Understanding ASHRAE's Recommendations on Filtration and Disinfection for COVID

ASHRAE ETF: Filtration and Disinfection Group

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ASHRAE Epidemic Task Force (ETF)

- Formed in March 2020 in response to COVID19 crisis
- Led by former ASHRAE President Bill Bahnfleth
- Serves as a clearinghouse to review all technical questions and requests for technical guidance submitted to ASHRAE
- Coordinates activities of ASHRAE's internal resources
- Partners with and monitors the activities of external organizations, including the more than 60 members of the ASHRAE Associate Society Alliance (AASA) of organizations related to the HVAC&R industry around the world
- Reviews, organizes, consolidates and publishes clear and concise summaries with citations of the most relevant information available to the built environment
- https://www.ashrae.org/technical-resources/resources

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Home › Technical Resources ›

CORONAVIRUS (COVID-19) RESPONSE RESOURCES FROM ASHRAE AND OTHERS

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Questions?
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ASHRAE Epidemic Task Force Full Roster

Please support ASHRAE's continuing work to combat the transmission of COVID-19

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Guide to the COVID-19 Pages

Follow the links on the Infographic

LEARN MORE

Questions Answered

Frequently Asked Questions and Glossary of Terms

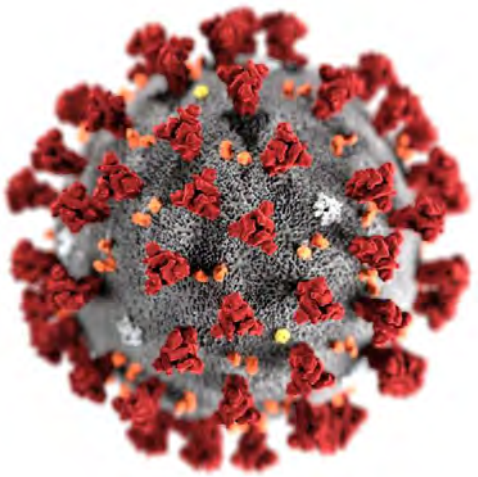
FAQ / GLOSSARY

This page is updated as new information becomes available

Main | Reopening | Buildings | Filtration/Disinfection | Transportation | Resources

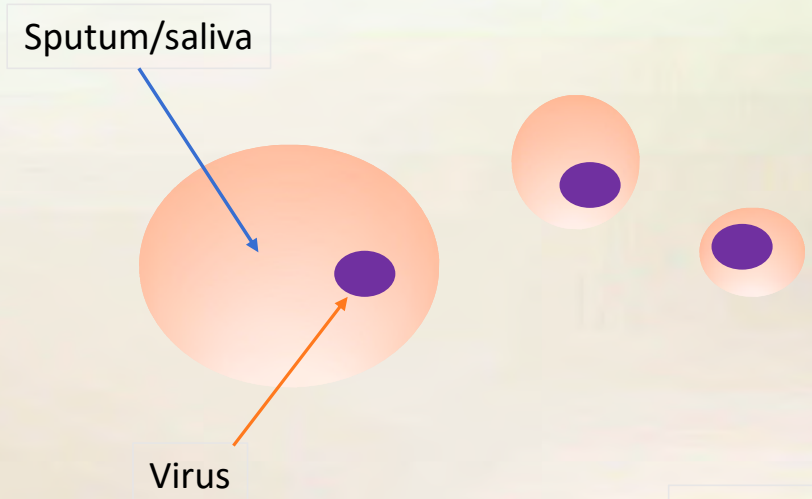
ASHRAE Epidemic Task Force (ETF)

- Many teams/working groups (140+ people)
  - Communications
  - Transportation
  - Residential
  - Literature
  - Building readiness
  - **Filtration & Disinfection**
  - Laboratories
  - Industrial
  - Applications
  - Healthcare
  - Developing economies
  - Schools
  - Commercial/retail
  - Research



Filtration Basics

- Particles come from many sources.
- For COVID – sneezes, coughs, breathing, singing, etc.
- Virus - ~70-120 nm (0.07-0.12 μm)
- Humans add sputum/saliva to make huge droplets and smaller particles.
- These dry down to smaller ones that can stay in the air for hours.
- Drying is usually rapid, seconds to minutes. Rate varies by RH/T/content of particle.
- Recent studies show the virus and its RNA is particles in air.

