Bi-Polar Ionization

What is the science behind it and what to consider?

Presented by: Andy Daniels, Bill Freeman, Ben Patterson and Tom Beutell

Facilities Management Conference

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Andy

Viruses and COVID- size- filtering- killing

HVAC Engineering Controls

Increase OA

(Ultra-Violet)

Increase to MERV 13 for Filtration

UV

Air Purification

Ionization

What is ionization?

How does it work?

Studies? EPA/ASHRAE/UL

Type of Bipolar equipment? Sizes/ portable?

Testing- ACI unit

What to consider-

All options

Your budget

Your existing HVAC equipment

Maintenance

Life expectancy

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Introduction – CDC & ASHRAE

Centers for Disease Control & Prevention (CDC)

- US Federal Agency, under the Department of Health and Human Services, and is headquartered in Atlanta, Georgia.

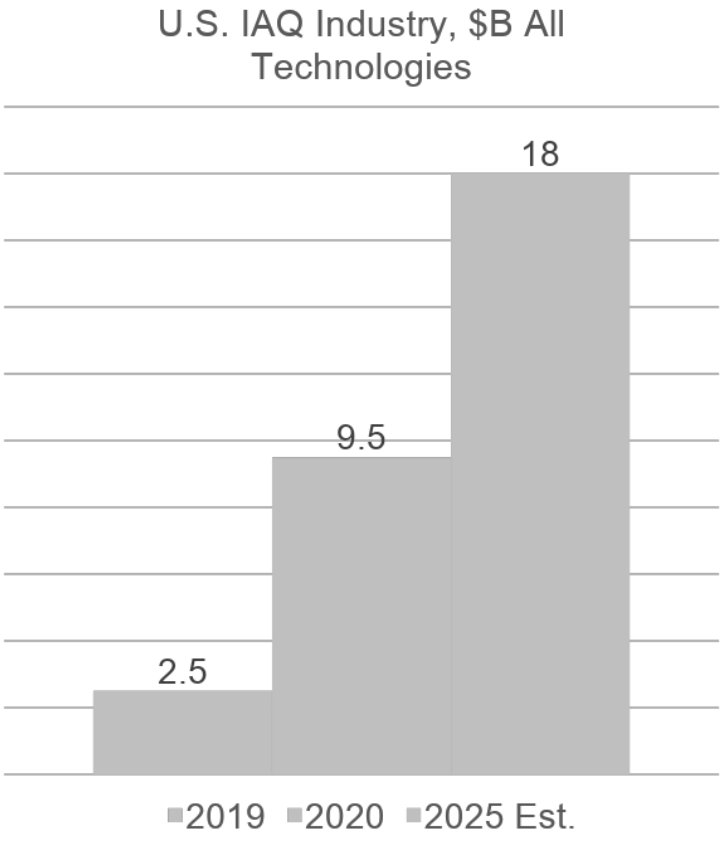
  https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html

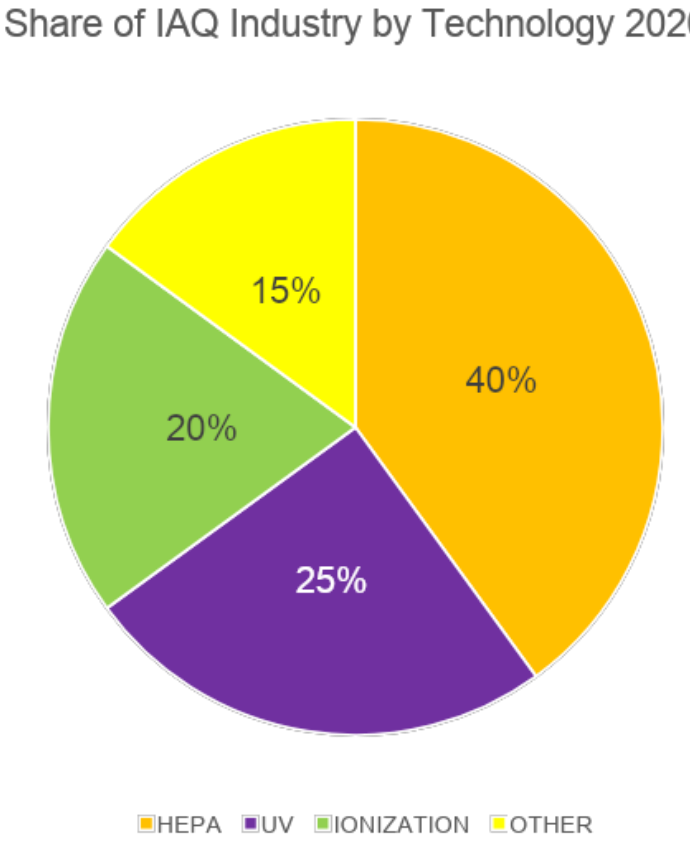
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

- **Mission:** "To serve humanity by advancing the arts and sciences of heating, ventilation, air conditioning, refrigeration and their allied fields."
- "State-of-the-art" design criteria
- Epidemic Task Force for Schools and Universities
  www.ashrae.org/covid19

Bill

INDOOR AIR QUALITY IS A LARGE & GROWING SEGMENT



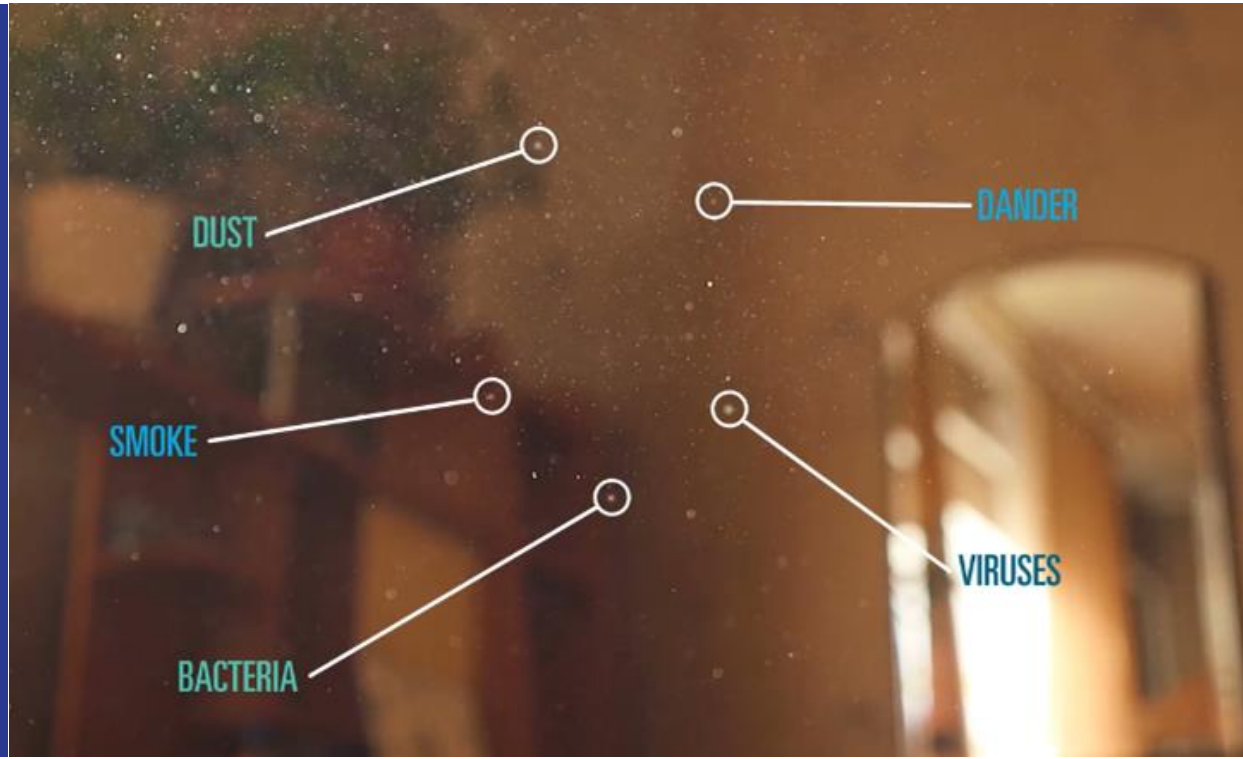


Source: Management estimate prepared by outside consulting firm

Bill

PARTICLES IN THE AIR DEGRADE AIR QUALITY

The air around us is filled with particles. A sunbeam through a window makes it possible to see some of these particles which can include dust, dander, smoke, and even certain viruses and bacteria.



Tom/Bill

AIR QUALITY INDEX

- There is no standard defining what is good or bad indoor air quality.
- The EPA's air quality index for outdoor air can be used as a proxy for indoor air.
- Think of the AQI as a yardstick that runs from 0 to 500. The higher the AQI index value, the greater the level of air pollution and the greater the health concern.

