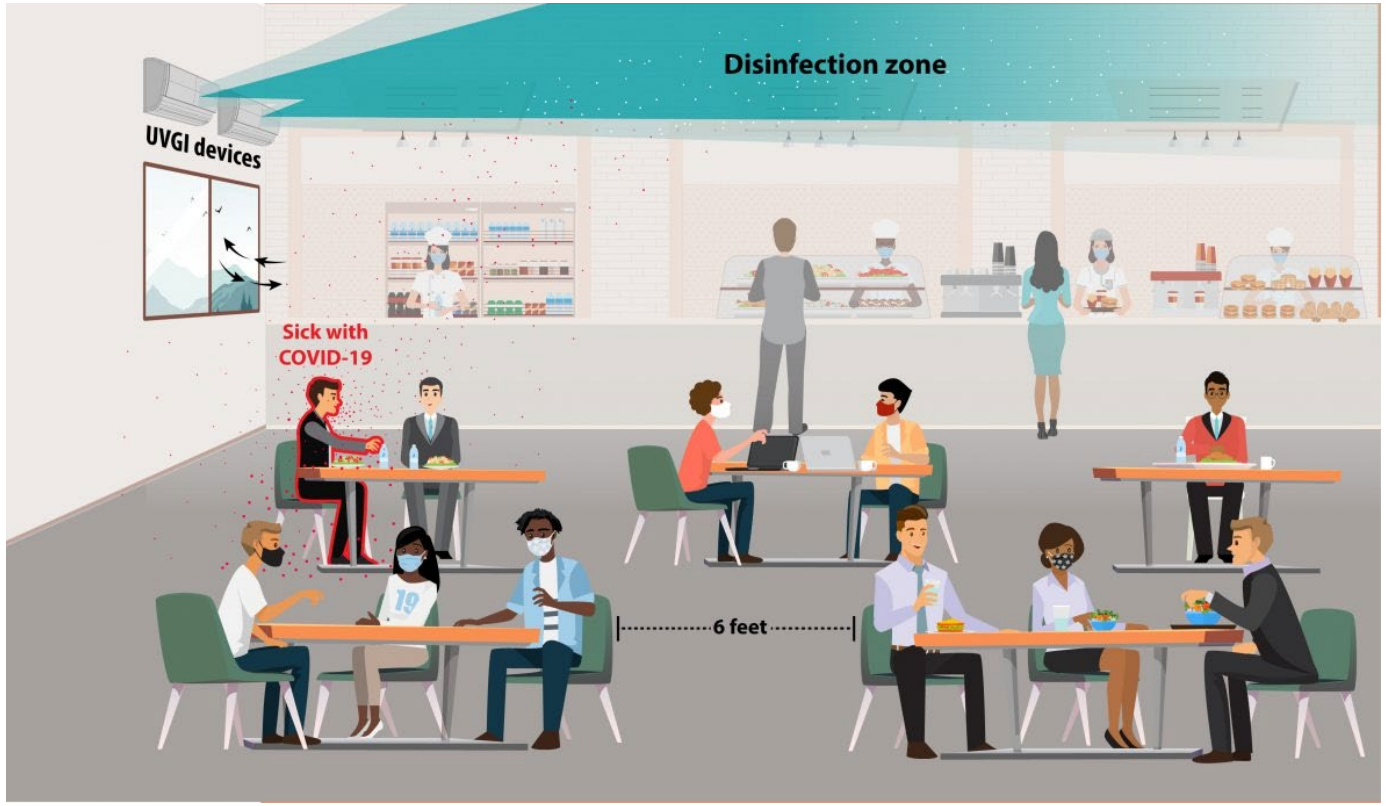
- Ultraviolet germicidal irradiation (UVGI) is also commonly referred to as germicidal ultraviolet (GUV).
- Located in FAQs 6 and 7 on *Ventilation in Buildings* page.
- UVGI should not be used alone, but as a supplemental treatment to inactivate infectious aerosols.
- Especially useful if options for increasing room ventilation and filtration are limited.