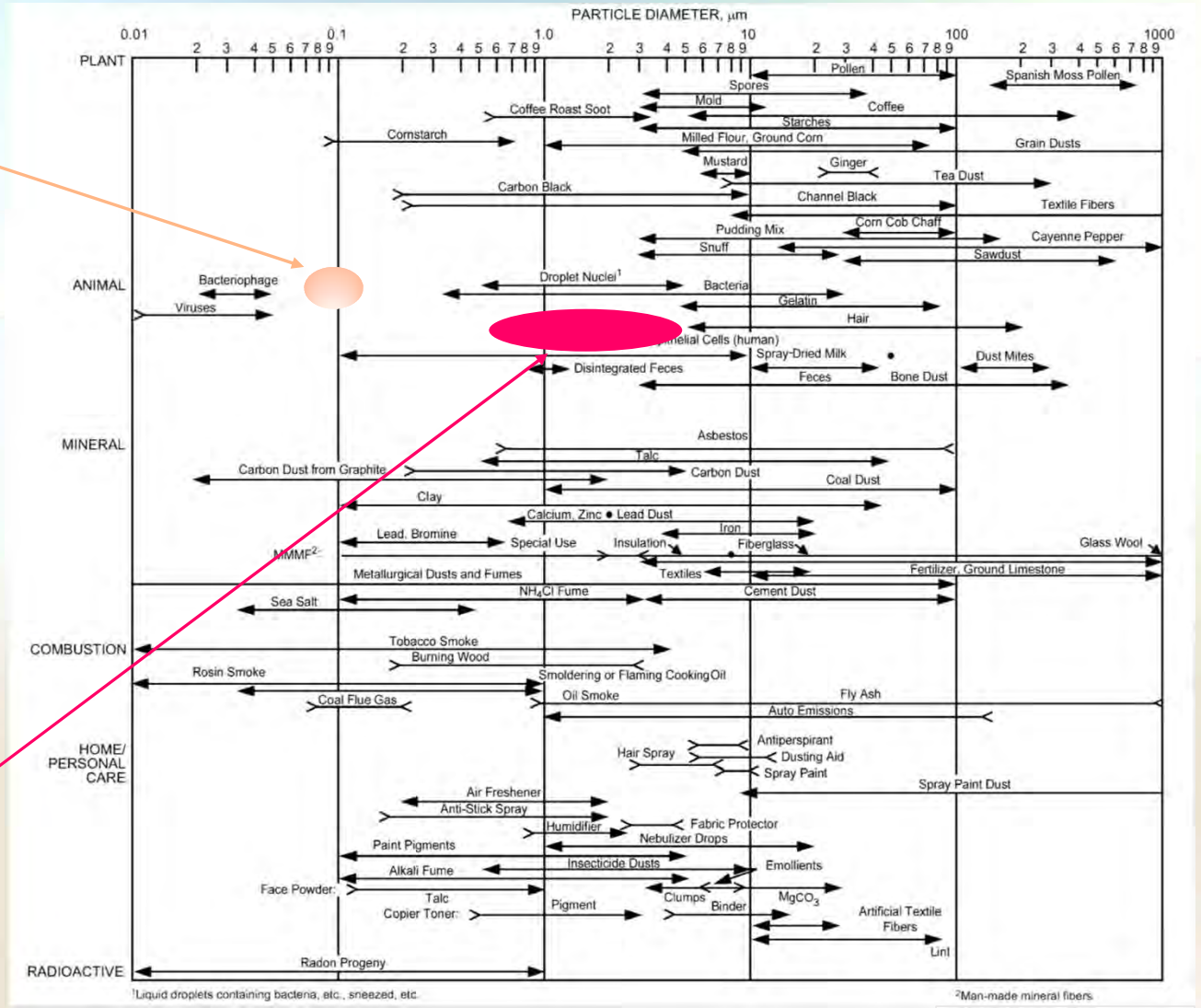


From tgp.com.ph

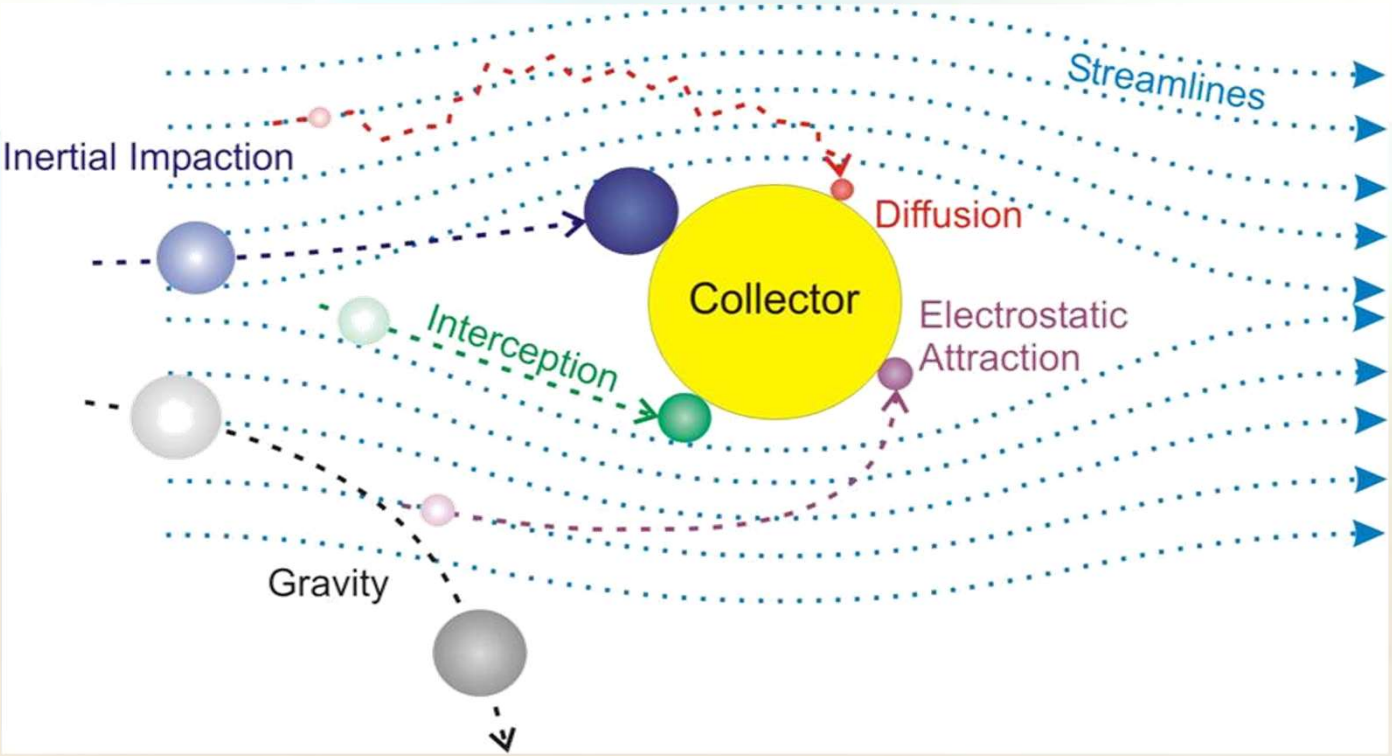
COVID19 virus

Particles are everywhere, but do you want to breathe them?