AQI Category	Index Values	Breakpoints (µg/m^3), 24 hr avg
Good	0-50	0-12
Moderate	51-100	12.1-35.4
Unhealthy for Sensitive Groups	101-150	35.5-55.4
Unhealthy	151-200	55.5-150.4
Very Unhealthy	201-300	150.5-250.4
Hazardous	>301	>250.5

https://www.epa.gov/outdoor-air-quality-data/air-data-basic-information

https://www.epa.gov/sites/default/files/2016-04/documents/2012_aqi_factsheet.pdf

Tom/Bill

ASHRAE – Design Recommendations

General – Schools & Other Public Buildings

- Temp. & Humidity
  - Winter – 72F & 40%-50% RH
  - Summer – 75F & 50%-60% RH
    - Less humid air – viral droplets lose water content and become more aerosolized. This likely increases the rate of transmission.
- Ventilation Design Criteria/Guideline
  - Follow ASHRAE 62 for outside air requirements
  - During pandemic, disable any Demand Control Ventilation (DCV) and maximize outside air 24/7.
- Filtration Design Criteria/Guideline
  - Apply the highest Minimum Efficiency Reporting Value (MERV) for the HVAC units.
  - MERV 13 is recommended, if equipment can accommodate pressure drop.

Bill

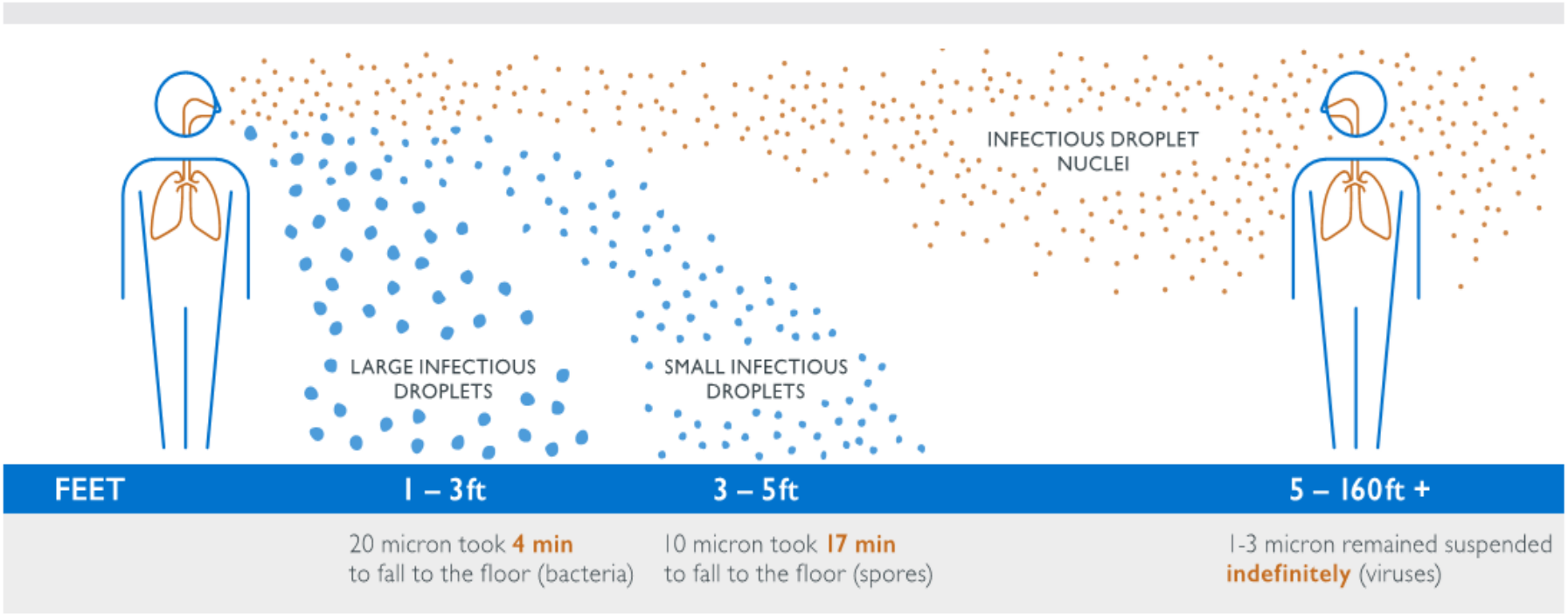
ASHRAE – Design Recommendations Continued

Operation & Scheduling Guidelines during Pandemic

- Cooling & Heating Equipment
  - Change the start and end times to run at least 2 hrs before & after occupancy.
  - Consider running 24/7
- Exhaust Fans – Turn on when DOAS is running
  - Only school days
  - Goal is to flush the building with OA and create slight positive pressure.
- Dedicated Outdoor Air Systems (DOAS)
  - Run units 2 hrs before & after occupancy.
  - New units – “Purge/Flush” mode for operations to min. virus transmission.
- Energy Recovery Systems
  - Some systems allow for exhaust air transfer from the exhaust airstream to the supply airstream. Depending on system configuration, this may be cause for concern.
  - Discontinue use/forget everything you have learned about saving energy!

Bill

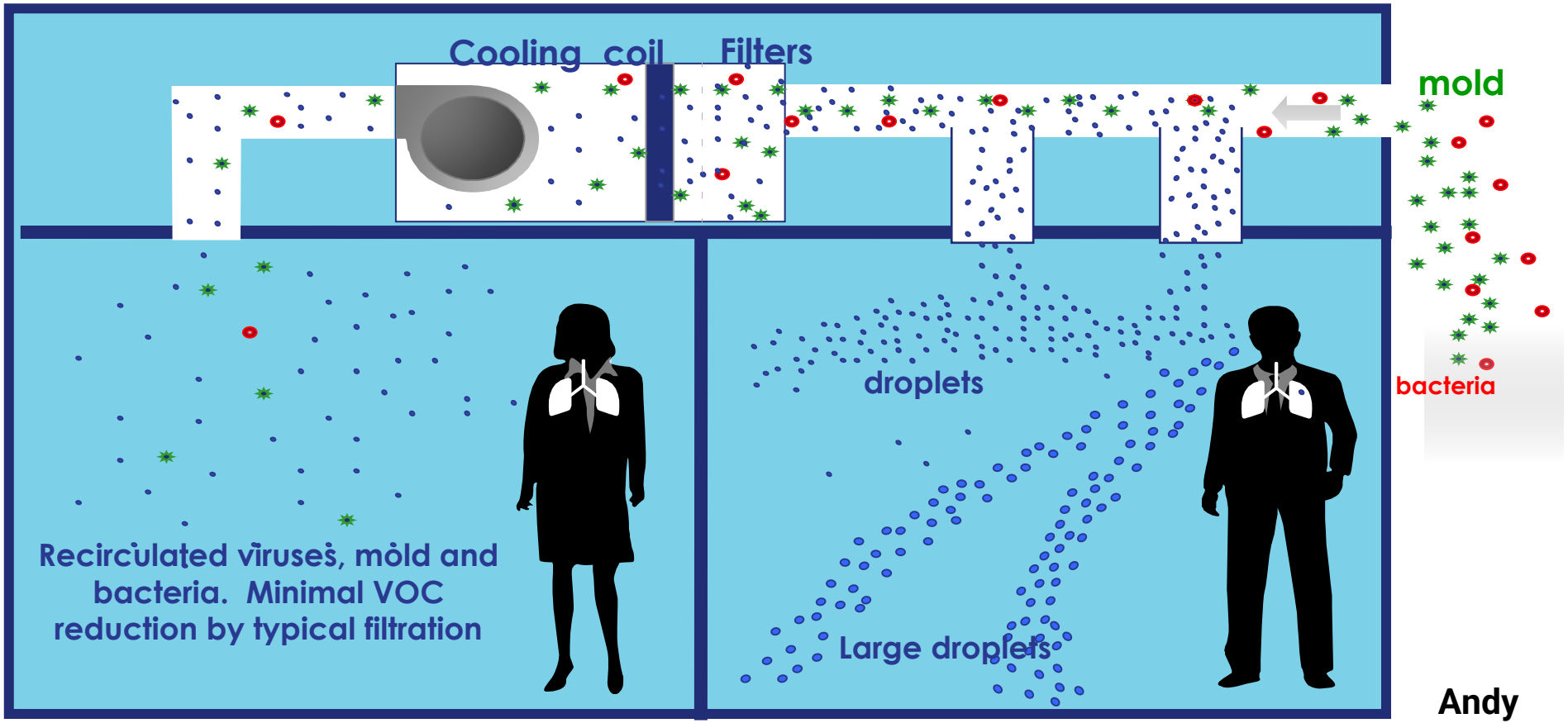
Aerosolized Risk [In Buildings]



J.W. Tang, Y. Li, I. Eames, P. K. S. Chan, G. L. Ridgway, Factors involved in the aerosol transmission of infection and control of ventilation in healthcare premises. Department of Microbiology, The Chinese University of Hong Kong, Prince of Wales Hospital. Hong Kong; Department of Mechanical Engineering, The University of Hong Kong, Pokfulam, Hong Kong; Department of Mechanical Engineering, University College London, London UK School of Public Health.

