Building Value

ABM AIR DISINFECTION TECHNOLOGY POSITION PAPER

Expert Advisory Council | September 2021

Overview

As in all aspects of life, we do not have control over every factor. As we contemplate re-entry into our facilities we must accept the fact that we may not be able to control occupant choices, but we do have control over the facilities and their ability to provide pandemic resilience. ABM has a plan that embraces this reality. Alongside our clients, we are addressing facility pandemic resilience with a multi-layered approach. This approach begins with risk assessment that then leads our clients to engineering and administrative controls and several air disinfection technologies with systematic reviews by ABM's Expert Advisory Council (EAC). These solutions will lead clients to improved pandemic resilience, better indoor air quality, increased confidence and health for occupants returning to facilities, and improved posture for any subsequent pandemics. Included in heating, ventilation, air conditioning (HVAC), lighting, and single room engineering controls, there are a multitude of ionization and ultraviolet light (UV-C) technologies on the market. The EAC vetted many of these technologies, but it collectively approved only a relatively small number that met both regulatory safety requirements and effectiveness criteria.

The EAC's vetting and approval process included rating each technology according to safety as it relates to engineering, administrative, and personal protective equipment (PPE) controls needed to operate and maintain the technology. The process included evaluation of laboratory, case study, and peer-reviewed research available regarding the efficacy and/or effectiveness of the technology's ability to inactivate viruses as a contribution to overall indoor air quality. Each technology was also evaluated according to its cost effectiveness and application for client needs across all industries.

As a result of this evaluation process, ABM can present the below options for air disinfection technology to help improve the overall indoor air quality of facilities and provide occupants with reassurance their health and safety is a top priority.

Ionization Technologies

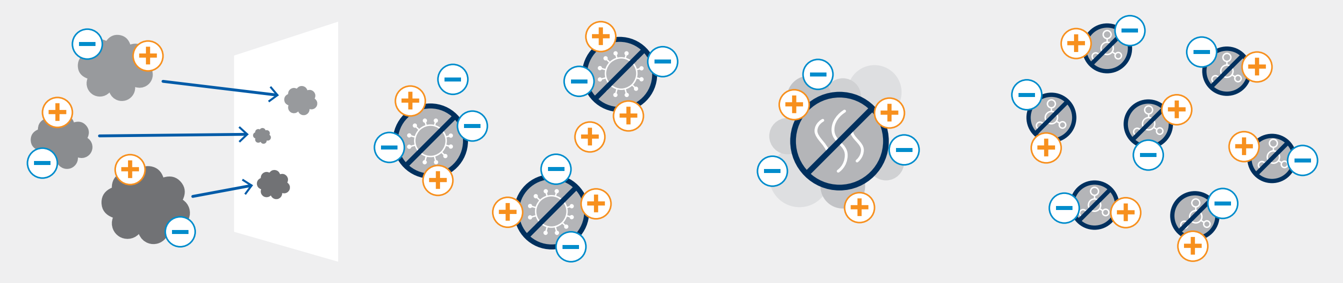
Types of Ionization Technologies

TYPE #1: NEEDLEPOINT BIPOLAR IONIZATION (NPBI)

NPBI technology relies on natural air-cleaning agents: electrically charged oxygen ions. NPBI technology within HVAC systems uses an electronic charge to create a plasma field filled with a high concentration of + (positive) and – (negative) ions. As these ions travel with the air stream, they attach to particles, pathogens, and gases. The ions help to agglomerate (to stick together) fine sub-micron particles into larger particles, making them filterable. The ions disinfect pathogens by robbing them of life-sustaining hydrogen. The ions also break down larger (and often foul smelling) volatile organic compounds (VOCs) such as ethylbenzene and xylene, into smaller compounds like oxygen (O_2), carbon dioxide (CO_2), nitrogen (N_2), and water (H_2O). The ions produced by the technology travel within the air stream into the occupied spaces, cleaning the air where the ions travel and have demonstrated effectiveness on a broad range of airborne contaminants as well as unpleasant odors.

With NPBI, the ions generated typically last for about 30 seconds in the air stream. Typical duct design is for 1,000 feet per minute (FPM) air velocity. Therefore, in 30 seconds, the ions will travel about 500 feet. If the ductwork and air distribution system is longer than 500 feet (unusual except for large variable air volume (VAV) systems), consult the engineering team to determine where best to install the technology. In VAV systems, you may be better off installing the ion generators at the VAV boxes.