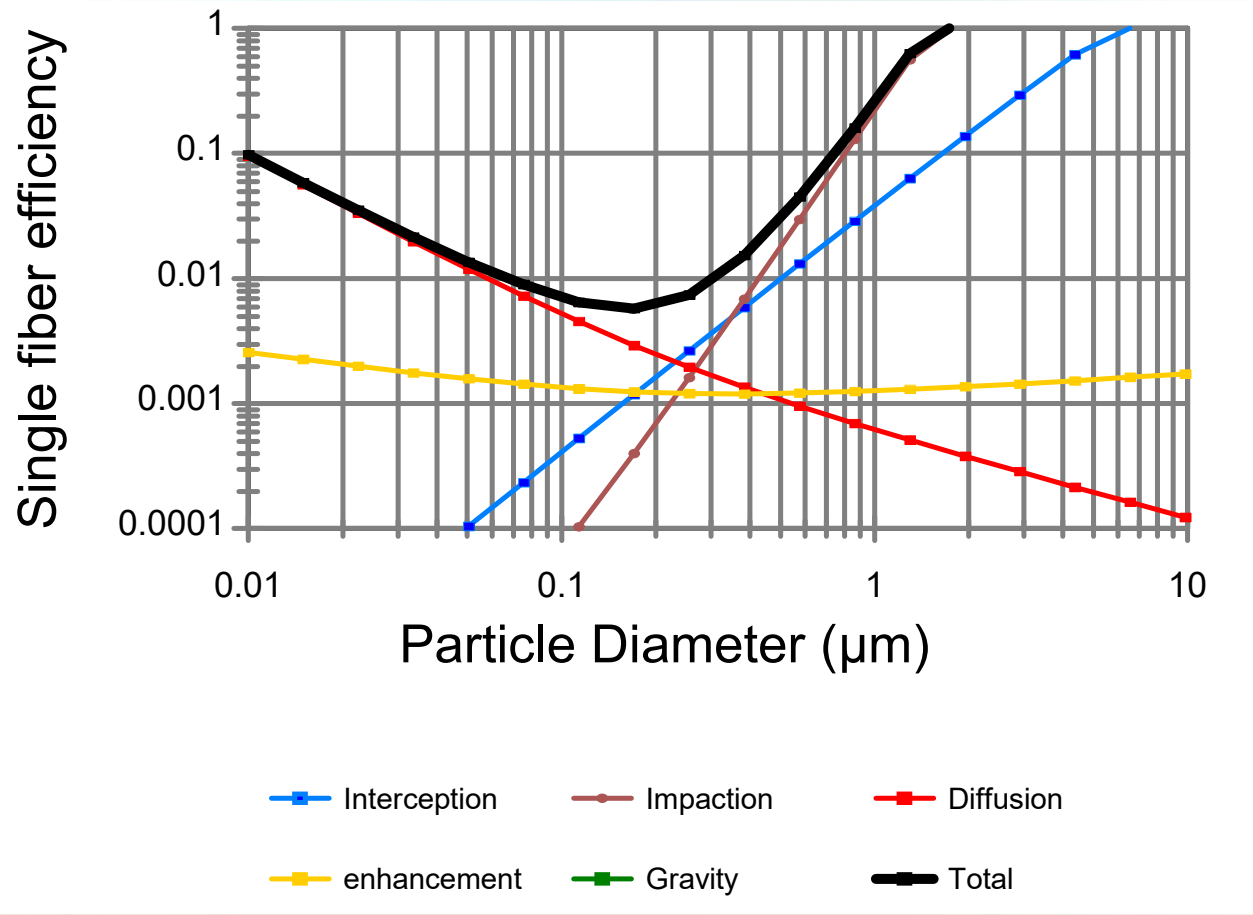
COVID19 - actually in the air



Filtration Mechanisms



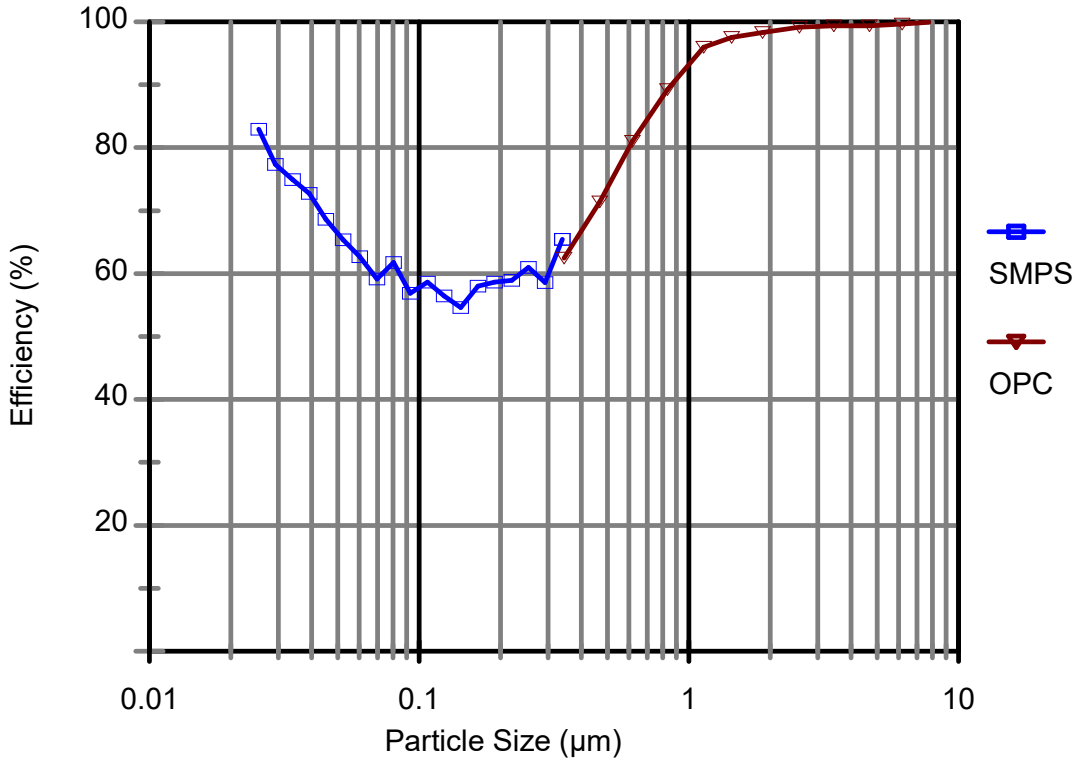
Particle Penetration by Particle Size



The "most penetrating particle size" is typically in the 0.1-0.3 µm range.

Computations based on Hinds, Aerosol Technology, 1982.

Efficiency Curve for MERV 14 Filter



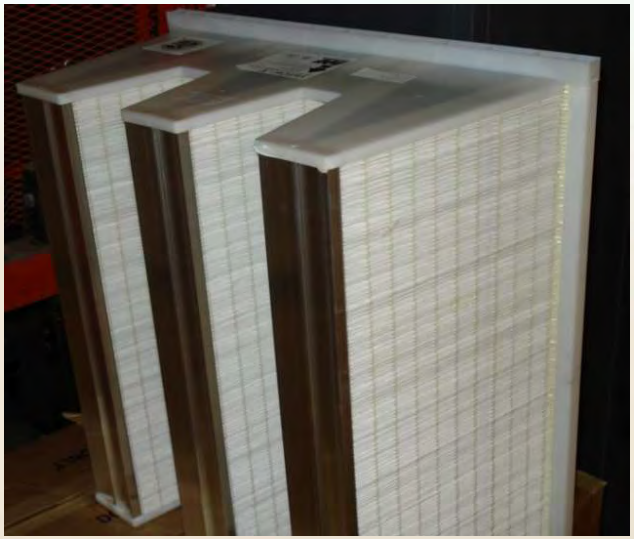
Owen 2013

Removal vs Dilution

- Much focus in our discussion of filtration has been simply the removal of the virus from the air.
- Another way to look at the influence of the HVAC air when filtered/cleaned is that it will serve to dilute the virus in the air when the clean air enters the space.
- Early on much of the advice was on increasing outdoor air. This was aimed at flushing the virus from the space/building as virus-free outdoor air entered pushing virus-laden air out.
- Clearly not all areas have clean and good T/RH air to dilute with.
- Thus, cleaned and returned by the HVAC air is recommended for dilution.

Note about Content

Slides with the white background have content taken directly from or based largely on material from the Filtration and Disinfection team on the ASHRAE COVID website. Because I made changes for this talk, please go to the ASHRAE site for exact content or if you wish to quote the ASHRAE COVID team's position.



ASHRAE EPIDEMIC TASK FORCE

FILTRATION & DISINFECTION | Updated 8-7-2020

BACKGROUND/CONTEXT

- Modes of Transmission
- ASHRAE Statements on Airborne Transmission
- Scientific Data & Literature

FACILITIES/MAINTENANCE

- Personal Protective Equipment (PPE) Basics
- HVAC System Maintenance and Filter Replacement
- Special Precautions

AIR FILTRATION

