ALABAMA SOCIETY FOR HEALTHCARE ENGINEERING

2023 AlaSHE Fall Conference

How to Reduce Particles, Pathogens & Odors in Healthcare Applications with Soft Ionization

Charlie Waddell, Founder @ GPS Air
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Learning Objectives:

1. To become familiar with soft ionization
2. Understand a typical filter MERV curve and how soft ionization can increase the filter effectiveness, thereby flattening the curve
3. Understand how soft ionization can clean coils vs UVC
4. Learn how soft ionization can reduce certain pathogens
5. Learn how soft ionization can reduce diesel genset, helicopter and loading dock odors

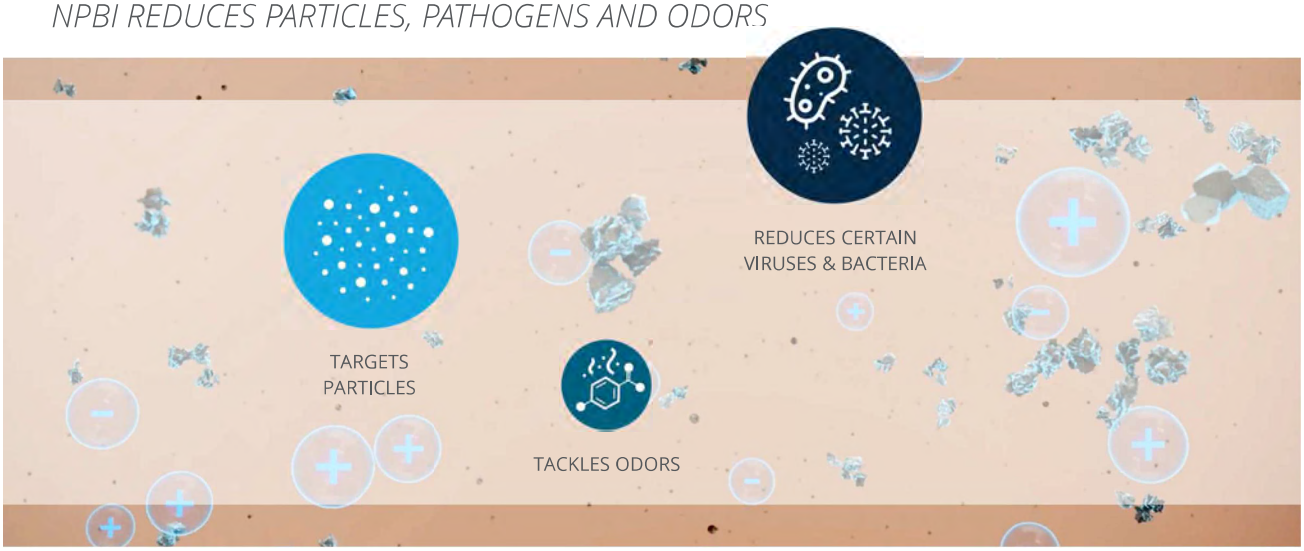
Acknowledgements:

Blue Heaven Technologies
Innovative Bioanalysis

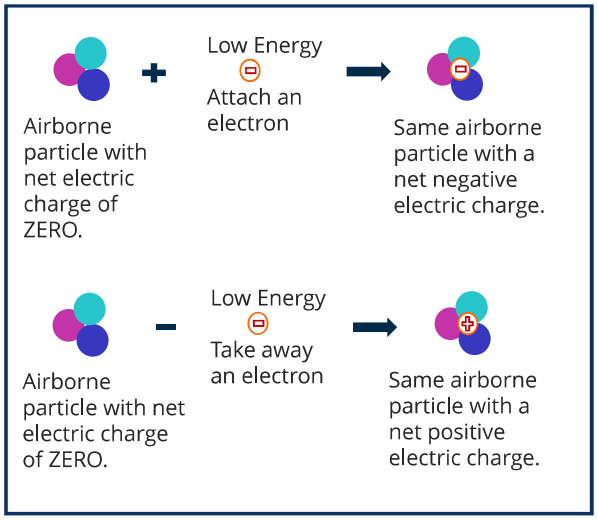
Bias Statement: Charles Waddell is the Founder & a minority shareholder at GPS Air, an OEM of soft ionization technology.

WHY USE NEEDLEPOINT SOFT IONIZATION?

NPBI REDUCES PARTICLES, PATHOGENS AND ODORS



What is Soft Ionization[1,2]?



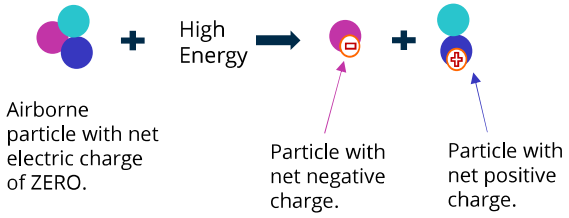
BENEFITS OF SOFT IONIZATION

- No Fragmentation = No Harmful Byproducts
- No Ozone
- Ultrafine Particles Not Created
- No Replacement Parts (most brands)
- Auto-Cleaning Options – No Maintenance

1. F.T. Hartley and I. Kanik, "A nanoscale soft-ionization membrane: A novel ionizer for ion mobility spectrometers for space applications," Proceedings of the SPIE, 2002, Vol. 4936, pp. 43-49. DOI: 10.1117/12.484271
2. Wang, Sun, Qiao, Ouyang, and Na, "A Soft and Hard Ionization Method for Comprehensive Studies of Molecules," Analytical Chemistry 2018, Vol 90, pp. 14095 – 14099, DOI: 10.1021/acs.analchem.8b04437

What is Hard Ionization[1,2]?

Hard Ionization breaks chemical bonds



Attributes of Hard Ionization:

- Fragmentation
- Ozone = Indoor Chemistry
- Replacement Parts Required

Hard Ionization Technology Examples

- Dielectric Barrier Discharge (Glass/Composite Ion Tubes)
- UVC
- PCO (UV Light + Catalyst ~ TiO2)

