Global Plasma Solutions®  
Engineering Air for a Cleaner World™

Charlie Waddell – Founder & CTO  
How Needlepoint Bipolar Ionization  
Reduces  
Particles, Odors, Pathogens & Energy

Member ASHRAE SSPC 62.1, TC 2.3, ICC, USGBC  
Formerly Secretary of TC 8.12
Installation Base

- Over 1,000 K-12 Schools with OA reduced to 5 CFM Per Person or LESS
- Many Healthcare Applications including hospitals, outpatient centers and MOBs
- Over 150,000 installations Worldwide
Hospitals

- NY Presbyterian, NYC
- Mayo Clinic, Rochester, MN
- Children’s Hospital, Boston
- Cleveland Clinic, Westin, FL
- University of Miami Medical Center
- Tulane Medical, New Orleans
- Methodist Hospital, Houston, TX
- Anderson Medical Center, Houston, TX
- Baylor College of Medicine, Houston, TX
- Winn Army Hospital, Ft. Stewart, GA
- Duke Medical, Raleigh, NC
- Banner Healthcare, Phoenix, AZ
- Al Dupont Hospital, Wilmington, DE
- Abbott NW Heart Hospital, Minn, MN
- Women’s Hospital Greensboro, NC
- Cleveland Clinic, Cleveland Ohio

Healthcare Applications Include:
- Odor Control – NPBI can be used as a **Substitute for Carbon**
- Coil Cleaning – NPBI can be used as a **Substitute for UVC**
- Pathogen Control – NPBI can be used to kill* pathogens in the air and on surfaces
- Particle Reduction – NPBI will decrease particles in the space due to agglomeration
- Static Control – NPBI will reduce static electricity in the space
- Face Mask Efficiency – Increased space ion levels increases face mask efficiency

*Deactivates virus
The Whitehouse
Higher Education

- SMU
- Harvard University
- The University of Tulsa
- UNT
- Ole Miss
- Texas A&M
- LSU
- Yale University
- Virginia Tech
- Clemson University
- UT Dallas
- Tulane University
GPS is the only ionization company to pass DO-160 for mounting products on airplanes, in this technology category. DO-160 tests for shock, vibration, EMF, line noise, extreme cold and high pressure.
Google
Chicago & San Jose

GPS’ Ion Bars Throughout Facility
Airports

Phoenix Skyharbor

Orion Jet Center
Sheikh Zayed Grand Mosque
Abu Dhabi
Shams Gate Tower
Abu Dhabi

Duct mounted GPS units in all AHUs
Presidential Palace
Abu Dhabi - $490M Project – 2M sqft

277 AHU’s with Ion Bars in each,
Averaging 4,000-10,000 CFM
4,000 tons total chiller load
Sheikh Khalifa Central Hospital
Fujairah, UAE

> 100 AHUs with Ion Bars
Valencia College – 3 Green Globes

Independent Testing Results:

0 Bacteria - 0 Fungi
Throughout Entire Depth
Of Cooling Coil

Indoor VOCs < OA VOCs!
No E/A Fans
No DCV
No Relief Fans
Boston Children’s Hospital
Bus Diesel Odor Control

NBPI as Substitute to Carbon

OA INTAKE

Post Ionization
### Case Study - Amalie Arena

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year Built:</td>
<td>1996</td>
</tr>
<tr>
<td>Year Renovated:</td>
<td>2011</td>
</tr>
<tr>
<td>Size:</td>
<td>670,000 square feet</td>
</tr>
<tr>
<td>Occupancy:</td>
<td>21,500 Occupants</td>
</tr>
<tr>
<td>OA Reduction:</td>
<td>94,274 CFM</td>
</tr>
<tr>
<td>Capacity Saved:</td>
<td>700 Tons</td>
</tr>
<tr>
<td>Equipment:</td>
<td>12 – 40,000 AHU’s with Needlepoint Equip.</td>
</tr>
<tr>
<td>Renovation $ Saved:</td>
<td>&gt; $1 million</td>
</tr>
<tr>
<td>Annual Energy $:</td>
<td>&gt;$115,000</td>
</tr>
<tr>
<td>C02 Reduction:</td>
<td>&gt; 1.25 millions pounds C02 annually</td>
</tr>
<tr>
<td>Environment Impact:</td>
<td>Equivalent to planting &gt; 3,000 trees</td>
</tr>
<tr>
<td>Design/Build Contractor:</td>
<td>Tappouni Mechanical, Tampa, FL</td>
</tr>
</tbody>
</table>
ASHRAE 62

- VRP – Dilution method, most often used
- IAQP – included since 1981, engineered app

5.7 Ozone Generating Devices. The use of ozone generating devices shall comply with the following sections.

Exception to 5.7: Electronic devices used exclusively for the operation of HVAC equipment and controls.

Informative Note: Ozone generation is expected from ozone generators, corona discharge technology, some ultraviolet lights, electronic devices that create chemical reactions within the system, and some devices using a high voltage (>480 V). Motors and relays are examples of electronic devices that would be exempt.

5.7.1 Air-Cleaning Devices. Air-cleaning devices shall be listed and labeled in accordance with UL 2998.

Informative Note: The use of devices not intended for air cleaning with the potential to generate ozone should be avoided.