Maintenance on smaller (non-bar type) generators and larger (bar-type) generators is minimal and consists of using compressed air to clean any built-up dust off the carbon fiber nanotubes or bar points. Given the ease of cleaning, we recommend doing this each time filters are changed on that unit. Anecdotal evidence exists that claims reduced biological build up on the wet side of the cooling coil when the ion generators are installed upstream of the cooling coil. While this is still in the process of additional research, it may lead to reduced coil cleaning effort and reduced labor on annual maintenance for larger air handlers.



Airborne particles are charged by the ions cuasing them to cluster and be caught in filters

Bacteria and viruses bond with oxygen ions and are inactivated

Many odorous gase and aerosols oxidize with oxygen ions and are neutralized

Oxygen ions cause a reaction with VOCs breaking down their molecular structure

SOURCE

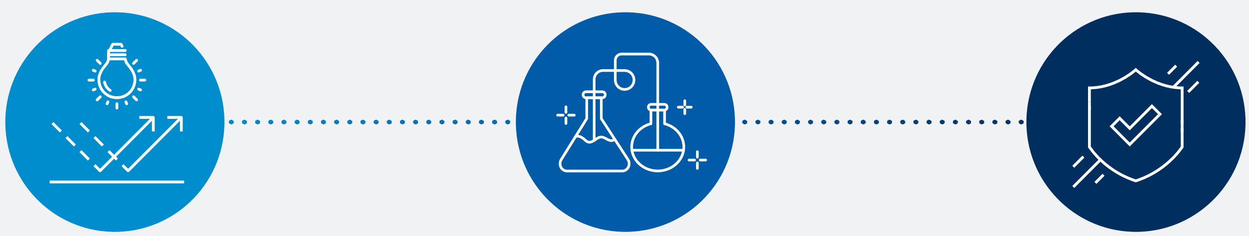
Types of Ionization Technologies (cont.)

TYPE #2: HVAC DRY HYDROGEN PEROXIDE (DHP) GENERATION

Unlike aqueous (wet) hydrogen peroxide technologies, dry hydrogen peroxide technology is a gas-phase hydrogen peroxide generating process placed inside HVAC ductwork and uses a catalytic converter to react with a multi-wavelength ultraviolet light to illuminate a target surface. The target surface is a honeycomb matrix treated with a proprietary photocatalytic coating. It then converts water and oxygen molecules found naturally in the humidity of the air into safe but effective levels of hydroxyl radicals (OH-), oxygen ions (O_2-) and hydrogen peroxide (H_2O_2). These safe levels of ions and H_2O_2 provide a substantial germicidal impact verified in field studies at hospitals, universities and many other industries. This technology is UL certified to produce no ozone and generates hydrogen peroxide levels less than 1/100th of the Occupational Safety and Health Administration (OSHA) airborne limits.

These devices come in a variety of sizes and a combination of these units can be used to cover a facility. Depending on the unit, the device will cover 400, 1000, 2500, or 5000 square feet. The self-contained unit is installed by drilling a small hole into the side of the HVAC duct, inserting and securing the unit, plugging it in, and turning it on. This technology is great for elevators, kitchen areas, and restrooms given that the larger ions will act additionally to disinfect surfaces.

Maintenance on these devices often consists of removing the unit from the ductwork and wiping down the titanium dioxide screen several times annually. Additionally, the UV-C lamp that triggers the reaction needs to be replaced around the two-year mark.



An ultraviolet light source shines against a metallic surface.

This transforms air and water into hydrogen peroxide to be distributed in the air and onto surfaces.

This provides a strong level of protection against pathogens.

SOURCE

Considerations for Ionization Technologies

CONSIDERATION #1: OZONE PRODUCTION

Ozone exposure, by itself, can be a human health concern since it is capable of producing lung irritation and can aggravate other lung diseases, such as asthma and emphysema. Ozone, in combination with certain cleaning chemical vapors, can increase airborne particle concentrations, resulting in aggravation of lung conditions, even though many ionization technologies are known for their ability to reduce airborne particles.[2] For these reasons, ozone generation becomes a very important factor in indoor air quality.