1. F.T. Hartley and I. Kanik, "A nanoscale soft-ionization membrane: A novel ionizer for ion mobility spectrometers for space applications," Proceedings of the SPIE, 2002, Vol. 4936, pp. 43-49. DOI: 10.1117/12.484271
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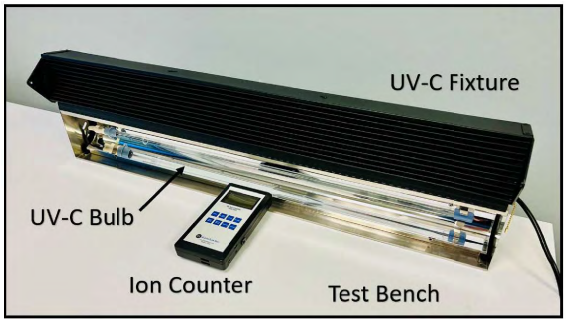
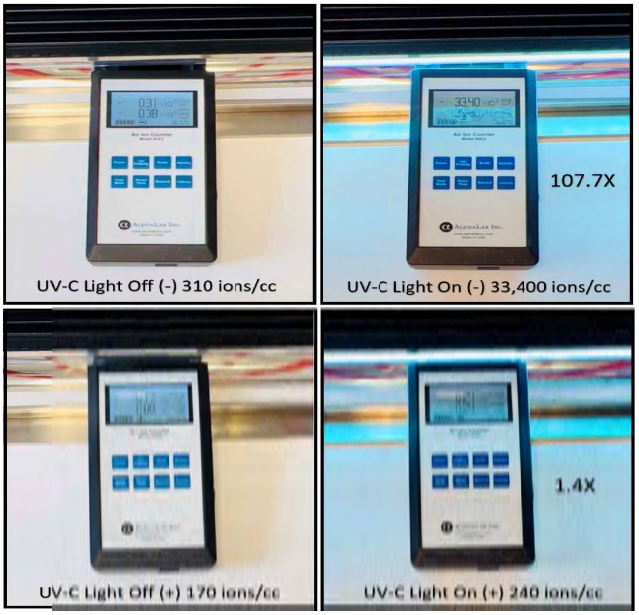
UVC Creates Ions?



- Few Are Aware of this Fact
- UVC Generates Negative Ions
- Polarizes the Air – Wall/Diffusers Dirty?
- 33″ Lamp = 551K ions/cc NAIs



UVC Publications

- *Model Evaluation of Secondary Chemistry due to Disinfection of Indoor Air with Germicidal Ultraviolet Lamps (November 2022)*

https://pubs.acs.org/action/showCitFormats?doi=10.1021/acs.estlett.2c00599&ref=pdf

"Our analysis shows that GUV254, usually installed in the upper room, can significantly photolyze O3, generating OH radicals that oxidize indoor volatile organic compounds (VOCs) into more oxidized VOCs. Secondary organic aerosol (SOA) is also formed as a VOC-oxidation product. GUV254-induced SOA formation is of the order of 0.1−1 μg/m3 for the cases studied here."

UVC Publications

- *Unwanted Indoor Air Quality Effects from Using Ultraviolet C Lamps for Disinfection (January 2023)*
  https://pubs.acs.org/action/showCitFormats?doi=10.1021/acs.estlett.2c00807&ref=pdf

"We find that the UVC (254 nm) caused dramatic increases in particle number concentrations, and nearly all (~1000) monitored gas phase species also increased."

HEPA Filters Rated at 0.3um (MPPS) | 2.5nm = 0.0025um

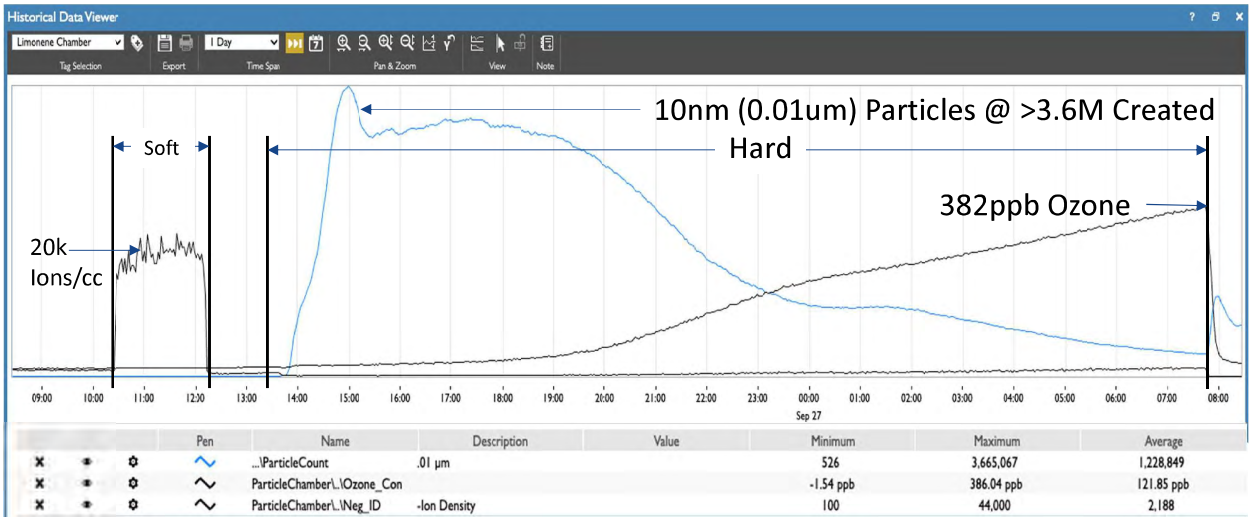
*"Formation rates (Table S1) of **2.5 nm** particles were determined to be 250 particles cm^-3 s^-1 (median), increasing the particle number concentrations from background levels of <1000 cm^-3 to between 4.5x10^4 cm^-3 and 1.6x10^5 cm^-3, depending on the irradiation time and ozone concentration (Figure S1)."*

Increase in 2.5nm Particles = 3,000 cm3 to 160,000 cm3!

Soft vs Hard Ionization: A Chamber Study

Chamber:
- Conforms to UL 867 Ozone chamber standard
- 12'L x 8'W x 10'H

Test conditions:
- 6ACH
- 10mL Limonene
- MERV 8 Filter



Soft Ionization PEER Reviewed Articles

Current Peer Reviewed Publications

1. Mathematics Journal: *Quantifying the Natural Variation of 'Data Signatures' from Aerosols Using Statistical Control Bands*
2. 2022 Electrostatics Conference Paper: *Application of Soft Ionization in Improving Indoor Air Quality*
3. *Plos One* - Bipolar Ionization Rapidly Inactivates Real-World, Airborne Concentrations of Infective Respiratory Viruses

Submitted Publications – in Peer Review

1. Application of Soft Ionization to Improve Filtration
2. Application of Soft Ionization to Improve IAQ

Newly Accepted Soft Ionization PEER Reviewed Article

Scientific Journal: Plos One

Title: Bipolar ionization rapidly inactivates real-world, airborne concentrations of infective respiratory viruses