ANSI/ASHRAE Standard 62.1-2019

ASHRAE 62.1-2019 REQUIRES UL 2998
**UL 867 vs UL 2998**

- **UL 867** – All EACs tested to this standard for electric safety
  - Requires an ozone test, if the EAC is a portable room air cleaner
  - If product is duct mounted, no ozone test required! LOOP HOLE!
  - Ozone limit is 50.0 PPB when testing required

- **UL 2998** – Certification Standard “Certifies Ozone Free Technology”
  - Uses same ozone chamber test as UL 867
  - Maximum ozone output is 5.0 PPB!
  - Now required per ASHRAE 62.1-2019 Section 5.7.1
  - Applies to all devices requiring power to purify the air
  - Includes UV Lights, Polarized Filters, Ionizers, etc.
**CO2 Requirements VRP vs IAQP**

**Ventilation Rate Procedure - CO2 vs VOCs (without air cleaning)**

<table>
<thead>
<tr>
<th>Units</th>
<th>CO2</th>
<th>VOCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>4000</td>
<td></td>
</tr>
<tr>
<td>1500</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

**Indoor Air Quality Procedure - CO2 vs VOCs (with air cleaning)**

<table>
<thead>
<tr>
<th>Units</th>
<th>CO2</th>
<th>VOCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>4000</td>
<td></td>
</tr>
<tr>
<td>1500</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

**ASHRAE 62 VRP**
Must maintain 700 PPM above outdoors

**ASHRAE 62 IAQP**
Allows up to 5,000 PPM in accordance with OSHA & NIOSH PPM
According to the National Research Council, C02< 8,000 PPM has no affect on humans

**Conclusion from report:**

The subcommittee also considers a 8,000-ppm level to be protective against other end points, such as headache and metabolic and acid-base changes, that have been studied.
Harvard Study at Carrier’s Facility in Syracuse Lighting at 50% on Highest CO2 Days.....

<table>
<thead>
<tr>
<th>Variable</th>
<th>Day 1 Green</th>
<th>Day 2 Moderate CO₂</th>
<th>Day 3 High CO₂</th>
<th>Day 4 Green</th>
<th>Day 5 Conventional</th>
<th>Day 6 Green</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>4 November</td>
<td>5 November</td>
<td>6 November</td>
<td>11 November</td>
<td>12 November</td>
<td>13 November</td>
</tr>
<tr>
<td>Day of the week</td>
<td>Tuesday</td>
<td>Wednesday</td>
<td>Thursday</td>
<td>Tuesday</td>
<td>Wednesday</td>
<td>Thursday</td>
</tr>
<tr>
<td>Room</td>
<td>502</td>
<td>503</td>
<td>502</td>
<td>502</td>
<td>502</td>
<td>502</td>
</tr>
</tbody>
</table>

| Experimental parameters         |             |                    |                |             |                   |             |
| CO₂ (ppm)                       | 563         | 609                | 906            | 962         | 1,400              | 1,420       |
| Outdoor air ventilation (cfm/person)<sup>a</sup> | 40          | 40                 | 40             | 40          | 20                 | 20          |
| TVOCs (μg/m³)                   | 43.4        | 38.5               | 38.2           | 28.6        | 32.2               | 29.8        |

| Other environmental parameters  |             |                    |                |             |                   |             |
| Temperature (°C)                | 23.9        | 24.5               | 22.4           | 23.9        | 21.3               | 22.0        |
| Relative humidity (%)           | 31.0        | 30.4               | 34.2           | 31.6        | 38.7               | 38.3        |
| NO₂ (μg/m³)                     | 57.9        | 58.9               | 53.2           | 54.1        | 60.8               | 58.4        |
| O₃ (μg/m³)                      | 3.42        | 2.12               | 14.4           | 13.0        | 1.37               | 0.00        |
| PM₂.₅ (μg/m³)                   | 2.38        | 3.49               | 3.35           | 2.58        | 2.97               | 2.42        |
| Noise (dB)                      | 51.3        | 49.9               | 49.7           | 48.8        | 52.5               | 48.8        |
| Illuminance (mV)                | 2.95        | 2.70               | 2.89           | 2.83        | 2.31               | 2.04        |
| Irradiance (mV)                 | 9.07        | 8.76               | 9.45           | 9.37        | 6.00               | 6.05        |

Abbreviations: TIEQ, Total Indoor Environmental Quality; TVOCs, total volatile organic compounds.

<sup>a</sup>A constant air flow rate of 40 cfm/person was maintained on all study days, with 100% outdoor air used on days 1, 2, 3, and 6 and 50% outdoor air and 50% recirculated air used to achieve an outdoor air ventilation rate of 20 cfm/person on days 4 and 5. <sup>b</sup>Average concentration from 1400 to 1700 hours was 926 ppm, but lower CO₂ concentrations in the morning hours during the approach to steady state led to a lower average CO₂ concentration.
University of Denmark CO2 Study

2016 Study – Affects of CO2 at 5,000 PPM
**Contradicts Harvard/Carrier Study**

Highlights

- 2.5-hour exposure to CO2 up to 5,000 ppm did not decrease perceived air quality
- 2.5-hour exposure to CO2 up to 5,000 ppm did not evoke acute health symptoms
- The examined CO2 exposures did not affect performance of some cognitive tasks
- Discomfort and building related symptoms should not be attributed to CO2
IS CO2 DCV OUTDATED?

TVOCs Outside > Inside

If Space CO2 is > C02 Setpoint
AND
Space TVOCs are > than OA,
Ventilate
### Contaminants Generated by People