Ultraviolet Germicidal Irradiation UVGI

Photo: CDC.gov

Updated Discussion on UVGI

- Three types:
  - Upper-room UVGI systems provide air cleaning within occupied spaces.
  - In-duct UVGI systems can enhance air cleaning inside central HVAC systems. More powerful than typical coil cleaning systems.
  - Far UV systems (emerging technology; see FAQ 8 on *Ventilation in Buildings* page).



Source: https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation/UVGI.html

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

New Page when released.

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

Description

- Approximately 2-page document with text, graphics and inserts.
- Located in different 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

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

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

Improving Ventilation in Buildings:

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

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.

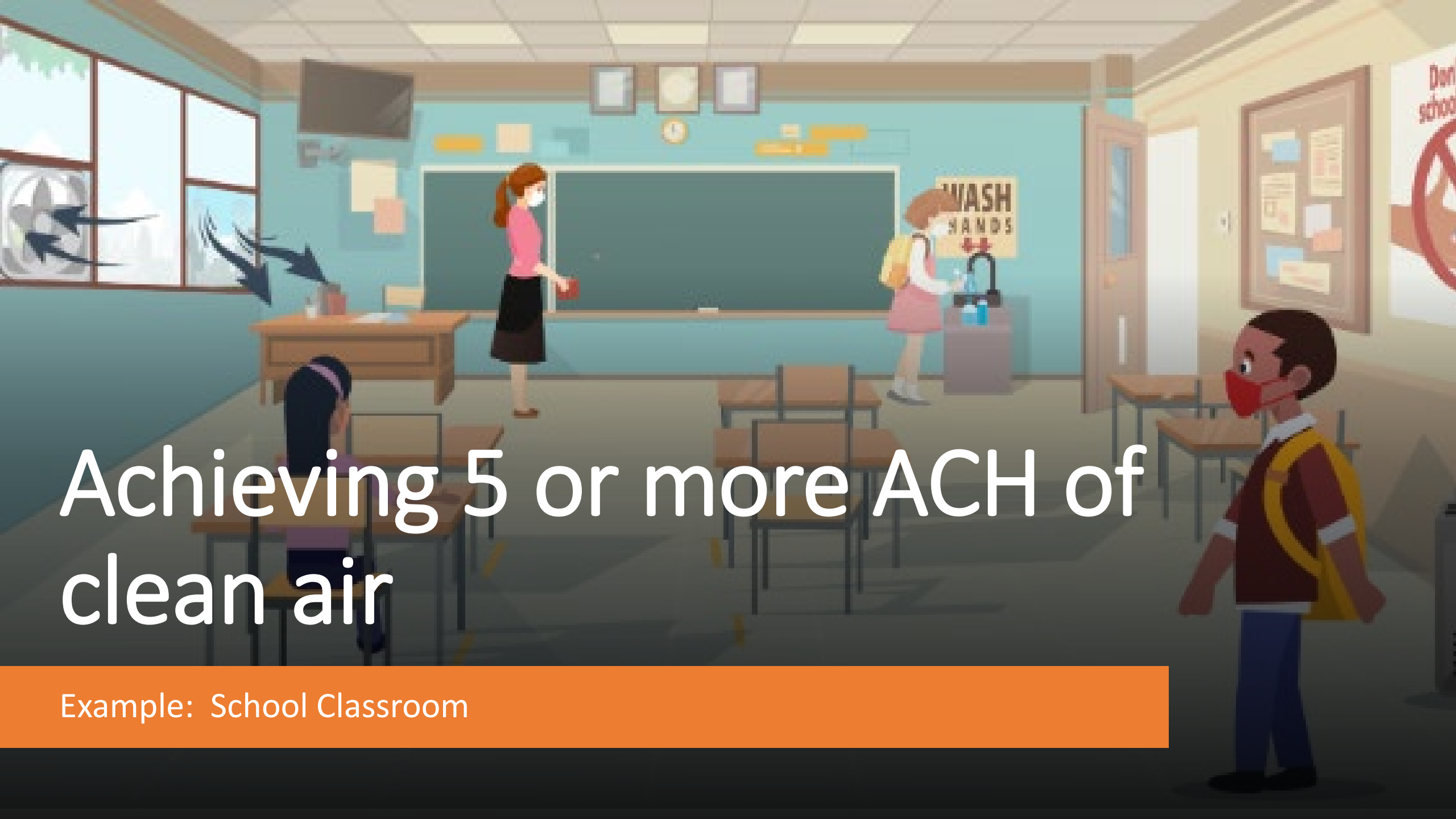
- ASHRAE (professional engineering association who writes ventilation standards) recently developed a new standard on ventilation design and operation to protect against infectious aerosol exposures within indoor environments (Standard 241).
  - Published in July 2023.
  - Applicable to indoor environments 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.