Most ionization technologies do produce ozone, but all of the ABM approved ionization technologies have earned Underwriters Laboratories certification 867 and/or 2998, proving that their ozone production is below all regulatory standards including the Occupational Safety and Health Administration (OSHA), the Environmental Protection Agency (EPA), the National Institute of Occupational Safety and Health (NIOSH), the Food and Drug Administration (FDA) and the California Air Resources Board (CARB).[8] This means that for ABM approved ionization technologies, the ozone concentrations, if any are produced, are within regulatory requirements.

CONSIDERATION #2: EFFECTIVENESS IN INACTIVATING THE SARS-COV-2 VIRUS

No air disinfection technology, including ionization, is 100% effective in inactivating a virus in real-world, non-laboratory conditions. This is one of the reasons why ABM considers ionization technologies as just one component of creating facility pandemic resilience in its EnhancedFacility program. The effectiveness or efficacy of ionization technologies in the inactivation of viruses depends on a number of factors, including the concentration of ions produced in the space, the continuous clean air delivery rate for effective mixing and distribution of the ions, and sources of infection in the facility. Ionization technologies, when coupled with other engineering and administrative changes, such as optimized HVAC performance and source controls, improves not only infection control resilience but also the overall indoor air quality.[4,5,6,7]

CONSIDERATION #3: VOLATILE ORGANIC COMPOUND (VOC) PRODUCTION

Volatile organic compounds are a broad assortment of gases in the air that are capable of producing a wide range of health issues. In indoor spaces, VOCs can result from cleaning chemicals, furniture, carpeting, lumber materials, and other furnishings. In addition to these sources, ABM acknowledges there can be an increase in some airborne (VOC) concentrations from some ionization technologies. However, for all ABM approved technologies, the VOC concentrations are in the part per billion concentration range, which is well below regulatory and guideline concentrations for VOCs of concern in the research studies available to date. In other words, the concentration of VOCs produced in the air by ABM's vetted and approved ionization technologies is very low, and not a health concern according to OSHA regulatory limits. This conclusion is in accordance with research studies that have evaluated this consideration.[1,3]

CONSIDERATION #4: OCCUPANT SAFETY

The ABM approved ionization technologies do not pose the same occupant skin and eye hazards that some ultraviolet (UV-C) solutions can introduce into facilities. ABM carefully screens ionization air disinfection solutions to ensure safety for both the facility maintenance staff and occupants is upheld as a high priority.

UV-C Technologies

Ultra-violet Background

Ultra-violet (UV-C) light, which can inactivate harmful microorganisms, is among the most recognized and effective technologies for air and surface disinfection. UV-C has been recognized as beneficial in reducing environmental pathogens and protecting healthcare patients and building occupants from contaminated air, surfaces, and water. Recently, extensive work has been done to better understand the broader spectrum of ultraviolet light and how to apply those findings in the indoor environment. UV-C technologies operate at either 254 or 222 nanometers in wavelength, which are the most common germicidal wavelengths used in today's air and surface disinfection technology. The most common UV-C wavelength is 254 nm, but it can pose health hazards upon direct exposure to the skin and eyes. UV-C at 222 nm, known as "far-UV", is a rapidly emerging technology wavelength that poses little hazard to human health since this wavelength does not penetrate skin and eyes like UV-C at 254 nm. While germicidal effectiveness of UV-C light depends upon a number of factors, the three primary factors directly associated with the technology effectiveness are:

- **Wavelength** of the UV-C (254 or 222 nanometers)
- **Length of time** the microorganism is exposed to UV-C
- **Intensity or closeness** of the UV-C to the microorganisms

Types of UV Technologies

There are currently four categories of UV-C technology solutions to consider, which are outlined below.