- Mechanical Air Filters
- High-Efficiency Particulate Air (HEPA) Filters
- Electronic Air Filters
- Gas-Phase Air Cleaners
- In-Room or Portable Air Cleaners

AIR DISINFECTION

- Ultraviolet Energy (UV-C)
- Photocatalytic Oxidation (PCO) and Dry Hydrogen Peroxide (DHP)
- Bipolar Ionization/Corona Discharge/Needlepoint Ionization and Other Ion or Reactive Oxygen Air Cleaners
- Ozone
- In-Room or Portable Air Cleaners

SURFACE DISINFECTION

- Spray/Wipe Chemical Disinfectants
- Ultraviolet Energy (UV-C)
- Vaporized Hydrogen Peroxide
- Ozone
- Pulsed Xenon Lamps
- 405 nm Visible Light
- Far Ultraviolet

HVAC System Maintenance and Filter Replacement during the COVID-19 Pandemic

For HVAC systems suspected to be contaminated with SARS-CoV-2, it is not necessary to suspend HVAC system maintenance, including filter changes, but **additional safety precautions are warranted**.

The risks associated with handling filters contaminated with coronaviruses in ventilation systems under field-use conditions have not been evaluated.

Workers performing maintenance and/or replacing filters on any ventilation system with the potential for viral contamination should wear appropriate personal protective equipment (PPE):

- A properly-fitted respirator (N95 or higher)
- Eye protection (safety glasses, goggles or face shield)
- Disposable gloves

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HVAC System Maintenance and Filter Replacement during the COVID-19 Pandemic

Consider letting the filter load up further than usual to reduce frequency of filter changes.

- Don't let pressure drop increase enough to disrupt room pressure differentials.
- Confirm filters are sealed in their frames.