Andy

Aerosolized Risk [HVAC Systems]



Andy

THE RELATIVE SIZE OF PARTICLES

From the COVID-19 pandemic to the U.S. West Coast wildfires, some of the biggest threats now are also the most microscopic.

A particle needs to be 10 microns (μm) or less before it can be inhaled into your respiratory tract. But just how small are these specks?

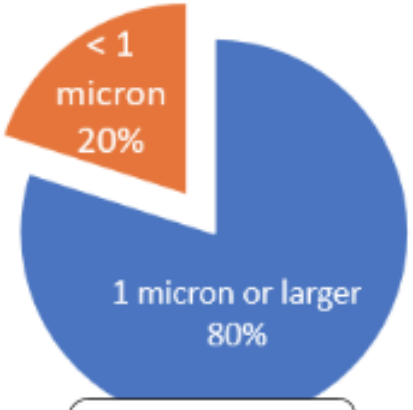
Here's a look at the relative sizes of some familiar particles »

Andy

Current State- What we know…

- **Transmission**
  - Droplets still the primary concern (6 ft +/-), but risk from airborne transmission is significant
  - Masks are effective (Reduced risk of infection by 50%, w/ ionization goes to 70%-80%)

- **Virus Size/ Particulate Removal**
  - Virus is 0.12 micron, but they tend to "clump" into larger particles (focus is now on particles > 1 micron).
  - It's more reasonable to view viral size in terms of a distribution of different particle sizes.



Distribution of SARS-CoV-2

MERV Rating	Filter Droplet Nuclei Efficiency
4	17%
5	27%
6	32%
7	41%
8	56%
9	62%
10	65%
11	73%
12	83%
13	90%
14	95%
15	96%
16	97%

Predicted Filter Efficiency for SARS-CoV-2

Andy

A Closer Look at HVAC Engineering Controls

Treat Your Air: Evidence Based Methodologies

DILUTION

FILTRATION

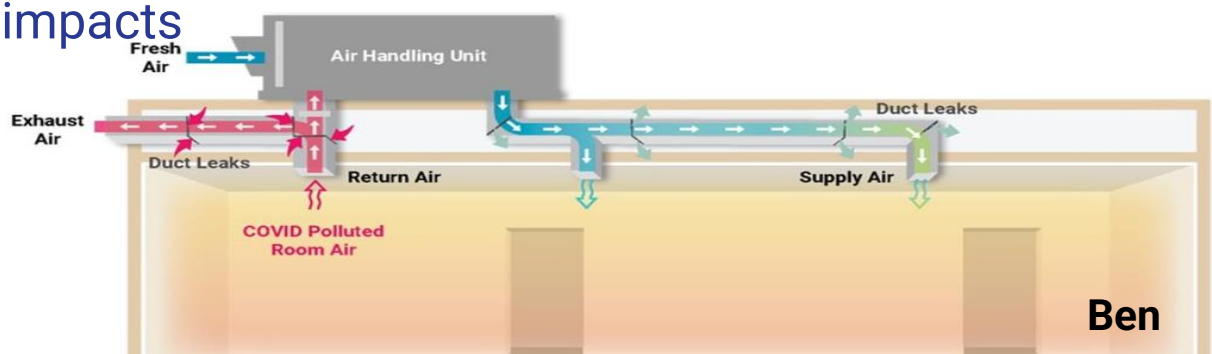
ULTRAVOILET

IONIZATION

Ben

Dilution

- Introduce additional clean air into your building so that the percentage of virus particles in your air (if a sick occupant is in the building) is decreased to reduce risk
- Seasonal impacts to your space (Winter/Summer)
- Utility cost impacts
- Maintenance cost impacts
- Equipment wear



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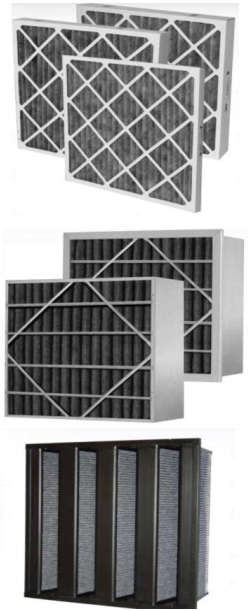
Filtration

MERV Rating	Air Filter will trap Air Particles size .03 to 1.0 microns	Air Filter will trap Air Particles size 1.0 to 3.0 microns	Air Filter will trap Air Particles size 3 to 10 microns	Filter Type ~ Removes These Particles
MERV 1	< 20%	< 20%	< 20%	Fiberglass & Aluminum Mesh
MERV 2	< 20%	< 20%	< 20%	~
MERV 3	< 20%	< 20%	< 20%	Pollen, Dust Mites, Spray
MERV 4	< 20%	< 20%	< 20%	Paint, Carpet Fibres
MERV 5	< 20%	< 20%	20% - 34%	Cheap Disposable Filters
MERV 6	< 20%	< 20%	35% - 49%	~
MERV 7	< 20%	< 20%	50% - 69%	Mold Spores, Cooking Dusts,
MERV 8	< 20%	< 20%	70% - 85%	Hair Spray, Furniture Polish
MERV 9	< 20%	Less than 50%	85% or Better	Better Home Box Filters
MERV10	< 20%	50% to 64%	85% or Better	~
MERV 11	< 20%	65% - 79%	85% or Better	Lead Dust, Milled Flour, Auto
MERV 12	< 20%	80% - 90%	90% or Better	Fumes, Welding Fumes
MERV 13	Less than 75%	90% or Better	90% or Better	Superior Commercial Filters
MERV 14	75% - 84%	90% or Better	90% or Better	~
MERV 15	85% - 94%	90% or Better	90% or Better	Bacteria, Smoke, Many
MERV 16	95% or Better	90% or Better	90% or Better	Viruses



- Increased maintenance & utility costs
- Increased risk to equipment wear & facility worker exposure

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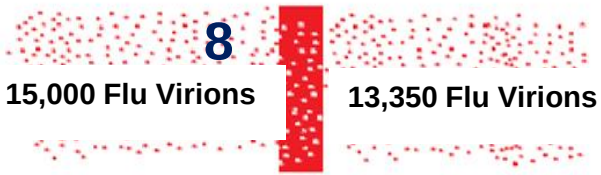
Filtration [Effect on Influenza A Virus]

MERV 8

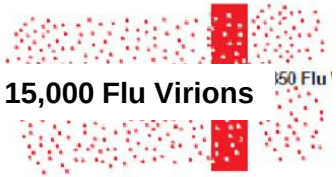


11% captured

MERV 13

46% captured

MERV 15



71% captured

HEPA*

HEPA is the most effective filter to remove virus particles

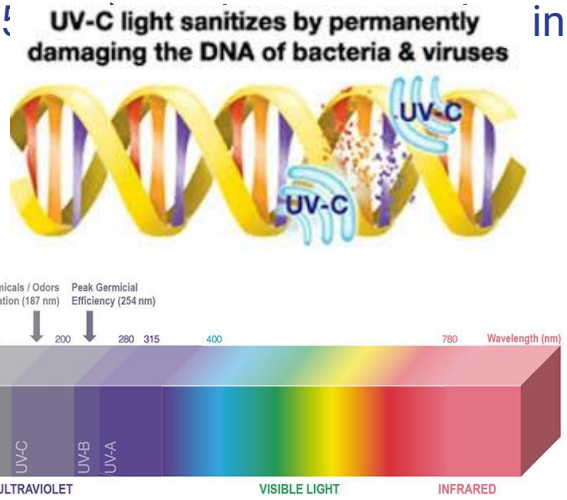
Source: Modeling Immune Building Systems for Bioterrorism Defense; Kowalski, Bahnfleth, Musser, Journal of Architectural Engineering, June 2003, v9(2), pp222-227.

* HEPA was not part of the study above. It's a graphical representation of 99.97% efficiency HEPA filter (defined by DOE) with particulates in 0.3µm which is the toughest size to catch.

