TIP No. 98-126-0820

CONSIDERATIONS FOR THE USE OF IONIZED AIR FILTRATION UNITS TO MITIGATE COVID-19

INTRODUCTION

The use of air cleaners is one strategy employed to control the spread of aerosolized infectious disease agents. However, the effectiveness of utilizing air cleaners—specifically electronic air cleaners (including ionizers)—to control the transmission of COVID-19 has not been clearly documented. The following is a summary of the guidance provided by American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE®) and U.S. Environmental Protection Agency (EPA) on electronic air cleaners (including effectiveness, mechanism, cautions, advantages/disadvantages, maintenance and operation). Both portable units and units inside a heating, ventilation, and air conditioning (HVAC) system are addressed.

CLEAN AIR DELIVERY RATE (CADR)

You will see reference to the Clean Air Delivery Rate (CADR). The CADR is a unit of measurement used to compare the performance of portable household electronic room filters. Note that the CADR measures an air cleaner's delivery of relatively clean air at the air cleaner's highest setting; if the cleaner is used at a lower setting, then it may not provide the same CADR. The Association of Home Appliance Manufacturers (AHAM) has established testing protocols for specific contaminants that represent "fine" (e.g., tobacco smoke; 0.09-1.0 micrometers (μm)), "medium" (e.g., dust; 0.5-3.0 μm), and "large" (e.g., pollen; 0.5-11.0 μm) particles. Ensure you are familiar with the basis for CADR ratings (i.e., fine, medium, and large particles). The formula used to derive CADR is Filter Efficiency x Filter Airflow Volume (cubic feet per minute [cfm]). The AHAM also recommends appliances be submitted for inspection and listing per Underwriters Laboratories (UL) 867, Standard for Electrostatic Air Cleaners, and UL 507, Standard for Fans. Additional testing information can be found on the AHAM website: www.AHAM.org. See ASHRAE information below for CADR information and how it relates to product selection.

CONTROLLING INFECTIOUS AEROSOL TRANSMISSION

Please see the ASHRAE Position Document on Infectious Aerosols for recommendations on strategies to control transmission. https://www.ashrae.org/technical-resources/resources

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA) GUIDANCE

An Extract from the EPA Website:

Will an air cleaner or air purifier help protect me and my family from COVID-19 in my home?
When used properly, air purifiers can help reduce airborne contaminants including viruses in a home or confined space. However, by itself, a portable air cleaner is not enough to protect people from COVID-19. When used along with other best practices recommended by the Centers for Disease Control and Prevention, operating an air cleaner can be part of a plan to protect yourself and your family.
https://www.epa.gov/coronavirus/air-cleaners-hvac-filters-and-coronavirus-covid-19

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Use of trademarked name(s) does not imply endorsement by the U.S. Army but is intended only to assist in identification of a specific product.

EPA Residential Air Cleaners—A Technical Summary
https://www.epa.gov/sites/production/files/2018-07/documents/residential_air_cleaners_-_a_technical_summary_3rd_edition.pdf

Electronic air cleaners (including electrostatic precipitators [ESPs] and ionizers) remove particles by an active electrostatic charging process that requires electricity to charge particles that become attracted to and adhere to oppositely charged plates or other indoor surfaces. At the date of this document's publication, no studies were found that systematically investigated whether the use of sorbent media gas phase filtration, photocatalytic oxidation, plasma, or ionizer air cleaners in homes or other buildings has a positive effect on the health of occupants.

Summary of Air Cleaning Technologies: Ionizers (i.e., ion generators)
Mechanism/Collection: Ion generators are the simplest form of electronic air cleaner and are available as tabletop, portable, or ceiling-mounted units. Similar to ESPs, ionizers use a high-voltage wire or carbon fiber brush to electrically charge air molecules, which produces negative ions that attach to airborne particles; the charged particles are then collected either on oppositely charged plates in the air cleaner or become attracted to other surfaces in the room and deposited elsewhere. No test standards or rating metrics specific to ionizers, although AHAM AC-1 can be used to measure CADR.

