



HOW TO SUSTAINABLY OPTIMIZE INDOOR AIR QUALITY

AGENDA

**Defining a Healthy Building and IAQ
Analyzing Existing School Infrastructure
Review of Current Codes and Recommendations
Measures that Can be Implemented
Case Studies of a Microenvironment (Mini-Cleanroom)**

“Finding the intersection between efficacy, cost, practicality and energy conservation is a bit like threading a very small needle”

Speaker Today

Andy Weidert

**Vice President of Business Development
Stark Tech**

**20 Years Designing & Implementing
Mission Critical HVAC Solutions**



ABOUT STARK TECH GROUP

We are a leader in facility optimization, aligning technology with real world experience across a diverse portfolio of capabilities. We are a single agent source for Building Automation, Intelligence & Equipment offering a unique customer experience throughout the lifecycle of the building.



Integration



Equipment



Intelligence



Turnkey
Services

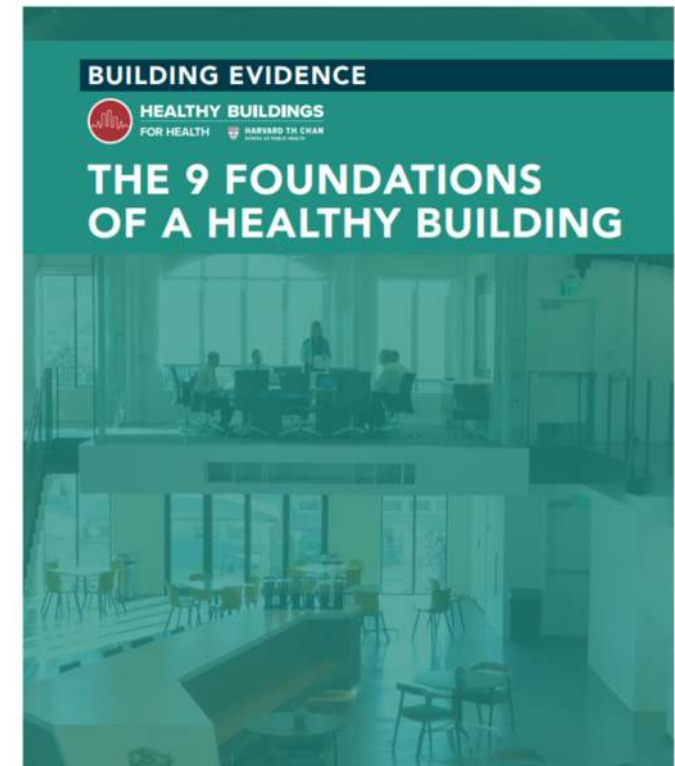


Idea of a Healthy Building

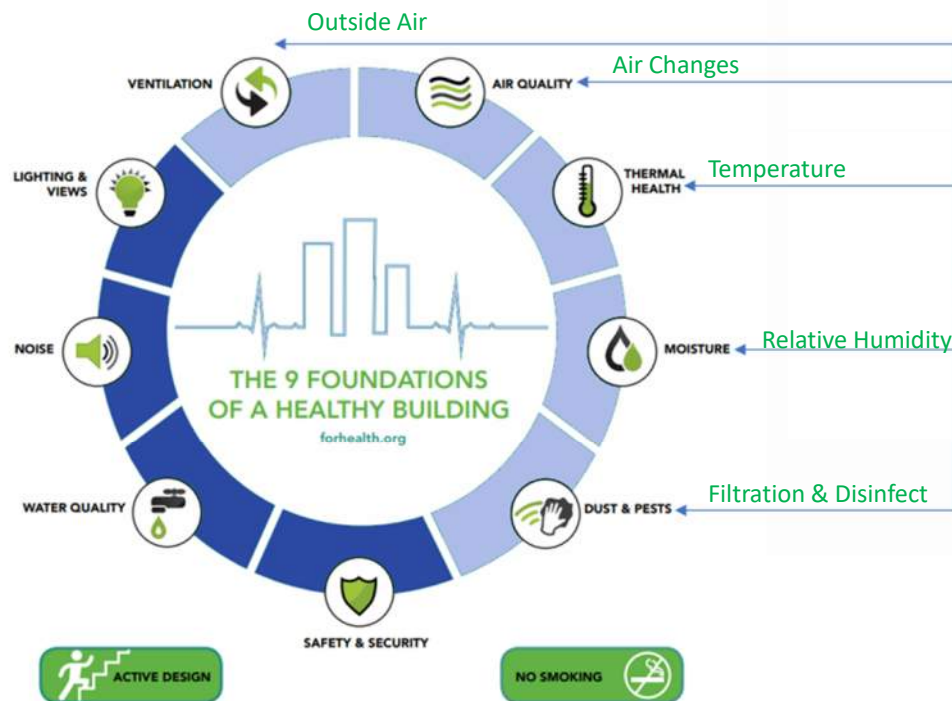
Harvard School of Public Health The 9 Foundations of a Healthy Building

Established in 2017

The idea for the “The 9 Foundations of a Healthy Building” arose from many interactions over the past several years with real estate professionals, building owners, hospital administrators, facilities directors, homeowners, and academic colleagues. Two things stood out. First, during these discussions, we would often say, “The idea of a healthy building has been made too complicated. We know how to make buildings healthy. There are a few simple foundations.” This of course led to requests to name the foundations of a healthy building. In the ensuing discussion and debate we realized that we, the public health community, have failed to translate our research into actionable information; the richness of the public health literature was invisible to key decision-makers. Second, in these presentations and meetings we would often hear some variation of the refrain, “Your research is very interesting, but I can’t take a scientific paper into my meeting on Monday and convince a building owner or manager to do things differently. I need a short summary.” Thus, the 9 Foundations project was born.



THE 9 FOUNDATIONS OF A HEALTHY BUILDING



Defining a Healthy Building



HEALTHY BUILDINGS

FOR HEALTH



HARVARD T.H. CHAN
SCHOOL OF PUBLIC HEALTH

Indoor Air Quality

Is directly Associated with 5 out of 9 Foundations of a Healthy Building

- *Significantly Improve IAQ
- *Increase Attendance
- *Greater Productivity
- *Better Performance
- *Improve Morale
- *Boost Collaboration
- *Support Mental Health



**World Health
Organization**

Air pollution is the greatest environmental threat to human health

- 7 Million people died prematurely from illnesses attributable to air pollution in 2016
 - 9 out of 10 people worldwide do not breathe safe air
- Head of WHO, Dr. Tedros Adhanm Ghebreyesus, calls air pollution the “new tobacco” (2018)

Why is Indoor Air Quality (IAQ) so Important?



Average Student from Kindergarten to High School Graduation will spend over 15,000 HRS in a classroom



Close to 1/3 of the United States Population resides in an Educational Facility during a school Day.



1 in 13 Americans suffer from Asthma with an associated annual economic impact of 82 Billion



Studies suggest up to 65% of Asthma cases in school aged children could be prevented with proper IAQ in school and at home

AVERAGE AMERICAN SPENDS CLOSE TO 90% INDOORS



- 68.7% In a Residence



- 12.8% Other Indoor Locations



- 5.4% Office/Factory



- 7.6% Outdoors



- 5.5% In a Vehicle

REVIEW OF EXISTING SCHOOL INFRASTRUCTURE



Schools



53% OF PUBLIC-SCHOOL DISTRICTS NEEDED TO "UPDATE OR REPLACE MULTIPLE BUILDING SYSTEMS OR FEATURES" IN THEIR SCHOOLS



45% OF DISTRICTS NEEDED TO RENEW OR UPGRADE HVAC SYSTEMS IN AT LEAST ½ OF THEIR SCHOOLS, REPRESENTING AN ESTIMATED 36,000 SCHOOLS NATIONWIDE



OVER **30%** OF BUILDING SYSTEMS FOR HVAC, VENTILATION & FILTRATION SYSTEMS ARE IN FAIR OR POOR CONDITION

The United States allocates 11.6% of public funding toward education, well below the International standard 15.00%

How well can our Schools HVAC Infrastructure Provide INDOOR AIR QUALITY



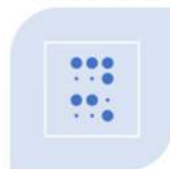
VENTILATION



OUTSIDE AIR

AVERAGE SCHOOL ACHIEVES **1.5 AIR CHANGES PER HOUR** WHICH IS A MINIMUM STANDARD DESIGNED TO PROVIDE MERELY "ACCEPTABLE IAQ"

FILTRATION



FILTRATION

MAJORITY OF HVAC SYSTEMS WERE DESIGNED TO HAVE **MERV 8 FILTERS**. THIS LEVEL OF FILTRATION IS **NOT** EFFECTIVE FOR CAPTURING BACTERIA OR VIRUS CARRIERS. MINIMAL LEVEL OF FILTRATION IN THE HVAC WORLD

AIR QUALITY



AIR CHANGES

MAJORITY OF CLASSROOMS TOTAL AIR CHANGES PER HOUR FALLS IN THE **LOW TO BARE MINIMUM TARGET**

Green	Ideal (6 ACH)
Light Green	Excellent (5-6 ACH)
Yellow	Good (4-5 ACH)
Light Red	Bare minimum (3-4 ACH)
Dark Red	Low (<3 ACH)

$$\text{Air changes per hour} = \frac{\text{"clean" air rate}}{\text{room volume}} = \frac{\text{cubic feet per minute} \times 60 \text{ minutes}}{\text{length} \times \text{width} \times \text{height (in feet)}}$$

6 Air Changes an Hour is Ideal

SUMMARY OF STANDARDS AND CODES FOR ASHRAE PRIOR TO THE EPIDEMIC



ANSI/ASHRAE Standard 62.1-2019
Supersedes ANSI/ASHRAE Standard 62.1-2016
Includes ANSI/ASHRAE addenda listed in Appendix D

Ventilation for Acceptable Indoor Air Quality

See Appendix D for approval data 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 voting, documented, consensus-driven requests for change or any part of the Standard. Instructions for how to submit a change can be found on the ASHRAE website (www.ashrae.org/standards).
The latest edition of an ASHRAE Standard may be purchased from the ASHRAE website (www.ashrae.org) or from ASHRAE Customer Service, 1791 Taylor Circle, NE, Atlanta, GA 30329-2020. E-mail: orders@ashrae.org Fax: 478/533-2127. Telephone: 404/843-8400 (toll-free 1-800-527-4772) (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.
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ANSI/ASHRAE Addendum d to
ANSI/ASHRAE Standard 55-2017