<table>
<thead>
<tr>
<th>Indoor Contaminants</th>
<th>Maximum Threshold Value (PPM)</th>
<th>Maximum Range of Activity</th>
<th>Steady State Using the VRP* (Prescribed OA)</th>
<th>Steady State Using the IAQ Method (Reduced OA)</th>
<th>Is Steady State Level Acceptable at Reduced OA Levels?</th>
<th>Contaminant Generation Rate (PPM)</th>
<th>Contaminant Filtration Efficiency</th>
<th>Cognizant Authority**</th>
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</thead>
<tbody>
<tr>
<td>Acetaldehyde</td>
<td>100.0</td>
<td>0.01112</td>
<td>0.00113</td>
<td>Yes</td>
<td>0.00048</td>
<td>50%</td>
<td>OSHA</td>
<td></td>
</tr>
<tr>
<td>Acetone</td>
<td>250.0</td>
<td>0.00175</td>
<td>0.00175</td>
<td>Yes</td>
<td>0.00064</td>
<td>25%</td>
<td>NIOSH</td>
<td></td>
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<tr>
<td>Ammonia</td>
<td>25.0</td>
<td>0.01771</td>
<td>0.01339</td>
<td>Yes</td>
<td>0.21460</td>
<td>50%</td>
<td>NIOSH</td>
<td></td>
</tr>
<tr>
<td>Benzene</td>
<td>1.000</td>
<td>0.02522</td>
<td>0.00922</td>
<td>Yes</td>
<td>0.00022</td>
<td>20%</td>
<td>OSHA</td>
<td></td>
</tr>
<tr>
<td>2-Butanone (MEK)</td>
<td>500.0</td>
<td>0.00020</td>
<td>0.00019</td>
<td>Yes</td>
<td>0.00133</td>
<td>20%</td>
<td>NIOSH</td>
<td></td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>1115</td>
<td>2802</td>
<td>2802</td>
<td>Yes</td>
<td>441</td>
<td>0%</td>
<td>NIOSH</td>
<td></td>
</tr>
<tr>
<td>Chloroform</td>
<td>2.000</td>
<td>0.00011</td>
<td>0.00001</td>
<td>Yes</td>
<td>0.00004</td>
<td>80%</td>
<td>NIOSH</td>
<td></td>
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<tr>
<td>Dioxane</td>
<td>100.0</td>
<td>0.00000</td>
<td>0.00000</td>
<td>Yes</td>
<td>0.00000</td>
<td>10%</td>
<td>OSHA</td>
<td></td>
</tr>
<tr>
<td>Hydrogen Sulfide</td>
<td>1.0</td>
<td>0.00000</td>
<td>0.00000</td>
<td>Yes</td>
<td>0.00000</td>
<td>25%</td>
<td>NIOSH</td>
<td></td>
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<tr>
<td>Methane</td>
<td>NA</td>
<td>1.68949</td>
<td>1.68949</td>
<td>Yes</td>
<td>0.00000</td>
<td>0%</td>
<td>NA</td>
<td></td>
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<tr>
<td>Methanol</td>
<td>200.0</td>
<td>0.00000</td>
<td>0.00000</td>
<td>Yes</td>
<td>0.00000</td>
<td>0%</td>
<td>NIOSH</td>
<td></td>
</tr>
<tr>
<td>Methylene Chloride</td>
<td>25.0</td>
<td>0.00078</td>
<td>0.00057</td>
<td>Yes</td>
<td>0.00121</td>
<td>10%</td>
<td>OSHA</td>
<td></td>
</tr>
<tr>
<td>Propane</td>
<td>1000.0</td>
<td>0.00998</td>
<td>0.00998</td>
<td>Yes</td>
<td>0.00000</td>
<td>0%</td>
<td>NIOSH</td>
<td></td>
</tr>
<tr>
<td>Tetrachloroethane</td>
<td>5.000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>Yes</td>
<td>0.00000</td>
<td>0%</td>
<td>NIOSH</td>
<td></td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>100.000</td>
<td>0.00037</td>
<td>0.00016</td>
<td>Yes</td>
<td>0.00001</td>
<td>15%</td>
<td>OSHA</td>
<td></td>
</tr>
<tr>
<td>Toluenes</td>
<td>100.000</td>
<td>0.00533</td>
<td>0.00134</td>
<td>Yes</td>
<td>0.00032</td>
<td>30%</td>
<td>NIOSH</td>
<td></td>
</tr>
<tr>
<td>1,1,1-Trichloroethane</td>
<td>350,000</td>
<td>0.00078</td>
<td>0.00013</td>
<td>Yes</td>
<td>0.00058</td>
<td>50%</td>
<td>ASHRAE</td>
<td></td>
</tr>
<tr>
<td>Xylene</td>
<td>100.000</td>
<td>0.00230</td>
<td>0.00057</td>
<td>Yes</td>
<td>0.00000</td>
<td>30%</td>
<td>OSHA</td>
<td></td>
</tr>
</tbody>
</table>

**Building materials and furnishings assumed to have no VOCs and off-gassing is complete. All yellow shaded boxes require user input or review.**

**Table 6.1 OA per Occupant (Rg) and RA per Occupant (Rg)**

- **Table 6.2 Ventilation Effectiveness (Ez)**
- **Table 6.2 Ventilation Effectiveness (Ez) with Vb correction**
- **Table 6.2 Ventilation Effectiveness (Ez) with Vb and Dc correction**

**Date:** 1/12/16

**Job Name:**

**Representative:**

**Engineer:**

**IMC 2006 & later allows for ASHRAE 62 IAQ through the engineered exception found in Section 403.2**

**Exhaust flow rates may differ from Table 6.5 based on ASHRAE 62 IAQ via Section 6.5.2**

**Carbon dioxide**

1 = ASHRAE & NIOSH C02 Limit
2 = C02 Level at Ventilation Rate OA Flow Rate
3 = C02 Level at IAQ Procedure OA Flow Rate

**Carbon dioxide has been provided for reference only for gathering demand control ventilation (DCV) setpoints. The National Research Council was commissioned by the US Navy to prove CO2 is not a contaminant of concern when using air purification to control the other contaminants of concern, as found on submarines.**
Plasma was first identified in a Crooks tube, and so described by Sir William Crookes in 1879 (he called it "radiant matter"). The nature of the Crookes tube “cathode ray” matter was subsequently identified by British physicist Sir J.J. Thomson in 1897. The term "plasma" was coined by Irving Langmuir in 1928, perhaps because the glowing discharge molds itself to the shape of the Crooks tube. Other terms associated with this technology are Dielectric Barrier Discharge, DBD and Corona Discharge.