When feasible, filters can be disinfected with a 10% bleach solution or another appropriate disinfectant, approved for use against SARS-CoV-2, before removal. Filters (disinfected or not) can be bagged and disposed of in regular trash.

When maintenance tasks are completed, maintenance personnel should immediately wash their hands with soap and water or use an alcohol-based hand sanitizer.

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Modes of Transmission

SARS-CoV-2, the virus that causes COVID-19, is thought to spread mainly from person-to-person through respiratory droplets and aerosols.

Infectious respiratory droplets are produced when an infected person coughs or sneezes or sings or breathes.

- Droplets can land in the mouths or noses of nearby people.
- Droplets can land on surfaces and be spread through contact with contaminated surfaces.
- When in close contact with an infected person, droplets can be inhaled into the lungs.

Airborne transmission in some circumstances seems probable. See ASHRAE Statements on Airborne Transmission

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Airborne Transmission

ASHRAE Statement on airborne transmission of SARS-CoV-2:

Transmission of SARS-CoV-2 through the air is sufficiently likely that airborne exposure to the virus should be controlled. Changes to building operations, including the operation of HVAC systems can reduce airborne exposures.

ASHRAE Statement on operation of heating, ventilating and air-conditioning systems to reduce SARS-CoV-2 transmission:

Ventilation and filtration provided by heating, ventilating and air-conditioning systems can reduce the airborne concentration of SARS-CoV-2 and thus the risk of transmission through the air. Unconditioned spaces can cause thermal stress to people that may be directly life threatening and that may also lower resistance to infection. In general, disabling of heating, ventilating and air-conditioning systems is not a recommended measure to reduce the transmission of the virus.

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Mechanical Air Filters

Filters consist of media with porous structures of fibers or stretched membrane material to remove particles from airstreams.

The fraction of particles removed from air passing through a filter is termed "filter efficiency" and is provided by the Minimum Efficiency Reporting Value (MERV) from ASHRAE 52.2 under standard conditions.

- MERV ranges from 1 to 16; higher MERV = higher efficiency
- MERV ≥13 (or ISO ePM_1) are efficient at capturing airborne viruses
- MERV 14 (or ISO 16890 equivalent) filters are preferred
- High efficiency particulate air (HEPA) filters are more efficient than MERV 16 filters.

Some filters have a static electrical charge applied to the media to increase particle removal. Since the efficiency of these filters often drops off over months of initial use, MERV-A, if available, will reflect the actual minimum efficiency better than a standard MERV value.

Increased filter efficiency generally results in increased pressure drop. Ensure HVAC systems can handle filter upgrades without negative impacts to pressure differentials and/or air flow rates prior to changing filters.

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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

ASHRAE Standard 52.2-2017 Minimum Efficiency Reporting Value (MERV)

ASHRAE MERV vs. ISO 16890 Ratings

Approximate Equivalent Ratings for Filters Tested Under ASHRAE Standard 52.2 (MERV) and ISO 16890		
ASHRAE MERV* (Standard 52.2)	**ISO 16890 Rating**	**PM52.2[+] (Standard 52.2)**
1-6	ISO Course	0-25
7-8	ISO Course >95%	25-40
9-10	ePM_{10}	40-50
11-12	$ePM_{2.5}$	55-75
13-16	ePM_{1}	75-100

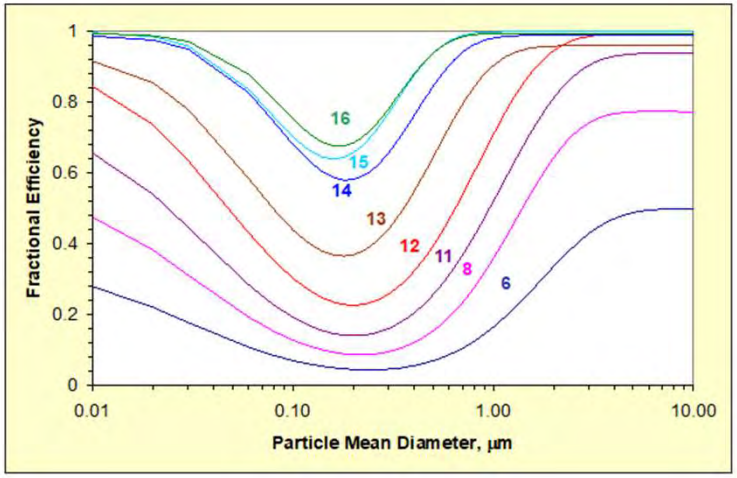
[+]Not on the ETF website

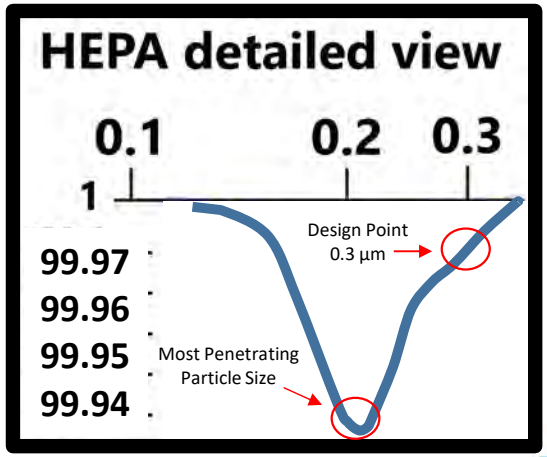
*MERV-A will give closer results. Charged media filters usually show a drop-off in efficiency with use. ISO 16890 captures this with an IPA condition step. ASHRAE 52.2 can capture this drop if the test is done with the optional Appendix J which gives the MERV-A. Thus the MERV and the ePM ratings do not reflect the same testing. For charged media, the MERV will likely make the filter appear more efficient than the ePM rating.

