AIR CLEANERS and COVID19
ASHRAE ETF: Filtration and Disinfection Group

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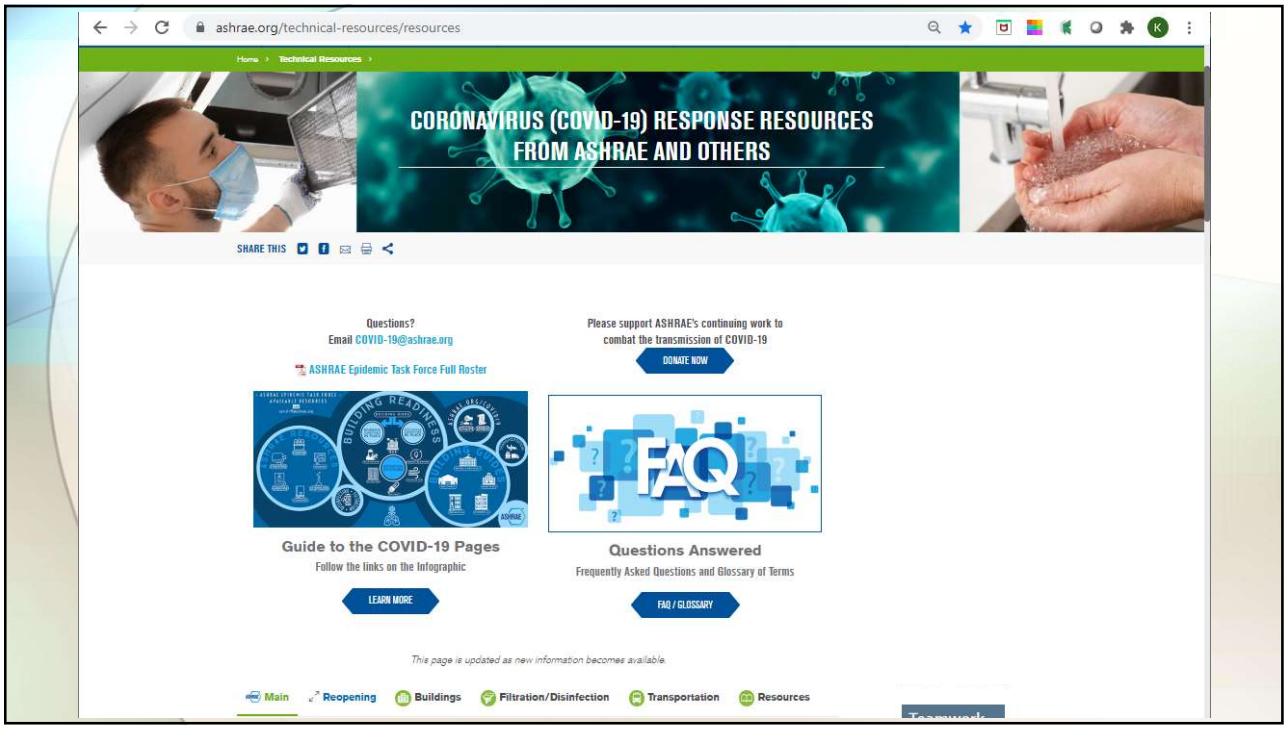
1

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

2



3

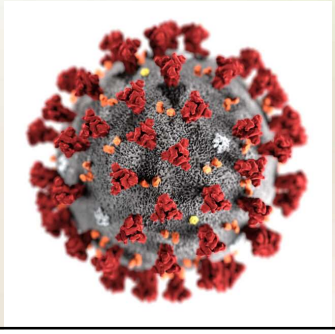
ASHRAE Epidemic Task Force (ETF) – in other words

- Providing guidance regarding HVAC and Indoor Air from the engineering and air quality perspective (we are not CDC or WHO, not MD type advice)
- Posting guidance and answering questions
  - COVID related standards available free (at ASHRAE and other groups)
  - Articles available free and/or pre-publication
- Answered questions lead to posted content
- Changes rapidly due to the science related to COVID and to needs of the community