Ben

Ultra-Violet

- UV lamps create high energy UV rays that scramble and destroy the viruses
  - UV-C band (at 25[illegible]inant used against bacteria & viruses



Ben

Ultra-Violet [Effectiveness]

Common Name	Pathogenic name	Known, Published UVC value for pathogen reduction		FILTER EFFICIENCY		UVC-only Pathogen reduction/air pass	Pathogen reduction UVC + filtration
		UVGI K m^2/J	$\mu w/cm^2$	MERV 8	MERV 10	URV 11 1000$\mu J/cm^2$ Coil Cleaning	MERV 11 + URV 11
Pneumonia	Pseudomonus aeruginosa	0.5721	0.005721	14	15	99.96%	99.99%
TB / Tuberculosis	Mycobacterium tuberculosis	0.4721	0.004721	19	21	99.85%	99.99%
Corona Virus	Caronavirus	0.3770	0.00377	18	20	99.45%	99.99%
Legionella	Legionella pneumophila	0.1930	0.0019298	15	16	93.00%	99.79%
Acinetobactor	Acinetobacter baumannii	0.1280	0.00128	42	44	82.86%	99.79%
Flu	Influenza A & B	0.1190	0.00119	30	31	80.60%	99.47%
Staph / MRSA	Staphylococcus aureus	0.1130	0.00113	28	30	78.93%	99.00%
Avian Flu	Avian Influenza Virus	0.1060	0.00106	12	13	76.79%	97.00%
Measles	Measles	0.1051	0.001051	10	9	76.50%	97.00%
Chicken Pox	Varicella Zoster	0.105	0.00105	10	9	76.47%	97.00%
Strep	Streptococcus pyogenes	0.8110	0.00811	29	31	99.99%	99.00%

Airborne Pathogen Reduction Rates at specific MERV filter + UVC Fixture ratings

Ben

Ultra-Violet [Air Handling Units]

UVC Dose = Intensity x Exposure (dwell) Time
UVC energy is cumulative

Disinfection is accomplished by exposing a pathogen to:

High-intensity UVC energy for a **short time period**,
i.e 2000 µW for only 1 second

Low-intensity UVC energy for **long time period**,
i.e 20 µW for 100 seconds

NOTE: A 60W lamp is rated at 2047µW @ 7", or 200µW @ 38"

Air Disinfection vs. Surface Disinfection

Air moves through AHU at 500 f/m (@ 40° F)

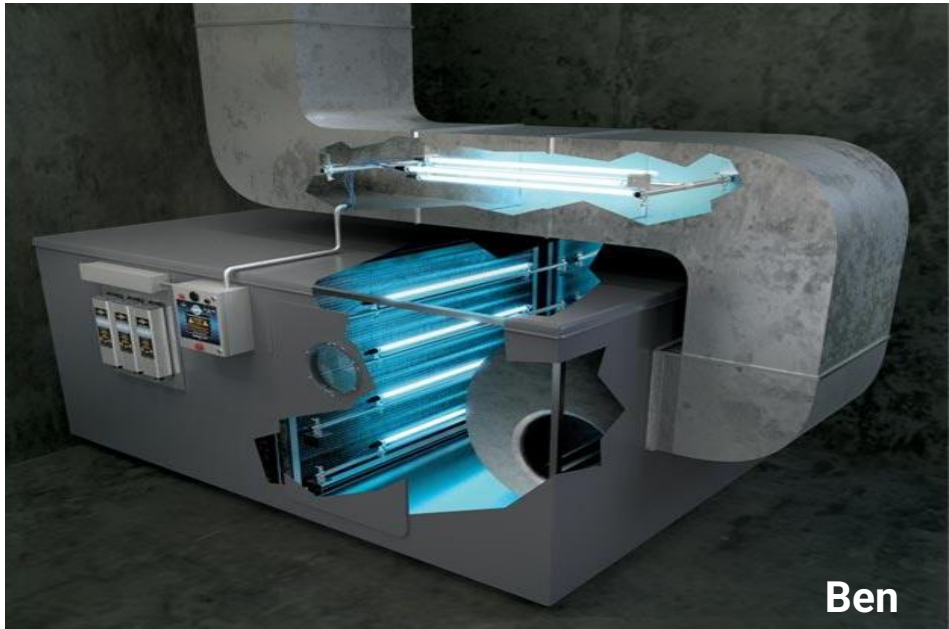
½ second moving air exposure

A high-intensity dose of UVC is required to achieve the desired level of disinfection. Therefore must generate 4000 µ to achieve 2000 µ intensity in ½ sec dwell time.

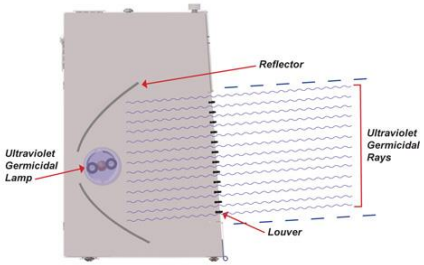
Contaminated cooling coil are stationary, and therefore receive

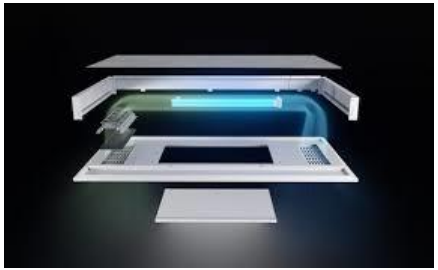
86,400 second surface exposure / 24 hours

A low-intensity dose of UVC energy is all that is required!



Ultra-Violet [In Space]





Ben

Ultra-Violet [Considerations]

+

- Options for in room and in unit technologies
- Equipment protection from mold and mildew
- Quick kill of pathogens that are exposed to the light
- Long track record for medical use in virus & bacteria control

−

- Installation costs
- Equipment, electrical, install, reflective linings, safeties
- Increased utility costs
- Increased bulb replacement costs
- UV Lights will continue to glow and be “on” after effectiveness degrades (Replace 1-2 years per MFG.)
- Safety risks
- 12-24 week lead times

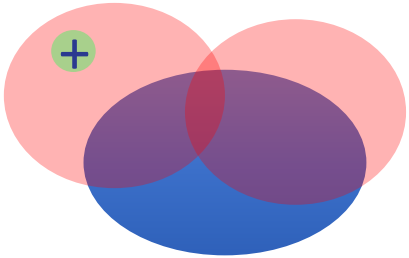
Ben

What is Bi-Polar Ionization?

- uses electric voltage to convert oxygen molecules to charged atoms that inactivate airborne contaminants. These negatively and positively charged atoms, called ions, are effective against viruses, bacteria, and mold.

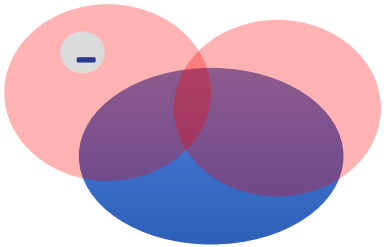
- the charged particles surround the microbe and break it down. In the case of viruses, the ions induce a chemical reaction on the cell membrane surface. They **envelop the COVID-19 virus and puncture the protein spikes on its membrane, neutralizing them.**
- the ions attach to contaminants and **enlarge them enough to be trapped by the HVAC system filters**.

Tom



WHAT IS AN ION?

An ion is an atom or a molecule that is positively or negatively charged – meaning it must either gain or relinquish electrons in order to become neutral.

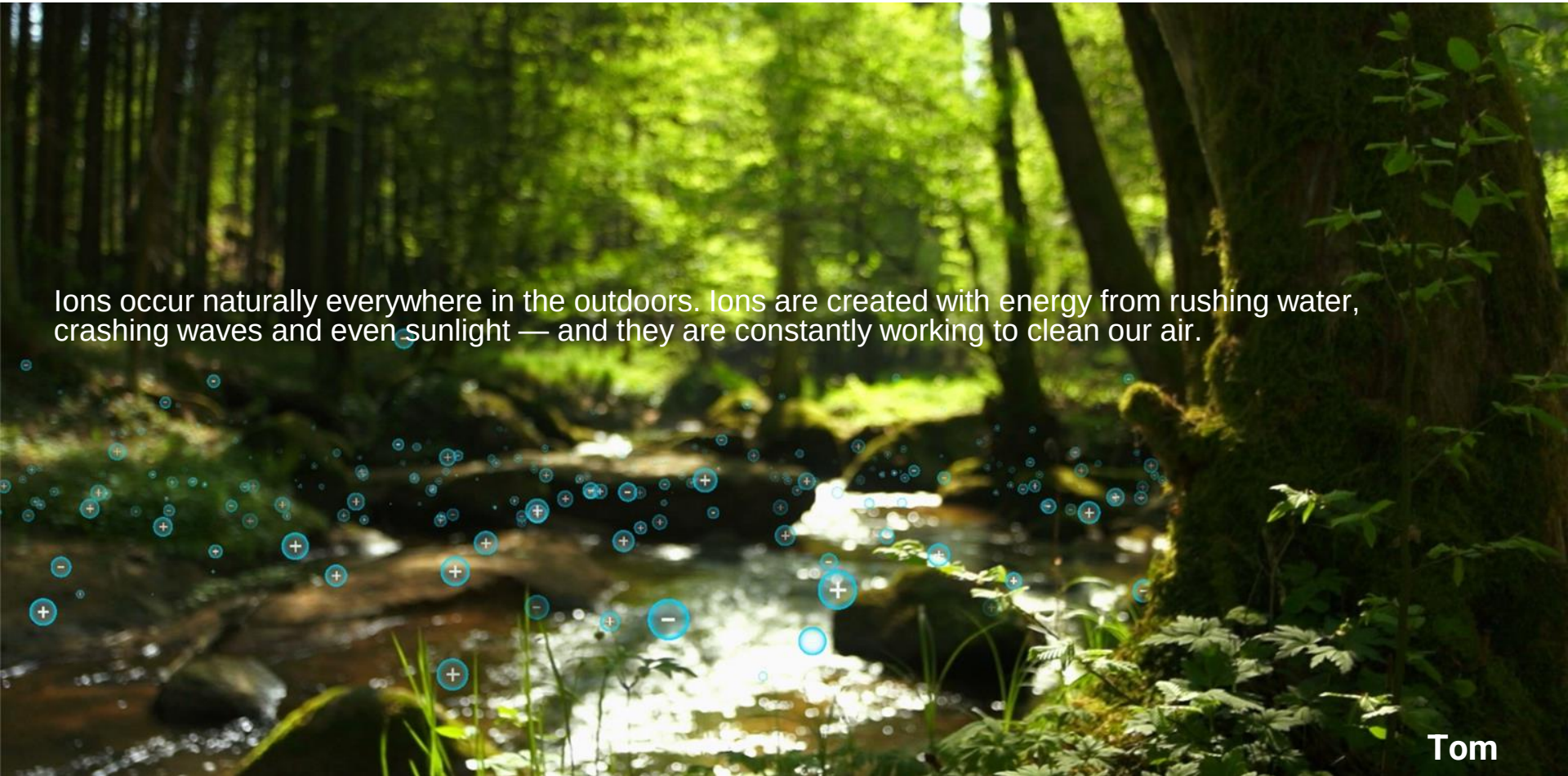


WHAT IS IONIZATION?