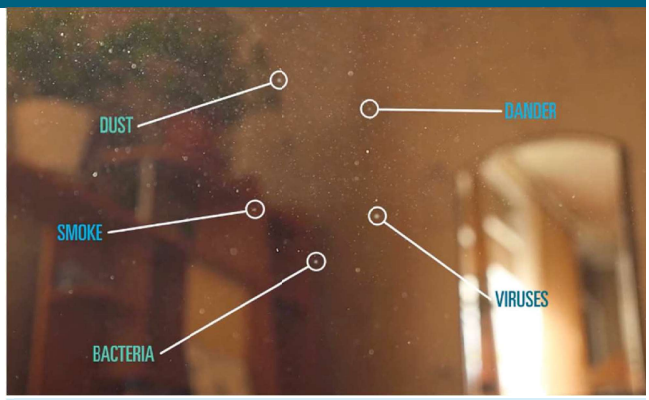
The study demonstrates the effectiveness of bipolar ionization technology, particularly needlepoint bipolar ionization (NPBI), to significantly reduce the infectivity of respiratory viruses, specifically SARS-CoV-2 strains, in realistic indoor conditions. Using real-world virus concentrations, the research highlights the potential of NPBI to enhance indoor air quality and mitigate the spread of infectious diseases in large indoor spaces.

https://journals.plos.org/plosone/

SOFT IONIZATION 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, and decreased exposure to dust and allergens.

Source: New York Times "New Research Links Air Pollution to Higher Coronavirus Death Rates"



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

PARTICLE DISTRIBUTION

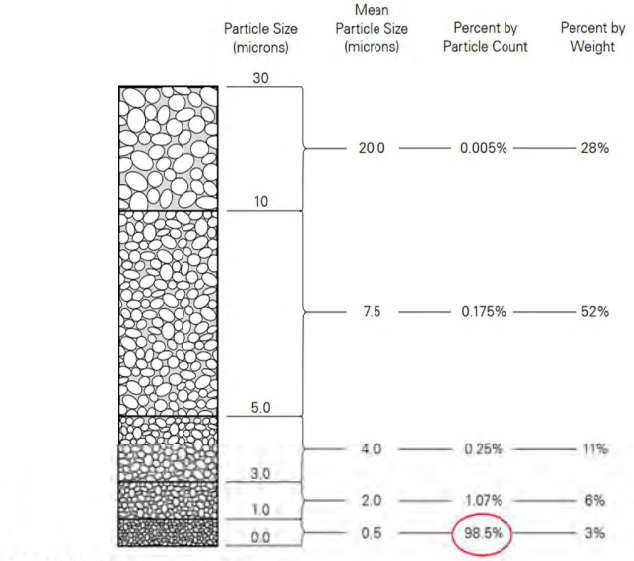
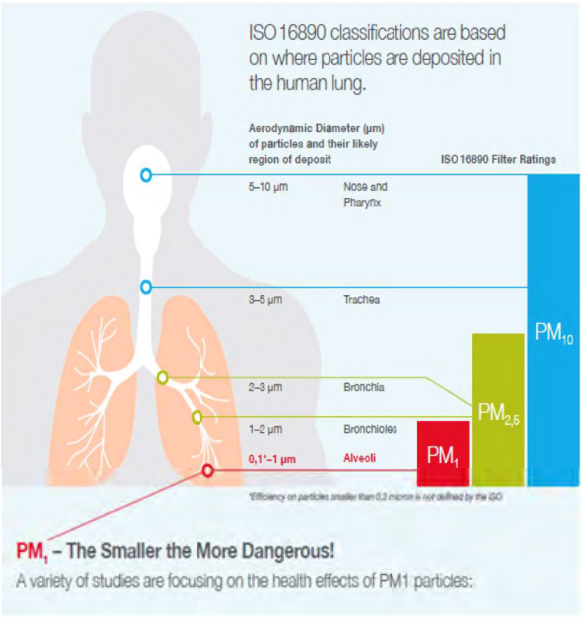


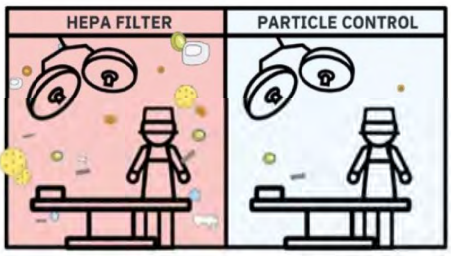
Figure 7.5-B Particle Size Distribution in the Atmosphere
Adapted from NAFA (2006), Figure 1.4.

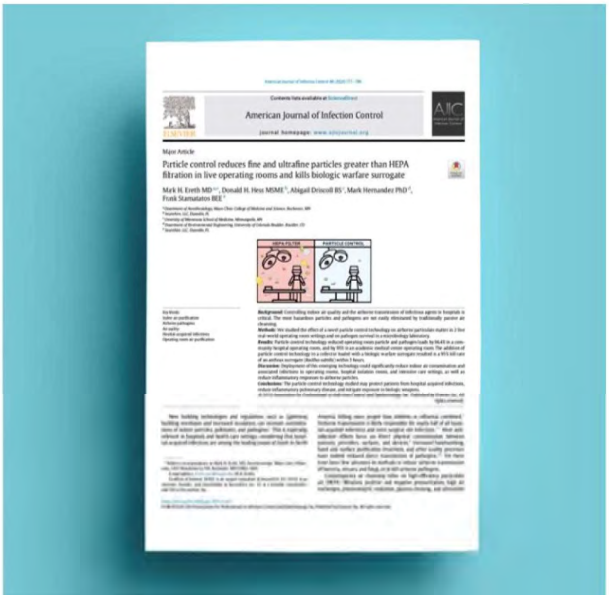


American Journal of Infection Control
Ionization Assists Filters via Agglomeration

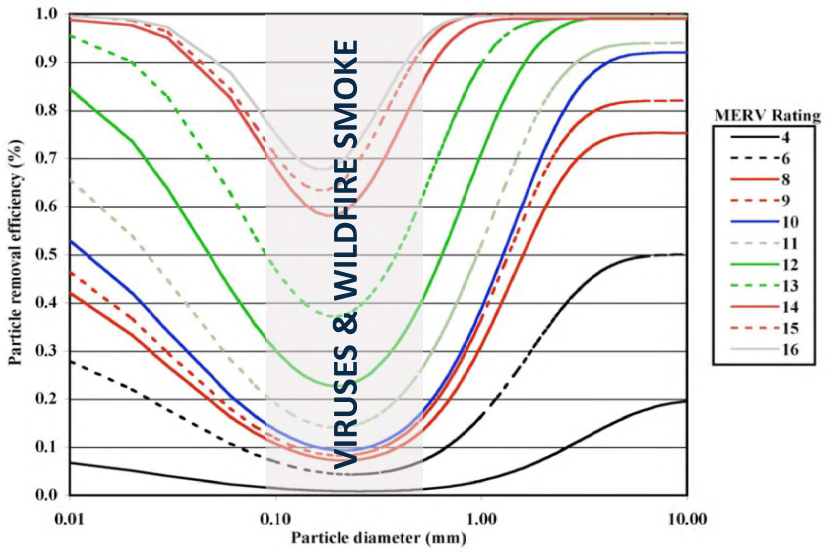
"The majority of airborne pathogens fall into the fine particle or ultrafine particle ranges.