Sir William Crookes, OM, FRS was a British chemist and physicist who attended the Royal College of Chemistry, London, and worked on spectroscopy.
Corona Tube Manufacturers

Atmos Air - Fun Facts….

• Can no longer bid NY State Schools – removed from a test school after the State of NY verified they produced ozone, aldehydes and ultrafine particles making the IAQ worse than without it. Refer to December 2018 ASHRAE Journal article.
• Removed from a FEMA study to find technology that could be used to reduce formaldehyde in trailers. All products were tested for ozone prior to the formaldehyde reduction testing and AA produced more ozone than any other technology!

• Listed by the State of California as "Potentially Dangerous Ozone Generator"

Plasma Air
Bioclimatic
Bentax
BioOxygen
+ Many Others!
**NPBI vs Corona Tube Technology**

Glass/Ceramic/Mica/Composite material is the dielectric (insulator) barrier to voltage completing the path to ground. Voltage and current (power) must be higher than NPBI systems to make the dielectric conduct electricity to complete the electrical circuit. That overall power level exceeds 12.07 eV; therefore, oxygen is ionized and ozone produced.

NPBI systems can operate with precise power output since there is no dielectric, which prevents ionizing oxygen and ensures no ozone is produced.

Ions leave tip based on polarity of voltage applied.

Ions emit directly into the airflow and the ion polarity is based on the polarity of voltage applied to the needles.
Types of NPBI

Direct Current (DC) Output –

• Each needle stays the same polarity

• Metal needles will corrode over time and dull, reducing ion output

• Carbon fiber brushes do not corrode or dull over time, regardless of DC or AC output

• Input voltage may be AC or DC

Alternating Current (AC) Output –

Each needle cluster alternates between +/- at the frequency applied
Self-Cleaning is Critical in DC Ionization Systems

6 Month Experiment
Self-Cleaning Ionization Compared to Non-Self-Cleaning Ionization

- Self-Cleaning
- Not Self-Cleaning

Israeli Ion Module
Plasma Air Uses the Israeli Ion Modules

Series 7000

SPECIFICATIONS:
Airflow Capacity: 
- Up to 1.400 CFM (7100)
- 1.40 to 2.800 CFM (7200)
- 2.80 to 4.200 CFM (7300)
- 4.20 to 6.000 CFM (7400)

Israeli Ion Modules – Needles are metal and the HV circuits don’t use epoxy – humidity over 70% RH will short the circuit and ruin the module. PA’s IOM states not to mount downstream of cooling coil!

Inside Israeli Ion Module
No Epoxy on HV Parts!

Plasma Bar

Israeli Module
Produces Only 15M ions/cc!
Bioclimatic Uses the Israeli Ion Modules

Ion Bar Model IGD-NR-"X"

![Ion Bar Model Diagram](image)

<table>
<thead>
<tr>
<th>Model</th>
<th>IGD-NR-1</th>
<th>IGD-NR-2</th>
<th>IGD-NR-3</th>
<th>IGD-NR-4</th>
<th>IGD-NR-5</th>
<th>IGD-NR-6</th>
<th>IGD-NR-7</th>
<th>IGD-NR-8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>1200 CFM</td>
<td>2400 CFM</td>
<td>3600 CFM</td>
<td>4800 CFM</td>
<td>6000 CFM</td>
<td>7200 CFM</td>
<td>8400 CFM</td>
<td>9600 CFM</td>
</tr>
<tr>
<td>Needles</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>Power</td>
<td>24 VAC 0.1 A</td>
<td>24 VAC 0.16 A</td>
<td>24 VAC 0.25 A</td>
<td>24 VAC 0.3 A</td>
<td>24 VAC 0.4 A</td>
<td>24 VAC 0.5 A</td>
<td>24 VAC 0.55 A</td>
<td>24 VAC 0.6 A</td>
</tr>
<tr>
<td>Weight</td>
<td>2.4 lb</td>
<td>2.5 lb</td>
<td>2.8 lb</td>
<td>3 lb</td>
<td>3.3 lb</td>
<td>3.5 lb</td>
<td>3.7 lb</td>
<td>4 lb</td>
</tr>
<tr>
<td></td>
<td>1.1 kg</td>
<td>1.2 kg</td>
<td>1.3 kg</td>
<td>1.4 kg</td>
<td>1.5 kg</td>
<td>1.6 kg</td>
<td>1.7 kg</td>
<td>1.6 kg</td>
</tr>
<tr>
<td>Max. Ambient Temp.</td>
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<td>150°F</td>
<td>150°F</td>
<td>150°F</td>
<td>150°F</td>
<td>150°F</td>
<td>150°F</td>
<td>150°F</td>
</tr>
<tr>
<td>66°C</td>
<td></td>
<td></td>
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<td></td>
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</tbody>
</table>

Duct Mount Unit Model IGD-N-"X"

![Duct Mount Unit Diagram](image)

<table>
<thead>
<tr>
<th>Model</th>
<th>IGD-N-1</th>
<th>IGD-N-2</th>
<th>IGD-N-3</th>
<th>IGD-N-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>1200 CFM</td>
<td>2400 CFM</td>
<td>3600 CFM</td>
<td>4800 CFM</td>
</tr>
<tr>
<td>Needles</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Power</td>
<td>2.2 VA</td>
<td>3.8 VA</td>
<td>5.3 VA</td>
<td>6.7 VA</td>
</tr>
<tr>
<td>Weight</td>
<td>1.65 lb</td>
<td>1.7 lb</td>
<td>1.75 lb</td>
<td>1.8 lb</td>
</tr>
<tr>
<td></td>
<td>0.75 kg</td>
<td>0.77 kg</td>
<td>0.80 kg</td>
<td>0.82 kg</td>
</tr>
<tr>
<td>Max. Ambient Temp.</td>
<td>150°F</td>
<td>150°F</td>
<td>150°F</td>
<td>150°F</td>
</tr>
<tr>
<td>66°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Image]
CLEAN THE AIR NATURALLY

Ions are present naturally in the air and are found in the highest concentrations where the ocean meets the shore and high elevation in the mountains.