Thermal Environmental Conditions for Human Occupancy

Approved by ASHRAE and the American National Standards Institute on July 21, 2020.
This addendum was approved 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 voting, documented, consensus-driven requests for change or any part of the Standard. Instructions for how to submit a change can be found on the ASHRAE website (www.ashrae.org/standards).
The latest edition of an ASHRAE Standard may be purchased from the ASHRAE website (www.ashrae.org) or from ASHRAE Customer Service, 1791 Taylor Circle, NE, Atlanta, GA 30329-2020. E-mail: orders@ashrae.org Fax: 478/533-2127. Telephone: 404/843-8400 (toll-free 1-800-527-4772) (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.
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Designer Guidelines – General
Maintain Temperature & Humidity
Winter: 72 F/40-50% RH / Summer: 75 F/50-60% RH



ASHRAE Position Document on Filtration and Air Cleaning

Approved by ASHRAE Board of Directors
January 28, 2015

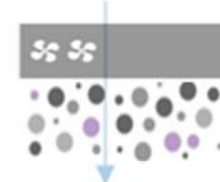
Reaffirmed by Technology Council
January 13, 2018

Expires January 23,
2021

Operating Cost

ASHRAE 62.1

MERV 8
1 to 4.5 A/C
Minimal
Ventilation



Efficiency	20-50%
Particle Size	0.3-1.0 microns
Air Pressure Requirement	
Captures	Lead Dust Vehicle Emissions



CURRENT SUMMARY OF GUIDANCE AND CODES ASHRAE, CDC, NYS DOH, NYSED



ASHRAE EPIDEMIC TASK FORCE

Core Recommendations for Reducing Airborne Infectious Aerosol Exposure

The following recommendations are the basis for the detailed guidance issued by ASHRAE Epidemic Task Force. They are based on the concept that within limits ventilation, filtration, and air cleaners can be deployed flexibly to achieve exposure reduction goals subject to constraints that may include comfort, energy use, and costs. This is done by setting targets for equivalent clean air supply rate and expressing the performance of filters, air cleaners, and other removal mechanisms in these terms.

1. **Public Health Guidance** - Follow all regulatory and statutory requirements and recommendations for social distancing, wearing of masks and other PPE, administrative measures, circulation of occupants, reduced occupancy, hygiene, and sanitation.
2. **Ventilation, Filtration, Air Cleaning**
 - 2.1 Provide and maintain at least required minimum outdoor airflow rates for ventilation as specified by applicable codes and standards.
 - 2.2 Use combinations of filters and air cleaners that achieve MERV 13 or better levels of performance for air recirculated by HVAC systems.
 - 2.3 Only use air cleaners for which evidence of effectiveness and safety is clear.
 - 2.4 Select control options, including standalone filters and air cleaners, that provide desired exposure reduction while minimizing associated energy penalties.
3. **Air Distribution** - Where directional airflow is not specifically required, or not recommended as the result of a risk assessment, promote mixing of space air without causing strong air currents that increase direct transmission from person-to-person.
4. **HVAC System Operation**
 - 4.1 Maintain temperature and humidity design set points.
 - 4.2 Maintain equivalent clean air supply required for design occupancy whenever anyone is present in the space served by a system.
 - 4.3 When necessary to flush spaces between occupied periods, operate systems for a time required to achieve three air changes of equivalent clean air supply.
 - 4.4 Limit re-entry of contaminated air that may re-enter the building from energy recovery devices, outdoor air, and other sources to acceptable levels.
5. **System Commissioning** - Verify that HVAC systems are functioning as designed.

January 6, 2021

ASHRAE EPIDEMIC TASK FORCE JAN 6, 2021



Centers for Disease Control and Prevention
CDC 24/7: Saving Lives. Protecting People™



CDC GUIDANCE ON REOPENING SCHOOLS



Department
of Health

HOWARD A. ZUCKER, M.D., J.D.
Commissioner

LISA PIRRO, M.A., J.D.
Executive Deputy Commissioner

INTERIM NYSDOH GUIDANCE FOR CLASSROOM INSTRUCTION IN P-12 SCHOOLS DURING THE 2021-2022 ACADEMIC YEAR

September 2, 2021

Background

New York State recognizes that opening pre-kindergarten through grade 12 schools for in-person instruction is critical to student health, well-being, academic success, and social functioning. In alignment with international and national experts, the State is committed to prioritizing in-person learning while adhering to multiple mitigation strategies that include vaccination, the appropriate use of face masks, physical distancing and screening testing to monitor transmission and inform local public health actions. Combining these mitigation strategies increases community confidence in in-person instruction and prevents transmission of COVID-19. This reduces exposures and quarantines and increases schools' ability to remain open despite fluctuating background COVID-19 rates in the community.

Please note that the following guidance applies to P-12 elementary and secondary, public, charter, private, and state-operated schools, including residential schools and programs serving students with disabilities, as regulated by the NYS Education Department. It does not apply to institutions of higher education. It does not apply to "standalone" pre-kindergarten schools (that is, schools that only serve pre-kindergarten students and are not located in a building that also serves older students). Further, this document provides an operational framework for schools to fulfill their primary purpose of educating children during the COVID-19 pandemic (including sports, transporting children, field trips, extracurricular activities, and other ancillary educational activities conducted by schools). The Department recognizes that school buildings may be used for community-based activities where students are not present; the guidance herein does not apply in such situations.

Lastly, references are provided to regulatory requirements and associated Commissioner's determinations for masking and COVID-19 testing and reporting in school settings. Appendix A of this guidance contains a summary of these regulations and associated determinations.

Purpose

The New York State Department of Health hereby establishes the following for P-12 schools for the 2021-2022 school year. The following guidance addresses the minimum expectations for classroom instruction in P-12 schools. In accordance with applicable state and federal laws, schools may apply additional or more restrictive requirements in support of the health and wellness of students, faculty, and staff.

INTERIM NYSDOH GUIDANCE FOR CLASSROOM SEPTEMBER 2, 2021



Health and Safety Guide for the 2021-2022 School Year New York State Education Department August 2021



CURRENT SUMMARY OF GUIDANCE AND CODES ASHRAE, CDC, NYS DOH, NYSED



Use Combination of Filters and Air Cleaners that achieve MERV 13 or Better



Maximize Ventilation / Disable any demand control ventilation



Increase Air Changes and Keep systems running longer on school days, 24/7 if possible



Designer Guidelines – General
Maintain Temperature & Humidity
Winter: 72 F/40-50% RH / Summer: 75 F/50-60% RH



Recommended “Flush Cycle”
Between Occupied Periods
3 A/C of Clean Air Supply



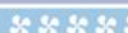
Units that feature ionizers, precipitators, or ozone generators do not help and can generate harmful byproducts.



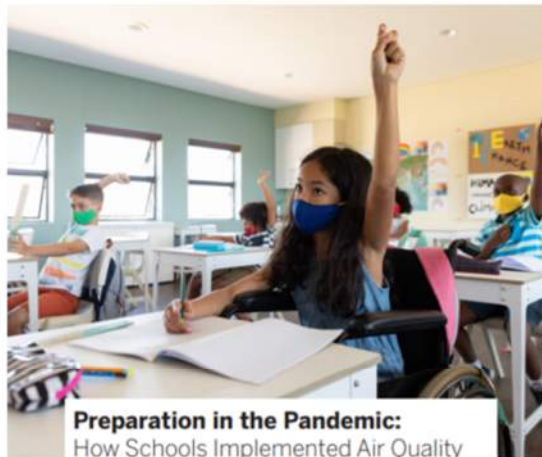
3rd Party Validated data on removal efficacy and safety. Documentation and Testing to CARB and UL is essential.

CURRENT

**MERV 13 or Better
+ Portable HEPA
Optimize A/C
Maximize Ventilation
Flush Period**

	MERV 11-13	HEPA Filter
		
Efficiency	20-50%	99.97-99.99%
Particle Size	0.3-1.0 microns	0.3 microns
Air Pressure Requirement		
Captures	Lead Dust Vehicle Emissions	Lead Dust Vehicle Emissions Smoke Exhalation Droplets Bacteria Some Viruses

IMPLEMENTED INDOOR AIR QUALITY SCORECARD



Preparation in the Pandemic: How Schools Implemented Air Quality Measures to Protect Occupants from COVID-19

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MPH Candidate, Harvard TH Chan School of Public Health
MD Candidate, University of California – San Francisco School of Medicine (UCSF)

ANISA HEMING
Director, The Center for Green Schools



Executive Summary

Upgrade to higher grade MERV filters

- Schools not designed to support this strategy
- High cost
- Lack of availability of filters

Air cleaners with HEPA Filters

- High Cost

Increase outdoor air system via HVAC system

- Schools not designed to support this strategy

Open windows

- Climate and weather challenges
- Schools not designed to support this strategy

Use fans in doors and windows to increase exhaust

- Climate and weather challenges
- Not a priority of school district leaders
- School not designed to support this strategy

Pre/post-occupancy flushing

- School not designed to support this strategy

We found that school districts relied heavily on their mechanical systems to implement air quality measures. Using mechanical ventilation to increase fresh air was most commonly adopted by schools, followed by filtration measures to remove airborne contaminants from recirculated air. The most frequently cited challenge to implementing protective air quality measures at schools was that school buildings were not designed to support the strategies that were being recommended.

Efficacy of Portable Air Cleaners and Masking for Reducing Indoor Exposure to Simulated Exhaled SARS-CoV-2 Aerosols — United States, 2021

William G. Liddell, PhD¹, Raymond C. Dick, MS¹, James F. Cook, PhD², Stephen R. Martin, D. PhD³, Kenneth R. Moud, PhD⁴, Francisco M. Blachon, MS⁵, Donald H. Berke, PhD⁶, John T. Brooks, MS⁷, Thomas Brown, MS⁸, John D. Nee, PhD⁹

On July 2, 2021, this report was posted as an MMWR Early Release on the MMWR website (<https://www.cdc.gov/mmwr>).

SARS-CoV-2, the virus that causes COVID-19, can be spread by exposure to droplets and aerosols of respiratory fluids that are released by infected persons when they cough, sing, talk, or exhale. To reduce indoor transmission of SARS-CoV-2 between persons, CDC recommends measures including physical distancing, universal masking (the use of face masks in public places by everyone who is not fully vaccinated), and increased room ventilation (1). Ventilation systems can be supplemented with portable high efficiency particulate air (HEPA) cleaners¹ to reduce the number of infectious particles in the air and provide enhanced protection from transmission between persons (2). Two recent reports found that HEPA air cleaners in classrooms could reduce overall particle concentrations by 80% within 30 minutes (3,4). To investigate the effectiveness of portable HEPA air cleaners and universal masking at reducing exposure to exhaled aerosol particles, the investigation team used respiratory simulators to mimic a person with COVID-19 and other, uninfected persons in a conference room. The addition of two HEPA air cleaners that met the Environmental Protection Agency (EPA)-recommended clean air delivery rate (CADR) (5) reduced overall exposure to simulated exhaled aerosol particles by up to 65% without universal masking. Without the HEPA air cleaners, universal masking reduced the combined mean aerosol concentration by 72%. The combination of the two HEPA air cleaners and universal masking reduced overall exposure by up to 90%. The HEPA air cleaners were most effective when they were close to the aerosol source. These findings suggest that portable HEPA air cleaners can reduce exposure to SARS-CoV-2 aerosols in indoor environments, with greater reductions in exposure occurring when used in combination with universal masking.