It is a common misconception that these small particles are effectively cleared from a space (such as an operating room) via HEPA filtration. Unfortunately, most very small particles and pathogens are of insufficient mass to be controlled by bulk airflow and can remain suspended for days or even weeks. Significant fractions of these suspended particles and pathogens cannot be effectively transported to or removed by conventional air filters".





MERV Rated Filters - Performance Curves

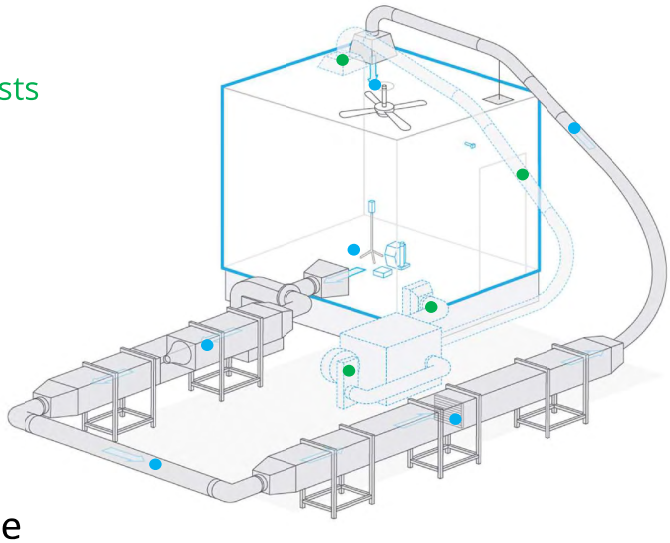


https://www.researchgate.net/figure/Representative-curves-of-particle-removal-efficiency-for-various-MERV-Levels-Kowalski_fig2_258688768

Independent Test Lab Confirms Performance

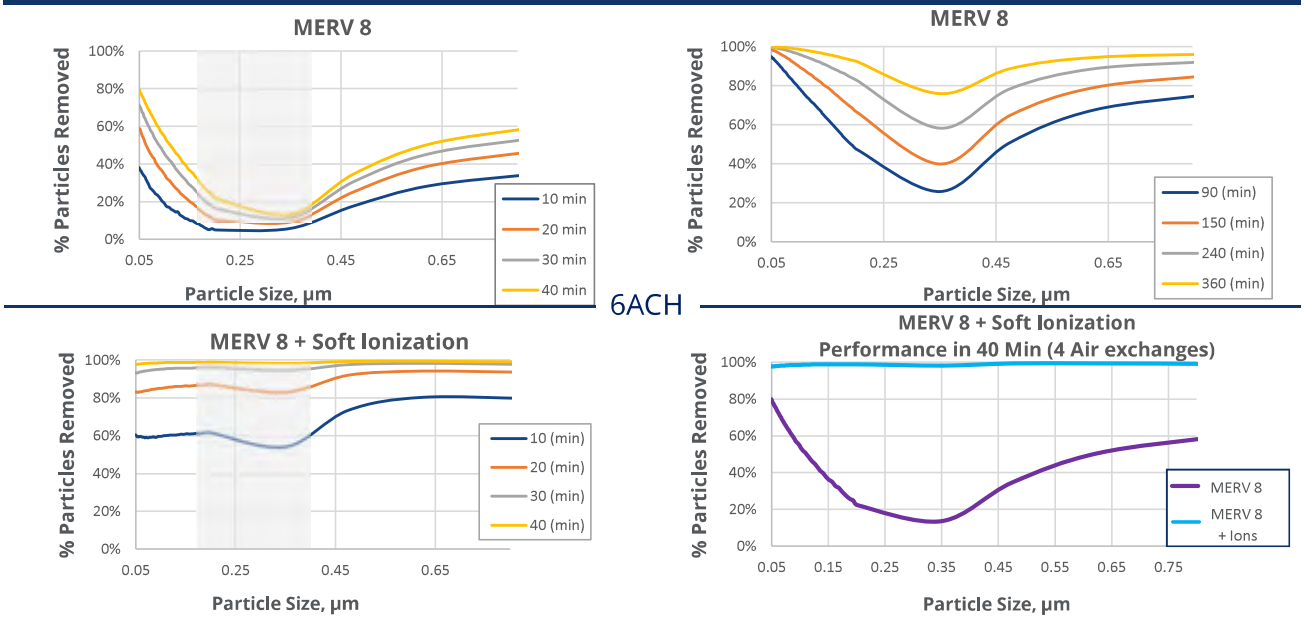
Two separate duct loops:

- Test Loop
- Cleaning loop used only between tests



Ionization installed after
the filter so ions reach the space

MERV 8 Filter vs MERV 8 Filter + Soft Ionization



Wildfire Smoke is Problematic for Most of the USA

https://www.nytimes.com/interactive/2022/09/22/climate/wildfire-smoke-pollution.html

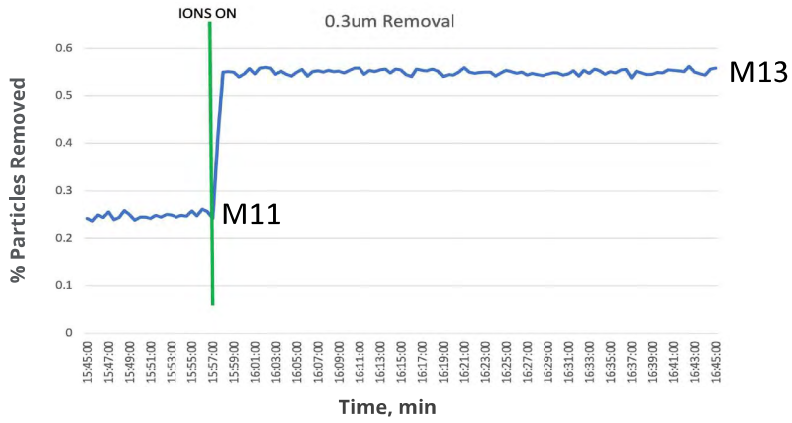
Wildfire Smoke Test Design

Chambers Simulate Single Pass 100% OA
Prefilter Ionization Testing

www.airnow.gov

Wildfire Smoke Results – Single Pass Testing

Test Conditions		
• 1" MERV 11 Pleated	• Single Pass	• Filter Face Velocity = **275 fpm**