Advantages of Ionizers:

- Typically low power draw requirements
- Quiet
- Low maintenance
- The charged particles can attach to nearby surfaces such as walls or furniture (i.e., plate-out), or to one another, and settle faster.

Disadvantages of Ionizers:

- Generates ozone
- Typically low effectiveness because of very low airflow rates and clean air delivery rates (CADRs)
- Charged particles will deposit on and soil room surfaces such as walls and curtains (Melandari et al. 1983; Offermann et al. 1985).
- Particles remain in the room or area and may be re-suspended from the surfaces when disturbed by human activities such as walking or vacuuming, especially those larger than approximately 2 μm (Ferro et al. 2004; Qian and Ferro 2008).

Possible Negative Effects of Particle Charging.
Another factor to consider related to ion generators is the effect of particle charging on deposition in the respiratory tract. Experiments have shown that particle deposition in the respiratory tract increases as particles become charged, so using ion generators may not reduce the dosage of particles which make it into a person's lungs (Melandari et al. 1983; Offermann et al. 1985). The effect of charge on very fine particles results in their higher deposition rate in the lungs compared to that of uncharged particles. Additionally, ESPs and ionizers may make a crackling sound as they accumulate dust, which may be a nuisance to some occupants.

Ozone Considerations

Appliances Tested for Ozone Emission.
Both the California Air Resources Board and the AHAM maintain lists of air cleaners that have been tested and shown to emit little or no ozone. See the guidance at:
https://www.epa.gov/sites/production/files/2018-07/documents/guide_to_air_cleaners_in_the_home_2nd_edition.pdf

Ozone Generation.
Many electronic air cleaner devices—including portable and duct-mounted ESPs, ionizers or ion generators, uncoated ultraviolet germicidal irradiation lamps, and other products that advertise the use of "plasma," "ions," and other similar terms—can generate high amounts of ozone. Ozone is a well-documented lung irritant. Intentional ozone generators should not be used in occupied spaces. No federal agency has approved the use in occupied spaces of air cleaners that intentionally emit ozone. Ozone and ozone-generating devices are also discussed in more detail in EPA's "Ozone Generators that are Sold as Air Cleaners," which can be found at: https://www.epa.gov/indoor-air-qualityiaq/ ozone-generators-are-sold-air-cleaners.

Cautions Concerning Ozone Production by ESPs and Ionizers.
Like fibrous media air filters, ESPs and ionizers can be installed in HVAC systems or used in portable units. Although ESPs and ionizers remove small particles (including ultrafine particles), they do not remove gases or odors (Poppendieck et al. 2014; Sultan et al. 2011; Waring et al. 2008). Additionally, because ESPs and ionizers use high voltage to generate ionized fields, they may produce ozone either as a byproduct or by design (EPA 2014). Ozone is a lung irritant that poses risks to health. Some portable air cleaners that use ESPs and ionizers produce ozone as a byproduct (Consumers Union 2005; Waring et al. 2008; Jakober and Phillips 2008). Some makes and models of ESPs and ionizers can increase indoor ozone concentrations to levels that can exceed public health standards (Morrison et al. 2014). The California Air Resources Board, under Title 17 Regulation for Limiting Ozone Emissions from Indoor Air Cleaning Devices (California Code of Regulations 2009), certifies air cleaners in regard to ozone production. The Title 17 Regulation relies on a test method for evaluating ozone emissions from air cleaners described in American National Standards Institute/Underwriters Laboratory Standard 867 (UL 2011). Even at concentrations below public health standards, ozone reacts with chemicals emitted by common indoor sources such as household cleaning products, air fresheners, deodorizers, certain paints, polishes, wood flooring, carpets, and linoleum. The chemical reactions produce harmful byproducts that may be associated with adverse health effects in some sensitive populations. Byproducts that may result from reactions with ozone include ultrafine particles, formaldehyde, other aldehydes, ketones, peroxides, and/or organic acids (Shaughnessy and Sextro 2006; EPA 2014; Wechsler 2006).

