How to Reduce Pathogens in Senior Care Facilities via HVAC Modifications & Technology

Published 9/16/2020

An analysis of scientific research on ionization, pathogens, and air quality

Introduction:

Senior Living healthcare-associated infections (HAIs) such as MRSA, C. diff, influenza and other viruses that cause respiratory infections impact thousands of Long Term Care facilities across America every year. With the advent of the COVID-19 pandemic, the need to address pathogen exposure in Long Term Care facilities has become an increasingly urgent need. According to the Centers for Disease Control and Prevention, as of September 16, 2020, COVID-19 has killed 195,053 Americans, 58.1% of whom are over the age of 75 years old.[1] According to the Centers for Medicare and Medicaid Services, over 216,219 cases and 53,196 deaths have been reported in Skilled Nursing facilities as of September 16, 2020.[2] In the setting of limited therapeutics and lack of a vaccine to treat or prevent this highly contagious respiratory illness, constrained resources for testing and personal protective equipment and influenza season rapidly approaching, Senior Living facilities will need to adopt novel and multilayered approaches to enhance patient safety. In a statement on airborne transmission of SARS-CoV-2, The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has discussed the importance of HVAC systems in reducing airborne exposures. This whitepaper provides an overview of Direct Supply's recommendations for modifications to and technology for HVAC systems to address exposure to SARS-CoV-2 and other HAIs in Senior Living communities.

[1]"CDC COVID Data Tracker." Centers for Disease Control and Prevention, Centers for Disease Control and Prevention, 16 Sept. 2020, covid.cdc.gov/covid-data-tracker/.
[2]"COVID-19 Nursing Home Data." Centers for Medicare and Medicaid Services, Centers for Medicare and Medicaid Services, 16 Sept. 2020, https://data.cms.gov/stories/s/COVID-19-Nursing-Home-Data/bkwz-xpvg/

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Section 1: Infectious Pathogens and Routes of Transmission

Infection control professionals describe the chain of infection as a process in which a pathogen (a microbe that causes disease):

- Is carried in an initial host or reservoir
- Gains access to a route of ongoing transmission
- With sufficient virulence, finds a secondary susceptible host

According to ASHRAE guidance, ventilation, filtration, air distribution systems and disinfection technologies have the potential to limit airborne pathogen transmission through the air and thus break the chain of infection.[3]

Infectious Diseases Transmit in Two Ways

As established in The Principles of Epidemiology in Public Health, all infectious diseases spread from infected and contagious individuals to susceptible hosts via one of two routes of transmission:

- Direct (person-to-person contact or droplet spread)
- Indirect (e.g. transmission from surfaces, medical devices, air or vectors such as mosquitoes or ticks)[4]

Differentiating Droplets vs. Aerosols

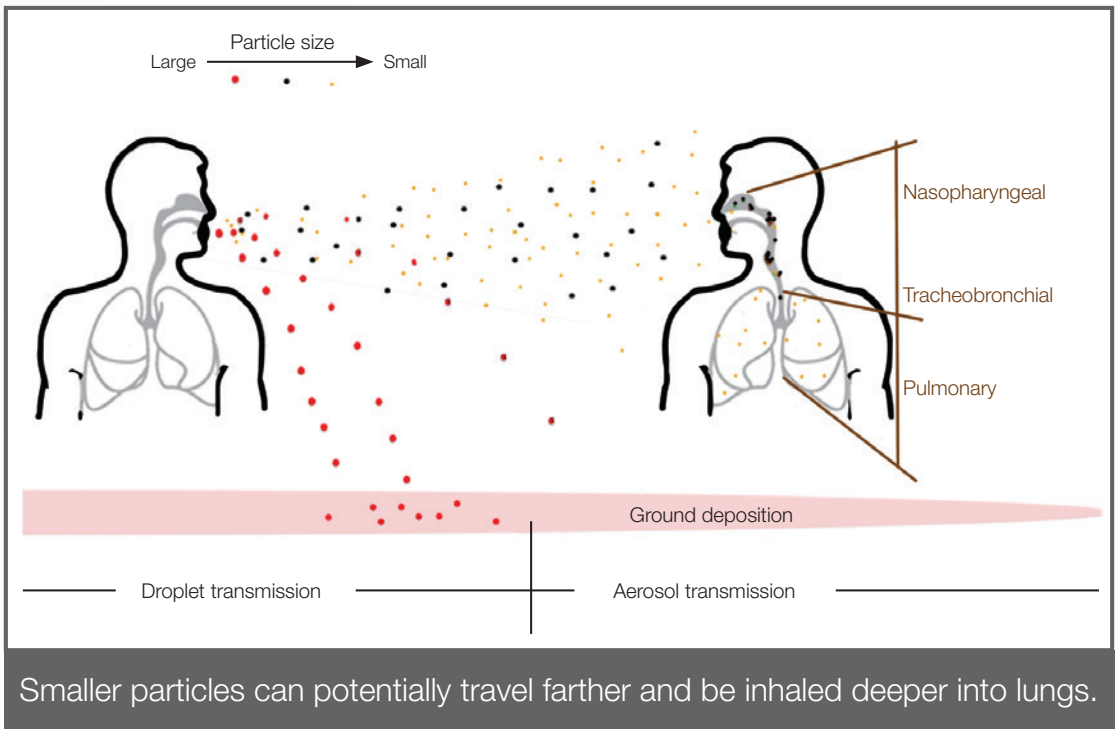
Both droplets and aerosols can be generated when a contagious person coughs, sneezes, talks or exhales. The distinction is both a matter of size and effect. Droplets are larger than 5 microns and tend to have enough weight to fall out of the air and onto surfaces that can then lead to surface transmission. Aerosols are smaller than 5 microns and can accumulate and linger in the air[5], based on a study published in Science magazine. Historically, the most contagious airborne pathogens, such as tuberculosis and measles, have been characterized by airborne transmission, allowing them to spread over long distances.

Virus-containing aerosols can be generated from an infected individual in the course of normal daily activities or through mechanical means when air currents around contaminated surfaces disperse viruses into the air.[6] Medical procedures (e.g., nebulization, CPAP and high-flow oxygen[7]), some surgeries, fast-running tap water and toilet flushes can all generate aerosols contaminated with infectious pathogens.[8]

[3]Society's Environmental Health Position Document Committee. ASHRAE Position Document on Infectious Aerosols. p. 4. 14 Apr. 2020, www.ashrae.org/file library/about/position documents/pd_infectiousaerosols_2020.pdf.
[4]Dicker MD, MSc, , Richard C. "Lesson 1: Introduction to Epidemiology, Section 10: Chain of Infection." Principles of Epidemiology in Public Health Practice, Third Edition An Introduction to Applied Epidemiology and Biostatistics, U.S. Department of Health and Human Services, Centers for Disease Control and Prevention (CDC) Office of Workforce and Career Development, 2006, pp. 62–71,https://www.cdc.gov/csels/dsepd/ss1978/lesson1/section10.html.
[5]Prather, Kimberly A., et al. "Reducing Transmission of SARS-CoV-2." Science, American Association for the Advancement of Science, 26 June 2020, pp. 1422-1424, science.sciencemag.org/content/368/6498/1422.full.
[6]Verreault D, Moineau S, Duchaine C. Methods for sampling of airborne viruses. Microbiol Mol Biol Rev. 2008;72(3):413-444. doi:10.1128/MMBR.00002-08, https://pubmed.ncbi.nlm.nih.gov/18772283/.
[7]"Infection Control Guidelines for Aerosol-Generating Procedures." Massachusetts General Hospital, Massachusetts General Hospital, 28 May 2020, www.massgeneral.org/assets/MGH/pdf/news/coronavirus/list-of-aerosol-generating-procedures.pdf.
[8]Judson, Seth D, and Vincent J Munster. "Nosocomial Transmission of Emerging Viruses via Aerosol-Generating Medical Procedures." Viruses vol. 11,10 940. 12 Oct. 2019, doi:10.3390/v11100940, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6832307/.