Ionization is the process of using voltage to electrically charge air molecules, thus creating ions.

Tom

IONS OUTDOORS



There are lower concentrations of ions indoors.

Indoor ion concentrations are typically under 2,000 ions per cubic centimeter (cc).

The highest outdoor ion concentrations are in the tens of thousands of ions per cc, at higher elevation or near rushing water.

*In-room ion density is dependent on a variety of factors, including ionizing equipment, proximity of the ionizing equipment to the occupied space, airflow rates and path of ductwork within the building.

Tom

NEEDLEPOINT BIPOLAR IONIZAITON

is a lower-voltage form of ionization that uses carbon fiber needles to release positive and negative ions.

Higher-energy forms of ionization result in the breaking apart of molecules and production of byproducts, including ozone.

Tom

TARGETS PARTICLES

Dust, dander, smoke, viruses and bacteria often go unseen in the air.

Various studies have demonstrated the potential benefits of reduced airborne particles, which could include:

- improved air quality
- diminished HVAC strain
- decreased exposure to dust and allergens.

Needlepoint bipolar ionization reduces particulate matter by introducing ions into the airstream, causing particles to cluster together for easier filtration by your HVAC system.

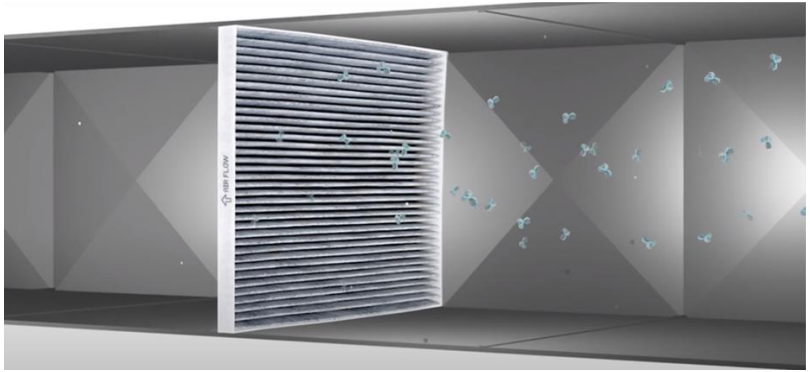
Tom

NPBI technology can make a MERV 8 filter perform like a MERV 13 filter.

MERV measures a filter's ability to capture particles of varying sizes. It stands for Minimum Efficiency Reporting Value and ranges from 1 to 20. The higher a system's MERV rating, the more effective — and more expensive — a particular filter is.

NPBI is verified by Blue Heaven Labs, a third-party laboratory, to enable MERV 13 efficiency using only MERV 8-level filtration.

Buying replacement MERV 13 filters would cost substantially more than MERV 8 filters … in perpetuity.



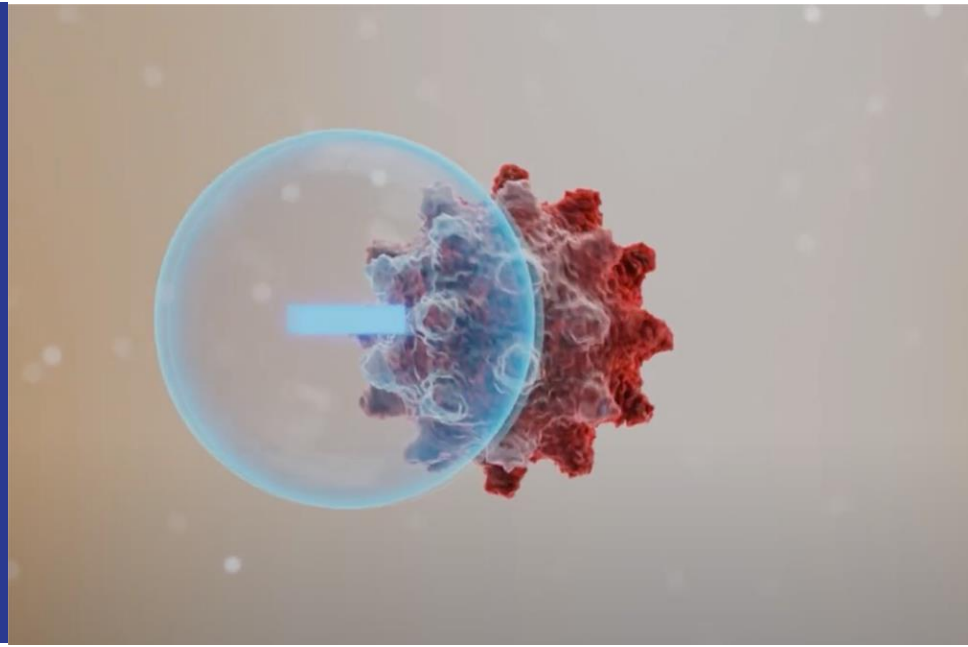
Tom

REDUCES CERTAIN VIRUSES AND BACTERIA

Needlepoint bipolar ionization has been shown to reduce certain viruses and bacteria:

- In the air and on surfaces
- At various ion densities
- In large chambers
- On a variety of specimens

Contact manufacturer for performance results.