Achieving 5 or more ACH of clean air

Example: School Classroom

Calculating ACH

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.

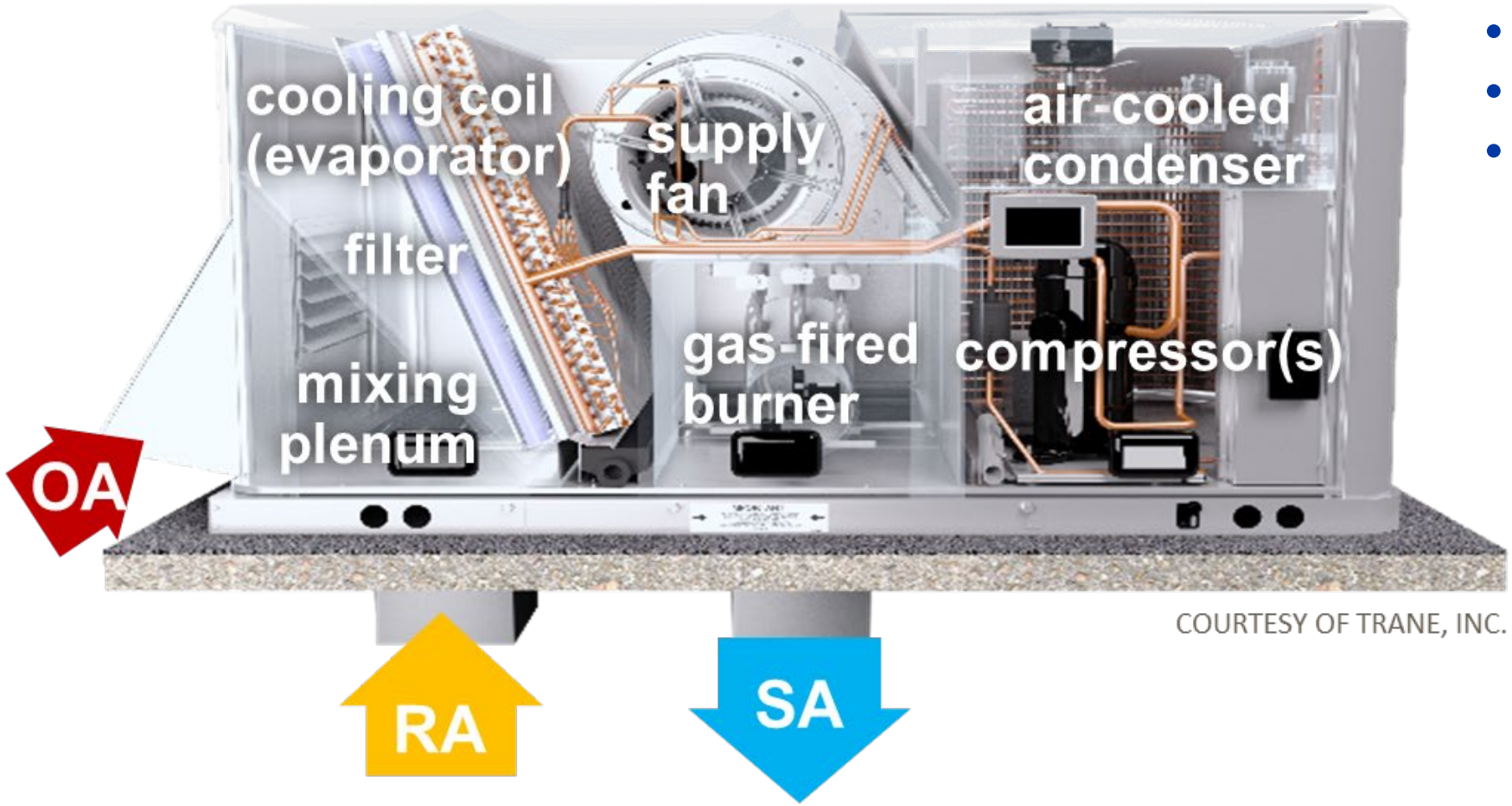
From: Ventilation in Buildings | CDC

School Classroom

- Area = 30 ft × 20 ft = 600 ft^2
- Ceiling height = 9 ft
- 20 students (age 9+)
- 1 teacher