Overall, smaller particles that contain respiratory viruses can potentiate the risk of infection compared to other modes of transmission because:

- They can stay airborne longer thus prolonging exposure to the virus
- They can get inhaled into the lower lungs, potentially causing diseases with more severe outcomes[9] as evidenced by a study published by the Society for Applied Microbiology



Smaller particles can potentially travel farther and be inhaled deeper into lungs.

Comparison between droplet transmission (●) and aerosol transmission (●). Large droplets settle close to the source, while smaller aerosol particles stay aloft and can drift long distances. Once inhaled, very small particles can reach deeper to the pulmonary region while larger particles are captured in the nasopharyngeal region in the upper respiratory system.[9]

Airborne Transmission of HAIs

The CDC (NIOSH) completed a multi-year study of air samples from the West Virginia University Hospital in 2008[10] and in 2009[11] to investigate the amount of airborne influenza virus in healthcare facilities during influenza season. According to the CDC,[12] both studies found:

- Highest concentrations of influenza RNA correlated to where and when the number of influenza patients was highest
- 42% to 53% of the influenza viral RNA was contained in respirable aerosolized particles less than 4 microns in aerodynamic diameter

[9]Pan, M., et al. "Collection, Particle Sizing and Detection of Airborne Viruses." Society for Applied Microbiology, John Wiley & Sons, Ltd, 26 June 2019, sfamjournals.onlinelibrary.wiley.com/doi/full/10.1111/jam.14278.
[10]Blachere FM, Lindsley WG, Pearce TA, et al. Measurement of airborne influenza virus in a hospital emergency department. Clin Infect Dis. 2009;48(4):438-440. doi:10.1086/596478, https://pubmed.ncbi.nlm.nih.gov/19133798/.
[11]Lindsley WG, Blachere FM, Davis KA, et al. Distribution of airborne influenza virus and respiratory syncytial virus in an urgent care medical clinic. Clin Infect Dis. 2010;50(5):693-698. doi:10.1086/650457, https://pubmed.ncbi.nlm.nih.gov/20100093/.
[12]"CDC - Seasonal Flu in the Workplace - Activities: Transmission Research - Workplace Safety and Health Topic." Centers for Disease Control and Prevention, Centers for Disease Control and Prevention, 28 Mar. 2018, www.cdc.gov/niosh/topics/flu/transmission.html.

Moreover, it wasn't until 2010 that studies[13] began linking clostridium difficile (C. diff) to airborne transmission of spores. C. diff spores remain active and airborne for up to 5 months post initial exposure.[14]

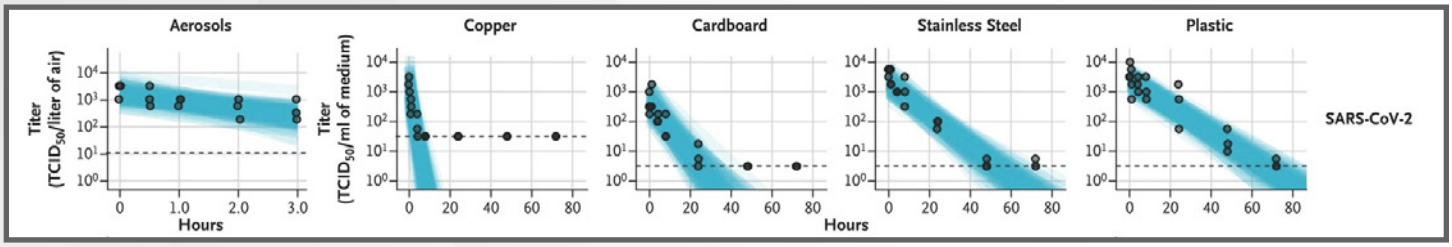
Also of heightened concern to Senior Living is the Legionella bacterium's unique water-to-air transmission route. Typically, the bacterium resides and grows in water systems (including as a biofilm on pipes), but as noted in the Centers for Medicare and Medicaid Services 2017 mandate,[15] Legionella has the greatest risk of transmission when aerosolized. High-risk areas identified are showers, faucets, hot tubs, swimming pools, cooling towers and fountains.

COVID-19: What It Is and How It's Transmitted

SARS-CoV-2 (Severe Acute Respiratory Syndrome Coronavirus 2) is the virus that causes the disease COVID-19 (Coronavirus Disease, 2019). It is a novel coronavirus, meaning that it is a new strain that was unknown before being discovered in late 2019. It is similar to other coronaviruses such as those that cause Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS).

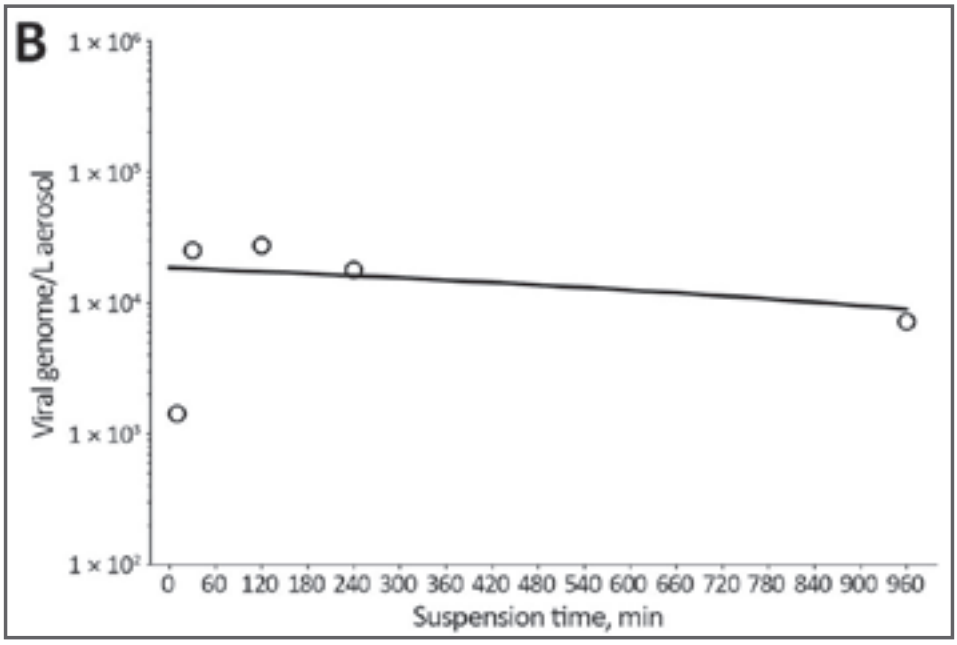
Studies indicate the virus can stay in the air for up to 16 hours.