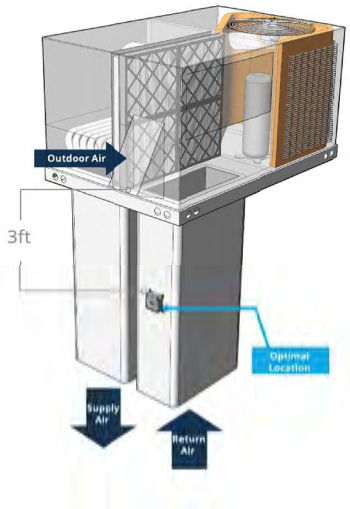


Ionizer mounted before the filter

Removal efficiency improved by 120%

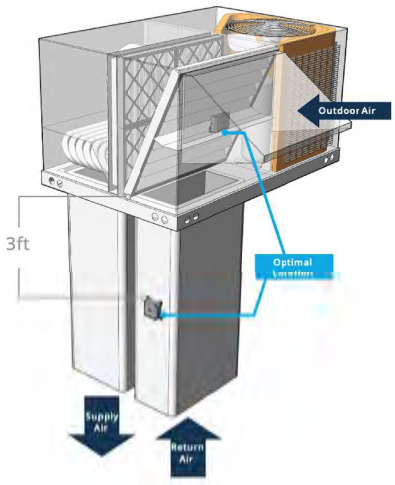
5-25 Ton RTU

In cases without an economizer, Opti-Lok devices can be placed in the return air as outdoor air will effectively be treated in the mixing chamber.



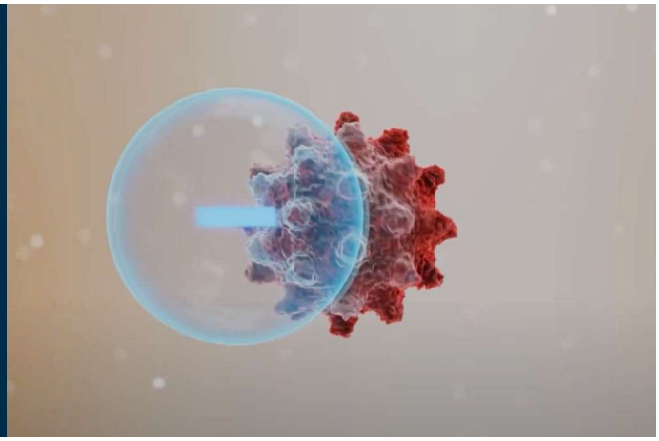
5-25 Ton RTU w/ Economizer

In cases with an economizer, Opti-Lok devices must be placed both in the return air source as well as the outdoor air source.



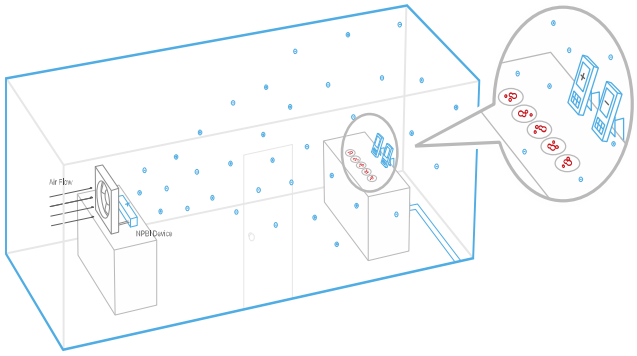
NPBI SOFT IONIZATION REDUCES CERTAIN VIRUSES AND BACTERIA

Using a sealed, unoccupied testing chamber, we work to obtain data that is relevant to real world applications. This includes using a large chamber for testing to approximate an office space and introducing ionized air in a similar way to how an HVAC system would deliver ions in an actual room.



Soft Ionization Testing: Surface Organisms

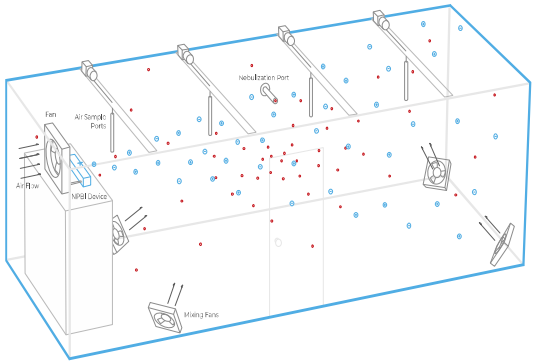
Chamber: 20'L x 8'H x 8'W
BSL3 Lab



Specimen	Avg. Ion Density (ions/cc)	% Net Reduction	
		30 minutes	**60 minutes**
SARS-CoV-2	-9,700	55.50%	62.85%
	-10,250	55.94%	70.71%
	-20,600	97.90%	99.97%
	-23,600	98.49%	99.98%
Staphylococcus Aureus	-14,000	36.61%	91.55%
E. Coli	-14,000	31.46%	86.36%
MRSA	-14,000	44.91%	87.87%

Soft Ionization Testing: Aerosolized Viruses and Bacteria

Chamber: 20'L x 8'H x 8'W
BSL3 Lab



Microorganism	Avg. Ion Density (ions/cc)	Beginning Viral Concentration (TCID50/mL)	% Net Reduction 30 Minutes	% Net Reduction 60 Minutes
SARS-CoV-2	-3,500	9.97E+05	99.87%	NA
SARS-CoV-2	-4,900	9.63E+05	99.51%	NA
SARS-CoV-2	-12,000	1.08E+06	99.96%	NA
SARS-CoV-2	-18,000	9.97E+05	99.96%	NA
SARS-CoV-2 Delta Variant	-24,000	2.47E+07	47.56%	99.98%
Influenza A	-22,000	3.15E+07	43.32%	99.78%
Influenza B	-22,000	3.66E+06	36.21%	85.44%
RSV	-23,000	4.15E+06	35.85%	97.06%

Multi-Layer Air Defense Strategy (MLADS) – Mission-Next Foundation

www.mission-next.com

Engineering Controls to consider for indoor/enclosed "shared air":

1) Increasing air turnover with fresh outdoor air using open windows
2) Increasing air turnover with fresh air using HVAC room turnover
3) Installing physical barriers between people where they share air
4) Providing directional air flow as a virtual barrier between "shared" and "personal" air.
5) Surveying/mapping/mitigating air flow hazards in high risk public indoor spaces (bathrooms, elevators, etc)
6) Filtering shared indoor air with virus/bacteria/mold killing through UV or ceramic filtration
7) Installing pathogen-scavenging (virus, but potentially also bacteria and mold) technology that provides a continuous level of protection using ionized compounds (vaporized low-level Hydrogen Peroxide, Hypochlorous Acid, etc.), repurposed to target aerosolized or vaporized COVID-19, as well as other pathogens that may be encountered in the future

Col (ret) Dr. Paul H. Nelson, MD, MPH

McCrary Institute

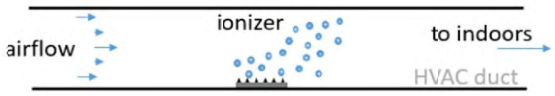
The McCrary Institute, based in Auburn with additional centers in Washington DC and Huntsville, seeks practical solutions to pressing challenges in the areas of cyber and critical infrastructure security. Through its three hubs, the institute offers end-to-end capability – policy, technology, research and education – on all things cyber.