A breathing aerosol source simulator was used to mimic a meeting participant exhaling infectious particles (source), and three breathing simulators were used to mimic a speaker and two participants exposed to these aerosol particles (receivers) (Figure 1). The methods used were similar to those used in previous studies of aerosol dispersion and transport in indoor spaces (3,4,6). The simulators were placed in a 304-ft² (34-m²)

conference room with a heating, ventilation, and air conditioning (HVAC) system that provided 0.1 m³ per second of air flow (202 ft³ per minute; two air changes per hour) with no air recirculation. Two HEPA air cleaners (Honeywell 50250-S, Kar Inc.) were used, each rated to provide 250 ft³ per minute (0.12 m³ per second) of air filtration for a combined total of 5.2 air changes per hour. The two air cleaners were used in four different locations: 1) center of the room on the floor behind the source simulator; 2) left and right sides of the room on the floor; 3) left and right sides of the room and elevated 52 in (0.8 m); and 4) front and back of the room on the floor.

Control experiments used no air cleaners. The source simulator (6) breathed continuously at 15 L/min. Two participant simulators (participant receivers) similar in design to the respiratory aerosol source simulator breathed continuously at 15 L/min. The speaker simulator (speaker receiver) was a commercial simulator (Warwick Technologies Ltd.) that breathed at 28 L/min. To mimic human hands, all simulators had headpieces with electronic skin (source simulator headpiece, Human Robotics; receiver simulator headpieces, Respirator Testing Head Form 1-Static, Crawley Creations Ltd.). The face masks used on the headpieces were three-ply cotton cloth face masks with ear loops (Defender, HandBrands Inc.). Experiments were conducted either with all simulators unmasked or all simulators masked (universal masking).

The concentrations of 0.3-µm to 3-µm aerosol particles were measured at the mouth of each receiver using optical particle counters (Model 1-108, Grimm Technologies, Inc.) to determine the exposure of each receiver simulator to aerosol particles. When the simulators were masked, the particle counters collected aerosol samples from inside the masks (i.e., the particle counter measured the concentration of the aerosol being inhaled by the receiver simulator). For each optical particle counter, the total aerosol mass concentration was averaged over 60 minutes to determine the mean aerosol mass concentration (mean aerosol exposure) to which each receiver was exposed. Each experiment was repeated four times for a total of 20 runs. All data were analyzed using the Kruskal-Wallis test to assess overall significance, followed by a Wilcoxon Rank-Sum pairwise comparison with a Benjamini and Hochberg adjusted p-value for multiple comparisons. R software (version 3.6.0, R Foundation) was used to conduct all analyses.

¹ HEPA air cleaners consist of a filter capable of removing ≥99.97% of particles from the air and clean air before it flows through the filter. HEPA air cleaners are commercially available, relatively inexpensive, and easy to use.

July 9 2021, CDC Document Efficacy of Portable Air Cleaners and Masking

CDC RESPONSE

July 15 2021, CDC Webinar on Returning to Schools

Ventilation

- Improving ventilation reduces the number of virus particles in the air.
- Bringing fresh outdoor air into a building helps keep virus particles from concentrating inside:
 - Open multiple doors and windows.
 - Use child-safe fans to increase the effectiveness of open windows.
 - Make changes to the HVAC or air filtration systems.
- Funds provided through the Elementary and Secondary Schools Emergency Relief Programs and the Governors Emergency Education Relief Programs can support improvements to [ventilation](https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/ventilation.html).

<https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/ventilation.html>

Morbidity and Mortality Weekly Report

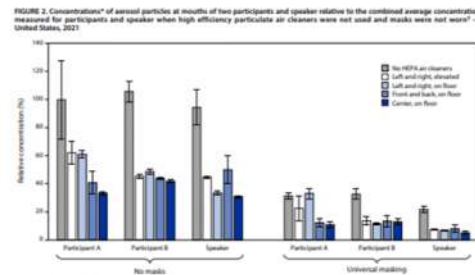


FIGURE 2. Concentrations of aerosol particles at mouths of two participants and speaker relative to the combined average concentration measured for participants and speaker when high efficiency particulate air cleaners were not used and masks were not worn¹ — United States, 2021

¹ The aerosol concentrations were measured at the mouths of two simulated participant receivers and simulated speaker receiver for 60 minutes while the simulated infected participant source exhaled aerosols into the room.

² The legend indicates the locations of the HEPA air cleaners in the room. Each bar is the mean of four experiments. Error bars show the standard deviation.

typically are not designed to have the much higher airflow rates that are needed to reduce disease transmission (6). During the ongoing pandemic, public health and professional organizations have provided guidance for increasing ventilation and air filtration to decrease the spread of SARS-CoV-2 (2,3,10). One recommended option, especially when existing HVAC systems might be insufficient, is adding portable HEPA air cleaners to rooms (2). The results of this study support the use of portable HEPA air cleaners to reduce exposure to airborne particles.

The findings in this report are subject to at least five limitations. First, the dispersion of aerosols in a room depends upon air currents, which are unique to each setting. In this study, the conference room air was well mixed, which helped transport aerosols to the air cleaners. In rooms with poor air mixing and potential recirculation issues, air cleaners might be less effective. Airflow patterns in real-world settings such as classrooms will vary among buildings and rooms, and rooms of different dimensions and with different ventilation rates will also have different airflow patterns. Second, the aerosol source mask used in this study was kept in one fixed location. In reality, potentially infectious occupants could be anywhere in the room and might move around the room occasionally. Third, this study

only used one source mask and three receiver masks; additional sources and receivers could change the dynamics of aerosol dispersion within a room. Fourth, the study was limited to aerosol particles of 0.3 µm to 3 µm in size, which are small enough to remain airborne for an extended time but large enough to carry pathogens. However, particles outside this size range would behave differently. Finally, the study only assessed aerosol exposure; it did not directly examine disease transmission. Although the study provides useful information about the dynamics of respiratory aerosol particles and the effect of HEPA air cleaners and universal masking, many other factors are also important for disease transmission, including the amount of virus in the particles, how long the virus survives in air, and the vaccination status of the room occupants.

Portable HEPA air cleaners offer a simple means to increase the filtration of aerosol particles from a room without modifying the existing building ventilation system (2). The optimal location for HEPA air cleaners will depend upon the unique conditions in each room, but they are likely to be most effective when they are placed as close to the occupants as is practicable. Larger reductions in exposure occur when air cleaners are used in combination with universal masking. These

Released October 26, 2021
LATEST INFORMATION

Series Overview

What is airborne transmission?

Strong evidence tells us that the dominant way that diseases like COVID-19 spread is through droplets and respiratory aerosols, which can float and travel, infecting people who inhale them at short and long distances from the infected person.

SERIES: Indoor Air Quality Fact Sheets

This overview introduces the series and provides important background information.

Indoor air quality and COVID-19:

To protect against COVID-19, schools have implemented many measures recommended by public health professionals: distancing, cohorts, masking, hand-washing, and vaccination. These are effective actions to reduce the spread of the virus, but they rely on human behavior and choice.

After studying viral transmission pathways, **scientists are confident** that people are less likely to get sick from COVID-19 and other respiratory pathogens when the air around them is refreshed continuously with clean air that is free from the virus. Investing in indoor air quality (IAQ) is a straightforward and non-controversial way to stop the spread of COVID-19.

Know your buildings: What systems do you have?

- **Window unit, radiator, or no space conditioning:** If a mechanical system is present, it is for temperature only and not ventilation (window unit or radiator). Where no mechanical system is present, windows and/or fans may be in use.
- **Unit ventilator or univent:** Located on an outside wall with a filter, fan, and coil capable of mixing outdoor air with recirculated air. Air is heated/cooled as it passes the coil.
- **Decentralized heating/cooling systems:** Heats or cools recirculated air and, in some but not all systems, outdoor air. Typically, it has a 1" filter rack. Includes heat pumps and fan coil units.
- **Central system (100% recirculation):** Serves multiple rooms and heats and cools recirculated air. Typically has a filter. Examples: AHU and RTU units.
- **Central system (recirculation + ventilation):** Serves multiple rooms and mixes outside air with recirculated air while heating and cooling. Typically has a filter. Examples: AHU and RTU units.

The right strategy for your classrooms?

Mechanical systems can include heating, ventilation, and/or air-conditioning, but they do not always provide all three. Strategies that can be considered will depend on the capabilities of your system.

Fact Sheet Topic	Building System Type				
	Window unit, radiator, or no space conditioning	Unit ventilator or univent	Decentralized heating/cooling systems	Central System serving one or multiple rooms/zones 100% recirculation	Central System serving one or multiple rooms/zones Recirculation + ventilation
Ventilation: Mechanical		✓	Depending on system		✓
Ventilation: Natural (operable windows)	✓		✓	✓	
HVAC Filtration		Depending on pressure drop might need to increase filter rack from 1" to 2"	Depending on pressure drop might need to increase filter rack from 1" to 2"	Depending on pressure drop	Depending on pressure drop
In-Room HEPA Air Cleaners	✓	✓	✓	✓	✓
Upper-room Germicidal UV	✓	✓	✓	✓	✓
In-duct Germicidal UV				✓	✓

THE CENTER
FOR GREEN SCHOOLS

The IAQ Fact Sheet Series was authored in collaboration with Marwa Zazawi, with technical assistance from Sarah Gudeman. The fact sheet series is intended for informational purposes only. See [disclaimer](#) on USGBC's web site.



THE CENTER
FOR GREEN SCHOOLS



Recommendations for schools from ASHRAE's COVID Epidemic Task Force

ASHRAE is an organization known for establishing standards for building design, including strategies that impact air quality.

Ventilate spaces per minimum standards (ASHRAE 62.1)

Clean recirculated air using MERV 13 filtration or equivalent

Use only air cleaners for which evidence of safety is clear

Use air cleaners (HEPA, UVGI) where needed to minimize exposure while considering energy impacts

Proven strategies include "subtractive" technologies like filters, sorbent media, and UVGI, which remove targeted contaminants from the air.