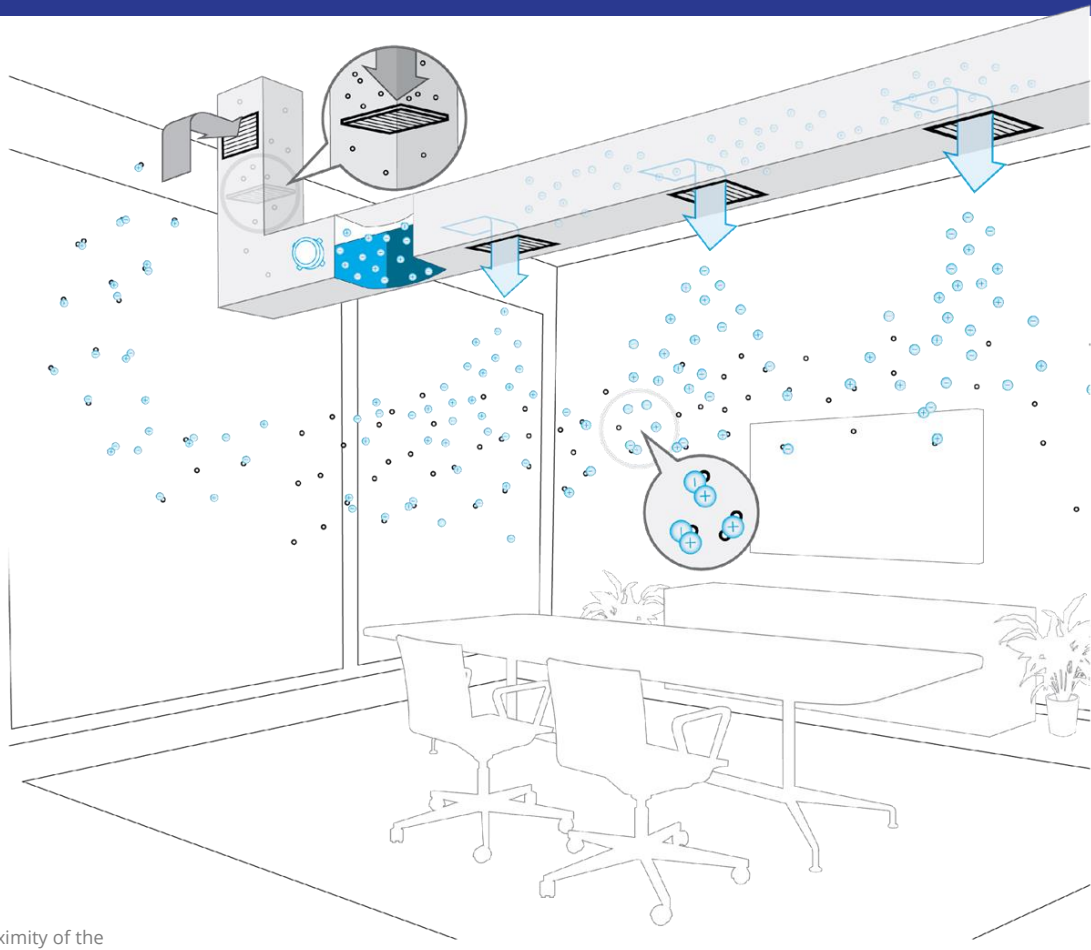


Tom

ION DELIVERY

NPBI technology can enhance your ion density to help deliver cleaner indoor air

HERE'S HOW

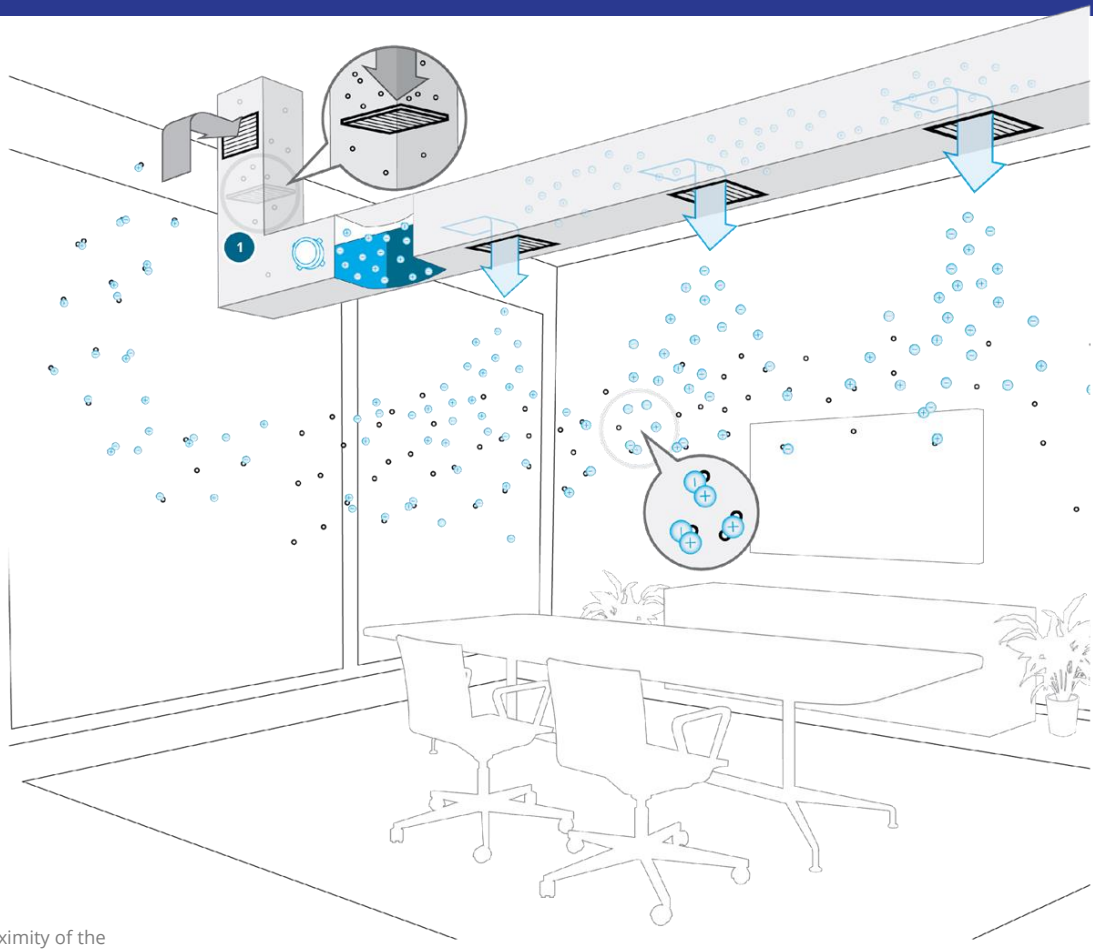


*In-room ion density is dependent on a variety of factors, including ionizing equipment, proximity of the ionizing equipment to the occupied space, airflow rates and path of ductwork within the building.

Tom

ION DELIVERY

1. Air passes through your existing duct system, over the ionizer.



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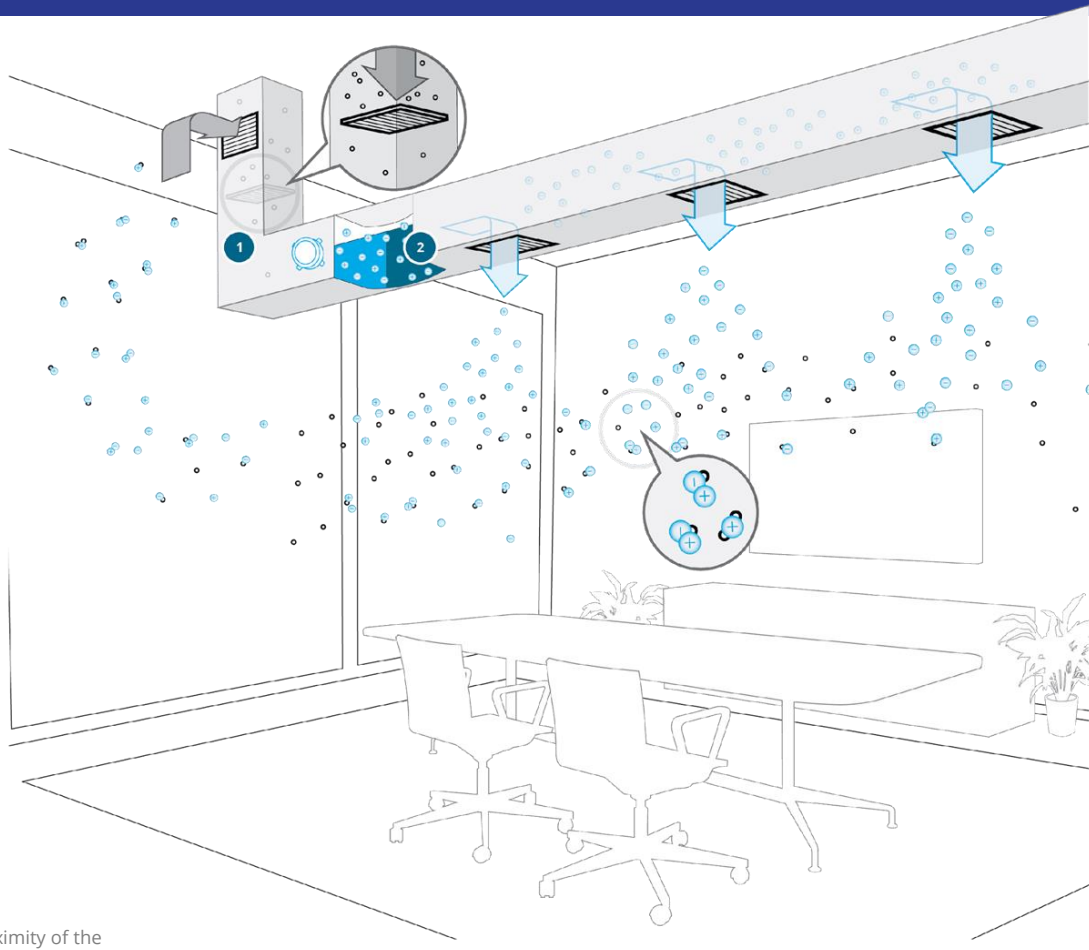
ION DELIVERY

1. Air passes through your existing duct system, over the ionizer.
2. The ionizer produces positive and negative ions that are carried by the airstream through the ductwork and into the room