There's increasing evidence, notably in research published by the Proceedings of the National Academy of Sciences, that it can spread via surfaces and via the air in both droplets and aerosolized particles.[16] On July 9, 2020, the WHO updated its guidance about how SARS-CoV-2 may be spreading: "There have been reported outbreaks of COVID-19 in some closed settings, such as restaurants, nightclubs, places of worship or places of work where people may be shouting, talking, or singing. In these outbreaks, aerosol transmission, particularly in these indoor locations where there are crowded and inadequately ventilated spaces where infected persons spend long periods of time with others, cannot be ruled out."[17] A recent study found viable SARS-CoV-2 at distances of up to 15.75 feet away from COVID-19 patients.[18] One study published in MedRxiv found remnants of SARS-CoV-2 in the HVAC system of a hospital, indicating potential spread over long distances, but the study did not determine if the remnant virus was linked to transmission of the disease.[19] Additionally, evidence published by the CDC found that the virus can be spread even by asymptomatic or presymptomatic individuals who are unaware they have the disease.[21] These factors create unique challenges for infection control, making additional proactive preventive measures essential.



[22] Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1: NEJM.

Several studies have looked at how long SARS-CoV-2 can survive in the air and on various surfaces. Research published in the CDC's Emerging Infectious Diseases Journal indicates that the virus can stay in the air for up to 16 hours.[20] Survival time on surfaces varies between types of surfaces, but can be as long as several days.



[20] (Figure 2B) Corresponding aerosol concentration of SARS-CoV-2 in time-matched impinger samples as a function of viral genome copies as measured by reverse transcription quantitative PCR.

Three Potential Real-World Examples of Airborne Spread of SARS-CoV-2

1. In China, an air conditioner pushed virus-laden air across three tables in a restaurant, infecting people seated at each one. Researchers reviewed video from the restaurant and saw many of these patrons were more than 6 feet apart from one another, suggesting that the virus traveled through the air following the path of the HVAC system.[23]
2. In Washington state, one person at a choir practice infected 52 of the other participants; it's thought the singing could have led more virus to linger in the air.[24]
3. In a South Korean call center, 44% of workers on one floor got the coronavirus.[25]

[13]Emma L. Best, Warren N. Fawley, Peter Parnell, Mark H. Wilcox, The Potential for Airborne Dispersal of Clostridium difficile from Symptomatic Patients, Clinical Infectious Diseases, Volume 50, Issue 11, 1 June 2010, Pages 1450–1457, https://doi.org/10.1086/652648

[14]Claro, Tânia et al. "Detecting Clostridium difficile spores from inanimate surfaces of the hospital environment: which method is best?." Journal of clinical microbiology vol. 52,9 (2014): 3426-8. doi:10.1128/JCM.01011-14, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4313175/#B17.

[15]Director, Survey and Certification Group. "Requirement to Reduce Legionella Risk in Healthcare Facility Water Systems to Prevent Cases and Outbreaks of Legionnaires' Disease (LD)." Received by State Survey Agency Directors, Centers for Medicare and Medicaid Services, 2 June 2017, www.cms.gov/Medicare/Provider-Enrollment-and-Certification/SurveyCertificationGenInfo/Downloads/Survey-and-Cert-Letter-17-30.pdf.

[16]Zhang, Renyi et al. "Identifying airborne transmission as the dominant route for the spread of COVID-19." Proceedings of the National Academy of Sciences Jun 2020, 117 (26) 14857-14863; DOI: 10.1073/pnas.2009637117, https://www.pnas.org/content/117/26/14857.

[17]"Q&A: How Is COVID-19 Transmitted?" World Health Organization, World Health Organization, www.who.int/news-room/q-a-detail/q-a-how-is-covid-19-transmitted.

[18]Lednicky, John A, et al. "Viable SARS-CoV-2 in the Air of a Hospital Room with COVID-19 Patients." MedRxiv, Cold Spring Harbor Laboratory Press, 1 Jan. 2020, www.medrxiv.org/content/10.1101/2020.08.03.20167395v1.

[19]Horve, Patrick F. "Identification of SARS-CoV-2 RNA in Healthcare Heating, Ventilation, and Air Conditioning Units." MedRxiv, Cold Spring Harbor Laboratory Press, 1 Jan. 2020, www.medrxiv.org/content/10.1101/2020.06.26.20141085v1.

[20]Fears AC, Klimstra WB, Duprex P, et al. Persistence of Severe Acute Respiratory Syndrome Coronavirus 2 in Aerosol Suspensions. Emerging Infectious Diseases. 2020;26(9):2168-2171. doi:10.3201/eid2609.201806, https://wwwnc.cdc.gov/eid/article/26/9/20-1806_article.

[21]Furukawa NW, Brooks JT, Sobel J. Evidence supporting transmission of severe acute respiratory syndrome coronavirus 2 while presymptomatic or asymptomatic. Emerg Infect Dis. 2020 Jul. https://doi.org/10.3201/eid2607.201595.

[22]J. H. Beigel and Others. "Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1: NEJM." New England Journal of Medicine, New England Journal of Medicine, 14 May 2020, N Engl J Med 2020; 382:1564-1567, DOI: 10.1056/NEJMc2004973, www.nejm.org/doi/10.1056/NEJMc2004973.

[23]Lu J, Gu J, Li K, et al. COVID-19 Outbreak Associated with Air Conditioning in Restaurant, Guangzhou, China, 2020. Emerging Infectious Diseases. 2020;26(7):1628-1631. doi:10.3201/eid2607.200764, https://wwwnc.cdc.gov/eid/article/26/7/20-0764_article.

[24]Hamner L, Dubbel P, Capron I, et al. "High SARS-CoV-2 Attack Rate Following Exposure at a Choir Practice - Skagit County, Washington, March 2020." Centers for Disease Control and Prevention, Centers for Disease Control and Prevention, 14 May 2020, www.cdc.gov/mmwr/volumes/69/wr/mm6919e6.htm?s_cid=mm6919e6_w.

[25]Park S, Kim Y, Yi S, et al. Coronavirus Disease Outbreak in Call Center, South Korea. Emerging Infectious Diseases. 2020;26(8):1666-1670. doi:10.3201/eid2608.201274, https://wwwnc.cdc.gov/eid/article/26/8/20-1274_article.

Section 2: Your HVAC System and Infection Control

According to ASHRAE, "HVAC systems can have a major effect on the transmission from the primary host to secondary hosts. Decreasing exposure of secondary hosts is an important step in curtailing the spread of infectious diseases."[3]

ASHRAE notes the importance HVAC systems have on any infectious diseases transmitted through aerosols, but recently added specific statements in regards to SARS-CoV-2 as part of their Position Document on Infectious Aerosols:[3]

- 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 heating, ventilating, and air-conditioning systems, can reduce airborne exposures."