TYPE #1: UPPER ROOM UV-C

Upper room UV-C has the longest track record of all the solutions. Special fixtures irradiate the air in a room at 7 feet or above, so it can be safely used in rooms that are occupied. These fixtures have been successfully used to control the spread of airborne pathogens in hospitals, prisons, clinics, and government buildings for over 60 years. The fixtures incorporate adjustable louvers that safely direct UV-C energy above contact level (7+ feet) with occupants, ensuring the fixture disinfects the air in both occupied and unoccupied rooms. As a result of these safety and technology factors the following should be considered:

- **Ensure adequate ventilation or air mixing is present since the fixture is dependent on pathogens reaching the upper portion of the space.**
- **Careful installation is required to ensure the louvers or other mechanisms for directing the UV-C light are well above head level for all potential occupants.**

TYPE #2: FIXED-AIR HANDING UNIT UV-C

Fixed-air handling unit UV-C directs a light fixture on HVAC drain pans, supply ducts, and cooling coils where pathogens may flourish. HVAC UV-C light fixtures installed in plenums are typically designed as HVAC air disinfection systems and are directed at drain pans and cooling coils to address potential pathogen sources. To better address recirculated air in facility disinfection and not just the HVAC sources, more technologies are offering 360-degree application so that the overall airborne germicidal effectiveness is improved. As this technology is evaluated, the following points should be considered:

- **Ensure systems have 360-degree application of UV-C light for the best germicidal outcomes:**
  - **Banks of UV-lamps installed inside HVAC units or associated ductwork; positioned parallel or perpendicular to airflow**
  - **Requires increased dose of UV to inactive microorganisms on-the-fly as they pass through the disinfection zone**
- **Fixtures must be mounted in careful configurations to ensure important factors, such as contact time and intensity, are addressed in delivering an effective dose of UV-C radiation.**
- **Require an increased dose of radiation to boost air disinfection beyond that needed for killing biofilm on cooling coils and drain pans to achieve a minimum UV-C exposure time of 0.25 seconds per ASHRAE guidelines.**
- **Individual HVAC UV-C air disinfection devices can be mounted to plenum walls or configured, so multiple fixtures can mount to frame assemblies that address supply ducts or cooling coils. Keep in mind that air is typically moving at 1,000 feet per minute in supply ductwork, so these arrays are normally much larger than those in the slower parts of the air stream.**
- **UV-C lamps are made with a very high-quality glass so that the radiation used to eliminate biological growth from either algae or pathogen is generated consistently. Maintenance of the UV fixture includes lamp replacements approximately once every 2 years. Maintenance is not inexpensive, but it is necessary to continue to get the indoor air quality benefits. Keep in mind that the typical array of lamps required to generate enough of a dose (measured in microwatts per square centimeter) to disinfect a cooling coil is only about 1/3 of the minimum dose needed to disinfect the air for a pathogen like COVID (1500 microjoules/cm^2).**

Types of UV Technologies (cont.)

TYPE #3: INSTALLED UV-C LIGHTING

Far UV-C at 222 nm is a UV-C technology that has been getting more recent recognition in the market as a safer alternative to fixtures utilizing UV-C at 254nm. According to research, it holds promise for delivering germicidal effectiveness without harming human skin or eyes with minimized exposures controlled by engineered safety features. Far-UV lighting is equipped with a 222-nanometer light source to inactivate microbes. Inactivation depends on the type of microbe, distance from the source, and duration.

- **As a result of improved safety at this wavelength, this technology may be especially useful in downlighting and air-circulating troffers.**

TYPE #4: MOBILE UV-C LIGHTING

The use and maintenance of UV-C (or ultraviolet germicidal (UV-GI)) mobile devices require specialized training. UV-C shielding must be in place between the UV-C energy source and the operator, and physical barriers must be in place to prevent facility occupants from entering the room while the device is operational. Safety equipment and actions that protect the eyes and skin must be used to prevent human exposure to the radiation, such as normal glass which can be used as a protective barrier.

"No-touch" (automated) mobile UV-C devices have been shown to reduce pathogenic contamination of surfaces after manual cleaning. Most UV-C mobile disinfection devices use one of the following UV-C sources:

- **Germicidal low-pressure mercury lamps that emit energy within the highest range of bacterial efficacy (200-280 nm)**
- **Pulse xenon that emits high intensity, pulses of UV-C light that cover the entire germicidal spectrum (210-280 nm)**
- **Far-UV, which operates at an even shorter, more germicidal wavelength, and is considered a rapidly emerging technology in lighting applications with greater occupant safety as described above with regard to fixed lighting.**