The plasma process will artificially create the ions found in these desirable locations and supply them into the building, enhancing the indoor air quality. Process has been around since the late 1800’s

Units of Measure = ions/cc (cubic centimeter)
Waterfalls/High Elevation – 5,000 i/cc
City – 200 ions/cc
Inside Buildings - <100 ions/cc

Ions Have a 60 Second Life Max!
“P.O.P.E.” – NPBI BENEFITS

Particle Reduction – Technology makes particles clump together and a lower efficiency filter can capture them from the air

Odor Control – Odors, volatile organic compounds and the like are oxidized to gases already prevalent in the air such as oxygen, nitrogen, water vapor or carbon dioxide, eliminating the odors

Pathogen Control – Independent testing by CDC Affiliate Labs confirms kill rates as high as 99.9% of various pathogens and mold spores. Keeps new cooling coils clean and cleans up old coils.

Energy Savings by Outside Air Reduction – By cleaning indoor air and recirculating it – Less Outside Air is required. Less OA = Less Load on Cooling/Heating System – ASHRAE 62 & IMC Compliant
HOW PARTICLES ARE CREATED

- A person sitting or stopped generates about 100,000 particles per cubic ft.
- Sitting down or standing up generates about 2,500,000 particles per cubic ft.
- Walking generates about 10,000,000 particles per cubic ft.
- Horseplay generates about 30,000,000 particles per cubic ft.
- Grinding, sweeping, welding adds billions of particles per cubic ft.
- Two surfaces rubbing generate billions of particles per cubic ft.

There are over 18 Million particles in 1 cubic ft of air
This graphic depicts size comparisons for particulate matter (PM) in micrometers (µm). Note that PM\(_{2.5}\) is not visible to the naked eye.
ISO 16890 classifications are based on where particles are deposited in the human lung.

<table>
<thead>
<tr>
<th>Aerodynamic Diameter (µm)</th>
<th>ISO 16890 Filter Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td>5–10 µm</td>
<td>Nose and Pharynx</td>
</tr>
<tr>
<td>3–5 µm</td>
<td>Trachea</td>
</tr>
<tr>
<td>2–3 µm</td>
<td>Bronchial</td>
</tr>
<tr>
<td>1–2 µm</td>
<td>Bronchioles</td>
</tr>
<tr>
<td>0.1–1 µm</td>
<td>Alveoli</td>
</tr>
</tbody>
</table>

*Efficiency on particles smaller than 0.3 micron is not defined by the ISO

**PM₁** – The Smaller the More Dangerous!

A variety of studies are focusing on the health effects of PM1 particles:
GPS’ technology can reduce particles, control odors & kill pathogens.

The Problem - A large Midwest medical device manufacturer contacted GPS due to a new chemical being introduced into the manufacturing process that was creating odor issues for the employees working in those rooms and adjoining spaces that shared the same air handling system. Upon reviewing the molecular structure of the chemical, it was determined that GPS’ cold plasma technology could control the odor effectively.

The Solution - A GPS-iBar system was installed on the air entering side of the cooling coil in the air handler conditioning the clean rooms.

The Results – After installation of the GPS-iBar system, the odors were eliminated in less than 24 hours. The GPS-iBar system also provided a pleasant surprise to the owner when the annual clean room certification occurred. The clean room certification company found the total particle counts to be 89.7% less than any other time prior to the GPS-iBar installation, which includes over 10 years of prior testing with similar, consistent results.
MERV 8 + GPS = > MERV 13

Test Results

1. It was determined that the 1" MERV 13 Panel filter reduced particle count from 2,730,958 to 808 particles in a timeframe of 34 minutes.
2. It was determined that the 1" MERV 8 Panel filter with GPS Technology reduced particle count from 3,645,943 to 745 particles in a timeframe of 16 hours.
3. It was determined that the 1" MERV 8 Panel filter with GPS Technology reduced particle count from 2,753,181 to 745 particles in a timeframe of 15 hours - 40 minutes in comparison to the MERV 13 at 34 minutes.

Quantitative Results

### MERV 13 Filter

<table>
<thead>
<tr>
<th>Elapsed Time, Min.</th>
<th>Microns</th>
<th># total Particles</th>
<th>#/cm³ Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.30</td>
<td>1805492</td>
<td>2730958</td>
<td>2730</td>
</tr>
<tr>
<td>0.40</td>
<td>738537</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.55</td>
<td>144867</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.70</td>
<td>40941</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.00</td>
<td>865</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.30</td>
<td>153</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.60</td>
<td>96</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.20</td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### MERV 8 Filter with GPS Technology

<table>
<thead>
<tr>
<th>Elapsed Time, Min.</th>
<th>Microns</th>
<th># total Particles</th>
<th>#/cm³ Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.30</td>
<td>1958081</td>
<td>3645943</td>
<td>3645</td>
</tr>
<tr>
<td>0.40</td>
<td>1222632</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.55</td>
<td>332433</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.70</td>
<td>129690</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.00</td>
<td>2610</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.30</td>
<td>341</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.60</td>
<td>136</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.20</td>
<td>6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Elapsed Time, Min. | Microns  | # total Particles | #/cm³ Concentration |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1876059</td>
<td>2753181</td>
<td>2753</td>
</tr>
<tr>
<td>19</td>
<td>736434</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 hours</td>
<td>619</td>
<td>745</td>
<td>0.74</td>
</tr>
<tr>
<td>90</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The combination of the NPBI with MERV 12 has the same efficiency as a MERV 16 filter for size bin E2 (PM2.5), i.e. a filter eff. ≥ 95%

*Testing based on GPS-iMOD in a western CA hospital*
Filtering Efficiency of N95- and R95-Type Facepiece Respirators, Dust-Mist Facepiece Respirators, and Surgical Masks Operating in Unipolarly Ionized Indoor Air Environments

Table 1. Enhancement factors due to the ion emission for four facepiece filtering masks.