4

ASHRAE Epidemic Task Force (ETF)

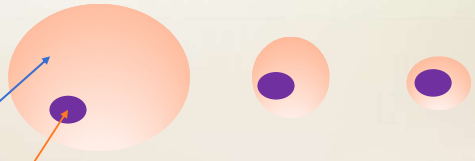
- Many teams/working groups (140+ people)
  - Communications
  - Transportation
  - Residential
  - Literature
  - Building readiness
  - **Filtration & Disinfection**
  - Laboratories
  - Industrial
  - Applications
  - Healthcare
  - Developing economies
  - Schools
  - Commercial/retail
  - Research



5

Filtration Basics

- Particles come from many sources.
- For COVID – sneezes, coughs, breathing, singing, etc.
- Virus - ~70-120 nm
- 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.
- Recent studies show the virus and its RNA is particles in air.



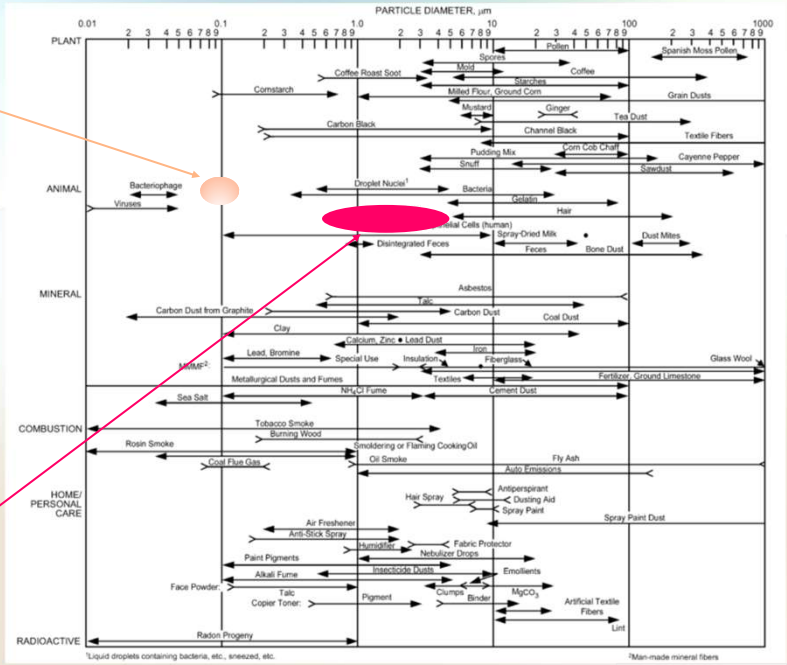
From tgp.com.ph

6

COVID19 virus

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

COVID19 - actually in the air



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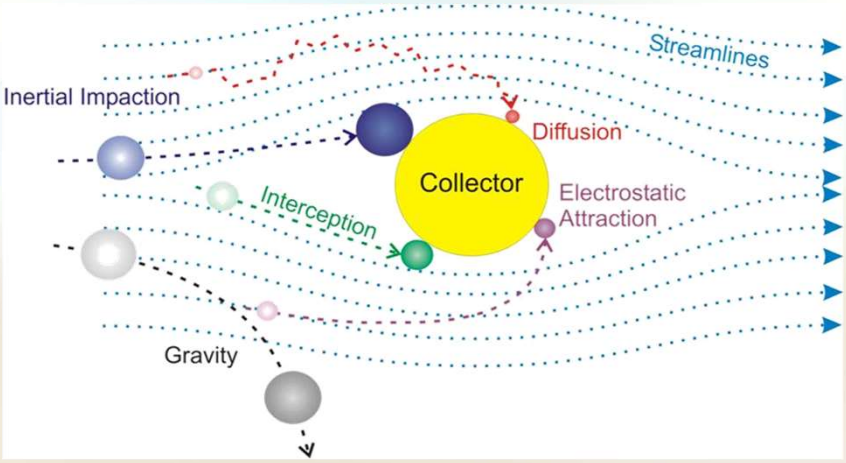