Unproven strategies include "additive" technologies like electronic air cleaners, ionizers, and fumigation that add things to the air to remove particles, inactivate microorganisms, or react with chemical contaminants.

Reaching your air change rate goal:

eACH is equivalent air change rate. It is calculated by adding all ventilation and air cleaning strategies. A reasonable target for air change rate in a classroom is at least 6 eACH.

Example eACH for a typical 1,000 ft² classroom

This eACH calculation may vary based on factors such as the amount of air supplied from an HVAC system. The graph is provided as a general comparison between strategies and as an example of how strategies can be combined for infection control.



Imagine measuring contaminants in a space and then starting a stopwatch. At 6 eACH, at the end of 30 minutes, 95% of the original contaminants would have been removed. At a lower eACH, it would take longer to get the same result. At a higher eACH, it would take less time.



Introduction to eACH Equivalent Air Changes an Hour

Healthy Buildings With Quality Indoor Air

MEASURES

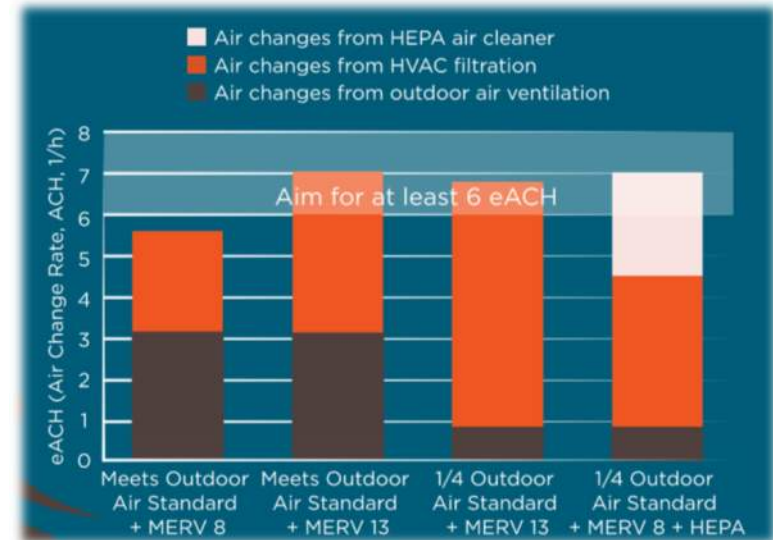
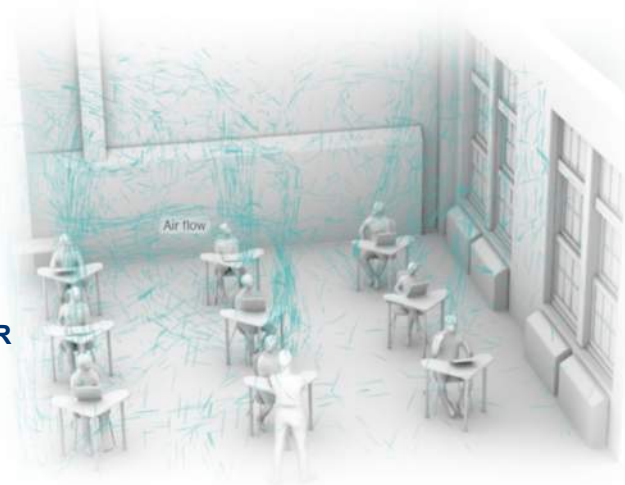
- **Ventilation**
- **UV-C**
- **Bipolar Ionization**
- **Humidification**
- **Filtration/Portable Air Cleaners**
- **Create a Microenvironment**



VENTILATION

MOST COMMONLY RECOMMENDED MEASURE

- EXISTING HVAC INFRASTRUCTURE IS NOT DESIGNED TO BRING IN MORE OUTSIDE AIR
- THIS APPROACH HAS SIGNIFICANT IMPACT ON OPERATIONAL EXPENSE
- ALL VENTILATION AIR ALL HAS TO BE FILTERED, HEATED AND DISTRIBUTED
- EXISTING CRITICAL INFRASTRUCTURE (BOILER, CHILLERS, FANS) ARE NOT DESIGNED TO MOVE OR CONDITION MORE AIR
- NEW EQUIPMENT (DOAS, MUA, AHU'S OR ROOM LEVEL VENTILATION) USUALLY REQUIRE HEAVY COST AND MODIFICATIONS
- OPENING WINDOWS IS NOT A SUSTAINABLE APPROACH
- VENTILATION DOES NOT ADDRESS THE NEED FOR MORE TOTAL AIR CHANGES, PROPER AIR DISTRIBUTION AND BETTER FILTRATION
- CONTROL UPGRADES CAN MODIFY SOME EXISTING SYSTEMS TO ASSIST

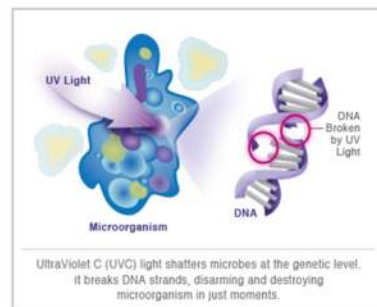




UV-C TECHNOLOGY

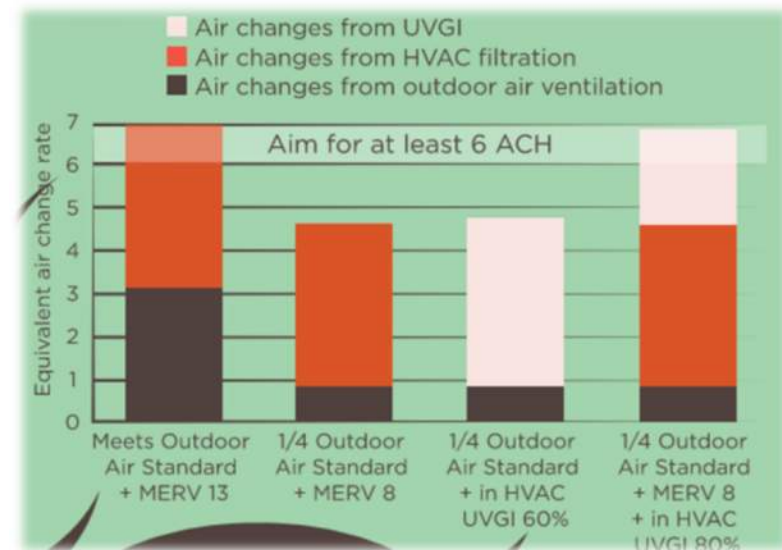
How UV-C Kills Viruses, Bacteria & Other Pathogens

- UV-C attacks at the genetic level
- Breaks DNA Strands and Mutates the Microorganism
- Microorganisms can instantly no longer replicate
- Cellular functions are disrupted to the point where microorganisms will eventually die

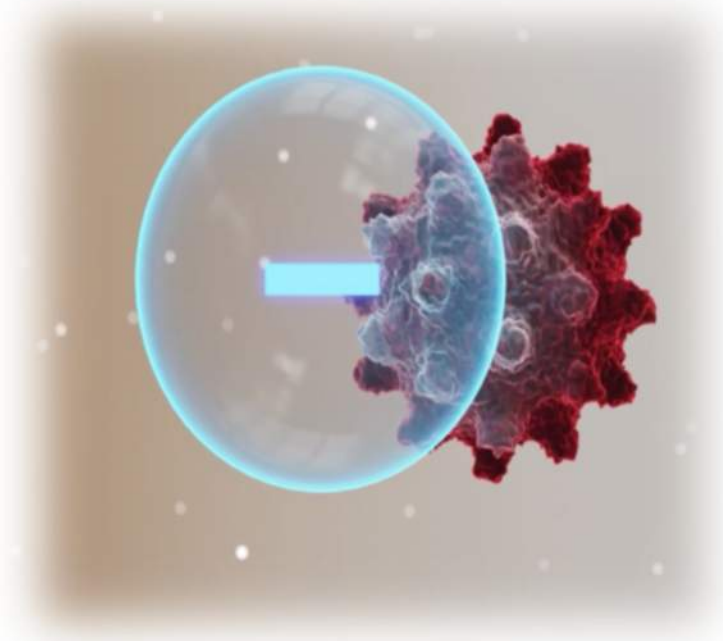


UV-C SUMMARY

- PROVEN TECHNOLOGY FOR REDUCING SPREAD OF HARMFUL BACTERIA AND PATHOGENS
- EFFECTIVE AT SURFACE AND AIR CLEANING
- AVAILABLE IN PORTABLE, FIXED (ROOM, DUCT, AHU)
- EFFICIENT FOR DISINFECTING AREAS DIFFICULT FOR MANUAL CLEANING
- CAN ONLY INACTIVE A VIRUS IF DIRECTLY EXPOSED TO RADIATION WITH PROPER INTENSITY
- RELIES ON EXISTING HVAC INFRASTRUCTURE TO MOVE PARTICULATE



BIPOLAR IONIZATION



Bipolar ionization technology creates and releases ions into the airstream using your existing HVAC system as the delivery method. When these ions disperse throughout a space, they seek out and form bonds with particles in the air through a process called agglomeration. This creates a snowball effect in which particles begin to cluster together. The larger a cluster of particles becomes, the easier it is for your system to filter it out of the air.

As a complement to air filtration and modern HVAC installations.