High Efficiency Particulate Air (HEPA) Filters

By definition, true HEPA filters are at least 99.97% efficient at filtering 0.3 µm mass median diameter (MMD) particles in standard tests.

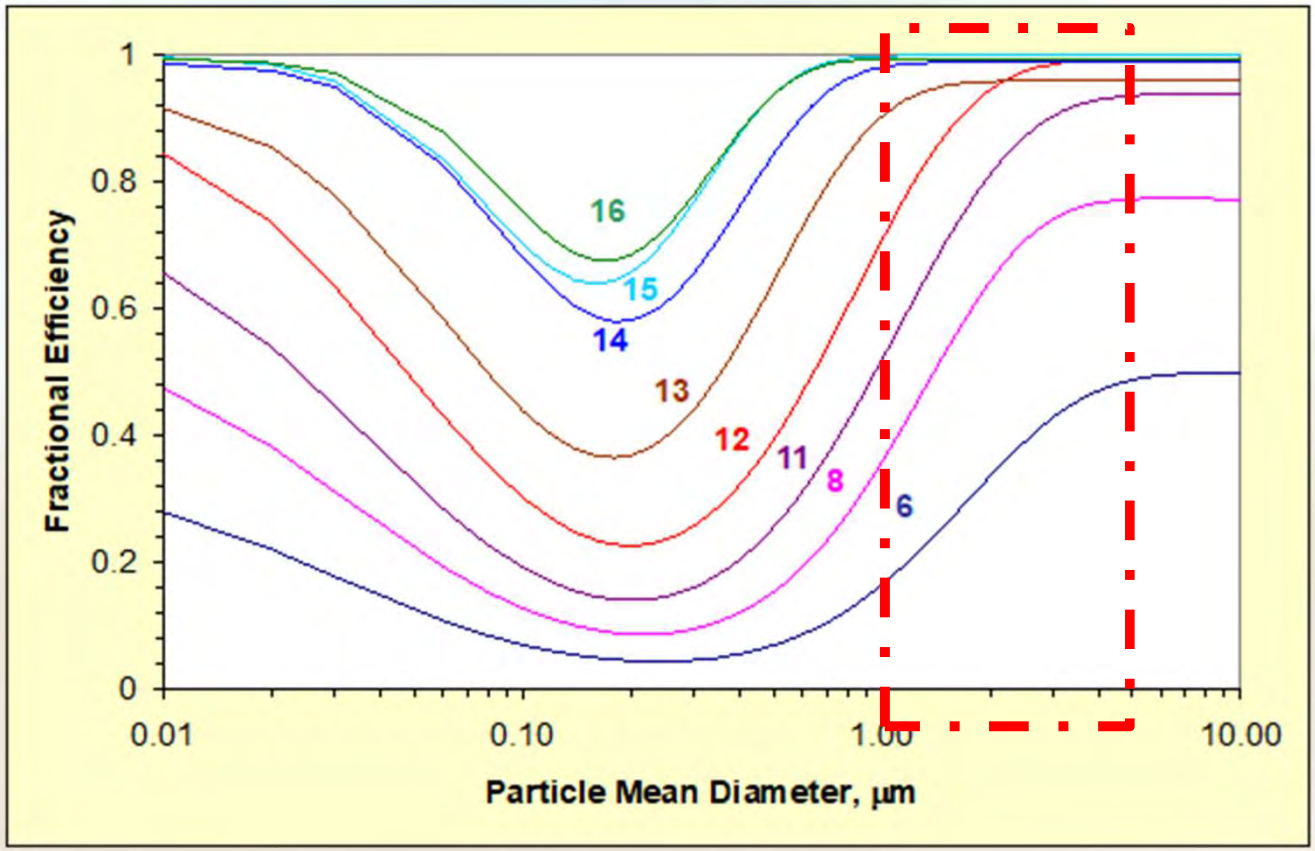
Most penetrating particle size may be smaller than 0.3 µm, so filtration efficiency of most penetrating particles can be slightly lower.





Note: Numbers in graph represent MERV values.

HEPA vs MERV


Fractional Efficiency
1
0.8
0.6
0.4
0.2
0
0.01
0.10
1.00
10.00
Particle Mean Diameter, µm
16
15
14
13
12
11
8
6

High Efficiency Particulate Air (HEPA) Filters

HEPA filter efficiency is better than MERV 16.

HEPA filters may not be an appropriate option for some HVAC systems due to high pressure drops and the likelihood that systems will need new filter racks to allow sufficient sealing to prevent filter bypass.

To function properly, HEPA filters must be sealed properly in filter racks.

Filters are often delicate and require careful handling to prevent damage and preserve performance.

HEPA filters can be located in HVAC systems or in:

- In-Room or Portable HEPA Air Cleaners
- Pre-Assembled Systems
- Ad Hoc Assemblies