- 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."

Senior Living communities must think about modifications and enhancements to their HVAC systems to reduce pathogens in the air, including the ventilation of indoor spaces and new technologies such as Needlepoint Bipolar Ionization.

The Role of Ventilation In Reducing Exposure To Pathogens

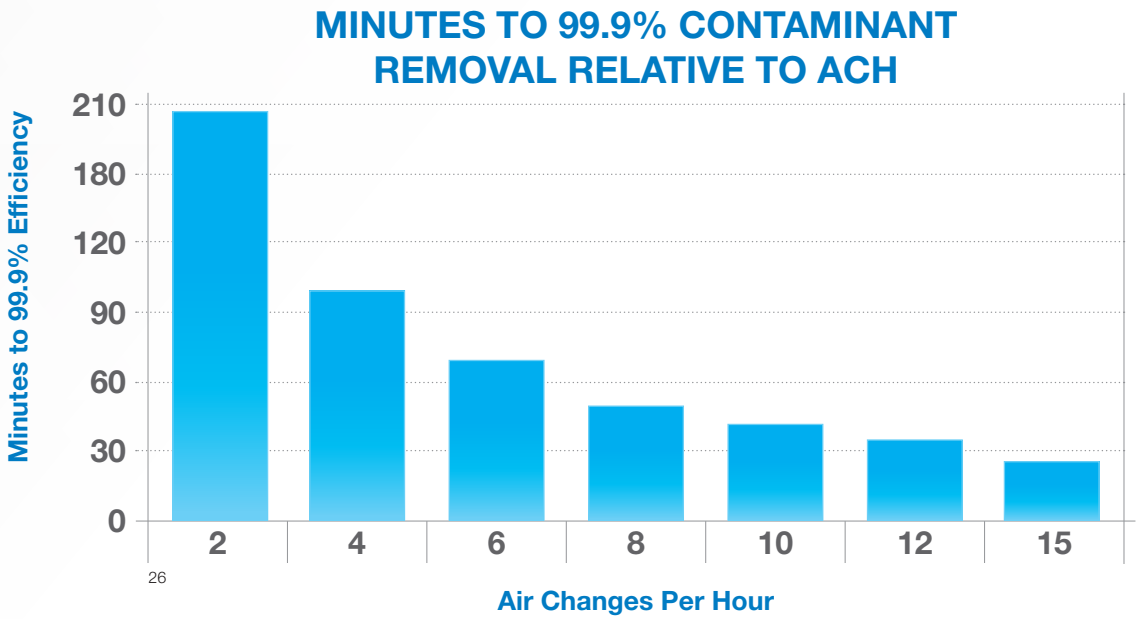
Ventilation reduces the concentration of particles and pathogens in the air in an indoor space. This can be accomplished by opening windows or by adjusting HVAC system air change rates to increase exhaustion of indoor air while bringing in outdoor air. This dilutes the concentration and reduces the level of exposure for residents.

ASHRAE and CDC guidelines indicate how many air changes per hour (ACH) various types of spaces within a building should receive. The higher the number of air changes per hour, the higher the dilution of contaminants.

RECOMMENDED GUIDELINES	
AREA	MINIMUM RECOMMENDED ACH
Operating Room	15
Intensive Care	6
LTC Resident Room	2
LTC Dining	4

26

At two ACH, it takes over three hours to remove 99% of a contaminant from the air. Increasing the number of air changes per hour will dilute the air faster, but the benefits diminish quickly:



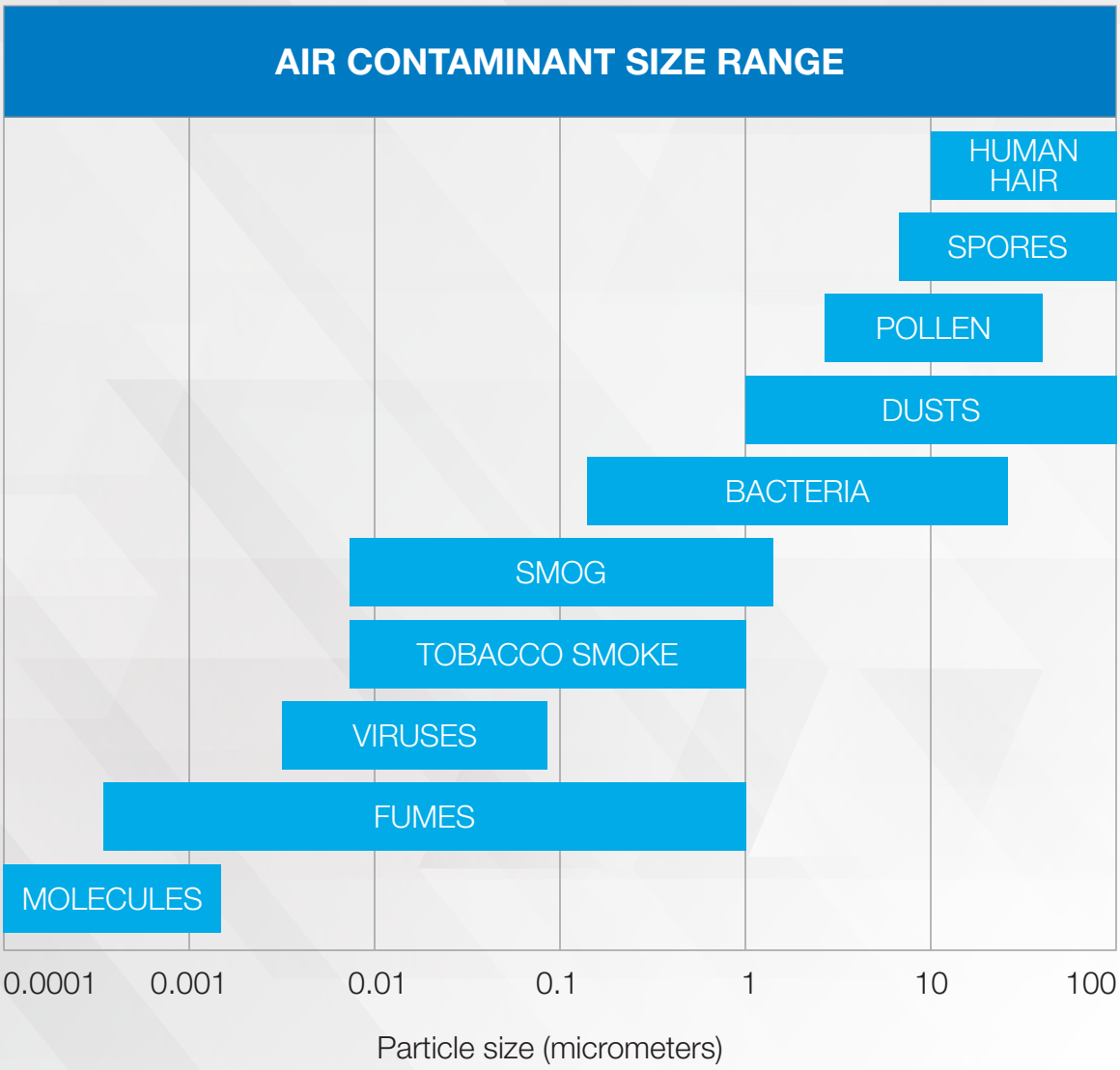
[26]

Some of the systems within Senior Living do not have the capabilities to meet the ventilation recommendations as fully as ASHRAE recommends. While packaged terminal air conditioners (PTACs) and rooftop units may provide some fresh air, the typical installation of these other systems makes it difficult to increase the fresh-air displacement within a specific area. Spaces that get low levels of ventilation may not effectively dilute contaminants in the air, such as pathogens. Additionally, in some cases, these systems may be designed to condition up to four or more resident rooms, which leads to air cross connection or cross-contamination. While these HVAC systems control the temperature in the space, there is rarely any capability to control the relative humidity within Senior Living facilities.