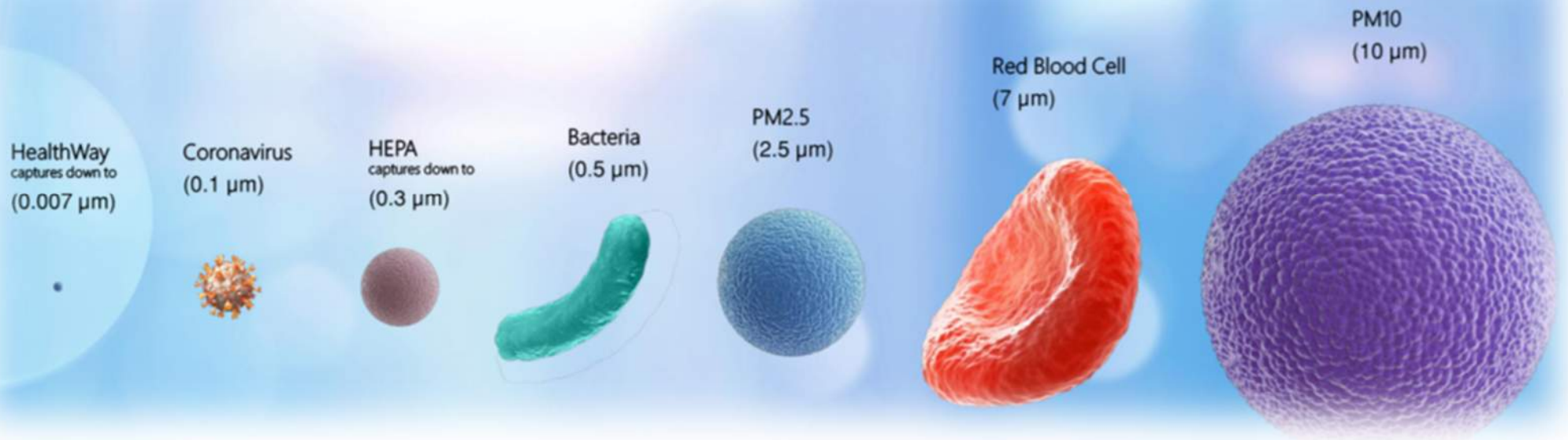


INTERIM NYSDOH GUIDANCE FOR CLASSROOM INSTRUCTION IN

P-12 SCHOOLS DURING THE 2021-2022 ACADEMIC YEAR

Units that feature ionizers, precipitators, or ozone generators **do not** provide additional benefit and can generate **harmful byproducts**

FILTRATION



COMMERCIAL FILTRATION



MERV 6
Dust/Lint
Pollen

MERV 8
Dust/Lint
Pollen
Dust Mite Debris
Pet Dander
Mold Spores

MERV 11
Micro Allergens
Dust/Lint
Pollen
Dust Mite Debris
Pet Dander
Mold Spores
Bacteria
Most Smoke
Virus Carriers

MERV 11
Micro Allergens
Dust/Lint
Pollen
Dust Mite Debris
Pet Dander
Mold Spores
Bacteria
Most Smoke
Virus Carriers
Odor

MERV 12
Micro Allergens
Dust/Lint
Pollen
Dust Mite Debris
Pet Dander
Mold Spores
Bacteria
Most Smoke
Virus Carriers
Smog

MERV 13
Micro Allergens
Dust/Lint
Pollen
Dust Mite Debris
Pet Dander
Mold Spores
Bacteria
Most Smoke
Virus Carriers
Smog
Odor

MERV 13
Micro Allergens
Dust/Lint
Pollen
Dust Mite Debris
Pet Dander
Mold Spores
Bacteria
Most Smoke
Virus Carriers
Smog
Odor



MOST COMMON HVAC FILTER

-MERV 8 FILTERS ARE COMMONLY USED AS A PREFILTER IN OTHER HVAC APPLICATIONS

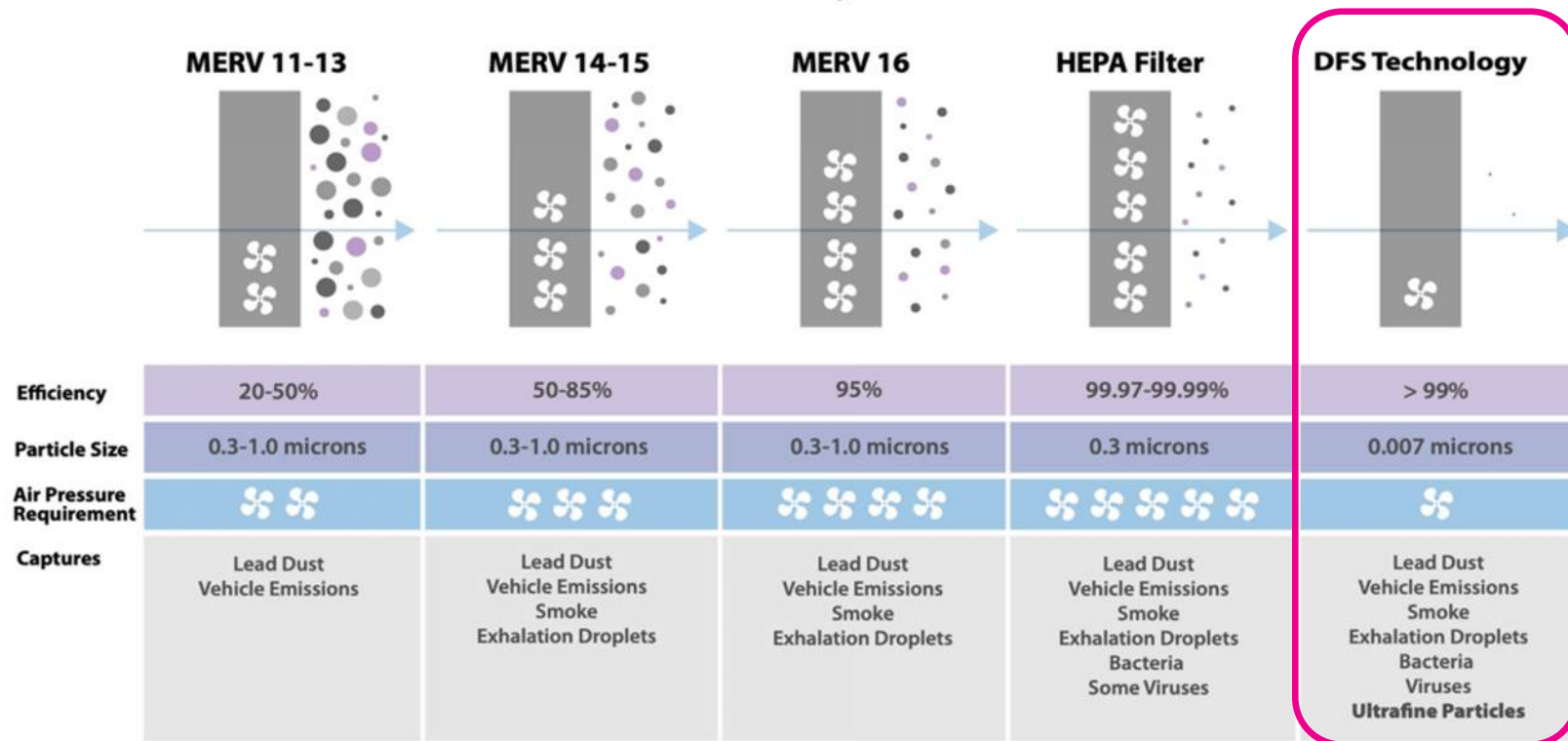
-85% CAPTURE OF PARTICLES FROM 3 TO 10 MICRONS

-EFFECTIVE AT CAPTURING DUST COMMONLY ASSOCIATED WITH ASTHMA

-MOST CURRENT HVAC SYSTEMS ARE NOT DESIGNED TO HANDLE BETTER THAN MERV 8 – INCREASE IN FILTER RESULTS IN DECREASE OF TOTAL AIRFLOW IN MOST CASES (LOWER AIR CHANGES)

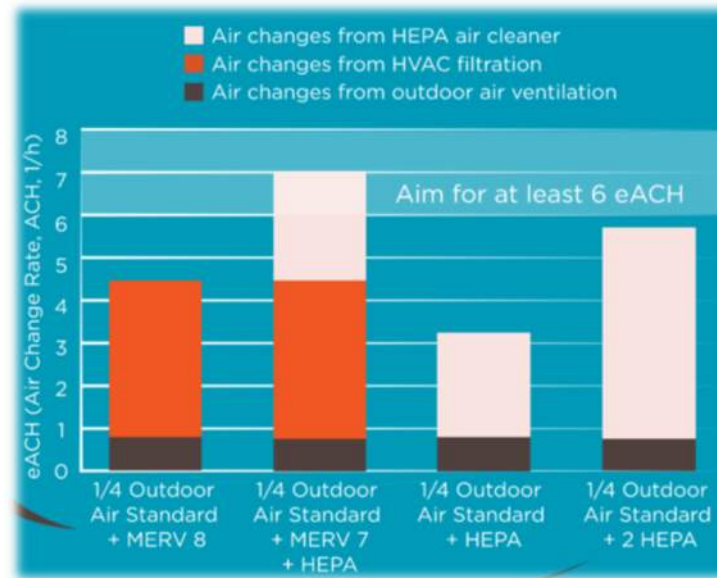
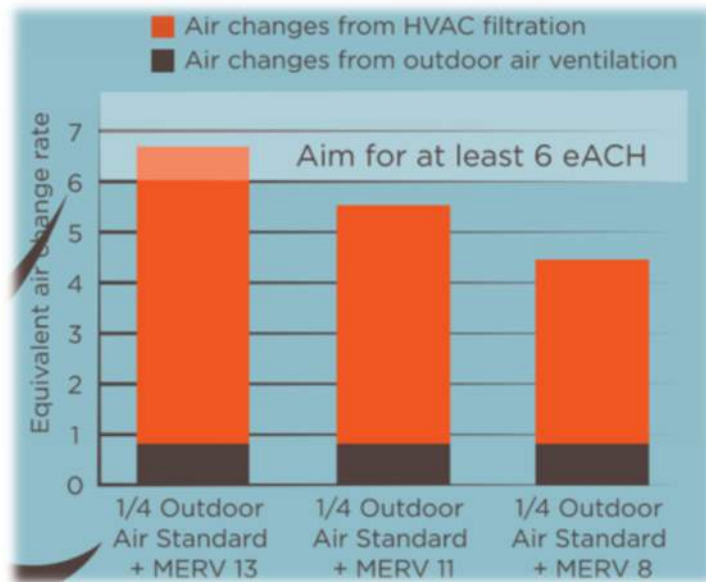
FILTRATION

Filtration Efficiency / Particle Size



FILTRATION

PORTABLE AIR CLEANERS



What is **CADR**?

An in-room air cleaner should be chosen so that its clean air delivery rate (CADR) meets the needs of the room. The CADR is usually given for the highest fan speed, so if the unit runs at lower speeds, the CADR will be lower. Look for a unit with a CADR at least $\frac{2}{3}$ your room's area. For example, a 20' x 30' room (600 ft²) would require CADR of at least 400. Multiple air cleaners can be added to get the total required CADR (e.g., two units with 200 CADR would meet the 400 CADR requirement).