Air University, based at Maxwell Air Force Base, Alabama, is the intellectual and leadership center of the U.S. Air Force, providing full-spectrum education, research and outreach, through professional military education, professional continuing education and academic degree granting.

Our mission is to provide clean indoor air and environmental solutions that are all-inclusive, scientifically-based, sustainable, resilient, and provide the highest level of indoor air quality services. https://www.oursharedair.com/#

ACE-IT Tool: Calculates Equivalent Air Changes and CADR

ACE-IT



AIR CLEANER EFFICACY INVESTIGATION TOOL

The air cleaner efficacy investigation tool (ACE IT) is a spreadsheet application designed to support you in translating air cleaner performance data of the type (X% reduction in Y hours) to a clean air delivery rate.

https://www.pdx.edu/healthy-buildings/ace-it

ACE-IT Tool: SARS-CoV-2 eCADR and eACH Results

ACE-IT Inputs: (Lab Test)

- Pathogen = SARS-CoV-2
- Ion density = 3,500 ions/cc
- Pathogen time in chamber = 30 min
- Chamber volume 1,936 ft^3
- 99.87% reduction for test*
- 90.96% reduction for control*

Results

- eCADR = 273.7
- eACH = 2.6

*Test performed by 3rd party lab

Case 1: % reduction (single data point)
Inputs to the spreadsheet are shown in orange
Outputs calculated by the spreadsheet are shown in green

1) Collect and input data
Data for test condition:

	Time in Chamber (min)	Reduction (%)
Pollutant or pathogen	30	99.87%

Data for control condition:

	Time in Chamber (min)	
Pollutant or pathogen	30	90.96%

Chamber volume	1936	ft^3

2) CADR calculation

	loss rate (1/h)	CADR (CFM)
control (w/ device off)	4.8	155.1
test (w/ device on)	13.3	428.8
Effect of device	8.5	**273.7**

3) Calculate clean air changes per hour (ACH) to the space in question

Floor area of indoor space device will serve	800	ft^2
Ceiling height of indoor space device will serve	8	ft
Clean air changes per hour (ACH) provided by device	**2.6**	1/h

ACE-IT Tool: SARS-CoV-2 eCADR and eACH Results

ACE-IT Inputs: (Real-World)

- Pathogen = SARS-CoV-2
- Ion density = 3,500 ions/cc
- Pathogen time in chamber = 30 min
- Chamber volume 25,600 ft³
- 99.87% reduction for test*
- 90.96% reduction for control*

Results

- eCADR = 3,619
- eACH = 8.4

*Test performed by 3rd party lab

Case 1: % reduction (single data point)
Inputs to the spreadsheet are shown in orange
Outputs calculated by the spreadsheet are shown in green

1) Collect and input data
Data for test condition:

	Time in Chamber (min)	Reduction (%)
Pollutant or pathogen	30	99.87000%

Data for control condition:

	Time in Chamber (min)	
Pollutant or pathogen	30	90.9600%
Chamber volume	25600	ft³

2) CADR calculation

	loss rate (1/h)	CADR (CFM)
control (w/ device off)	4.8	2050.9961
test (w/ device on)	13.3	5670.7337
Effect of device	8.5	**3619.7376**

3) Calculate clean air changes per hour (ACH) to the space in question

Floor area of indoor space device will serve	3200	ft²
Ceiling height of indoor space device will serve	8	ft
Clean air changes per hour (ACH) provided by device	**8.4838**	1/h

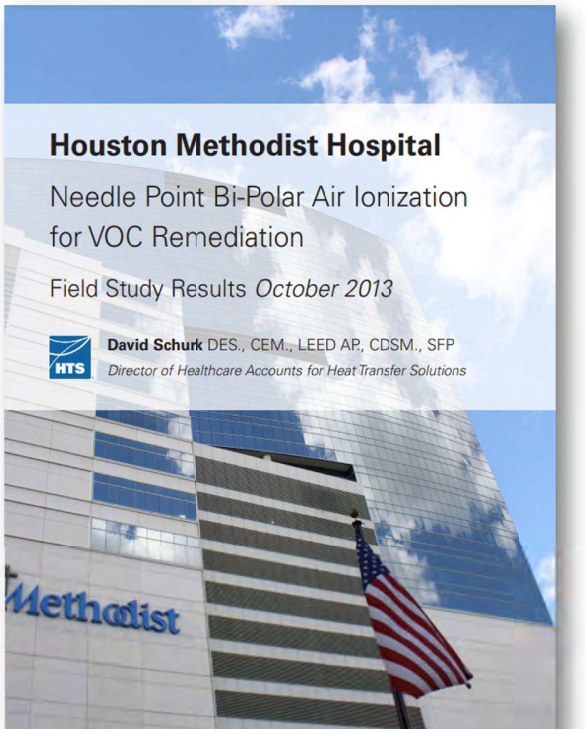
TACKLES ODORS

NPBI works with your ventilation system to introduce ions into your space, reducing airborne particles including odors and VOCs to improve indoor air quality.

What are VOCs ...

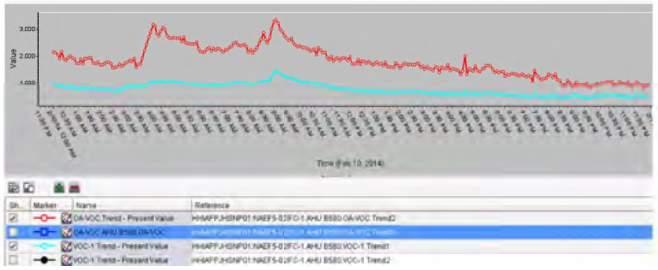
VOLATILE ORGANIC COMPOUNDS
We come in contact with hundreds of VOCs each day.