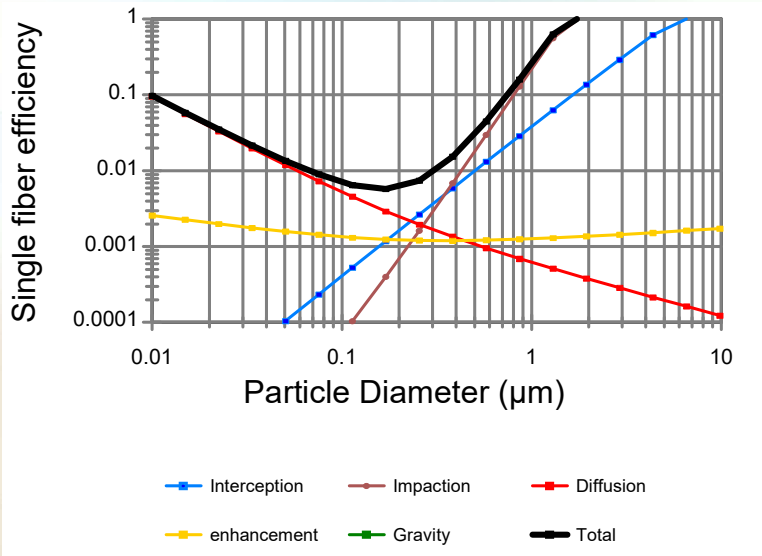
7

Filtration Mechanisms



8

Particle Penetration by Particle Size



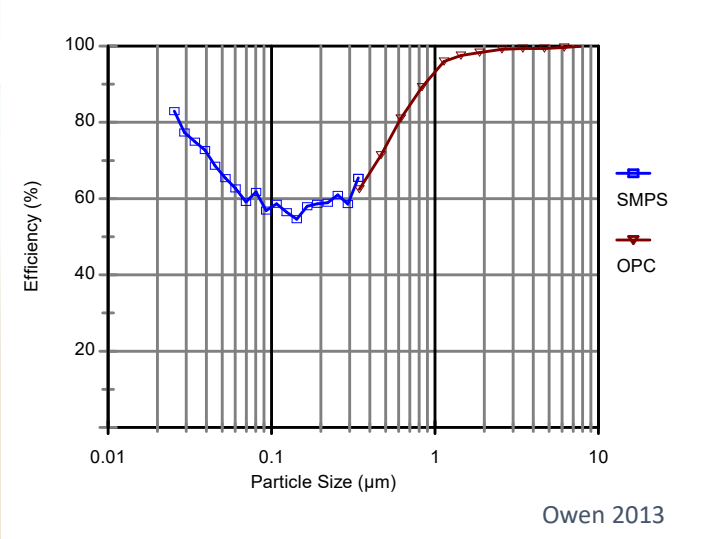
The "most penetrating particle size" is typically in the 0.1-0.3 µm range.

Computations based on Hinds, Aerosol Technology, 1982.

9

9

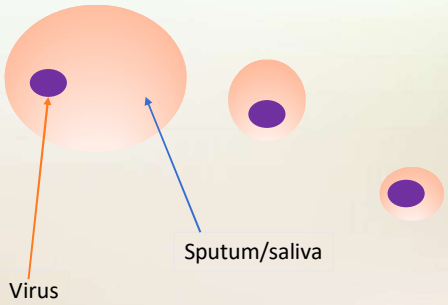
Efficiency Curve for MERV 14 Filter



10

UVC Bioaerosol Basics

- UVC inactivates/kills based on the dose of light. The irradiance over the time the virus is exposed.
- Bioaerosols resist inactivation by
  - Biological repair mechanisms
  - Shielding including the layer of sputum - dried on or wet

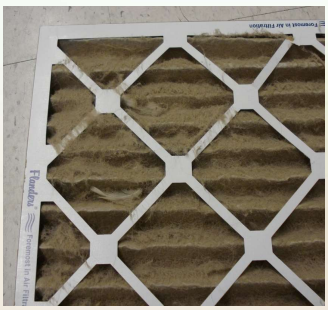


From tgp.com.ph

11

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, if you wish to quote the ASHRAE COVID team's position.