Cost Considerations

The cost of professional installation of an upgraded media filter or an electronic air filter in an HVAC system must also be considered. The most effective air cleaners, those with high airflow rates and efficient pollutant capture systems, are generally the most expensive. Maintenance and operating costs vary depending on the device, and these costs should be considered when choosing a particular unit. Operating cost is important to consider because air cleaning is an ongoing process, and units require ongoing filter replacement or cleaning and other maintenance to remain effective. Some units marketed as having the quietest operation may have no fan; however, units that do not have a fan typically are much less effective than units that have a fan.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE) GUIDANCE

An excerpt from the ASHRAE Position Document on Filtration and Air Cleaning. https://www.ashrae.org/file%20library/about/position%20documents/filtration-and-air-cleaning-pd.pdf

Filtration technologies that generate electrical fields and/or ions, often called electronic filters, have been documented to range from relatively ineffective to very effective in substantially reducing particles, including reductions from levels being above to levels being below the associated regulatory exposure limits for reducing health risks set by recognized cognizant authorities. (Conclusions and Recommendations). ASHRAE holds the following position (Section 3.2): Devices that use the reactivity of ozone for the purpose of cleaning the air should not be used in occupied spaces because of the negative health effects that arise from exposure to ozone and its reaction products. Extreme caution is warranted when using devices that emit a significant amount of ozone as by-product of their operation, rather than as a method of air cleaning, as an alternative to ventilation.

ASHRAE Epidemic Task Force (TF): Electronic Air Filters:
https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-filtration_disinfection-c19-guidance.pdf

In 2020 ASHRAE convened a group of subject matter experts to form the ASHRAE Epidemic TF in response to COVID-19. The TF goal is to provide guidance for protecting building occupants from COVID-19 and other infectious diseases. The TF issued the following talking points for 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),or
    - Charged particles' enhanced removal by a mechanical air filter, or
    - Charged particles' deposition on room surfaces

- The fraction of particles removed from air passing through an electronic filter is termed "removal efficiency."
    - For portable, self-contained electronic filters, the rate of particle removal from air is termed the CADR.
    - CADR ≈ airflow rate × 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 or room air cleaner
    - Maintenance and cleanliness of electronic filter components
- 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.

ASHRAE Systems and Equipment Handbook 2016, Chapter 29 Air Cleaners for Particulate Contaminants:
https://www.ashrae.org/technical-resources/resources

Electrically Enhanced Air Filtration.
Electrically enhanced air cleaners incorporate an electrostatic field to charge contaminants before capture in a high-efficiency pleated filter. Advantages include high efficiency and reduced maintenance frequency. The air cleaners consist of an ionizing section and a filtration section. The ionizing section has a pre-filter to prevent large debris from entering the air filter and to focus the electrostatic field. The air is charged in a high-voltage ionizing section. In the ionization section, the ionizer is connected to a high-voltage power supply, and the particulate is charged. The charged particles are collected in the media filter at earth ground potential.

Maintenance.
Plate-type air cleaner cells must be cleaned periodically with detergent and hot water. Some designs incorporate automatic wash systems that clean the cells in place; in others, the cells must be removed for cleaning. The required frequency of cleaning the cell depends on both the contaminants and the concentration of contaminants in the air. Industrial applications may require cleaning every 8 hours, but a residential unit may only require cleaning every 1-to-3 months. The timing of the cleaning schedule is important to keep the unit performing at peak efficiency. For some contaminants, special attention must be given to cleaning the ionizing wires. The air cleaner must be maintained based on the recommendations of the manufacturer. Electrically enhanced air cleaners have a longer service life between maintenance than plate-type precipitators. Maintenance consists of replacing the filter and cleaning the ionizing section and pre-filter.

Performance.
Currently, Air-Conditioning, Heating, and Refrigeration Standard 680 is the industry-accepted testing method for electronic air cleaners. This test involves loading the filter with a dust that does not contain a conductive component and allows comparison to media filtration. Electronic air cleaner design parameters of air velocity, ionizer field strength, cell plate spacing, depth, and plate voltage must match the application requirements (e.g., contaminant type, particle size,

volume of air, and required efficiency). Many units are designed for installation into central heating and cooling systems for total air filtration. Other self-contained units are furnished complete with air-movers for source control of contaminants in specific applications that need an independent air cleaner.