Applications - Diesel Gensets, Helicopters, Loading Docks, Morgues, Trash Rooms, Soiled Linens



The Problem:

The Results:



PRODUCT SIZE & FEATURES VARY BY OEM

Air Handler
Mounted Options

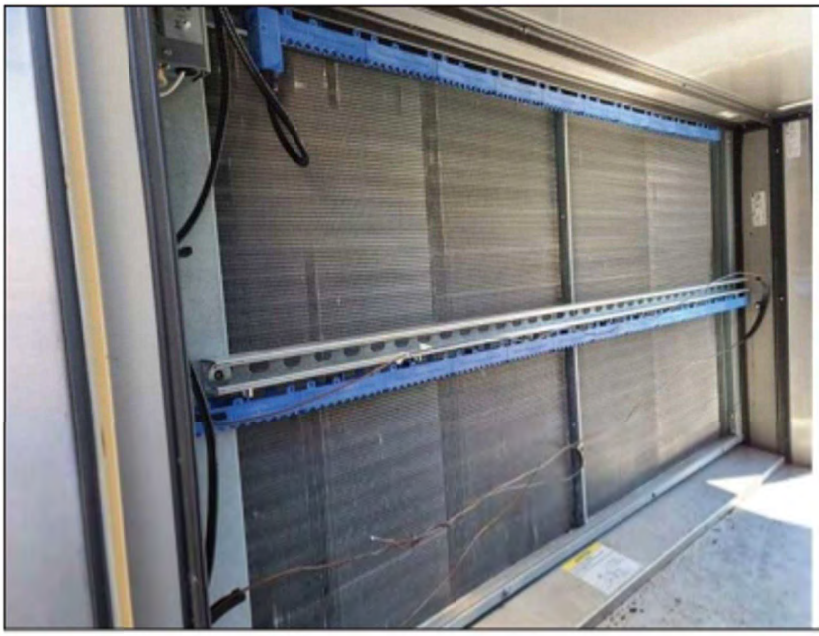
Duct Mounted Options

Ion Bars

Cooling Coil Mounted

Cleans Coils

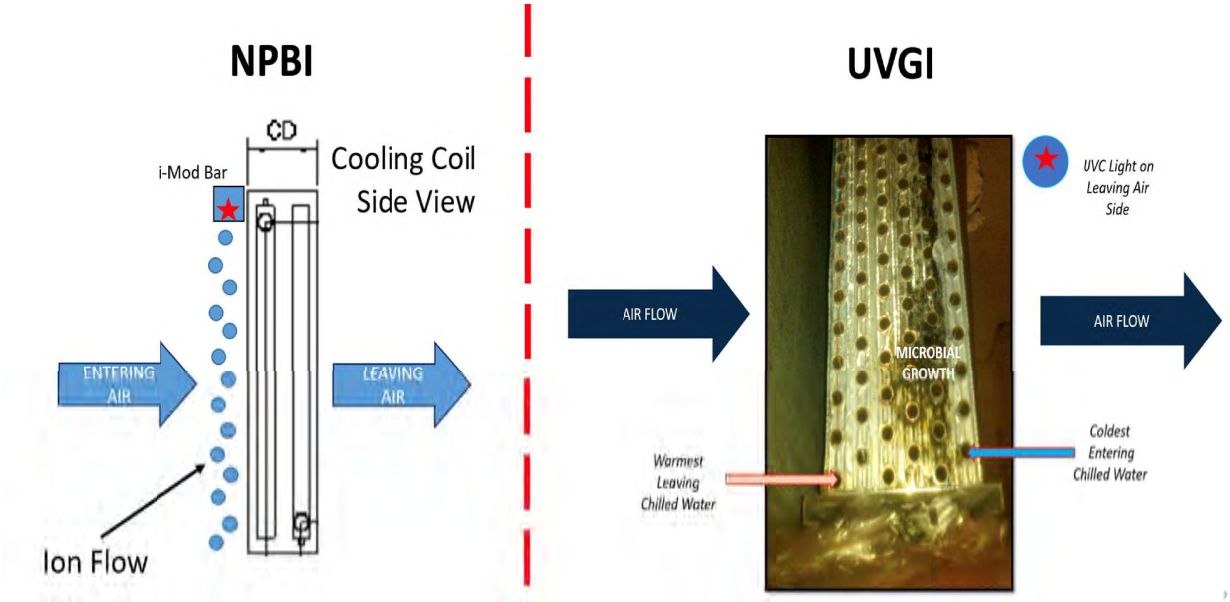
Ionizing Bars for Cooling Coil Cleaning



- No Replacement Parts
- <15 Watts Up to 60,000 CFM
- No Visible Light
- No Component Degradation

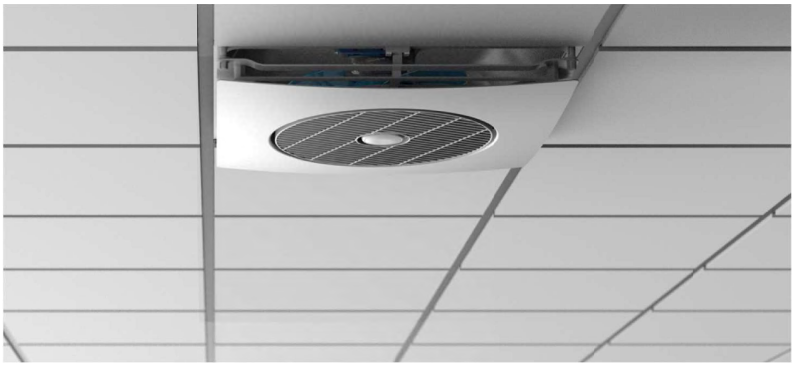
- No Measurable Pressure Drop

UVC DISINFECTS AND CLEANS ONLY WHAT IT CAN SHINE ON
CAUTION: WIRING AND GASKET DEGRADATION WILL OCCUR WITH UVC IF NOT PROTECTED