<table>
<thead>
<tr>
<th></th>
<th>Half-mask respirator</th>
<th>Dust-mist respirator</th>
<th>Surgical mask</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N95</td>
<td>R95</td>
<td></td>
</tr>
<tr>
<td>Enhancement factor</td>
<td>48.4</td>
<td>22.3</td>
<td>3250</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>194</td>
</tr>
</tbody>
</table>

*Note*: Ion emitter = VI-2500; inhalation flow rate = 30 L/min; emission time = 12 min.

Data Provided by:

Center for Health-Related Aerosol Studies

Dept. of. Environ. Health
University of Cincinnati
Needlepoint Bipolar Ionization for TVOC CONTROL

What Are VOCs?

**Volatile:** Vapor at Room Temperature

**Organic:** Contains Hydrogen & Carbon

**Compounds:** More than one gas

- Natural & Man-Made
- We Come in Contact w/100’s Each Day
- Human & Non-Human Sources
Plasma Breaks Down Gases To Less Objectionable Forms

Ammonia Molecule

Plasma Field
The Objectionable Gases Regroup To Form Safe & Desirable Gases Already Prevalent in Our Atmosphere!

- Oxygen
- Nitrogen
- Water Vapor
# Chemical Compounds Ionization Can Easily Control

<table>
<thead>
<tr>
<th>CHEMICAL</th>
<th>FORMULA</th>
<th>Electron Volt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xylene*</td>
<td>C8H10</td>
<td>7.89</td>
</tr>
<tr>
<td>Styrene*</td>
<td>C8H8</td>
<td>8.46</td>
</tr>
<tr>
<td>Methyl Ethyl Ketone*</td>
<td>C3H8O</td>
<td>9.52</td>
</tr>
<tr>
<td>Ammonia*</td>
<td>NH3</td>
<td>10.07</td>
</tr>
<tr>
<td>Acetaldehyde*</td>
<td>CH3CHO</td>
<td>10.23</td>
</tr>
<tr>
<td>Ethyl Alcohol*</td>
<td>C2H5OH</td>
<td>10.48</td>
</tr>
<tr>
<td>Formaldehyde*</td>
<td>CH2O</td>
<td>10.88</td>
</tr>
<tr>
<td>Oxygen</td>
<td>O2</td>
<td>12.07</td>
</tr>
</tbody>
</table>

Corona tubes require >12.07 to break down the dielectric

* Typical contaminants of concern as contained within ASHRAE 62.1
  - Electron Volt Energy greater than 12Ev, creates ozone (O3)

Atmos Air, Plasma Air, Bioclimatic & Ion Aire use Corona Tubes
Mold, Virus & Bacteria Control

The Positive and Negative Ions Attack DNA/RNA

Cell Structure of Single Cell Organisms & Removes Hydrogen*

Plasma Source

Like Purell for the air and surfaces

*Living Organisms Only
Independent Testing by World Renowned EMSL & ATS Labs

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Time Exposed</th>
<th>Kill/Deactivation Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>E.coli</td>
<td>15 minutes</td>
<td>99.68%</td>
</tr>
<tr>
<td>MRSA</td>
<td>30 minutes</td>
<td>96.24%</td>
</tr>
<tr>
<td>TB</td>
<td>60 minutes</td>
<td>69.01%</td>
</tr>
<tr>
<td>Noro Virus*</td>
<td>30 minutes</td>
<td>93.50%</td>
</tr>
<tr>
<td>Human Coronavirus**</td>
<td>60 minutes</td>
<td>90.00%</td>
</tr>
<tr>
<td>C.diff</td>
<td>30 minutes</td>
<td>86.50%</td>
</tr>
</tbody>
</table>

*Norovirus is not an enveloped virus and is harder to kill than COVID-19, an enveloped virus.

**Residential product with 40% less output used for first test
Viruses can be generally categorized in three groups by virus structure

*Structure affects the effectiveness of disinfectants in killing the viruses*

- Enveloped viruses are easiest to kill. (An example is Influenza A Virus)
- Large, non-enveloped viruses are more difficult to kill. (An example is Rotavirus)
- Small, non-enveloped viruses are hardest to kill. (An Example is Norovirus)

Coronaviruses are enveloped viruses, meaning they are one of the easiest types of viruses to kill with the appropriate product.
## % of SARS Virus Controlled Based on Technology

<table>
<thead>
<tr>
<th>MERV Rating</th>
<th>Filter Only</th>
<th>Filter+UVC***</th>
<th>Filter + Ionization* , **</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>6.2%</td>
<td>10%</td>
<td>34%</td>
</tr>
<tr>
<td>7</td>
<td>7%</td>
<td>12%</td>
<td>61%</td>
</tr>
<tr>
<td>8</td>
<td>11%</td>
<td>19%</td>
<td>84%</td>
</tr>
<tr>
<td>10</td>
<td>12%</td>
<td>35%</td>
<td>89%</td>
</tr>
<tr>
<td>13</td>
<td>46%</td>
<td>84%</td>
<td>97%</td>
</tr>
<tr>
<td>15</td>
<td>71%</td>
<td>97%</td>
<td>99%</td>
</tr>
<tr>
<td>16</td>
<td>76%</td>
<td>98.80%</td>
<td>99.90%</td>
</tr>
<tr>
<td>17 (HEPA)</td>
<td>99.90%</td>
<td>99.99%</td>
<td>99.999%</td>
</tr>
</tbody>
</table>

*Ionization increases the filter efficiency 4-5 MERV levels – this column added by GPS

**Does not take into account ionization kills in the space and on surfaces

***UVC does not effectively kill airborne pathogens in high RH conditions²

1. 2009 EPA Tech Paper
2. ASHRAE Technical Paper on Airborne Infectious Diseases
HOW CAN WE REDUCE GERM TRANSMISSION IN THE ENVIRONMENT?

