

# ***Saving Energy & Providing Excellent IAQ using Cold Plasma Technology***

***Presented by***

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***Founder & CTO – Global Plasma Solutions***

***Member ASHRAE, USGBC & ICC***

***TC 2.3 / 145.2 (Gas Phase Filtration)***

***SSPC 62.1 (Ventilation Requirements)***

***Former – Secretary 8.12 (Desiccant Dehum)***

***Member USGBC Committee - Indoor Air Assessment Group***

# ASHRAE 62 METHODS

## Ventilation Rate Procedure (Section 6.1.1)

### Requirements

- a. CFM Per Person
- b. CFM Per Square Foot
- c. Ventilation Effectiveness
- d. System Type – i.e., single zone, multi-zone, etc.
- e. Outside Air Quality Investigation

(Prerequisite – Section 4.1 to 4.3)

# Outside Air Quality Investigation

## 4. OUTDOOR AIR QUALITY

Outdoor air quality shall be investigated in accordance with Sections 4.1 and 4.2 prior to completion of ventilation system design. The results of this investigation shall be documented in accordance with Section 4.3.

**4.1 Regional Air Quality.** The status of compliance with national ambient air quality standards shall be determined for the geographic area of the building site.

**4.1.1** In the United States, compliance status shall be either in “attainment” or “non-attainment” with the *National Ambient Air Quality Standards* (NAAQS)<sup>1</sup>. In the United States, areas with no EPA compliance status designation shall be considered “attainment” areas.

*Note:* The *National Ambient Air Quality Standards* (NAAQS) are shown in Informative Appendix I, Table I-1.

**4.2 Local Air Quality.** An observational survey of the building site and its immediate surroundings shall be conducted during hours the building is expected to be normally occupied to identify local contaminants from surrounding facilities that may be of concern if allowed to enter the building.

**4.3 Documentation.** Documentation of the outdoor air quality investigation shall be reviewed with building owners or their representative and shall include the following as a minimum:

a. Regional air quality compliance status.

*Note:* Regional outdoor air quality compliance status for the United States is available from the U.S. Environmental Protection Agency located under [www.epa.gov](http://www.epa.gov).

b. Local survey information:

1. Date of observations
2. Time of observations
3. Site description
4. Description of facilities on site and on adjoining properties
5. Observation of odors or irritants
6. Observation of visible plumes or visible air contaminants
7. Description of sources of vehicle exhaust on site and on adjoining properties
8. Identification of potential contaminant sources on the site and from adjoining properties

c. Conclusions regarding the acceptability of outdoor air quality based on consideration of information from investigation.

## Outdoor Air Quality

Section 4.3 of this standard requires an investigation of the outdoor air quality in the vicinity of the project site. This template offers a means of documenting the results of both the regional and local investigations and the conclusions reached concerning the acceptability of the outdoor air quality for indoor ventilation.

**TABLE H-1**

<b>Regional Outdoor Air Quality Pollutants</b>	<b>Attainment or Nonattainment According to the U.S. Environmental Protection Agency</b>
Particulates (PM 2.5)	(Yes/No)
Particulates (PM 10)	(Yes/No)
Carbon monoxide—1 hour/8 hours	(Yes/No)
Ozone	(Yes/No)
Nitrogen dioxide	(Yes/No)
Lead	(Yes/No)
Sulfur Dioxide	(Yes/No)
<b>Local Outdoor Air Quality Survey</b>	<b>Date:</b> _____ <b>Time:</b> _____
a) Area surveyed	(Brief description of the site)
b) Nearby facilities	(Brief description type of facilities—industrial, commercial, hospitality, etc.)
c) Odors or irritants	(List and describe)
d) Visible plumes	(List and describe)
e) Nearby sources of vehicle exhaust	(List and describe)
f) Prevailing winds	(Direction)
g) Other observations	
Conclusions	(Remarks concerning the acceptability of the outdoor air quality)