Considerations for All UV-C Disinfection Technologies

CONSIDERATION #1: SAFETY

All the current UV-C applications require specialized training and installation as well as scrupulous attention to safety features, application procedures, and controls. UV-C in the range of 231-280nm must be shielded from humans as it poses potential cancer safety risks to the skin and risks damage to the eyes. While some wavelengths are proving to be less harmful to the skin and eyes (e.g. far-UV), excessive and unprotected exposure to UV-C radiation, just like sunlight, should be minimized or eliminated according to its potential hazards. Also, employing safety engineering controls for all the technologies should always be a priority consideration. [9,10]

CONSIDERATION #2: MAINTENANCE AND EFFECTIVENESS

UV-C technology does have some limitations with regard to the relationship between maintenance and effectiveness. Facilities with UV-C technology installed will still require proper cleaning of surfaces in order to enable the UV-C disinfection. If the organism is somehow protected from UV-C by surface soil or debris, this may improve the microorganism's ability to withstand the effects of the UV-C exposure.[11]

CONSIDERATION #3: ENVIRONMENT AND EFFECTIVENESS

Additional environmental factors that influence the germicidal effectiveness include air mixing, environment humidity, and photo reactivity (the pathogen's sensitivity to UV-C). [12,13]

Conclusion

Conclusion

There is a wide variety of indoor air quality technologies out there, and more and more are coming to market each day. When cutting through the noise and determining which technologies to use in a facility, it is important to use a trusted advisor who has done proper research and vetting of all solutions to provide a customized solution for your space.

When considering the best technologies for your space, there are many factors to consider. This includes your current facility risk level and key risk drivers, occupant expectations, budget, facility archetype and restrictions, and timelines. The table below is a great summary to help you understand key factors around each technology category that could influence your decision. ABM can help you understand which is best aligned to your needs, as well as advise on which specific vendors in each category have been vetted by our EAC.

CRITERIA	IMPORTANCE OF CRITERIA	Technology Categories Approved by ABM*							Comparison
Technology Type		Needlepoint Bipolar Ionization (NPBI)	Dry Hydrogen Peroxide	Upper room / UV-C HVAC systems / UVGI (254 nm)	Downlights - Far-UV (222 nm)	HEPA or MERV 13+ Filtration	Portable / Mobile Air Cleaners	LED (280-405 nm)	MERV 6-12 Filtration - Common
Technology Mechanism of Action	Mechanism impacts occupant safety and disinfection efficacy	Ionization	H2O2	Ultraviolet Irradiation	Ultraviolet Irradiation	Filtration Media	Filtration & Ionization	Ultraviolet Irradiation	Filtration Media
Air or Surface Disinfection	The application determines whether both are needed	Both	Both	Both	Both	Air	Air	Air	Air
Effective For Inactivating Viruses	Physically trapping with filters is different than inactivation	🟢	🟢	🟢	🟢	🟢	🟡	🟢	🟠
Effective Against Bacteria and Mold	Physically trapping with filters is different than kill	🟢	🟢	🟢	🟢	🟢	🟡	🟢	🟠
Effective Against Gases and Odors	Gases and odors are often the first motivation to address IAQ	🟢	🟢	🟠	🟠	🟠	🟡	🟠	🟠
Effective Against Dust/Particulates	Viruses are aerosols that act like dust particles	🟢	🟢	🟠	🟠	🟢	🟢	🟠	🟡
Below Regulatory Limits for Ozone or Safety Hazards	Ozone is a health hazard and a common by-product of some unapproved technologies	🟢	🟢	🟡	🟢	🟢	🟢	🟢	🟢
Units Applied In HVAC Systems, Portable or Stationary Single Room	The application determines which capability is needed	Both	Both	Both	Room	HVAC and Portable	Portable	Both	HVAC and Portable
Installation Effort Level	Based upon the time and complexity of the installation	Low	Low	Moderate - High	Moderate - High	Moderate	Moderate	Low	Low
Maintenance Requirement Level	Based on replacement part cost and frequency	Low	Moderate	Moderate - High	Moderate - High	Moderate	Moderate- High	Low	Moderate
Energy Savings	The time for return on investment can be impacted by energy efficiency	High	Moderate	Low	Low	Low		High	Low
Return- On- Investment Level	ROI takes into account installation, operational and maintenance costs	High	Moderate	Low	Moderate	Moderate	Low	High	Low

Sources

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