CONTROL WHAT WE CAN CONTROL

and

LET PPE DO THE REST!

• CONTROL HUMIDITY – 40% to 60%
• REDUCE STATIC ELECTRICITY
• REDUCE PARTICLES
• USE “ACTIVE” TECHNOLOGY
UVC CHARACTERISTICS

1. OUTPUT REDUCES AS TEMPERATURE DROPS
2. EFFECTIVENESS REDUCES AS HUMIDITY GOES UP*
3. LAMP OUTPUT DECREASES WITH TIME
4. LAMPS MUST BE REPLACED
5. LAMPS CONTAIN MERCURY – HOW DO YOU DISPOSE?
6. HARMFUL VISIBLE LIGHT PRODUCED
7. ORGANICS EXPOSED TO LIGHT WILL BREAK DOWN

*ASHRAE AIRBORNE INFECTIOUS DISEASE WHITEPAPER
# NPBI as Replacement to UVC

## Needlepoint Bi-Polar Ionization v/s UVC

<table>
<thead>
<tr>
<th>CHEMICAL</th>
<th>Bi-polar Ionization</th>
<th>UVC Light</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replacement Interval?</td>
<td>None</td>
<td>Annually</td>
</tr>
<tr>
<td>Produces Detectable Ozone?</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Kill Mold, Bacteria and Virus?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Kills Pathogens in the Space?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Controls Odors?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Reduces Particulates?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Contains Mercury?</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Electrodes Fragile?</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Shock Resistant</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Hazardous Disposal Req’d No Yes

Note: Cleans entire coil depth, not just “line of sight”.
**UVC Wavelength Decreases Over Time**

Effective UV Lamp Life – 1 year

UV output decreases over time

All UV performance data reviewed to date is based on new lamps

Eventually UV lamps become “NEON” lights and then mold, bacteria and virus can survive on the surface of the light as shown in the photo.

This photo was taken just after the lights were turned off for the safety of the photographer. The lamps still had “blue” light produced, but not enough output to kill mold since it was growing!

**GPS’ NPBI DOES NOT DECREASE OVER TIME!**
# Needlepoint Ionization vs UVC

<table>
<thead>
<tr>
<th></th>
<th>Needlepoint Ionization</th>
<th>UVC</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFM</td>
<td>10,000</td>
<td>10,000</td>
</tr>
<tr>
<td>Product</td>
<td>AC Ion Bar</td>
<td>UVC Lamps</td>
</tr>
<tr>
<td>Product Cost</td>
<td>$3,500.00</td>
<td>$2,000.00</td>
</tr>
<tr>
<td>Installation Labor</td>
<td>$105.00</td>
<td>$760.00</td>
</tr>
<tr>
<td>Installation Material**</td>
<td>$ -</td>
<td>$220.00</td>
</tr>
<tr>
<td>First Cost Total</td>
<td>$3,605.00</td>
<td>$2,980.00</td>
</tr>
<tr>
<td>Utility Cost $/KWh</td>
<td>$0.10</td>
<td>$0.10</td>
</tr>
<tr>
<td>Annual Utility Cost</td>
<td>$52.56</td>
<td>$219.00</td>
</tr>
<tr>
<td>Annual Hours of Operation</td>
<td>8,760</td>
<td>8,760</td>
</tr>
<tr>
<td>Annual Replacement</td>
<td>NA</td>
<td>$533.40</td>
</tr>
<tr>
<td>Annual Replacement Labor</td>
<td>NA</td>
<td>$185.00</td>
</tr>
<tr>
<td>Annual Cleaning Labor</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>First Year Total Cost</td>
<td>$3,657.56</td>
<td>$3,917.40</td>
</tr>
<tr>
<td>10 Year Cost</td>
<td>$4,130.60</td>
<td>$12,354.00</td>
</tr>
<tr>
<td>Years to Break Even Point</td>
<td>(0.07)</td>
<td></td>
</tr>
</tbody>
</table>
Biofilm Reduces Heat Transfer

• Amount of Scale........................% Heat Transfer Reduction
  • 0.006”...............................16%
  • 0.012”...............................20%
  • 0.024”...............................27%
  • 0.036”...............................33%

• “Equipment operating with dirty coils may use as much as 37% more energy than equipment with clean coils.”
  • Source: Air Conditioning, Heating & Refrigeration News
Classroom Dirty Coil Analysis

<table>
<thead>
<tr>
<th>Scale Thickness</th>
<th>% Loss</th>
<th>Added Tons</th>
<th>Added Annual Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.006</td>
<td>16%</td>
<td>0.48</td>
<td>$86.40</td>
</tr>
<tr>
<td>0.012</td>
<td>20%</td>
<td>0.6</td>
<td>$108.00</td>
</tr>
<tr>
<td>0.024</td>
<td>27%</td>
<td>0.81</td>
<td>$145.80</td>
</tr>
<tr>
<td>0.036</td>
<td>33%</td>
<td>0.99</td>
<td>$178.20</td>
</tr>
</tbody>
</table>