- Served by rooftop air handling unit
- Total supply air = 400 cfm
- Meets current ventilation code
- Filter upgraded to MERV 13

School Classroom: Rooftop Air Handling Unit



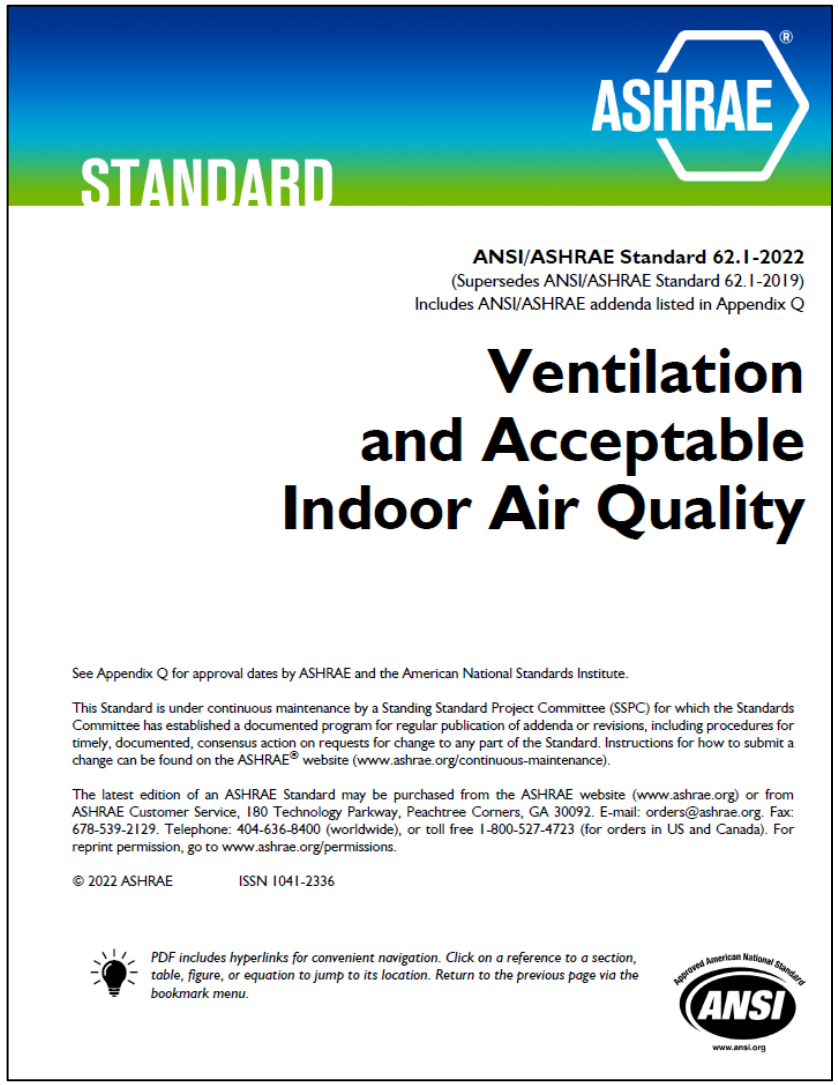
COURTESY OF TRANE, INC.

- OA = Outdoor Air
- RA = Return Air
- SA = Supply Air

SA = OA + RA

SA = 400 cfm

School Classroom: Meets Current Code



STANDARD

ASHRAE

ANSI/ASHRAE Standard 62.1-2022
(Supersedes ANSI/ASHRAE Standard 62.1-2019)
Includes ANSI/ASHRAE addenda listed in Appendix Q

Ventilation and Acceptable Indoor Air Quality

See Appendix Q for approval dates by ASHRAE and the American National Standards Institute.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. Instructions for how to submit a change can be found on the ASHRAE® website (www.ashrae.org/continuous-maintenance).