CADR (Clean Air Delivery Rate)

Important to know at desired operating condition

Noise at operating condition

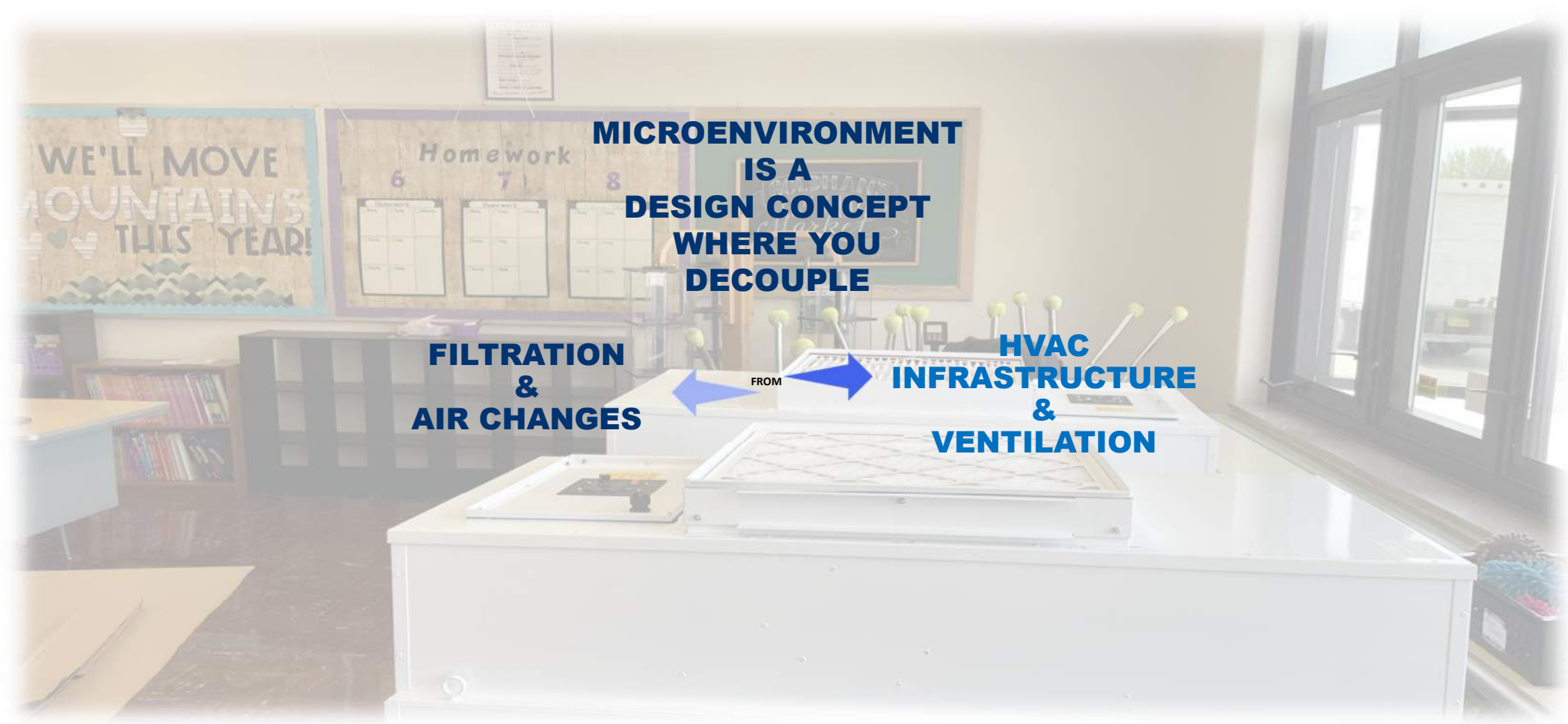
Central location is best for Airflow

**MICROENVIRONMENT
IS A
DESIGN CONCEPT
WHERE YOU
DECOUPLE**

**FILTRATION
&
AIR CHANGES**

FROM

**HVAC
INFRASTRUCTURE
&
VENTILATION**



CREATE A MICROENVIRONMENT

- * Provide Locally a High Amount of Air Changes an Hour *
- * Create Optimal Airflow at Room Level *
- * Implement Best in Class Disinfecting & Filtration *

EACH ROOM



Provides an additional 4-10 Air Changes an Hour at Room



Sub Micron Filtration able to capture Particles and individually tested to meet and exceed the HEPA standard of 99.97% @.3 Micron



Energy Efficient Solution Typical Room requires less than 3 AMPS of Power at 115 Volt / 1 Ph



Certified Testing and Proven Technology
UL867 Tested and CARB. Guaranteed Performance



Disinfect the Air



Quiet Operation and Compliant with NC35



Designed to work in conjunction with any existing HVAC system



Compatible with Drop or Hard Ceilings



Provide optimal Airflow Patterns

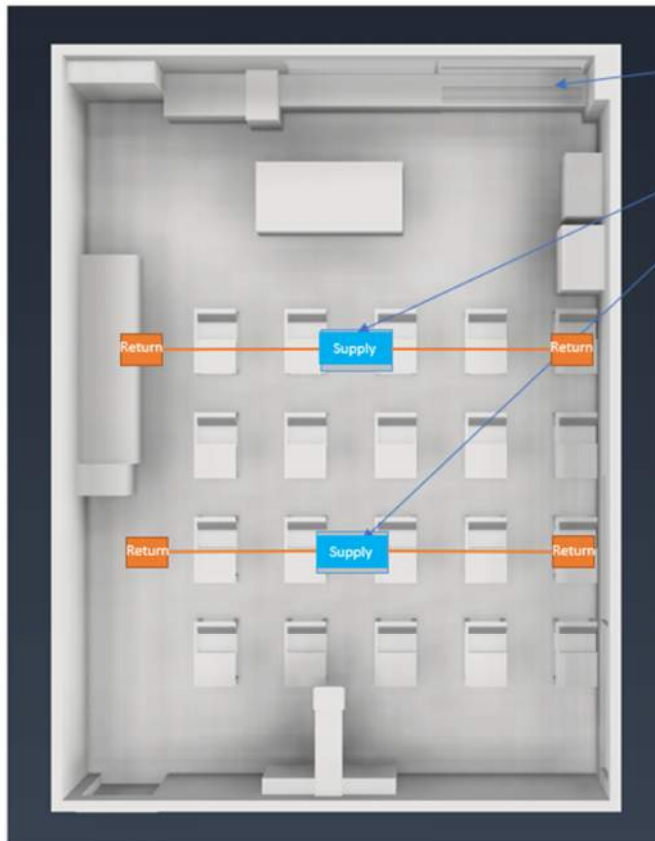


Sustainable for Operation and Maintenance



BEST IN CLASS eACH and CADR

Microenvironment Classroom Layout



Unit Ventilator

Fan Filter Units (FFU)

Fan Filter Units (FFU)



Example of FFU Install

Each Room
Depending on Cubic Feet of Space and Existing HVAC
Quantity of Fan Filter Units can Vary

A fan filter unit is a motorized unit which supplies clean, filtered air to a cleanroom. Air is drawn via the fan, through a pre-filter and then through a HEPA or better filter which filters the sub-micron particles ensuring a clean and processed air supply. Using FFUs to provide localized clean air is a more energy efficient route than using a traditional Air Handling Unit (AHU) and is a more frequently adopted approach in modern cleanroom design.

MICROENVIRONMENT DIFFERENCE



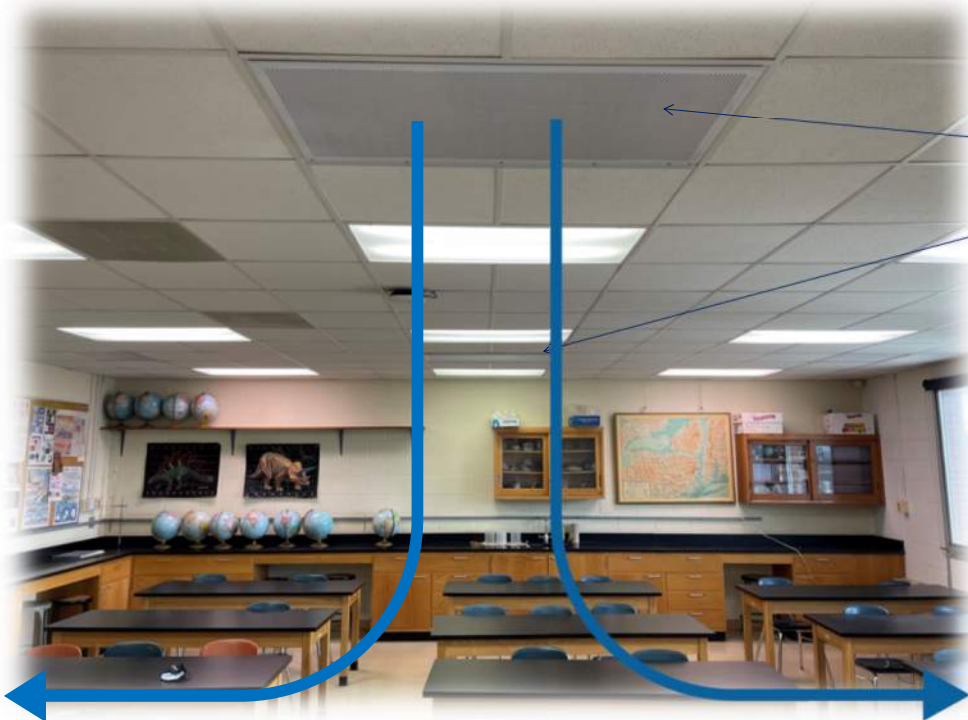
- * Vertical streamlines *
- * High supply and low returns *
- * No streamlines flowing across many desks *
- * Short streamlines *
- * Avoid Horizontal Streamlines
- * No dead spots *
- * Middle Central Location *



Spencerport CSD



-Top Central Supply
-Vertical Streamlines



**Microenvironment
Classroom Layout Installation**



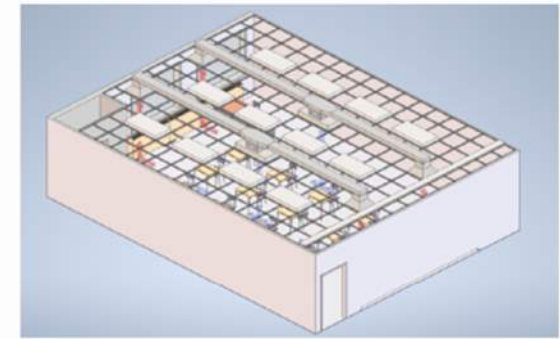
Microenvironment Proof of Concept



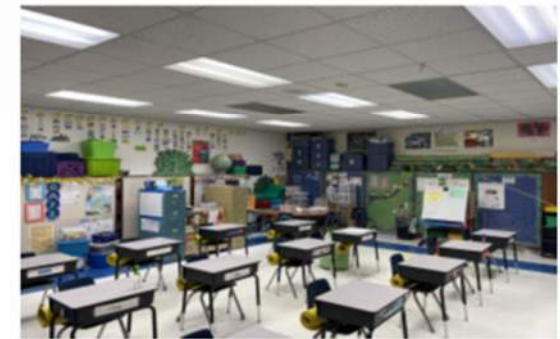
**Amherst CSD – 1,035 Sq. Ft.
Special Education Room MS**