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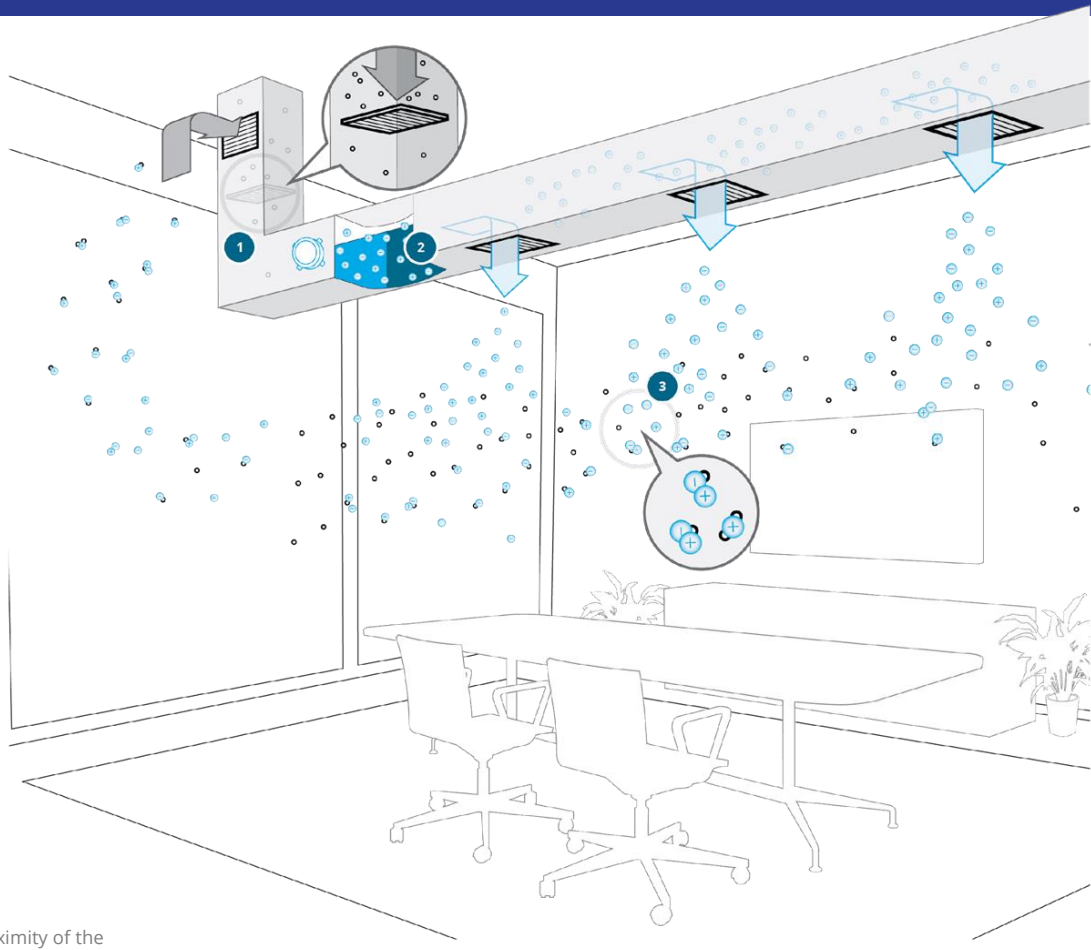
Tom

ION DELIVERY

1. Air passes through your existing duct system, over the ionizer.
2. The ionizer produces positive and negative ions that are carried by the airstream through the ductwork and into the room
3. These ions seek out and combine with particles, forming larger clusters that are more effectively captured by the HVAC system.



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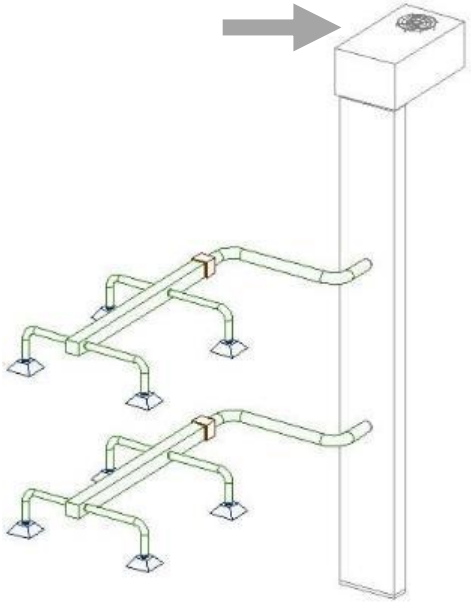
Tom

FACTORS THAT NEGATIVELY IMPACT IONIZATION IN THE SPACE



The ionizer mounted far away from the space it's treating

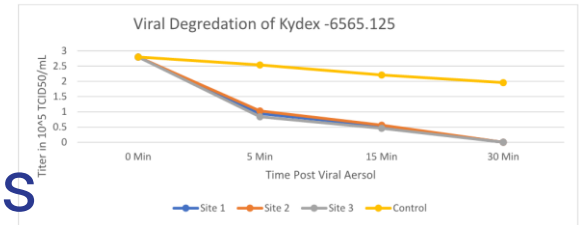
Slow moving or stagnant air flow

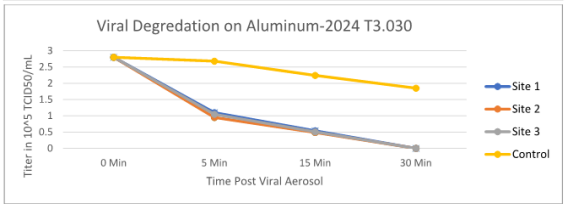
Complex airflow path

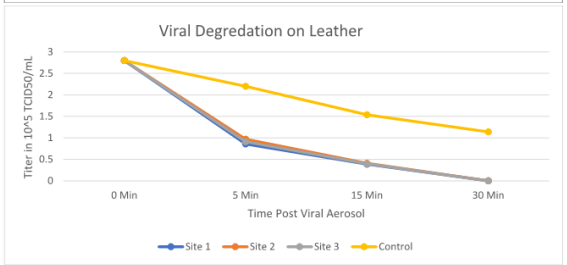
Tom

Ionization [Effectiveness]

- Surface sample testing against SARS-CoV-2
  - 84.2% in 10 minutes
  - 92.6% in 15 minutes
  - 99.4% in 30 minutes
- Testing against other pathogens
  - E.Coli – 15 minutes – 99.68%
  - MRSA – 30 minutes – 96.24%
  - C. Diff – 30 minutes – 86.87%
  - TB – 60 minutes – 69.01%







Is it safe?

- EPA
  - Bipolar ionization has the potential to generate ozone and other potentially harmful by-products indoors, unless specific precautions are taken in the product design and maintenance. If you decide to use a device that incorporates bipolar ionization technology, EPA recommends using a device that meets UL 2998 standard certification (Environmental Claim Validation Procedure (ECVP) for Zero Ozone Emissions from Air Cleaners).
- Harmful Byproducts?
- Ozone?

Ionization [Safety Considerations]

- Verify UL ratings for “Ozone Free” generation
  - (UL 2998) – Required under ASHRAE 62.1-2019 Section 5.7.1 for air purifiers applying to all UV, Ionizers, etc.

CHEMICAL	FORMULA	Electron Volt
Xylene*	C_8H_{10}	7.89
Styrene*	C_8H_8	8.46
Methyl Ethyl Ketone*	C_3H_8O	9.52
Ammonia*	NH_3	10.07
Acetaldehyde*	CH_3CHO	10.23
Ethyl Alcohol*	C_2H_5OH	10.48
Formaldehyde*	CH_2O	10.88
Oxygen	O_2	12.07
Corona tubes require >12.07 to break down the dielectric		

NPBI

DIELECTRIC/CORONA DISCHARGE TUBE > 12.07eV

* Typical contaminants of concern as contained within ASHRAE 62.1

- Electron Volt Energy greater than 12Ev, creates ozone (O_3)

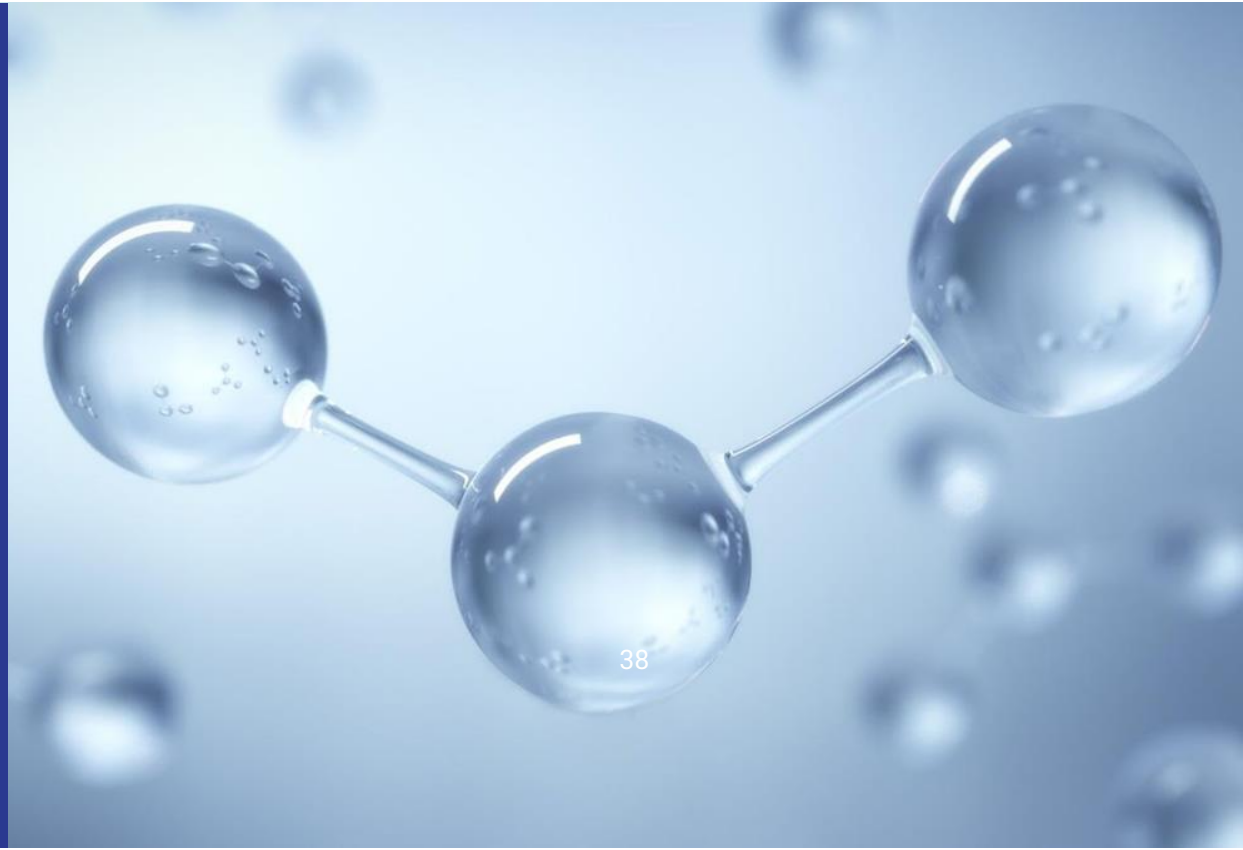
WHAT IS OZONE?