PRODUCT SIZE & FEATURES VARY BY OEM

Drop/Hard Ceiling Mounted Options

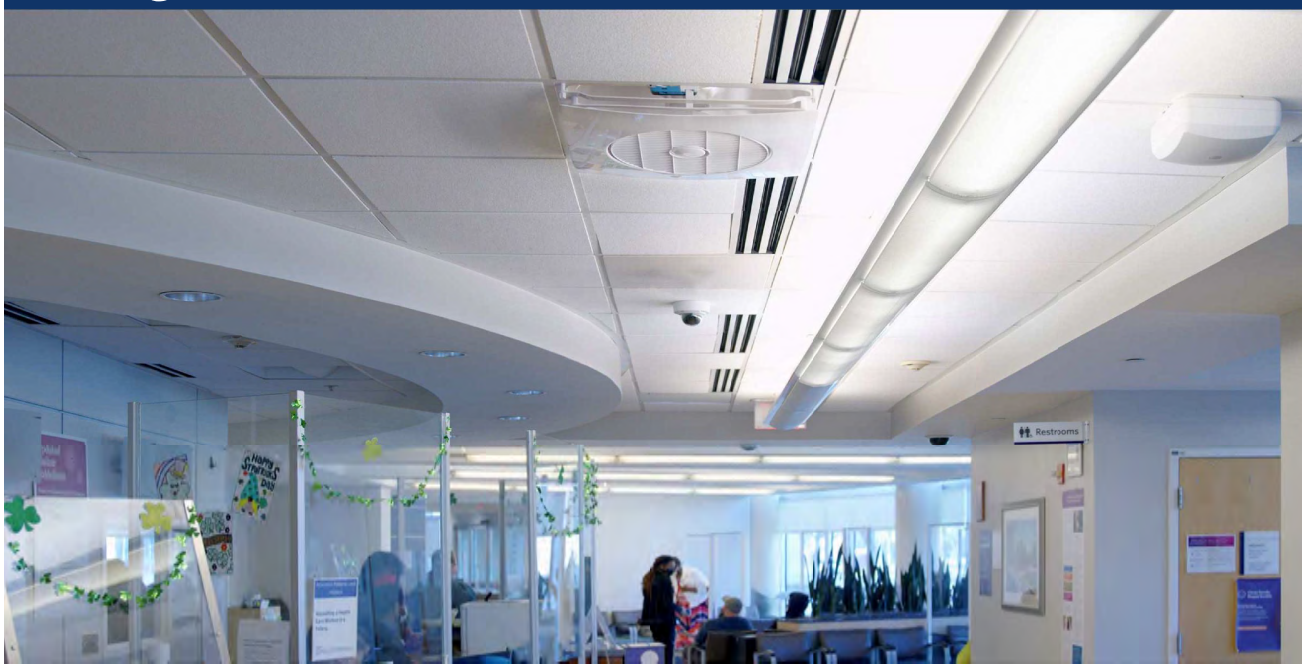


Pharmacy Spaces
Waiting Areas
Hallways

Nurses Stations
Soiled Linen Rooms
Break Rooms

Patient Rooms
Isolation Rooms
Bathrooms

Ceiling Mounted Air Ionizer with Fan



2nd Floor Cath Lab - Pre and Post NPBI Activation Nemours A.I. duPont Hospital for Children

1600 Rockland Road Wilmington, Delaware 19803

90-Day IAQ Comparison Assessment and Sampling Final Report May 17, 2021

Harvard Environmental Project No. 22157

CHILDRENS HOSPITAL PRE AND POST TESTING
January 28 vs April 21, 2021

January 28 vs April 21, 2021 Comparisons

HARVARD Environmental, Inc.

Timestamp	Location (Name)	0.3 micron (Counts)	0.5 micron (Counts)	1.0 micron (Counts)	2.5 micron (Counts)	5.0 micron (Counts)	10.0 micron (Counts)	PM0.5 (ug/m^3)	PM1.0 (ug/m^3)	PM2.5 (ug/m^3)	PM5.0 (ug/m^3)	PM10.0 (ug/m^3)	TPM (ug/m^3)	Temperature (F)	Relative Humidity (%)
1/28/2021 Average	Location 001	2013	156	22	15	3	3	0.71	1.08	1.74	6.11	13.75	27.76	39.5	24.8
4/21/2021 Average	Location 001	4083	262	65	37	6	2	1.45	2.06	3.98	14.88	29.66	42.22	63.1	51.4
LOADING DOCK	Percent Change	103%	67%	191%	149%	94%	-10%	103%	91%	129%	143%	116%	52%	60%	107%
1/28/2021 Average	Location 002	95	10	5	6	1	0	0.03	0.06	0.21	1.94	4.65	7.27	66.1	75.2
4/21/2021 Average	Location 002	1	1	1	1	0	0	0.00	0.00	0.02	0.19	0.19	0.77	71.4	36.0
CATH LAB	Percent Change	-99%	-93%	-89%	-90%	-100%	-78%	-99%	-96%	-91%	-90%	-96%	-89%	8%	-52%
1/28/2021 Average	Location 003	128	46	39	44	14	6	0.05	0.15	1.31	14.08	47.33	78.57	68.8	65.6
4/21/2021 Average	Location 003	6	2	1	1	0	0	0.00	0.01	0.04	0.25	0.99	1.87	70.1	38.5
CATH CONTROL	Percent Change	-96%	-96%	-97%	-98%	-98%	-97%	-96%	-96%	-97%	-98%	-98%	-98%	2%	-41%
1/28/2021 Average	Location 004	1302	1127	831	824	266	98	0.46	3.10	27.80	268.72	890.23	1432.11	69.8	59.1
4/21/2021 Average	Location 004	44	7	3	4	1	2	0.02	0.03	0.13	1.28	4.61	13.95	70.2	36.1
CATH HALLWAY	Percent Change	-97%	-99%	-100%	-100%	-99%	-98%	-97%	-99%	-100%	-100%	-99%	-99%	1%	-39%
1/28/2021	Interior Average	509	394	292	291	94	35	0.18	1.10	9.77	94.91	314.07	505.98	68.2	66.6
4/21/2021	Interior Average	17	3	2	2	1	1	0.01	0.01	0.06	0.58	1.93	5.53	70.6	36.9
	Percent Change	-97%	-99%	-99%	-99%	-99%	-98%	-97%	-99%	-99%	-99%	-99%	-99%	3%	-45%

CHILDRENS HOSPITAL PRE AND POST TESTING
January 28 vs April 21, 2021

HARVARD Environmental, Inc.

	TYPE	LOCATION	SAMPLE TYPE & NUMBER	1/28/2021 (Spores/m^3) (CFU/m^3)	4/21/2021 (Spores/m^3) (CFU/m^3)	Percent Change
1	Exterior	Exterior - Loading Dock	Spore Trap - 01	91	884	871%
			Viable Molds - 01	50	180	260%
			Bacteria - 01	75	155	107%
2	Interior	Cath Lab - Exam Room	Spore Trap - 02	26	0	-100%
			Viable Molds - 02	0	0	0%
			Bacteria - 02	70	25	-64%
3	Interior	Cath Lab - Control Room	Spore Trap - 03	39	0	-100%
			Viable Molds - 03	0	0	0%
			Bacteria - 03	380	80	-79%
4	Total	Interior	Spore Trap	65	0	-100%
			Viable Molds	0	0	0%
			Bacteria	450	105	-77%

FEATURES VARY BY OEM

Some NPBI systems provide auto-cleaning AND zero maintenance.

Auto-Cleaning

- Auto-cleaning, lightweight systems are designed for easy use, ultimate convenience and optimal long-term performance.
- For products that are not auto-cleaning, buildup will form over time without regular cleaning, potentially diminishing performance.

Maintenance-Free

- Unlike UV lights or traditional BPI, NPBI technology does not require any replacement parts over the lifetime of the product.

AUTO-CLEANING FEATURE