**Southwestern CSD – 660 Sq. Ft.
HS AP History Room**



**Fairport CSD – 780 Sq. Ft.
HS AP History Room**



CFD ANALYSIS LOCATION IS CRITICAL TO AIRFLOW

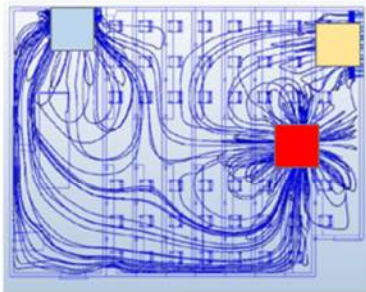


Figure 70: Preliminary Configuration 3 Top View

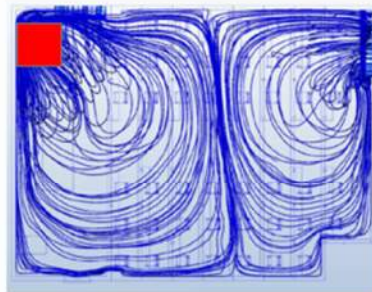


Figure 74: Preliminary Configuration 5 Top View

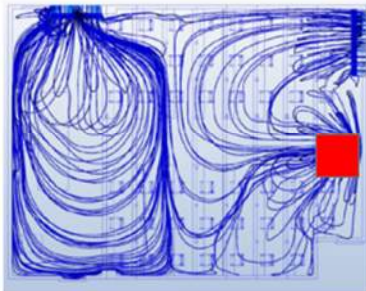


Figure 72: Preliminary Configuration 4 Top View

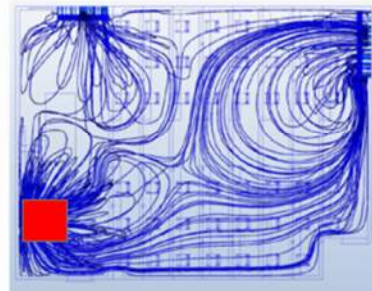


Figure 76: Preliminary Configuration 6 Top View

- Air Purifier
- Unit Ventilator
- Doorway

Optimal Central Location

Promotes Vertical Streamlines

Limits Horizontal Streamlines

No Dead Spots

High Supply

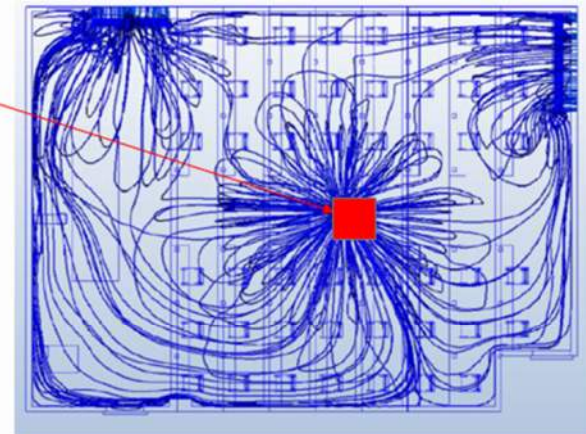


Figure 66: Preliminary Configuration 1 Top View

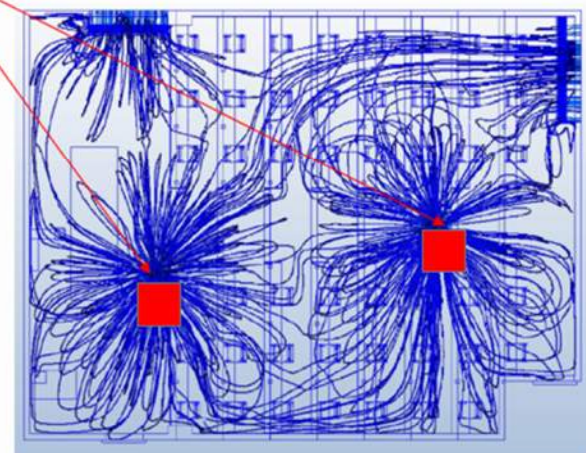
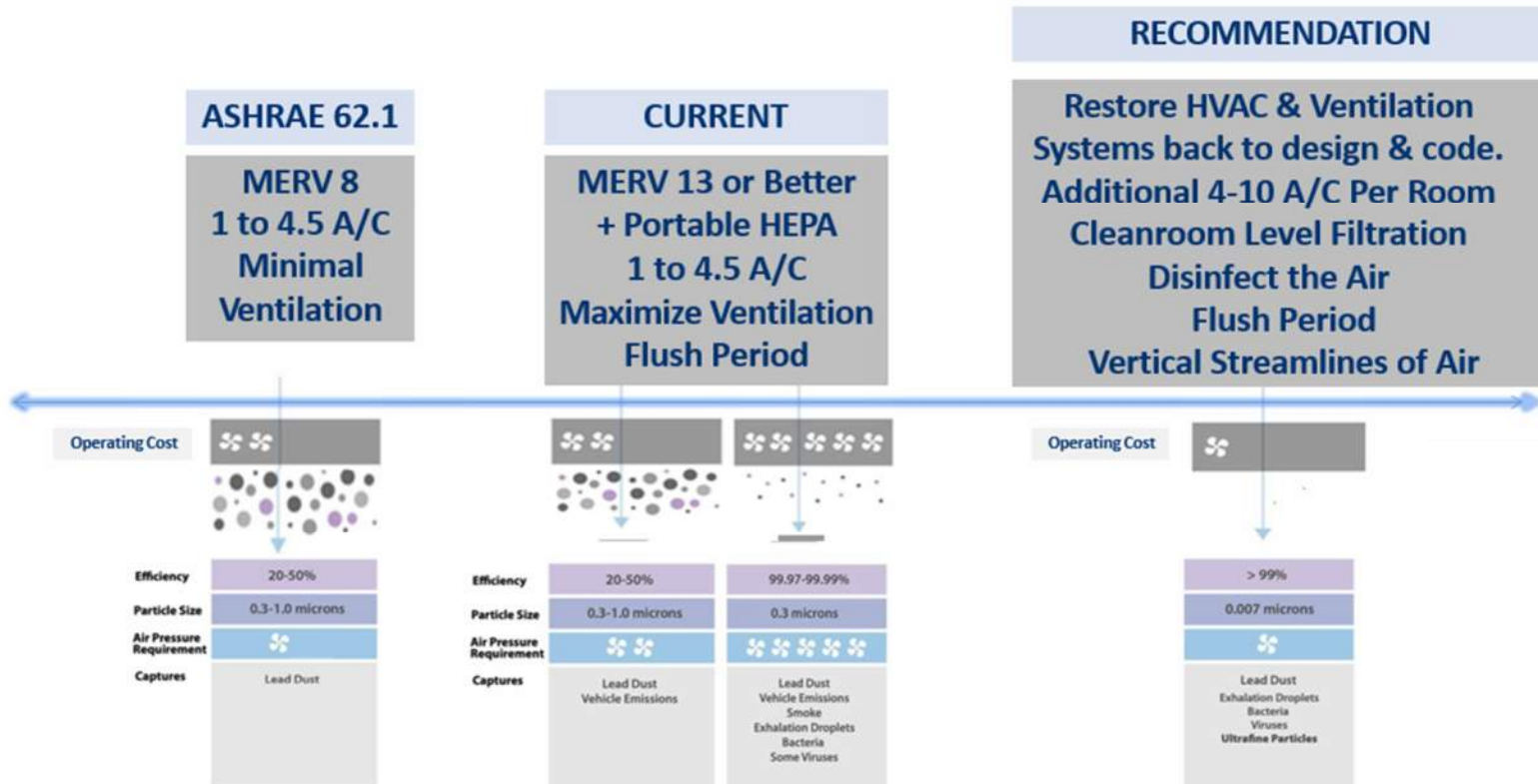


Figure 79: Effect of Two Air Purifiers Top View

Microenvironment Difference



Example eACH for a typical 1,000 ft² classroom



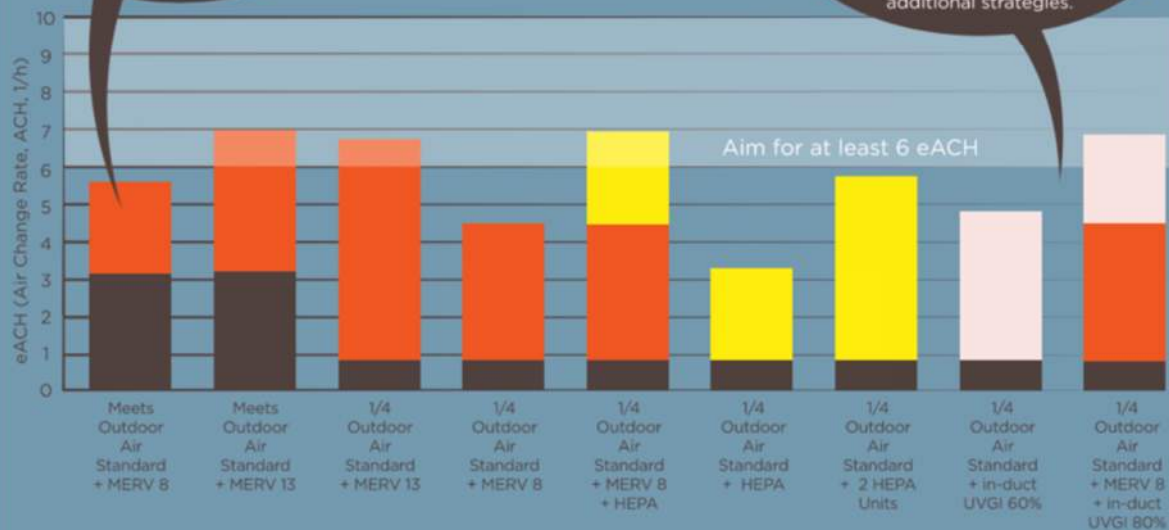
This eACH calculation may vary based on factors such as the amount of air supplied from an HVAC system. The graph is provided as a general comparison between strategies and as an example of how strategies can be combined for infection control.

Imagine measuring contaminants in a space and then starting a stopwatch. At 6 eACH, at the end of 30 minutes, 95% of the original contaminants would have been removed. At a lower eACH, it would take longer to get the same result. At a higher eACH, it would take less time.

Minimum outdoor air is governed by ASHRAE standard 62.1. However, older buildings may not meet this standard, and even newer buildings may not work as intended.