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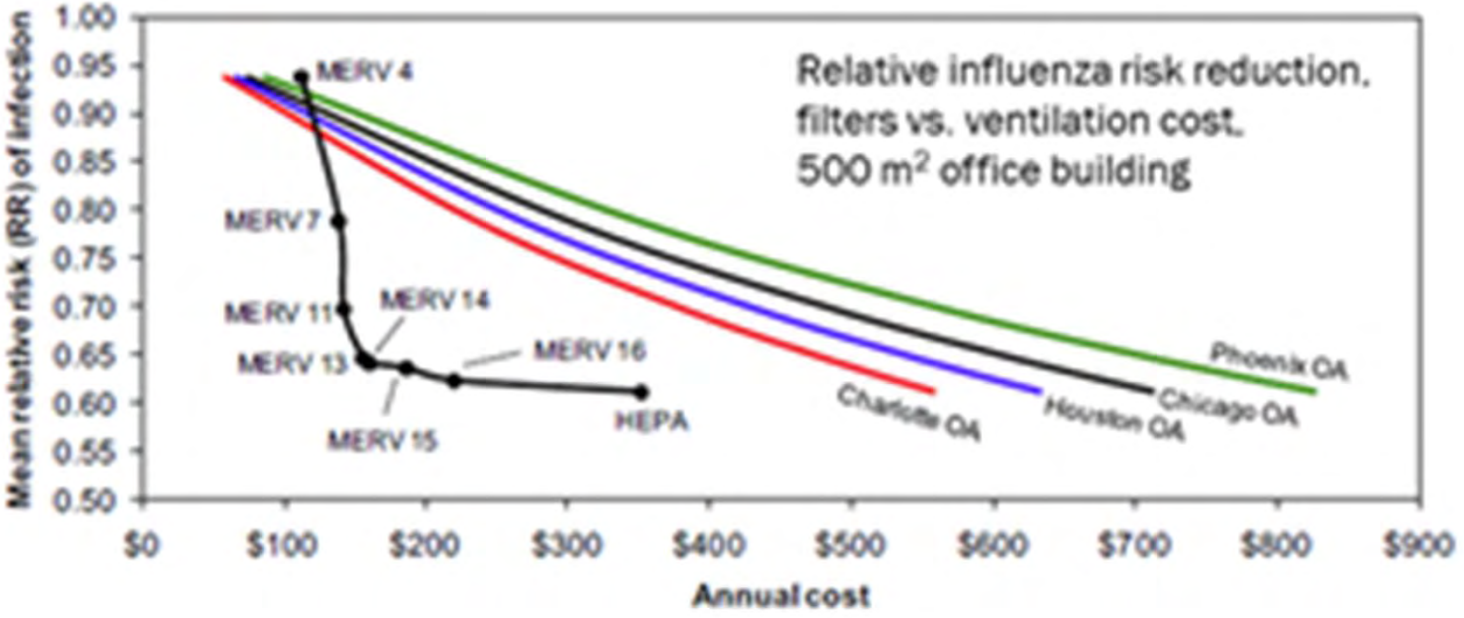
Enhanced filtration has energy and cost benefits over more ventilation



Azimi and Stephens, Building and Environment 70 (2013) 150-160

Electronic Air Filters

Include a wide variety of electrically-connected air-cleaning devices designed to remove particles from airstreams.

Removal typically occurs by electrically charging particles using corona wires
or by generating ions (e.g., pin ionizers) and:

- Collecting particles on oppositely charged plates (precipitators, ESP),or
- Charged particles' enhanced removal by a mechanical air filter, or
- Charged particles' deposition on room surfaces

Overall effectiveness of reducing particle concentrations depends on:

- Removal efficiency
- Airflow rate through the filter
- Size and number of particles
- Location of the filter in the HVAC system
- Maintenance and cleanliness of electronic filter components

It is critical to wipe the wires in electrostatic precipitators as silicone buildup reduces efficiency.

For more information, see the ASHRAE Position Document on Filtration and Air Cleaning.

Ultraviolet Energy (UV-C)

Ultraviolet energy inactivates viral, bacterial and fungal organisms so they are unable to replicate and potentially cause disease.

The entire UV spectrum is capable of inactivating microorganisms, but UV-C energy (wavelengths of 100 – 280 nm) provides the most germicidal effect with 265 nm being the optimum wavelength.

The majority of modern UVGI (ultraviolet germicidal irradiance) lamps create UV-C energy with an electrical discharge through a low-pressure gas (including mercury vapor) enclosed in a quartz tube, similar to fluorescent lamps.

Roughly 95% of the energy produced by these lamps is radiated at a near-optimal wavelength of 253.7 nm.

Types of disinfection systems using UV-C energy:

- In-duct air disinfection
- Upper-air disinfection
- In-duct surface disinfection
- Portable room decontamination

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Ultraviolet Energy (UV-C)

Requires special PPE to prevent damage to eyes and/or skin from overexposure.

The Illuminating Engineering Society (IES) Photobiology Committee published a FAQs on Germicidal Ultraviolet (GUV) specific to the COVID-19 pandemic.

For more information, see the ASHRAE Position Document on Filtration and Air Cleaning.

UV-C In-Duct Air Disinfection

Banks of UV-Lamps installed inside HVAC systems or associated ductwork

Requires high UV doses to inactivate microorganisms on-the-fly as they pass through the irradiated zone due to limited exposure time

- Minimum target UV dose of 1,500 $\mu W \cdot s/cm^2$
- COVID appears to need lower dosage
- Systems typically designed for 500 fpm moving airstream
- Minimum irradiance zone of two ft
- Minimum UV exposure time of 0.25 s

Should always be coupled with mechanical filtration

- MERV ≥8 filter for dust control
- Enhanced overall air cleaning with increased filter efficiency

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Fan Run Time

- Since the general goal is to provide as much clean air as possible, the recommendations for fan run times are to run as much as possible when spaces are occupied, preferably all the time.
- Fans should also be run for at least 3 air changes before occupancy (for example, before schools open in the morning).
- When this isn't possible, added ODA and in-room air cleaners can be good options.

UV-C Upper-Air Disinfection

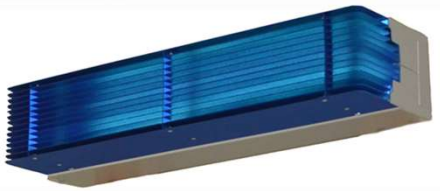
UV fixtures mounted in occupied spaces at heights of 7 feet and above.