[26]"Guidelines for Environmental Infection Control in Health-Care Facilities (2003), Appendix B: Air." Centers for Disease Control and Prevention, Centers for Disease Control and Prevention, 22 July 2019, www.cdc.gov/infectioncontrol/guidelines/environmental/appendix/air.html.

The Role of Filtration in Reducing Air Pathogens

Filtration traps particles and pathogens from outside or recirculated/conditioned air in a filter as they pass through an HVAC system. Filters can be added to virtually all air handlers and can be rated based on the ability to trap particles or contaminants of a certain size.



One such measure is Minimum Efficiency Reporting Values (MERV) ratings, which provides a scale showing the effectiveness of filters at removing certain percentages of particles of different sizes. In general, filters with higher MERV ratings capture higher percentages of particles as well as smaller particles.

MERV Level	0.3 – 1µm %	1 – 3µm %	3 – 10µm %
5			20-35
6			38-50
7			50-70
8			>70
9		>50	>85
10		50-85	>85
11		65-85	>85
12		>80	>90
13	>75	>90	>90
14	75-85	>90	>90
15	85-95	>90	>90
16	>95	>95	>95

Source: ASHRAE IAQ Guide

ASHRAE recommends a MERV 13 rating or higher (or ISO equivalent) as sufficient to capture airborne viruses.[27] To achieve this rating, a filter has to catch 90% of particles in the 3-10 micron range, 90% of particles in the 1-3 micron range, and 50% of particles in 0.3-1 micron range.

Many Senior Living buildings use a variety of filters and MERV levels, ranging from MERV 4 to MERV 8, and not yet the higher MERV 13 recommended by ASHRAE. Installing higher MERV-rated filters into an HVAC system for which it was not specifically designed has the potential to increase energy consumption and resultant costs. In addition, a higher-than-recommended MERV filter could add resistance to the airflow, increase system pressure and energy use, reduce airflow and ventilation rates, affect comfort, freeze the air conditioner coil, damage the compressor or crack the heat exchanger. Confirm your system can support higher MERV ratings before making any changes.[28]

If there has been SARS-CoV-2 in your building, when changing filters they should be disposed of quickly and bagged as soon as possible with the maintenance person wearing a properly fitted respirator, eye protection, and gloves. The area should be sprayed with disinfectant and wiped clean when new filters are installed,[29] according to ASHRAE guidance.

[27] "Filtration/Disinfection: Ozone." The American Society of Heating, Refrigerating and Air-Conditioning Engineers, www.ashrae.org/technical-resources/filtration-disinfection#ozone.
[28] Bailes, Allison. "The Unintended Consequences of High-MERV Filters." Energy Vanguard, 9 Nov. 2018, www.energyvanguard.com/blog/unintended-consequences-high-merv-filters.
[29] "Filtration and Disinfection FAQ." The American Society of Heating, Refrigerating and Air-Conditioning Engineers, The American Society of Heating, Refrigerating and Air-Conditioning Engineers, www.ashrae.org/technical-resources/filtration-and-disinfection-faq.

Going Beyond Ventilation and Filtration

It's possible to go beyond what ventilation and filtration are able to achieve. Buildings can be engineered to control the movement of air via positive and negative pressure in specific areas. In addition, if MERV 13 filters are unavailable or unable to be added to your system, ASHRAE recommends considering ionization or UV treatment of the air.[30]

Air Ionization

Ionization creates ions that seek out and attach to airborne contaminants, including viruses. There are many different forms and manufacturers of ionization. Some solely create negative air ions (NAI), others solely positive air ions, and others are bipolar and create both positive and negative ions.

ASHRAE notes that some systems may emit ozone, including some at high levels, and urges anyone considering air ionization to consult manufacturer ozone generation test data to ensure any ionization systems are operating safely.

Ultraviolet Light

Ultraviolet light has long been known for its disinfection properties. Ultraviolet germicidal irradiation (UVGI) emits a specific band of UV light (radiation) that can break down pathogens, and is available in many applications to treat water, surfaces and indoor air. It can be deployed in several ways, including portable options, cabinets solely for air disinfection, upper room systems to avoid bodily contact or harm and in HVAC air handling units.

ASHRAE and IES (Illuminating Engineering Society) have established clear safety guidelines for using UV lighting, noting that "UVGI lamp emissions can pose a workplace safety and health hazard to the eyes and skin if the lamps are improperly used or installed."[31]

Direct Supply's Recommendation for Your HVAC System

For your HVAC system, Direct Supply recommends:

- Increasing outdoor air ventilation as much as a system will allow without negatively impacting the temperature and humidity needed for keeping residents safe and comfortable
- Enhancing filtration to MERV 13 or the highest level HVAC systems will allow based on size and/or pressure ratings
- Installing Needlepoint Bipolar Ionization to further enhance an HVAC system and proactively inactivate and reduce pathogens in the air

ASHRAE cautions "Even the most robust HVAC system cannot control all airflows and completely prevent dissemination of an infectious aerosol or disease transmission by droplets or aerosols."[3] Therefore, the most effective infection prevention and control strategies will require a combination of new technologies in addition to more conventional methods such as maintaining proper hand hygiene, use of PPE and widespread testing.

[30]"ASHRAE Epidemic Task Force, Schools & Universities." The American Society of Heating, Refrigerating and Air-Conditioning Engineers, The American Society of Heating, Refrigerating and Air-Conditioning Engineers, 5 May 2020, www.ashrae.org/file library/technical resources/covid-19/ashrae-reopening-schools.pdf.
[31]"IES Committee Report: Germicidal Ultraviolet (GUV) – Frequently Asked Questions ." Illuminating Engineering Society, Illuminating Engineering Society, 15 Apr. 2020, media.ies.org/docs/standards/IES-CR-2-20-V1-6d.pdf.

Section 3: Needlepoint Bipolar Ionization – The Proven Indoor Air Quality Solution to Reduce Exposure to SARS-CoV-2 and Other Pathogens

Getting as much outside air and using the most effective filter systems are the first steps in reducing the amount of pathogens in the air. As has been discussed though, this may not be possible nor sufficient. Evidence supports Needlepoint Bipolar Ionization (NPBI™) as an effective solution to reduce the amount of pathogens in the air.