12

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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

QUESTIONS? COVID-19@ashrae.org www.ashrae.org/covid19

13

Facilities/Maintenance – PPE Basics

Refer to CDC Guidance on PPE use, especially banners at bottom of webpage

N95 filtering facepiece respirators
- Protects the wearer from respiratory droplets AND aerosols.
- Can be an effective tool for worker protection with proper use.
- Require fit testing and a medical clearance to wear for work.
- Tested for efficiency against 0.3 micrometer airborne particles.
- Certified to filter at least 95% of these particles.
- Generally disposed of after each use, but pandemic has resulted in limited supplies. CDC issued Strategies to Optimize the Supply of PPE

Silicone half mask respirators with N95 cartridges (or better) can be used instead of filtering facepiece respirators.

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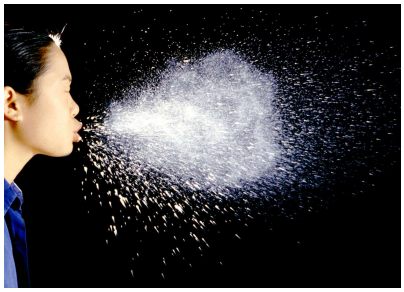
14

Facilities/Maintenance – PPE Basics



Eye Protection

- Safety glasses (side shields preferred)
- Goggles
- Face shields

Disposable Gloves

- Can be vinyl, rubber or nitrile
- Double gloves reduces likelihood of cuts/punctures
- Can be worn under work gloves if necessary

Disposable coveralls, gowns and/or shoe covers can be worn to enhance overall protection.

After maintenance activities, wash hands with soap and water or use an alcohol-based hand sanitizer. Change clothes if soiled.

15

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

16

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.

17

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.

- 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

The SARS-CoV-2 virus may be aerosolized by flushing the toilet.

18

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.

19

Transmission Through Air in Toilet Rooms

Studies have shown that toilets can be a risk of generating airborne droplets and droplet residues that could contribute to transmission of pathogens.

- Keep toilet room doors closed, even when not in use.
- Put the toilet seat lid down, if there is one, before flushing.
- Vent separately where possible (e.g. turn exhaust fan on if vented directly outdoors and run fan continuously).
- Keep bathroom windows closed if open windows could lead to re-entrainment of air into other parts of the building.

20

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) 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 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.

21

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)

22

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**
1-6	ISO Course
7-8	ISO Course >95%
9-10	ePM_{10}
11-12	$ePM_{2.5}$
13-16	ePM_1

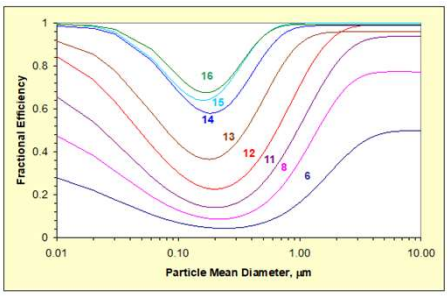
*MERV-A will give closer results. Charged media filters usually show a drop-off in efficiency with use. ISO 16890 captures this with an IPA condition step. ASHRAE 52.2 can capture this drop if the test is done with the optional Appendix J which gives the MERV-A. Thus the MERV and the ePM ratings do not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

23

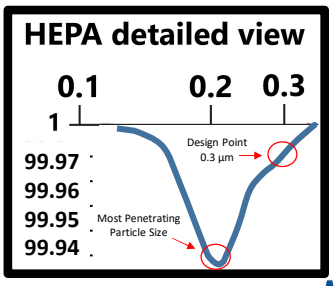
High Efficiency Particulate Air (HEPA) Filters

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.



24

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

25

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

The fraction of particles removed from air by an electronic filter is termed "removal efficiency."