Consider when:

- Limited or no mechanical ventilation
- Congregate settings and other high-risk areas
- Economics/other

Requires low UV-reflectivity of walls and ceilings

Needs good air mixing; use supplemental fans when ventilation is insufficient



In-Room or Portable Air Cleaners

- Device can be in the room where air cleaning is desired. Place air cleaner where air intake and discharge are not impeded (e.g., not near furniture or behind curtains).
- Air is pulled into the device, then cleaned air is returned. Flexible ductwork can be attached to some devices to allow positioning of intake and discharge locations, including discharge outside the room to create pressure differences.
- Devices may include any, or combinations of, air cleaning technologies. Users are advised to carefully determine that the technology is appropriate for their need.
- Devices are rated by the Association of Home Appliance Manufacturers.
- The rate of particle removal from air is termed the Clean Air Delivery Rate (CADR), typically in units of cubic feet per minute (CFM).

  CADR ≈ airflow rate × removal efficiency

- To reach a desired air exchange rate in air changes per hour (ACH):

  ACH = CADR (cfm) × 60 (min/hr) ÷ room volume (ft^3)

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Air Change Recommendations

- Air change rates expressed in air changes per hour (ach) are a topic of big discussion.
- Since we don't know the dose of virus needed and we don't know the source strength in a given location (#sick people, #viruses expelled), it is impossible to predict an exact answer.
- Different people/groups recommend ~3-10 ach with 10 commonly recommended for areas with known COVID patients
- 5-6 seems to be more commonly recommended
- ETF is looking at data

Air Changes Instead of Filter Efficiency

- Using ACH instead of air cleaner efficiency is an approach many of us are moving toward. It helps explain various concepts.
- Possible Approach (not on ETF website as such):
  - Determine desired ACH of clean air
  - Use Volume [cubic feet (cf)] of space to figure out needed Clean Air Flow in cfm
  - Determine or approximate incoming Outdoor Air cfm (use 0 if unknown)
  - Determine clean airflow from HVAC (Return Airflow * Filter Eff%)
  - Add In-Room air cleaner clean air to meet need
  - Adjust OA, HVAC runtime or efficiency, or in-room use to meet ACH need.

Summary

- It is likely that COVID19 is spread through the air.
- Air cleaning can help mitigate disease transmission by removing the virus and by diluting it in the air.
- Options for air cleaning include:
  - HVAC systems
  - In-Room devices
- Filters that are recommended include:
  - Mechanical Air Filters
  - Electronic Air Filters/Air Cleaners
  - Ultraviolet (UV-C)
- Care and professional judgement should be taken to understand choices for filtration, pros and cons of each option, and impact(s) on existing buildings systems.

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Most Important Take Aways

- Wear your mask!
- ASHRAE ETF information is **advice** not rules
- No solution is perfect, small improvements are better than none.
- Filters remove the virus (and other particles)
- Diluting with clean air will reduce the dose of the virus
- If you have HVAC and COVID19 questions, there are places to look and people who will try to help.

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- https://www.ashrae.org/technical-resources/resources
- Or search on-line for ASHRAE COVID19
- **Questions? Email COVID-19@ashrae.org**
- Or ask me and I will point you in the right direction

- How can you help? Get the word out!

In case of questions. . .

Bipolar Ionization/Corona Discharge/ Needlepoint Ionization and Other Ion or Reactive Oxygen Air Cleaners

- Air cleaners using reactive ions and/or reactive oxygen species (ROS) have become prevalent during the COVID-19 pandemic. New devices that are not mentioned elsewhere in this guidance likely fall into this category.
- Technologies create reactive ions in air that react with airborne contaminants, including viruses. The design of the systems can be modified to create mixtures of reactive oxygen species (ROS), ozone, hydroxyl radicals and superoxide anions.
- Systems are reported to range from ineffective to very effective.
- Convincing scientifically-rigorous, peer-reviewed studies do not currently exist on this emerging technology; manufacturer data should be carefully considered.
- Systems may emit ozone, some at high levels. Manufacturers are likely to have ozone generation test data.

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CDC Position on Bipolar Ionization

Thank you for your question. Although this was pointed out in the earlier CDC responses, it is important for me to re-emphasize that CDC does not provide recommendations for, or against, any manufacturer or manufacturer's product. While bi-polar ionization has been around for decades, the technology has matured and many of the earlier potential safety concerns are reportedly now resolved. If you are considering the acquisition of bi-polar ionization equipment, you will want to be sure that the equipment meets UL 2998 standard certification (Environmental Claim Validation Procedure (ECVP) for Zero Ozone Emissions from Air Cleaners) which is intended to validate that no harmful levels of ozone are produced. Relative to many other air cleaning or disinfection technologies, needlepoint bi-polar ionization has a less-documented track record in regards to cleaning/disinfecting large and fast volumes of moving air within heating, ventilation, and air conditioning (HVAC) systems. This is not to imply that the technology doesn't work as advertised, only that in the absence of an established body of evidence reflecting proven efficacy under as-used conditions, the technology is still considered by many to be an "emerging technology". As with all emerging technologies, consumers are encouraged to exercise caution and to do their homework. Consumers should research the technology, attempting to match any specific claims against the consumer's intended use. Consumers should request efficacy performance data that quantitively demonstrates a clear protective benefit under conditions consistent with those for which the consumer is intending to apply the technology. Preferably, the documented performance data under as-used conditions should be available from multiple sources, some of which should be independent, third party sources.