A WHITE PAPER

An Overview of Needlepoint Bipolar Ionization

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What is an Ion?

An ion is a charged atom or molecule. It is charged because the number of electrons does not equal the number of protons in the atom or molecule. An atom can acquire a positive charge or a negative charge depending on whether the number of electrons in the atom is greater or less then the number of protons in the atom.

The atom is called an ion when an atom is attracted to another atom because it has an unequal number of electrons and protons. If the atom has more electrons than protons, it is a negative ion, or ANION. If the atom has more protons than electrons, it is a positive ion, or CATION.

History of Air Ionization

Corona discharge ionization systems have been operating since the late 1800s. They were originally developed by Sir William Crooks. They were marketed as the "Crooks Tube," and sometimes called a cathode ray tube. Around 1928 William Langmuir changed the name to "plasma tube." Corona discharge ionization products have been in the market for a long time. They are also marketed as bipolar ionization systems, ionization systems, corona discharge tubes (CDT) or dielectric barrier discharge (DBD) systems. No matter what they are called, they are constructed in the same general manner. Many companies use CDT/DBD to generate ozone for various odor control applications, but generally the ozone produced is not discharged into an occupied space. In short, if you use corona CDT/DBD based ionization technology, there will be ozone as a byproduct, contrary to what some marketing materials from various manufacturers suggest. Some manufacturers try to disguise the ozone output by calling it activated oxygen, triatomic oxygen or activated plasma, to name a few. These name variations have caused confusion in the market.

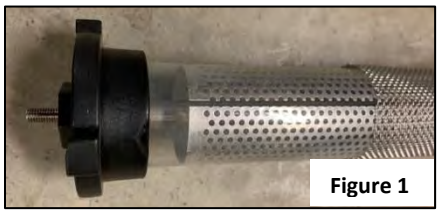

Figure 1

Figure 1 shows an example of a bipolar ionization CDT. There is an inner filament, a glass tube, and an outer filament. The glass is the "dielectric," or resistance to the voltage path to ground. The dielectric can be glass, quartz, mica, ceramic, or any other material that has a high dielectric (insulating) value. For a corona discharge system to operate, the voltage and current must be high enough to break down the dielectric material in order to complete the electrical path to ground. When the power output is sufficiently high and the path to ground is achieved due to the dielectric breakdown, a corona discharge is formed. The corona discharge is best seen in total darkness. It appears as a purple glow down the entire tube. Where you see the purple glow, ozone is being produced.

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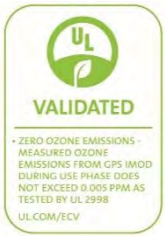
Understanding eV Potential

The power required to make most dielectrics break down is greater than 12.07eV (electron volts). Every gas has an electron volt potential. **Figure 2** shows a sample of eV potential for several compounds. Oxygen has an electron volt potential of 12.07eV, as shown in Figure 2. When the power input is greater than 12.07eV, ozone is created due to oxygen being ionized, or "activated." Every gas in the atmosphere has an electron volt potential. Understanding the relationship of power to eV is critical when designing air purification systems to produce the desired effect, while avoiding the formation of ozone and other by-products. ***Needlepoint bipolar ionization*** **(NPBI)** is uniquely different from corona discharge ionization systems. NPBI does not use a dielectric. The power output is controlled to less than 12.07eV to prevent the formation of ozone. GPS' NPBI technology has been certified by UL 867 and UL 2998 as an ozone free technology. Therefore, ozone, aldehydes and ultra-fine particles are not created. In fact, GPS' NPBI is used by multiple cleanroom manufacturers to reduce ultra-fine particles. NPBI has been successfully used in hospitals, offices, airports, schools, arenas, airplanes, veterinary offices and vivariums, to name a few applications.

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
Glass 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 (O_3)

Figure 2 CORONA DISCHARGE TUBE



Needlepoint Bipolar Ionization

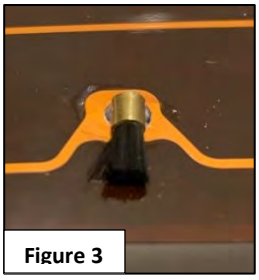


Figure 3

NPBI electrodes, or "needles," are made from carbon fiber (see Figure 3), titanium, silver, gold, stainless, or any other corrosion resistant, conductive material. As you can see from Figure 3, the electrodes are attached to the flexible circuit and there is no dielectric.

NPBI has been used for particle reduction, odor control, pathogen control, energy savings and static electricity control for more than 10 years. The production of unwanted by-products, including ozone, associated with corona discharge air cleaners are avoided when using NPBI. GPS' patented ***needlepoint bipolar ionization*** technology should **NOT** be associated with the older, ozone producing, corona discharge ionization systems. If it doesn't state needlepoint bipolar ionization, be careful!