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

26

Electronic Air Filters

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

Always follow manufacturer's instructions when using electronic air filters.

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

27

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

28

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.

29

UV-C LEDs

- Have been common in the UV-A spectrum (315 – 400 nm)
- LEDs are starting to be produced in the 265 nm range
- Efficiency is dramatically less than current low-pressure mercury vapor lamps
- Minimal UV output compared to a low-pressure mercury vapor lamp
- For equal output, UV-C LEDs are more expensive than current low-pressure mercury vapor lamps
- Limited availability; not yet practical for commercial HVAC applications

For more information, see the FAQs on Germicidal Ultraviolet (GUV) published by the Illuminating Engineering Society (IES) Photobiology Committee:

30

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 µW•s/cm^2
- Systems typically designed for 500 fpm moving airstream
- Minimum irradiance zone of two ft
- Minimum UV exposure time of 0.25 s

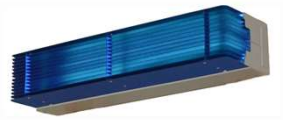
Should always be coupled with mechanical filtration

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

31

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

32

UV-C In-Duct Surface Disinfection

Banks of UV-Lamps installed inside HVAC systems, generally focused on:

- Cooling coils
- Drain pans
- Other wetted surfaces

UV irradiance can be lower than in-duct air disinfection systems due to long exposure times.

Goals are:

- Even distribution of UV energy across the coil face
- Generally, 12 to 36 inches from the coil face
- Operated 24 hours a day, 7 days a week

33

UV-C Portable Room Decontamination

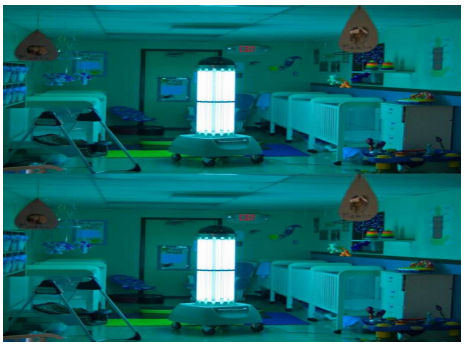
For surface decontamination

Portable, fully automated units; may use UV-C lamps or Pulsed Xenon technology

Settings for specific pathogens such as MRSA, *C. difficile,* both of which are harder to inactivate than coronaviruses

- >99.9% reduction of vegetative bacteria within 15 minutes
- 99.8% for *C.difficile* spores within 50 minutes

(Rutala et al. 2010)



34

Photocatalytic Oxidation (PCO) and Dry Hydrogen Peroxide (DHP)

- Consists of a pure or doped metal oxide semiconductor material (e.g, $Ti0_2$)
- Activated by a UV light source
  - UV-A (400-315nm) -- UV-C (280-200 nm)
  - UV-V (under 200nm) Ozone can be formed at UV-V wavelengths
- Light mediated, redox reaction of gases and biological particles absorbed on the surface
- Some units claim disinfection from gaseous hydrogen peroxide (sometimes called dry peroxide)
- Possible by-products formed by incomplete oxidation, including from gaseous contaminants
- Some PCO air cleaners remove harmful contaminants to levels below limits for reducing health risks.
- Some are ineffective in reducing concentrations significantly; manufacturer data should be considered carefully.

35

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.

36

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.

37

Ozone

Ozone (O3) is a reactive gas that can disinfect air and surfaces by killing viruses, bacteria and fungi.

Ozone is harmful for health and exposure to ozone creates risk for a variety of symptoms and diseases associated with the respiratory tract.

ASHRAE's Environmental Health Committee issued an emerging issue brief suggesting "safe ozone levels would be lower than 10 ppb" and that "the introduction of ozone to indoor spaces should be reduced to as low as reasonably achievable (ALARA) levels."

Should only be considered for disinfection on unoccupied spaces; it should never be used in occupied spaces.

- Available scientific evidence shows that, at concentrations that do not exceed public health standards, ozone is generally ineffective in controlling indoor air pollution.
- Reputable cleaning and restoration companies should be used for effective, safe disinfection of unoccupied spaces.