How NPBI Technology Works

Global Plasma Solutions' (GPS®) patented NPBI technology uses an electric charge to create a high concentration of positive and negative ions, which has been shown to be more effective than monopolar systems that emit only negative or positive ions[32] through a study published in the Journal of Aerosol Science. As these ions travel with the air stream, they attach to pathogens, particles and gas molecules. The ions produced travel within the air stream into the occupied spaces of a building, cleaning the air everywhere the ions travel.

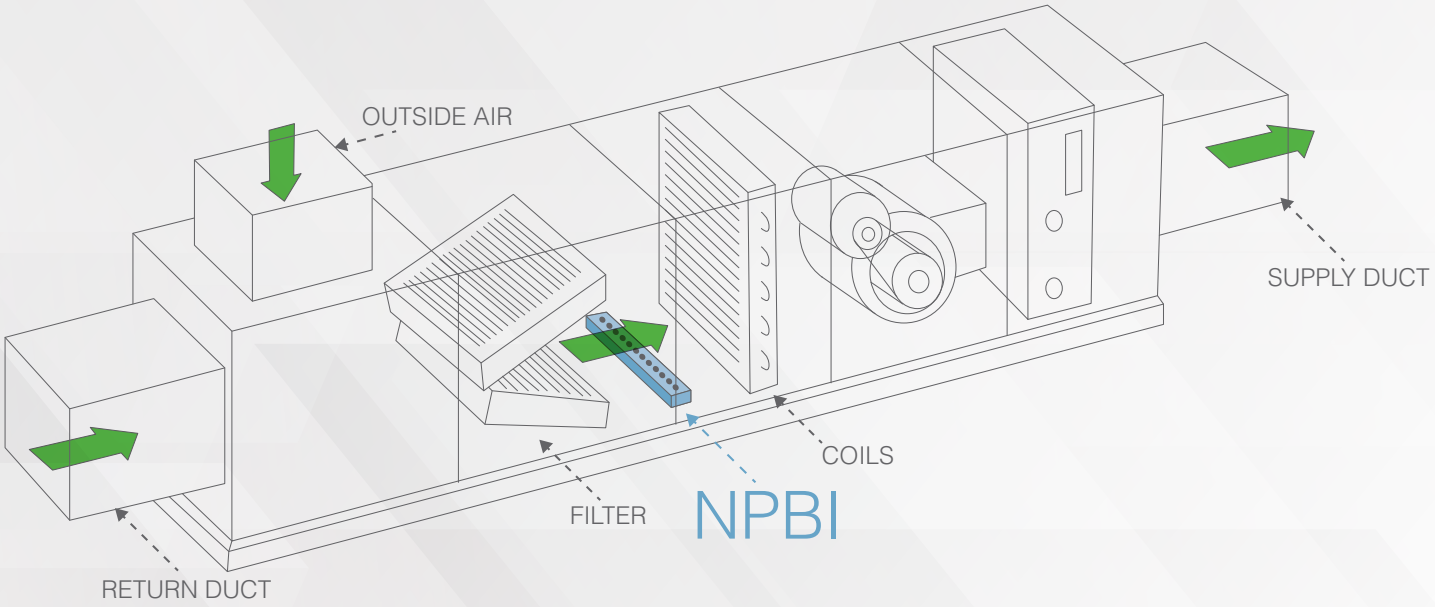
GPS's NPBI equipment is customizable to any HVAC system and matches system cubic feet per minute (CFM) to ensure levels of ionization (measured as ions per cubic centimeter) reach effective levels for controlling pathogens, particles and odors.

GPS PRODUCT CHART			
Auto cleaning line	**Voltage**	**CFM rating**	**Ions/cc/sec**
GPS-FC24-AC	24-240VAC	2,400	> 300 million
GPS-FC48-AC	24-240VAC	4,800	> 400 million
GPS-DM48-AC	24-240VAC	4,800	> 400 million
Bars & strips line	**Voltage**	**CFM rating**	**Ions/cc/sec**
GPS-iMOD	24-240VAC	50-250 CFM/in.	> 840 million/6 in.
GPS-iRIB-18	110-240VAC	3,200	> 35 million/ft.
GPS-iRIB-36	110-240VAC	3,200	> 35 million/ft.

[32]Hyun, Junho, et al. "Application of Corona Discharge-Generated Air Ions for Filtration of Aerosolized Virus and Inactivation of Filtered Virus." Journal of Aerosol Science, Pergamon, 11 Feb. 2017, www.sciencedirect.com/science/article/pii/S0021850216302798.

Where NPBI is Installed

The GPS iMOD® is designed to be installed after the blower and fan filter and before the dry side of the coils. Other GPS products have been designed for fan-coil mounting, in-duct mounting or even PTAC units. The GPS NPBI technology was designed to enhance your current levels of ionization by 1,500 to 15,000 ions per cubic centimeter in occupied space.



Surface Proteins: How NPBI Inactivates Pathogens

NPBI inactivates pathogens by creating positive and negative ions, which collide with these pathogens and disrupt their surface proteins. Several studies have proven ionization effective at inactivating pathogens, including: reovirus,[33] conducted and published by the Canadian Society for Bioengineering; MS2,[32] published in the Journal of Aerosol Science; and influenza,[34] published in Scientific Reports. That same study conducted using guinea pigs also showed that ionized air prevented the spread of influenza (0% transmission via ionized air vs. 75% in a control group).[34] Another preclinical study published in PLOS Medicine showed that ionized air reduced the spread of tuberculosis, also in guinea pigs.[35] GPS has conducted extensive research on NPBI's effect on a variety of pathogens, including SARS-CoV-2, MRSA, E.coli and C. diff.

Agglomeration: How NPBI Removes Particulate Matter

Particulate matter includes pollutants, dust, allergens, mold, bacteria and viruses. NPBI reduces airborne particles through agglomeration. The ions attach to airborne particles, and these particles are subsequently attracted to one another, effectively increasing their mass and size to be more easily captured by the air filtration system.

[33]Essien, Desmond et al. "Effectiveness of Negative Air Ionization for Removing Viral Bioaerosols in an Enclosed Space." The Canadian Society for Bioengineering, Paper No. CSBE17062, Aug. 2017, www.csbe-scgab.ca/docs/meetings/2017/CSBE17062.pdf.
[34]Hagbom, M., Nordgren, J., Nybom, R. et al. Ionizing air affects influenza virus infectivity and prevents airborne-transmission. Sci Rep 5, 11431 (2015). https://doi.org/10.1038/srep11431.
[35]Escombe, A Roderick et al. "Upper-room ultraviolet light and negative air ionization to prevent tuberculosis transmission." PLoS medicine vol. 6,3 (2009): e43. https://doi.org/10.1371/journal.pmed.1000043

Research published in the *Journal of Electrostatics* has demonstrated that ionization is effective for lowering particle counts, even in large spaces. "We conclude that air ionizers are more suited than high-flow air filters in removing ultrafine particles from rooms larger than about 25 cubic meters. The investigation also showed that small ions produced by the ionizer, placed in one room, were carried through the air conditioning system into other rooms, effectively removing particles from the air in these rooms in the process."[36]

One study in a highly polluted area of India showed a 76% reduction or decrease in particulate matter under 10 microns and 76% in particular matter under 2.5 microns.[37] NPBI was tested at an air travel command center and within 48 hours particles smaller than 0.3 microns were reduced by 87.2%, under 0.5 microns by 95.4%, and under 1.0 microns by 95.8%.[38]

NPBI Chemically Breaks Down and Neutralizes Odors

Chemical, pet, cooking and other odors, made of volatile organic compounds (VOCs), are broken down by NPBI into basic harmless compounds. This leaves indoor air fresh smelling and free of odor-causing VOCs.[39]

NPBI Testing and Results

To establish the effectiveness of NPBI, GPS partnered with several accredited third-party labs, including EMSL, ALG, and Innovative Bioanalysis. Most GPS testing has been conducted at an ionization level of 1,500 ions per cubic centimeter, which is similar to what will be found in occupied spaces inside buildings where NPBI technology has been properly installed. All tests are conducted against a control group, so comparisons can be made between the natural rate of decay for any pathogen and the efficacy of ionization.