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PDF includes hyperlinks for convenient navigation. Click on a reference to a section, table, figure, or equation to jump to its location. Return to the previous page via the bookmark menu.

Approved American National Standard
ANSI
www.ansi.org

PURPOSE

Specify minimum ventilation rates and other measures intended to provide indoor air quality that is acceptable to human occupants and that minimizes adverse health effects.

Regulatory application to new buildings, additions to existing buildings, and those changes to existing buildings that are identified in the body of the standard.

APPLICABILITY

Most spaces indoor spaces with two notable exceptions:

- Health Care Spaces (Standard 170-2021)
- Residential (Standard 62.2-2022)

School Classroom: Meets Current Code

ANSI/ASHRAE Standard 62.1-2022

- Three methods: Ventilation Rate Procedure is most common.
- Only prescribes the amount of outdoor air:
  - cfm/person
  - cfm/ft^2

OA = (10 cfm/person)(21 people) + (0.12 cfm/ft^2)(600 ft^2) = 282 cfm

Table 6-1 Minimum Ventilation Rates in Breathing Zone

Occupancy Category	People Outdoor Air Rate R_p cfm/person	People Outdoor Air Rate R_p L/s·person	Area Outdoor Air Rate R_a cfm/ft^2	Area Outdoor Air Rate R_a L/s·m^2	Default Values Occupant Density #/1000 ft^2 or #/100 m^2	Air Class	OS (6.2.6.1.4)
Educational Facilities							
Art classroom	10	5	0.18	0.9	20	2	
Classrooms (ages 5 to 8)	10	5	0.12	0.6	25	1	
Classrooms (age 9 plus)	10	5	0.12	0.6	35	1	
Computer lab	10	5	0.12	0.6	25	1	
Daycare sickroom	10	5	0.18	0.9	25	3	
Daycare (through age 4)	10	5	0.18	0.9	25	2	
Lecture classroom	7.5	3.8	0.06	0.3	65	1	✓
Lecture hall (fixed seats)	7.5	3.8	0.06	0.3	150	1	✓
Libraries	5	2.5	0.12	0.6	10		
Media center	10	5	0.12	0.6	25	1	
Multiuse assembly	7.5	3.8	0.06	0.3	100	1	✓
Music/theater/dance	10	5	0.06	0.3	35	1	✓
Science laboratories	10	5	0.18	0.9	25	2	
University/college laboratories	10	5	0.18	0.9	25	2	
Wood/metal shop	10	5	0.18	0.9	20	2	