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38

Vaporized Hydrogen Peroxide (VHP)

- Liquid hydrogen peroxide (H_2O_2) is vaporized and the vapor fills the space to disinfect all exposed surfaces.
- Space MUST be unoccupied during VHP treatment.
- Requires spaces to be sealed including all doorways, plumbing/electrical penetrations and HVAC supply and return vents to prevent vapor from escaping.
- After prescribed exposure times, remaining H_2O_2 vapor is scrubbed from air and converted back to oxygen and water before occupation.
- The effectiveness and safety of VHP when generated inside active HVAC ducts and occupied spaces has not been rigorously studied.
- VHP is hazardous at high concentrations. Lengthy exposure is often necessary to inactivate bacteria and viruses in sealed spaces.

39

Pulsed Xenon (Pulsed UV)

- High-powered UV lamps (generally containing xenon gas) used in rapid pulses of intense energy.
- Emits a broad brand of visible and ultraviolet wavelengths, with a significant fraction in the UV-C band.
  - Uses significantly higher power outputs that usual UV-C techniques
  - Inactivates viruses, bacteria and fungi using the same mechanisms as standard UV-C systems
- Typically used for healthcare surface disinfection but can be used in HVAC systems for air and surface disinfection.

For more information, see the FAQs on Germicidal Ultraviolet (GUV) published by the Illuminating Engineering Society (IES) Photobiology Committee.

40

405 nm Visible Light

- Sometimes referred to a "Near UV," although not in the UV spectrum.
- Generally integrated into standard room lighting systems.
- Kills bacteria and fungi via different mechanism than UV-C.
  - Targets and excites naturally-occurring porphyrin molecules inside organisms creating reactive oxygen species
  - Reactive oxygen species kill by a mechanism similar to bleach
- **Effectiveness at killing viruses, including SARS-CoV-2, is not as well documented.**
- Provides continuous disinfection of air and exposed surfaces in occupied spaces.
- In the FAQs on Germicidal Ultraviolet (GUV), the Illuminating Engineering Society (IES) Photobiology Committee notes that effectiveness is approximately **1000 times less than UV-C** and the effective doses are not practical in an occupied environment.

41

Far Ultraviolet

- Far UV spectrum is 205 to 230 nm
- Some deactivation of bacteria and viruses at the 207 nm and 222 nm range
- 222 nm is said to effectively penetrate microorganisms 1 µm in size and smaller.
- Unable to fully penetrate larger microorganisms
- UV Dose required to inactivate microorganisms is significantly higher at these wavelengths than in the UV-C range.
- While safety concerns are reduced, Far UV can still cause damage to eyes and skin.

42

Special Precautions

- Exposure to UV-C energy can cause eye and skin damage.
- Symptoms may not be evident until several hours after exposure and may include an abrupt sensation of sand in the eyes, tearing and eye pain, possibly severe.
  - Symptoms usually appear 6 to 12 hours after UV exposure
  - Symptoms are fully reversible and resolve within 24 to 48 hours
- Maintenance workers should receive special training before working on UV-C systems.
- If exposures are likely to exceed safe levels, special personal protective equipment (PPE) is required for exposed eyes and skin.

43

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 application of 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)

44

Summary

- It is likely that COVID19 is spread through the air.
- Air cleaning can help mitigate disease transmission.
- Options for air cleaning include:
  - HVAC systems
  - In-Room devices
- Technologies that can be effective include:
  - Mechanical Air Filters
  - Electronic Air Filters/Air Cleaners
  - UV-C Systems
  - Other Emerging Technologies
- Care and professional judgement should be taken to understand choices for filtration and air disinfection, pros and cons of each, and impact(s) on existing buildings systems.

45

Most Important Take Aways

- Wear your mask!
- ASHRAE is a great group to volunteer with!
- Your HVAC knowledge may come in handy in ways you never expected.
- If you have HVAC and COVID19 questions, there are places to look and people who will try to help.

46

ASHRAE ETF

- 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!

47