Ozone (O_3) is a natural gas that can be helpful or harmful depending on its location in the atmosphere.

In the upper atmosphere, ozone is protective, reducing the amount of harmful UV radiation reaching the Earth's surface.

Ozone in the lower atmosphere is linked to respiratory damage that increases with frequency and duration of exposure.

ASHRAE's Environmental Health Committee advises that "the introduction of ozone to indoor spaces should be reduced to as low as reasonably achievable."



sources:
EPA.gov Indoor Air Quality (IAQ)
ASHRAE Filtration/Disinfection

Tom

UL OZONE SAFETY STANDARDS

UL 867

- Threshold of 50 ppb (parts per billion), proven not to produce harmful levels of ozone
- Recognized by the California Air Resources Board as a safety standard and referenced by the CDC for consumers who desire this type of technology.

UL 2998

- Threshold of 5 ppb (parts per billion), certified to have zero ozone emissions.
- Recommended by ASHRAE, EPA and the Department of Education, and preferred by the CDC for consumers that desire this type of technology.

Tom/Ben

What to consider?

- Existing HVAC Systems
- Products? Alternatives?
- Budget?
- Maintenance?
- Life Expectancy?

Andy

Products vs. Solutions

Commonly Discussed/ Deployed

- Upgrade filtration
- UV (Ultraviolet) lighting
- Ionization
- In-room filtration
- System Modifications
- Measurement/ Monitoring
- Verification of Results

UV-C

Bipolar Ionization

In-Room Filtration Units

Filter Upgrades

Holistic Approach to IAQ

- Complete what is feasible in a timely manner
  - You can't complete everything overnight
- Develop a short and long term IAQ Plan
- Dilution/Filtration/UV Light/Ionization are one piece of the puzzle
  - Done in cooperation with Administrative and Engineering controls as well as PPE to reduce overall viral load long after a pandemic

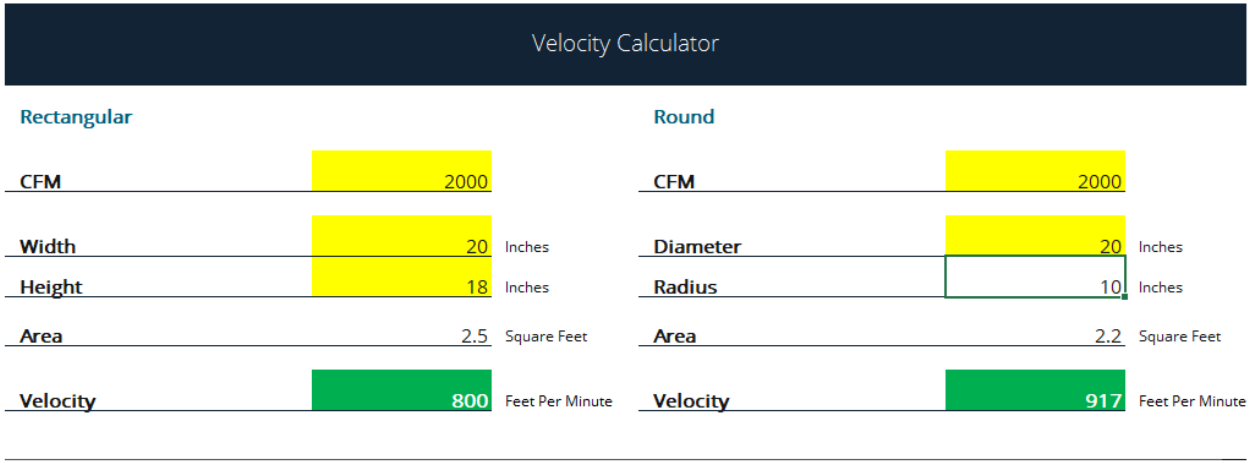
Measuring Success

- IAQ assessments prior to and after the installation of engineering controls
  - LEEDS-CO, CO2, PM10, TVOC's, Formaldehyde
  - Surface/Air sampling for SARS-CoV-2 (Covid-19)
    - Qualitative (presence/Absence)

Ionization [Options]

Ben

AIR VELOCITY MATTERS



Velocity Calculator

Rectangular			Round		
CFM	2000		CFM	2000	
Width	20	Inches	Diameter	20	Inches
Height	18	Inches	Radius	10	Inches
Area	2.5	Square Feet	Area	2.2	Square Feet
Velocity	800	Feet Per Minute	Velocity	917	Feet Per Minute

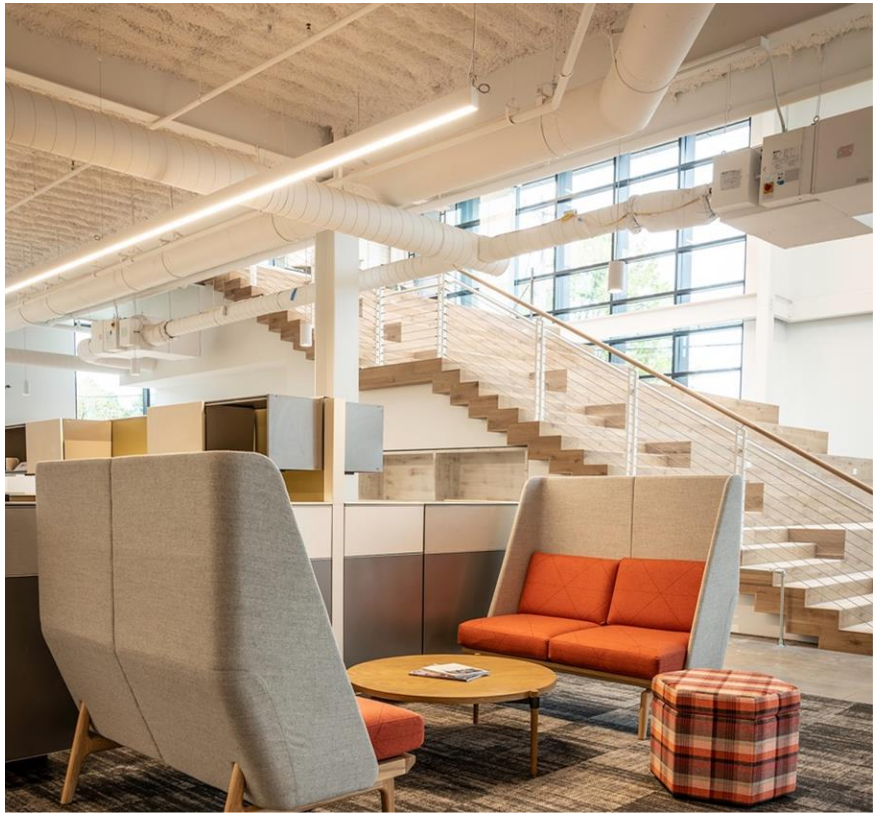
Calculate:

1. Airflow velocity
2. Time to supply diffuser
3. Whether time is sufficient for optimal ion delivery

Manufacturers may offer velocity calculation tools to assist you in determining the best mounting position for the ionizer, in order to optimize the delivery of ions in a wide variety of applications.

Tom

FOCUS ON IONIZATION IN THE SPACE



In real-world applications…

What matters most is not how many ions are produced at the source, but rather how many ions join the airstream and are present **in the space**.

Tom

Before proceeding on a technology…

- Ensure you objectively evaluate each within the context of your specific application(s).
- In addition to 1st cost, consider ongoing costs via maintenance, repairs, and energy costs.
- Consider performance validation. This applies to upfront evaluation (independent labs) AND potential before/ after testing for any installation.

Ben

Questions?