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Benefits of GPS' Needlepoint Bipolar Ionization

GPS Delivers ***P.O.P.E***

Particle Reduction – GPS' needlepoint bipolar ionization technology (NPBI) generates both positive and negative ions. Once produced, the ions have a life span of approximately 60 seconds. This lifespan gives the ions time to travel with the airflow into the space. In standard indoor air quality (IAQ) applications that are non-healthcare and cleanroom type systems, particle counts are normally in the range of 18 million particles per cubic foot. Most of these particles are below 0.3µm (micrometers, or microns) in diameter, which means they stay airborne almost indefinitely. Particles this small have very little mass and surface area. The air currents in the space have little leverage to move these particles back to the filter for capture. Most people have seen a sunbeam in their home or office when sunlight shines through a window, exposing the haze of fine particles in the air. The sunbeam is comprised of asthma and allergy triggering small particles that include mold, pollen, pet dander and many other organic contaminants. In fact, they are so small that when you walk through the sunbeam, you can't detect the particles moving. If the particles were like snow, the NPBI technology is the snow plow! As previously mentioned, ions produced using NPBI travel with the airflow and enter the space where the fine particles exist. The ions cause some particles to become positively charged, while others become negatively charged. Because opposite charges attract, these particles become magnets and start sticking to one another, which is called agglomeration (like creating a snowball). As the particles become larger, they gain surface area and mass. The particle growth enables the airflow within the space to push against the larger surface and propel those particles to the filter where they can be captured. In layman's terms, if you have sunbeams in your home or apartment, after 2-3 days of operating GPS' NPBI system, you will no longer see sunbeams, and there will be much less particles and dust in the indoor air. Blue Heaven Labs, a 3rd party laboratory, tested GPS' NPBI and confirmed that a system using a MERV 8 filter and NPBI will have the same or better particle control than a system using a MERV 13 filter without NPBI. This equates to fan energy savings and filter replacement cost savings.

Odor Control – The ions produced by GPS' patented NPBI devices break down gases with electron volt potential numbers below 12. The harmful gases are reduced to compounds or molecules already prevalent in the atmosphere, including oxygen, nitrogen, water vapor and carbon dioxide. The compounds are a result of the contaminants entering the NPBI field. Formaldehyde, for example, which is off-gassed by building furnishings, is known to be carcinogenic. Formaldehyde has an Electron Volt Energy of 10.88 eV. Formaldehyde breaks

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down to carbon dioxide and water vapor when it encounters the plasma field, thus eliminating the health hazard. Another example is ammonia, with a 10.07 eV. Ammonia is typically produced by occupants of a space, and best understood as typical body odor. Ammonia breaks down to nitrogen and water vapor. In summary, the chemical or contaminant in the space reacts with the NPBI field and results in harmless molecules common in the atmosphere. Many applications are now using GPS' NPBI technology instead of carbon filters or potassium permanganate to control odors. Carbon is expensive, requires frequent replacement, and must be "tuned" to the target odors and contaminants. Filters also have a high pressure drop, or drag, which result in greater energy demand. Carbon filters require a final filter for dusting because carbon particles are released from the filter. Finally, if you don't want any ultra-fine particles entering the airstream, a final filter is needed, which is typically an expensive Ultra-Low Particle Air (ULPA) filter, like what is used in radioactive applications.

Pathogen Control – The ions produced by NPBI are also attracted to pathogens, like ions attaching to and controlling particles. When the ions combine on the surface of a pathogen, they rob the pathogen of the hydrogen necessary for them to survive. During the final step of deactivation, the ions eliminate hydrogen from the pathogen, making the airborne virus, bacteria or mold spore inactive or non-viable. GPS has done substantial testing to confirm the kill rates of various pathogens. Below is a chart that shows the results of testing that has been completed by various 3rd party, independent testing firms.

Pathogen	Time in Chamber	Kill Rate	Test Agency
T.B.	60 minutes	69.09%	EMSL
C. difficile	30 minutes	86.87%	EMSL
Noro Virus	30 minutes	93.50%	ATS Labs
MRSA	30 minutes	96.24%	EMSL
Staph	30 minutes	96.24%	EMSL
Mold Spores	24 hours	99.50%	GCA
E. coli	15 minutes	99.68%	EMSL
Legionella	30 minutes	99.71%	EMSL

EMSL

BUREAU VERITAS

ATS LABS
EXCELLENCE IN ANTIMICROBIAL TESTING

GPS' technology is the only active air purification system that has been designed and approved to operate in commercial and private aircraft. Aviation applications require passing the stringent DO-160 test that proves the technology does not generate EMF, or line noise, that would interfere with the avionics equipment of the airplane. This is important to note because GPS'

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NPBI technology is used in many healthcare applications for pathogen and odor control. There is no interference with healthcare imaging equipment that would result in unreliable testing.

Energy Savings via Outside Air Reduction – Utilizing the ASHRAE 62 Indoor Air Quality Procedure (IAQP), combined with GPS' NPBI technology, outside air may be reduced by up to 75% in non-healthcare applications, subject to building pressure. The IAQP allows air purification to be applied to clean the air within the building and remove the contaminants of concern, thus reducing outside air intake need for dilution. The NPBI technology is controlling or destroying the contaminants of concern, and less so-called clean outdoor air is required, resulting in significant energy savings to condition the incoming air. NPBI has been installed in over 1,000 projects with the ventilation rates reduced to 5 CFM per person or less. For example, in a K-12 application in the southeast United States, on a 100,000 square feet school, the typical first cost savings are $500,000, and the annual energy savings are generally $0.25 to $0.40 per square foot!

If you have **P**articles, **O**dors or **P**athogen issues, or you need to reduce ventilation air to save **E**nergy while protecting your IAQ, GPS' Needlepoint Bipolar Ionization technology is the right solution for you! Below are a few clients that have used GPS' NPBI technology.

Needlepoint Bipolar Ionization (NPBI) is **NOT** corona discharge