GPS has conducted three kinds of tests:

1. Sensitivity: A petri dish containing a pathogen is placed underneath a laboratory hood, then monitored to assess the pathogen's reactivity to NPBI over time. This controlled environment allows for comparison across different types of pathogens.
2. Simulation testing: Counts of airborne pathogens are taken before and after aerosolizing them into a sealed, unoccupied laboratory environmental room installed with NPBI technology. The larger space more closely resembles a real-world environment.
3. Specialty testing: Unoccupied laboratory test environments are designed to evaluate NPBI performance in conditions unique to particular industries or customers and may include special circumstances such as higher-than-average ion concentrations.
4. Field testing: Measurements at actual customer locations can be compared in rooms with and without NPBI, or the same room before and after NPBI. Measurement variables and test criteria are determined by the customer. Pathogen findings occur as part of the customers' normal course of business and are not introduced specifically for testing purposes.

[36]Pushpawela, Buddhi. "Efficiency of Ionizers in Removing Airborne Particles in Indoor Environments." Journal of Electrostatics, Volume 90, December 2017, Pages 79-84, Elsevier, 12 Nov. 2017, www.sciencedirect.com/science/article/abs/pii/S0304388617302279.
[37]Mohammad, Seraj. "Managing and Monitoring Indoor Air Quality Using Bi-Polar Air Ionizer." Indian Journals, Invertis Journal of Science & Technology, 2019, https://www.indianjournals.com/ijor.aspx?target=ijor:ijst1&volume=12&issue=3&article=005.
[38]"Calgary International Airport Odor Control Case Study." Global Plasma Solutions, Global Plasma Solution, globalplasmasolutions.com/case-studies/Calgary-International-Airport-Case-Study.pdf.
[39]"Electron Volt (EV) Potential for Common Industrial Gases." Global Plasma Solutions, Electron Volt (eV) Potential for Common Industrial Gases, https://globalplasmasolutions.com/library/GP030-eV-Potential-Paper.pdf.

NPBI TESTING AND RESULTS			
Pathogen	**Test Time**	**Inactivation Rate**	**Test Agency**
SARS-CoV-2	30 minutes	99.99%	Innovative Bioanalysis
Human Coronavirus 229E	60 minutes	90.0%	ALG
E.coli	15 minutes	99.68%	EMSL
Legionella	30 minutes	99.71%	EMSL
Staphylococcus	30 minutes	96.2%	EMSL
MRSA	30 minutes	96.24%	EMSL
Norovirus (Feline Calicivirus)	30 minutes	93.50%	ATS Labs
Clostridium Difficile	30 minutes	86.87%	EMSL
Tuberculosis	60 minutes	69.09%	EMSL
Mold Spores	24 hours	99.50%	GCA

NPBI is Proven to Inactivate SARS-CoV-2

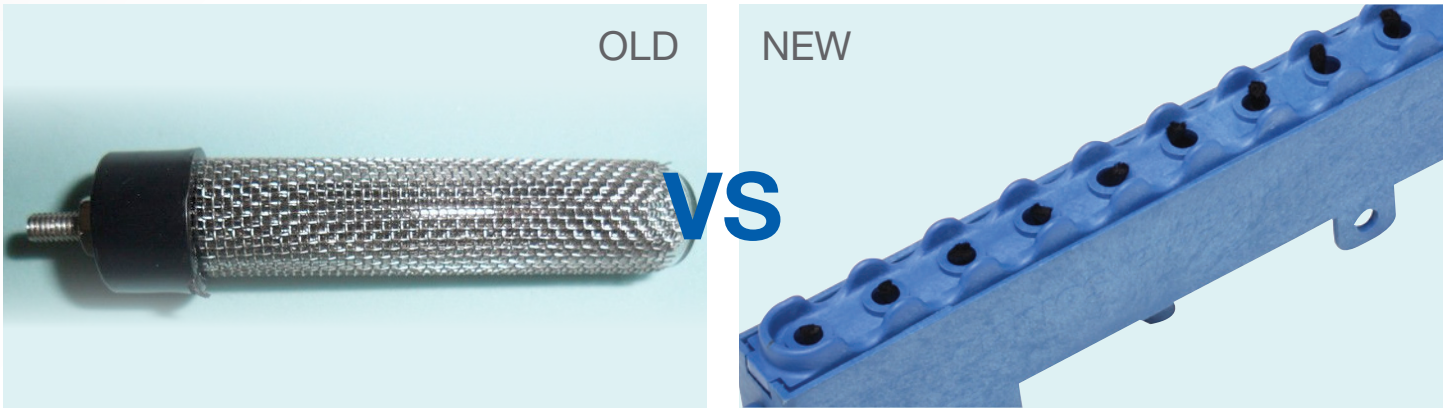
In August 2020, Aviation Clean Air tested the effectiveness of Global Plasma Solutions' NPBI technology on SARS-CoV-2, the virus that causes COVID-19. Aviation Clean Air has adapted NPBI technology for use in aircrafts, and the test was designed to simulate the level of ionization NPBI is able to achieve in an aircraft cabin: 27,000 ions per cubic centimeter. This test was conducted in a large 20' x 20' x 8' chamber by spraying several different surfaces with a viral solution, and then sampling the surfaces at specific intervals to measure how much of the virus had been inactivated relative to a control. The results showed between 99.89% to 99.99% of the virus was inactivated by NPBI.

It's important to note that this level of ionization is higher than typically used for GPS testing at 1,500 ions per cubic centimeter. While results will vary in any given environment, it is possible to compare the SARS-CoV-2 testing at 27,000 ions per cubic centimeter with other testing GPS has conducted on Human Coronavirus 229E, a different coronavirus but useful proxy. At 1,500 ions per cubic centimeter, 75% of the virus was inactivated in 30 minutes and 90% was inactivated within 60 minutes.