- Air changes from HEPA air cleaner
- Air changes from UVGI
- Air changes from HVAC filtration
- Air changes from outdoor air ventilation

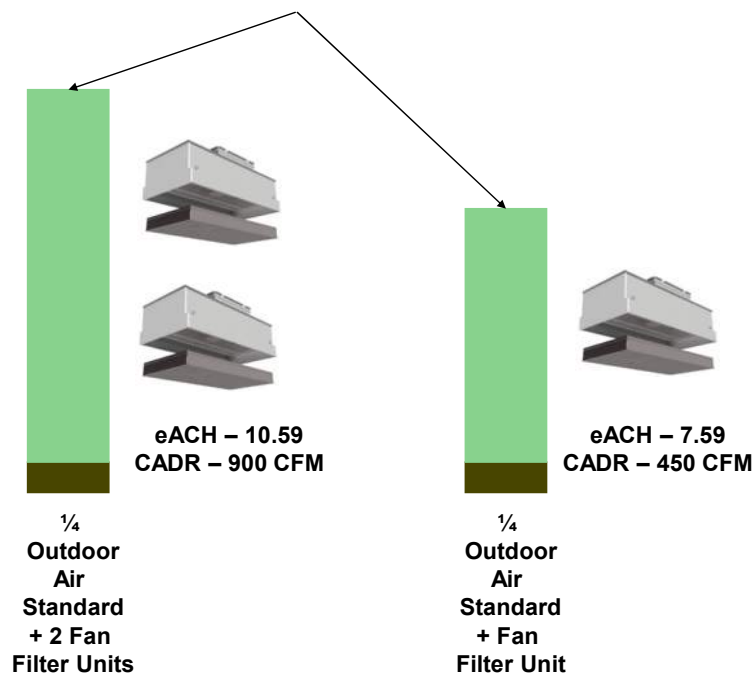
Ventilation and filtration are long-lasting strategies that work to combat viral transmission. Where they're not available, air cleaners with high efficiency particulate air (HEPA) filters or Germicidal UV (GUV, or UVGI) are good additional strategies.



MICROENVIRONMENT

**1,000 ft² Classroom
9' Ceilings**

**Power Requirements
2 AMPS @ 115 Volt
(Power Equivalent to 1 Laptop)**





Challenge Test

Baseline Smoke Test

Filled Room with Smoke 1 to 5 Micron
(2) Tests Run



TEST #1



TEST #2

← Test 1: Unit Ventilator Only
Test 2: Unit Ventilator and FFU's →
(Simulating Concept of 6.5 Air Changes)

Below Pictures are Results after 12
Minutes of Both Tests

**EVERY ROOM SHOWED
THE SAME TEST DATA**

Certified Technician: Chris Sanger



EACH SMOKE TEST SHOWED SIMILAR RESULTS



Smoke Challenge Test

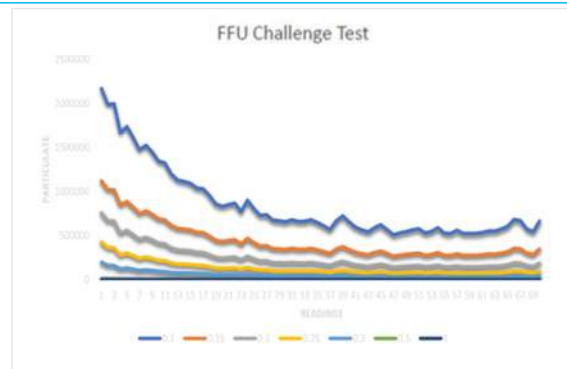
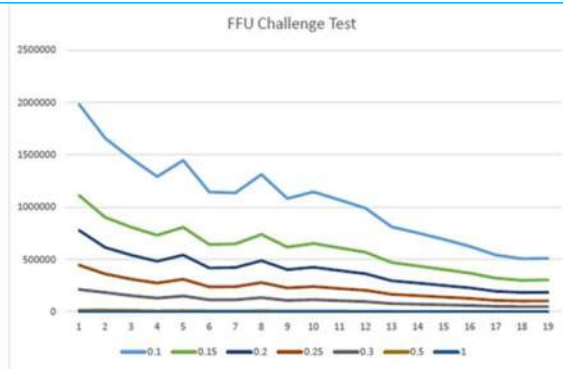
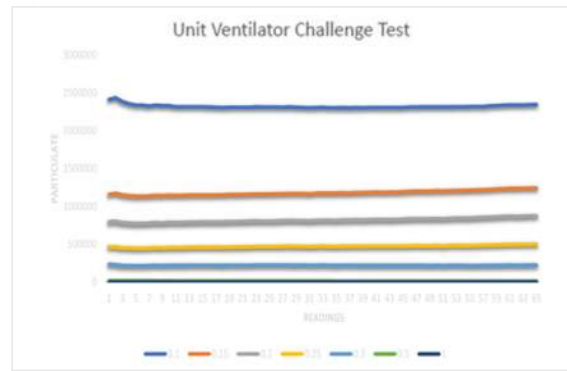
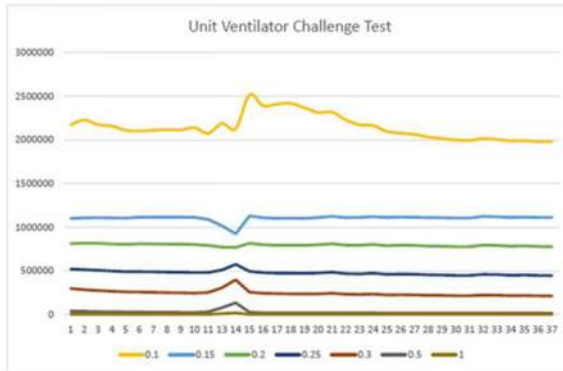
Certified Technician: Chris Sanger



Case Study Data

School A

School B



Filtration Effectiveness Test

Testing Procedure

Cleanroom testing agency to take baseline particle counts in classroom.

Introduce aerosol challenge into room to simulate an active classroom. Measure and record how fast and effective the existing infrastructure can remove particulate. Repeat with Microenvironment approach and measure and record.

Test 1: Unit Ventilator Only

Test 2: Unit Ventilator and FFU's
(Simulating Concept of 6.5 Air Changes)

**5 Classrooms
EVERY ROOM SHOWED
SIMILAR TEST DATA**

Certified Technician: Chris Sanger



U.S. School System Spending Per Pupil by Region

Nationwide average school spending per pupil: \$12,612

MIDWEST

Illinois	\$15,741
North Dakota	\$13,758
Ohio	\$13,027
Minnesota	\$12,975
Nebraska	\$12,491
Michigan	\$12,345
Wisconsin	\$12,285
Iowa	\$11,732
Kansas	\$11,653
Missouri	\$10,810
Indiana	\$10,262
South Dakota	\$10,073

Average per pupil current spending: **\$12,773**

NORTHEAST

New York	\$24,040
Connecticut	\$20,635
New Jersey	\$20,021
Vermont	\$19,340
Massachusetts	\$17,058
New Hampshire	\$16,893
Pennsylvania	\$16,395
Rhode Island	\$16,121
Maine	\$14,145

Average per pupil current spending: **\$19,953**

WEST

Alaska	\$17,726
Wyoming	\$16,224
Hawaii	\$15,242
Washington	\$12,995
California	\$12,498
Oregon	\$11,920
Montana	\$11,680
Colorado	\$10,202
New Mexico	\$9,582
Nevada	\$9,417
Arizona	\$8,239
Idaho	\$7,771
Utah	\$7,628

Average per pupil current spending: **\$11,582**

SOUTH

District of Columbia	\$22,759
Delaware	\$15,639
Maryland	\$14,762
Virginia	\$12,216
Louisiana	\$11,452
West Virginia	\$11,334
Kentucky	\$11,110
South Carolina	\$10,856
Georgia	\$10,810
Arkansas	\$10,139
Alabama	\$9,696
Texas	\$9,606
Tennessee	\$9,544
North Carolina	\$9,377
Florida	\$9,346
Mississippi	\$8,935
Oklahoma	\$8,239

Average per pupil current spending: **\$10,285**

AVERAGE COST PER CLASSROOM TO IMPLEMENT A MICROENVIRONMENT



TYPICAL 600 TO 1,000 SQ.FT CLASSROOM CAN IMPLEMENT A MICROENVIRONMENT FOR LESS THAN
1/2 THE COST OF 1 STUDENT

Per Classroom Facts:

- Typical Install Completed from Start to Finish in 1/2 Day
- Estimated Room Cost including Equipment, Controls, Electrical, Ductwork, and Installation

Commercial Buildings



Absenteeism

-For Every 1,000 Workers poor IAQ
Results in 600 Sick Days per Year.



Lack of Proper Air Filtration is the
#1 Cause of Poor IAQ.

Cost of Productivity

3/30/300 rule

Typical spend for an organization

The greatest financial savings may not be in energy but in productivity.

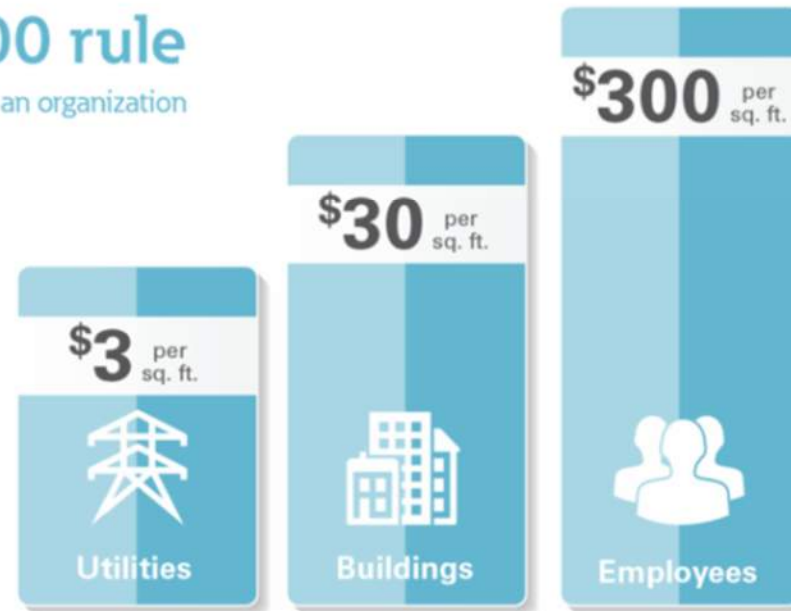
A 2% energy efficiency improvement results in savings of \$.06 per SF.

A 2% savings on real estate results in savings of \$.60 per SF.

As beneficial as energy savings can be, any green investment that increases employee wellness and productivity can have exponentially greater value.

A 2% improvement in productivity through increased employee performance results in savings of \$6 per square foot.

Source: Jones Lang LaSalle, IP, Inc.
www.us.jll.com



****WHAT IF EFFICIENCY IMPROVEMENT COULD BE BOTH UTILITY AND EMPLOYEES****



QUESTIONS?

Andrew Weidert

Vice President - Business Development

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 Total Facilities Optimization



Total Facilities Optimization