Optional features.
Optional features are often available for electronic air cleaners. After-filters such as roll filters collect particulates that agglomerate and blow off the cell plates. These are used mainly where heavy contaminant loading occurs and extension of the cleaning cycle is desired. Cell collector plates may be coated with special oils, adhesives, or detergents to improve both particle retention and particle removal during cleaning. High-efficiency dry extended-media filters are also used as after-filters in special designs. The electronic air cleaner used in this system improves the service life of the dry filter and collects small particles such as smoke.
A negative ionizer uses the principle of particle charging, but does not use a collecting section. Particles enter the ionizer of the unit, receive an electrical charge, and then migrate to a grounded surface closest to the travel path.

Space Charge.
Particulates that pass through an ionizer and are charged, but not removed, carry the electrical charge into the space. If continued on a large scale, a space charge builds up, which tends to drive these charged particles to walls and interior surfaces. Thus, a low-efficiency electronic air cleaner used in areas of high ambient dirt concentrations (or a malfunctioning unit), can blacken walls faster than if no cleaning device were used (Penney and Hewitt 1949; Sutton et al. 1964).

Ozone.
All high-voltage devices can produce ozone, which is toxic and damaging not only to human lungs, but also to paper, rubber, and other materials. When properly designed and maintained, an electronic air cleaner produces an ozone concentration that only reaches a fraction of the limit acceptable for continuous human exposure and is less than that prevalent in many American cities (EPA 1996). Continuous arcing and brush discharge in an electronic air cleaner may yield an ozone level that is annoying or mildly toxic; this is indicated by a strong ozone odor (a pungent smell described as similar to chlorine). Although the nose is sensitive to ozone, only actual measurement of the concentration can determine whether a hazardous condition exists. Outdoor air can also be a source of indoor ozone. Weschler et al. (1989) found that ozone levels indoors closely tracked outdoor levels, despite ozone's reactions with HVAC interior surfaces. Indoor concentrations were typically 20-to-80% of outdoor concentrations depending on the ventilation rate. The EPA limits the maximum allowable exposure to ozone in outdoor air to 0.070 ppm averaged over 8 hours (EPA 2015). ASHRAE Standard 62.1 requires ozone removal systems in buildings where the intake air concentration exceeds the EPA limit.

Selection and Maintenance.
To evaluate filters and air cleaners properly for a particular application, consider the following factors:

- Types of contaminants present indoors and outdoors
- Sizes and concentrations of contaminants
- Air cleanliness levels required in the space

- Air filter efficiency needed to achieve cleanliness
- Space available to install and access equipment
- Life-cycle cost
- Operating resistance to airflow (static pressure differential)
- Disposal or cleaning requirements of spent filters
- Initial cost of selected system
- Cost of replacement filters or cleaning
- Cost of warehousing filter stock and change-out labor

If efficiency of Minimum Efficiency Reporting Value 11 or higher is required, extended-surface filters or electronic air cleaners should be considered. The use of very fine glass fiber mats or other materials in extended-surface filters has made these available at the highest efficiency. Initial cost of an extended-surface filter is lower than for an electronic unit, but higher than for a panel type. Operating and maintenance costs of some extended-surface filters may be higher than for panel types and electronic air cleaners, but efficiencies are always higher than for panel types; the cost/benefit ratio must be considered.

Pressure drop of media-type filters is greater than that of electronic types, and slowly increases during their useful life. Advantages include the fact that no mechanical or electrical services are required. Choice should be based on both initial and operating costs (life-cycle costs), as well as on the degree of cleaning efficiency and maintenance requirements. Although electronic air cleaners have higher initial and maintenance costs, they also have higher initial efficiencies in cleaning atmospheric air, largely because of their ability to remove fine particulate contaminants. System resistance remains unchanged as particles are collected, and efficiency is reduced until the resulting residue is removed from the collection plates to prepare the equipment for further duty. The manufacturer must supply information on maintenance or cleaning. Also, note that electronic air cleaners may not collect particles greater than 10 µm in diameter.

Electronic air cleaners and charged-fiber media filters start at high efficiency when new (or after proper service, in the case of electronic air cleaners), but their efficiency decreases as contaminants accumulate.

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