Ionization is Safe for Building Occupants

Two thorough metastudies have assessed the safety of ionization. “Air Ions and Respiratory Function Outcomes: A Comprehensive Review” concludes the reviewed human experimental studies “do not indicate a significant detrimental effect of exposure to positive air ions on respiratory measures. Exposure to negative or positive air ions does not appear to play an appreciable role in respiratory function.”[40] Another comprehensive review, “Negative Air Ions and Their Effects on Human Health and Air Quality Improvement found “no data showed the harmful effect of negative air ions on humans/animals.”[41]

Moreover, in contrast to older forms of bipolar ionization, usually referred to as corona discharge systems, Needlepoint Bipolar Ionization was specifically engineered not to produce ozone. ASHRAE recommends keeping ozone levels beneath 10 ppb and warns that some ionization technologies can create ozone,[27] which is known to be harmful.[42] GPS offers products that have passed the extremely stringent UL 2998 certification, which requires products to not produce ozone at levels higher than 5 ppb (0.005 ppm).



Reach Ionization Levels That Have An Impact

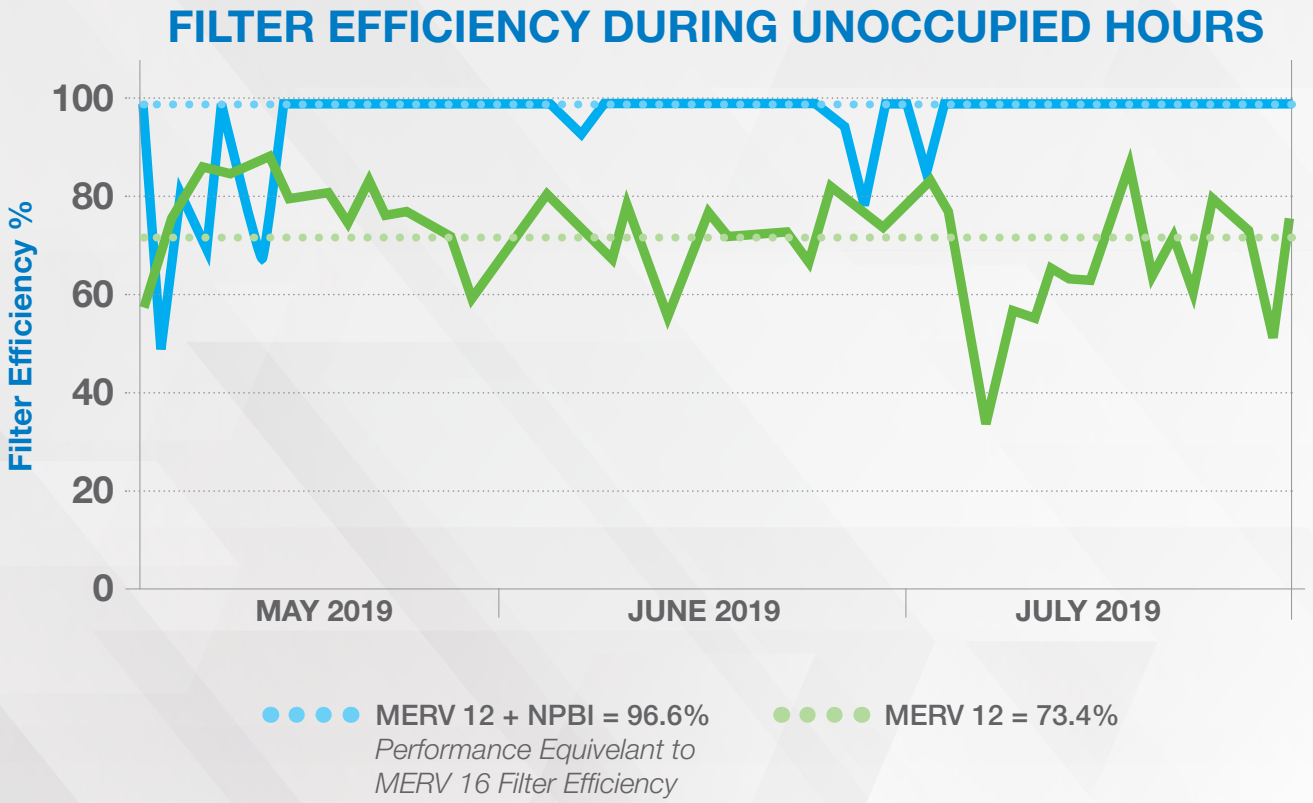
NPBI technology from Global Plasma Solution was designed to enhance your current levels of ionization by 1,500 to 15,000 ions per cubic centimeter, so it is important to test NPBI installations to confirm appropriate levels of ionization are being reached in your building. All testing should measure both positive and negative levels.

[40]Alexander DD, Bailey WH, Perez V, Mitchell ME, Su S. Air ions and respiratory function outcomes: a comprehensive review. J Negat Results Biomed. 2013;12:14. Published 2013 Sep 9. doi:10.1186/1477-5751-12-14, https://pubmed.ncbi.nlm.nih.gov/24016271/.
[41]Jiang, Shu-Ye et al. “Negative Air Ions and Their Effects on Human Health and Air Quality Improvement.” International journal of molecular sciences vol. 19,10 2966. 28 Sep. 2018, doi:10.3390/ijms19102966, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6213340/.
[42]“Environmental Health Committee (EHC) Emerging Issue Report: Note: Emerging Issue Reports Are Developed and Approved by the ASHRAE Environmental Health Committee (EHC). The Ozone and Indoor Chemistry Emerging Issue Report Was Approved by EHC in January 2011. Page 1 of 2 Ozone and Indoor Chemistry .” The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Jan. 2011, www.ashrae.org/file library/communities/committees/standing committees/environmental health committee (ehc)/ehc_emerging_issue-ozoneandindoorairchemistry.pdf.

NPBI Augments Existing, Complementing Infection Control Strategies

Filtration

NPBI improves the effectiveness of the filters you are already using, including a four- to five-fold increase in the efficiency of a filter when challenged with viable bacteria.[34] A study found NPBI combined with a MERV 12 filter removed as many 2.5 micron particles as a MERV 16 filter.[43]



PPE

Ionization has been found to increase the effectiveness of N95 masks and surgical masks, with the largest improvements found in the least-efficient masks. According to a study published in the Invertis Journal of Science & Technology conducted in a controlled environment using manikins, N95 mask effectiveness was increased from 98% to almost 100%, and surgical mask effectiveness increased from less than 80% to over 98%, even for the smallest particles.[44]

Conclusion

Maintaining the safety of Senior Living buildings, staff, residents and visitors is of the highest priority. The exposure to HAIs via surfaces, droplets and aerosols poses one of the greatest threats to that critical mission. HVAC systems play an important role by interrupting the indoor dissemination of infectious aerosols thereby reducing airborne exposure to pathogens. To support this goal Direct Supply recommends enhancing ventilation and filtration of HVAC systems with the addition of Needlepoint Bipolar Ionization.

[43]Nilsson, Greg. "Field Evaluation of GPS Needlepoint Bipolar Ionization." 27 Mar. 2019.
[44]Lee, B.U., Yermakov, M. and Grinshpun, S.A. (2005). Filtering Efficiency of N95- and R95-Type Facepiece Respirators, Dust-Mist Facepiece Respirators, and Surgical Masks Operating in Unipolarly Ionized Indoor Air Environments. Aerosol Air Qual. Res. 5: 25-38. https://doi.org/10.4209/aaqr.2005.06.0003