School Classroom: ACH from Outdoor Air

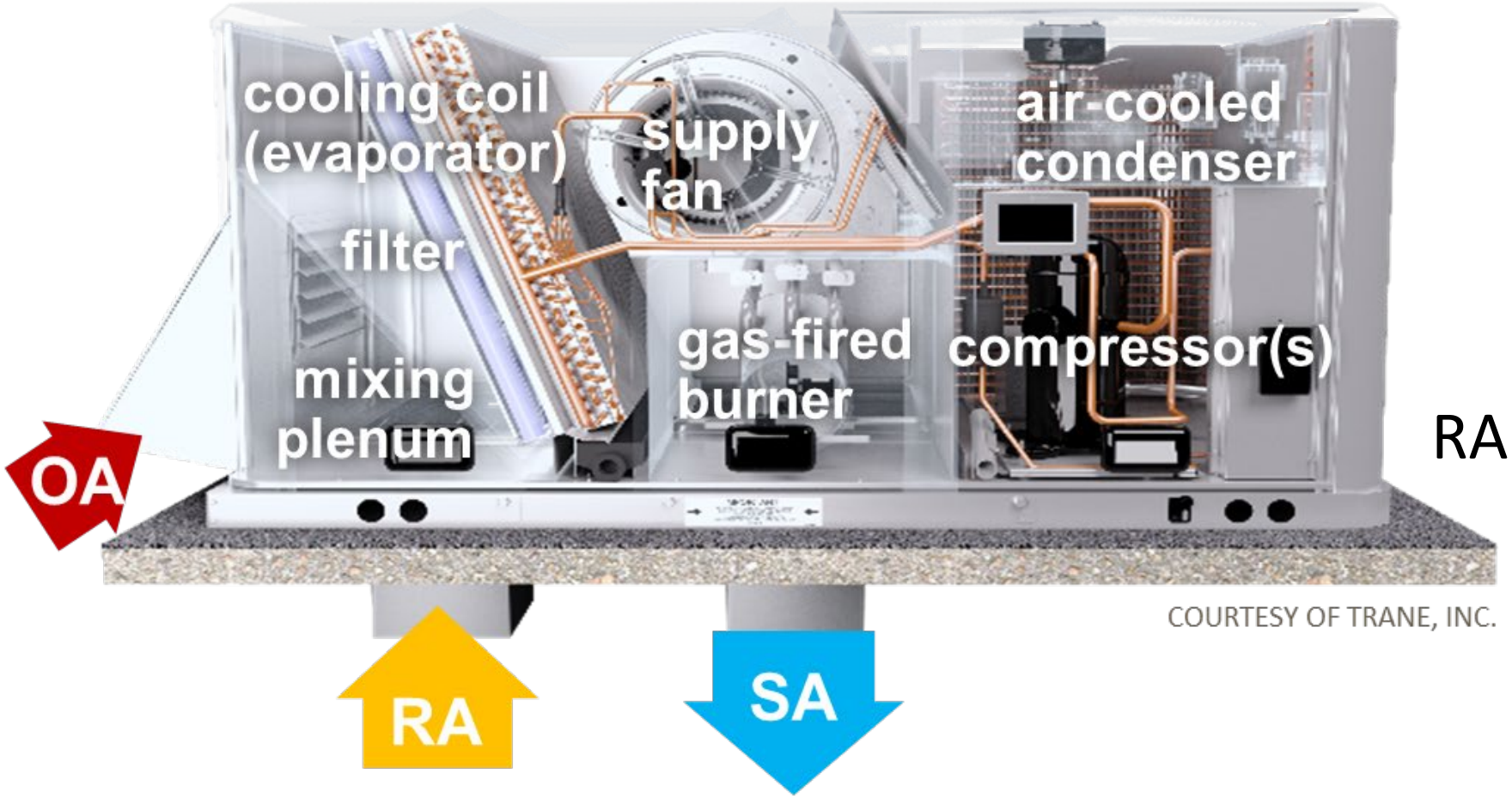
- Outdoor air is considered “clean” with respect to infectious aerosols.
- Get 100% credit.
- Do not get double credit for filtering outdoor air.

$$OA = 282 \text{ cfm } (282 \text{ ft}^3/\text{min})$$

$$ACH_{OA} = \frac{(282 \text{ ft}^3/\text{min}) \times (60 \text{ min/hr})}{(600 \text{ ft}^2) \times (9 \text{ ft})}$$

$$ACH_{OA} = 3.13 \approx 3$$

School Classroom: Rooftop Air Handling Unit



COURTESY OF TRANE, INC.