Annual Hours: 2000
$/KWh: $0.100
KW per Ton: 0.9

Notes:
1. Savings only applies to cooling hours unless it is a heatpump coil
**Fan Power Savings**

- CFM = 1,000
- Increased Static PD Due to Dirty Coil = 1.0” WC
- $ / KW = $0.10
- Operational Hours = 2000 (typical school annual hours)
- Total Savings = $37.28 Per 1,000 CFM @ 1” Static

*Dirty Coil Surfaces Affect Heat Transfer By Imposing More Load on System*
Mold Test (with & without NPBI)

Day 1

Day 12

KSU ASHRAE STUDENT PROJECT
**GPS-iRIB-36 or -18**

**Flexible Ionization Ribbon – 110V to 240VAC or DC**

**Typical Location Install on Ductless Wall System:**

*Figure 6*

- Affix the iRIB power pack to back of cabinet and wire to L1/L2 or S1/S2, leave on 24/7. Alarm contacts provided

- Affix the iRIB to the top of the coil on the plastic strip or to the top of the fins to treat the coil, blower and space
Self-Cleaning Ion Generator
GPS-FC24-AC

Two self-cleaning wiper blades for low profile

Designed for VRF/VRV Ceiling Cassette Units (only 1” high)
0-2,400 CFM
24VAC-240VAC or DC Input, includes BAS contacts
GPS-FC24-AC Installation
SELF CLEANING ION GENERATOR
GPS-FC48-AC

Capacity: 0-4,800 CFM
Self-Cleaning – No Maintenance
Universal Voltage: 24VAC-240VAC, with BAS contacts
GPS-FC48-AC Installed on Split DX 2 ton System
GPS-FC48-AC installed in RTU
GPS-DM48-AC
WORLD’S FIRST SELF-CLEANING NPBI GENERATOR

2016 HVAC IAQ PRODUCT OF THE YEAR!
0-4,800 CFM, Mounts Indoors or Out
24-240VAC Universal Voltage Input w/BAS Contacts
Provided with Display for Operation Status
GPS-DM48-AC Installation
GPS-iMOD (AC Output Device)

Modular Ionization Product – Fits Any Size HVAC System

- 24VAC, 110VAC or 208-240VAC INPUT
- 15W power total for any quantity/length bars attached
- Self-Cleaning Due to AC Output and “Wave” Design
- Up to 6 bars per power supply (total 50’ bar length)
- OSHPD CERTIFIED
GPS-iMOD Installation
GPS-iMOD
Installation Pics
GPS-iMOD Sizing

- Coil Cleaning – 1 bar for every 5’ of coil height
- Odor Control – 2 bars per coil, one at top and one midway down, both pointing towards floor
- Space Pathogen Control – Mount after final filters and provide 1” of bar length per 400 CFM
How do you know it’s working?

Measurement and Verification

Building Automation System integration and Sensors
- Unit operating (on/off)
- Ion meters
- Particle meters
- Sense of smell
- Lab results (EMSL and ATS)
Ion Sensing Solutions

GPS-iMEASURE™
The GPS-iMEASURE is the first commercially available ion detector that can be permanently mounted in the space to measure ion levels in real time and report back to a BAS.

MONITOR IONIZATION LEVELS REMOTELY
• Auto Calibration/Auto Zero
• 0 – 1,000,000 Ions/cc

GPS-iMEASURE-D™
The GPS-iMEASURE-D ion detector is permanently mounted in the duct downstream of any GPS ionization device. It measures ion levels in real time and reports back to a BAS. It includes three sensitivity levels: 20,000/200,000/2,000,000 ions/cc/sec that can be set based on the application and in-duct location.

MONITOR IN-DUCT IONIZATION LEVELS
• 20,000 to 2M Ions/cc
• Input Voltage 12 to 24V AC or DC
• LED Operation Status

GPS-AIC Handheld

GPS-iDETECT-P™
The GPS-iDETECT-P is a plenum-mounted ionization detector that confirms the output from the GPS-iMOD. The GPS-iDETECT-P provides the ability to monitor ionization status in a plenum to confirm that the ionization equipment is working properly.

Features
• Universal Voltage Input
• 1,000 – 200,000,000 Ions/cc (+ or -)
• 0-100% Humidity
**TVOC Sensing Solutions**

**Metal Oxide Semiconductor**
- Self-Calibrates
- 0-10VDC Output
- Correlated Value for DCV Apps
- Not “Absolute” Technology
- Cannot be used for “Inlet/Outlet”
- Approximately $500 from BAPI

**Photoionization Detector**
- Rib Relay ($150)
- Analog Input to BacNet
- RIBMNW24B-BCAI (0-10V)
- RIBTW24B-BCAO
- 4-20mA Device
- Annual Manual Recalibration
- 4-20mA Output
- “Absolute” Technology
- Used for “Inlet vs Outlet” Efficiency Calc
- Approximately $3,500 from Ion Science
Inlet v/s Outlet Efficiency Calculation

Use PID

Don’t Use Metal Oxide

Don’t Use Metal Oxide
**Particle Sensing**

- Measures PM 2.5 and PM 10.0
- 24VAC/DC Input
- Local Display
- BACnet, MODBUS and Analog Outputs
- 0 to 1,000 ug/m³ Scale
- Duct Probe or Wall Mounting Options
Monitoring Ions, TVOCs and Particles (PM10 and PM2.5)
**Benefits of NBPI**

- Saves on First & Renovation Construction Costs
  - Rule of Thumb – 5 CFM per person of Outside Air
    - OA Reduction Subject to Building Pressure and non-healthcare apps
- Reduces Maintenance
- Reduces Mold
- Treats the Space
- Reduces Static
- Reduces Particles, Odors, Pathogens and Energy (P.O.P.E.)
Questions?