- OA = 282 cfm
- RA = ?
- SA = 400 cfm

SA = OA + RA
RA = SA – OA
RA = 400 cfm – 282 cfm

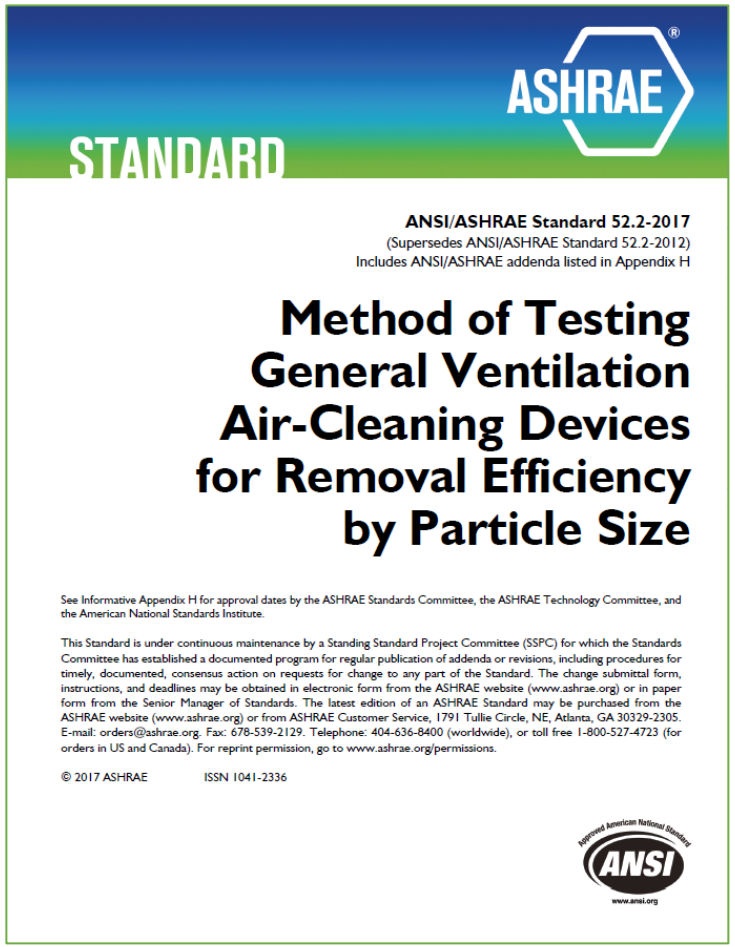
RA = 118 cfm

School Classroom: ACH from Return Air

- Return air is NOT considered “clean” with respect to infectious aerosols.
- Get partial credit based on filtration efficiency.

Table 12-1 Minimum Efficiency Reporting Value (MERV) Parameters

Standard 52.2 Minimum Efficiency Reporting Value (MERV)	Composite Average Particle Size Efficiency, % in Size Range, µm			
	Range 1 0.30 to 1.0	Range 2 1.0 to 3.0	Range 3 3.0 to 10.0	Average Arrestance, %
1	N/A	N/A	$E_3 < 20$	$A_{avg} < 65$
2	N/A	N/A	$E_3 < 20$	$65 \le A_{avg}$
3	N/A	N/A	$E_3 < 20$	$70 \le A_{avg}$
4	N/A	N/A	$E_3 < 20$	$75 \le A_{avg}$
5	N/A	N/A	$20 \le E_3$	N/A
6	N/A	N/A	$35 \le E_3$	N/A
7	N/A	N/A	$50 \le E_3$	N/A
8	N/A	$20 \le E_2$	$70 \le E_3$	N/A
9	N/A	$35 \le E_2$	$75 \le E_3$	N/A
10	N/A	$50 \le E_2$	$80 \le E_3$	N/A
11	$20 \le E_1$	$65 \le E_2$	$85 \le E_3$	N/A
12	$35 \le E_1$	$80 \le E_2$	$90 \le E_3$	N/A
13	$50 \le E_1$	$85 \le E_2$	$90 \le E_3$	N/A
14	$75 \le E_1$	$90 \le E_2$	$95 \le E_3$	N/A
15	$85 \le E_1$	$90 \le E_2$	$95 \le E_3$	N/A
16	$95 \le E_1$	$95 \le E_2$	$95 \le E_3$	N/A



School Classroom: ACH from Return Air

- Return air is NOT considered “clean” with respect to infectious aerosols.
- Get partial credit based on filtration efficiency.
- MERV 13 filters are 85% efficient against 1.0 – 3.0 µm particles.
- 85% of the air passing through a MERV 13 filter is “clean.”
- See FAQ # 3 at CDC’s Ventilation in Buildings | CDC webpage.

$$RA = 118\ cfm \times 0.85 = 100\ cfm\ (100\ ft^3/min)$$

$$ACH_{RA} = \frac{(100\ ft^3/min) \times (60\ min/hr)}{(600\ ft^2) \times (9\ ft)}$$

$$ACH_{RA} = 1.11 \approx 1$$

Total “Clean” ACH = $ACH_{OA} + ACH_{RA} = 3 + 1 = 4$ ACH (less than 5)

School Classroom: What Now?

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

Questions?

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