# ASHRAE 62 METHODS

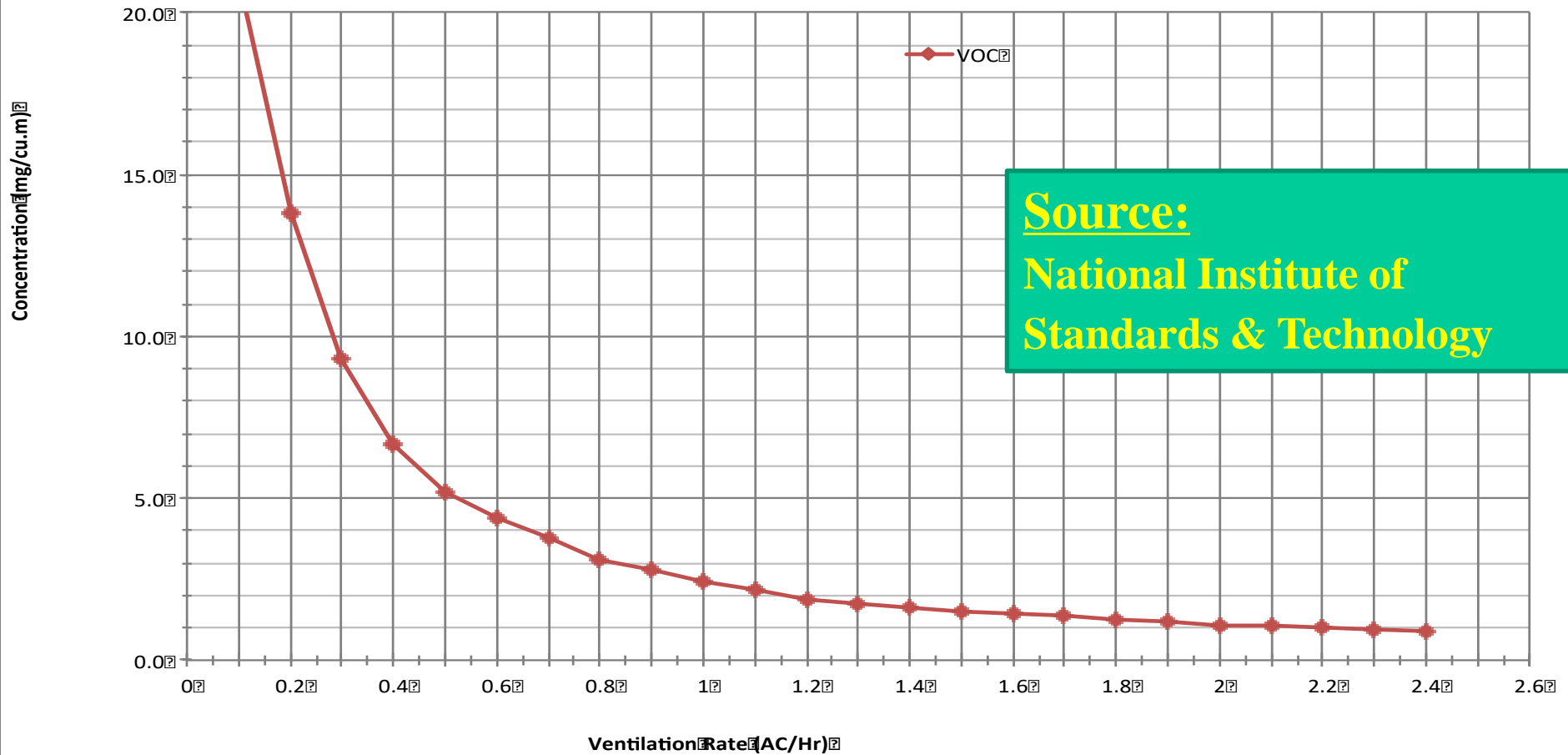
## Indoor Air Quality Procedure (Section 6.3)

### Requirements

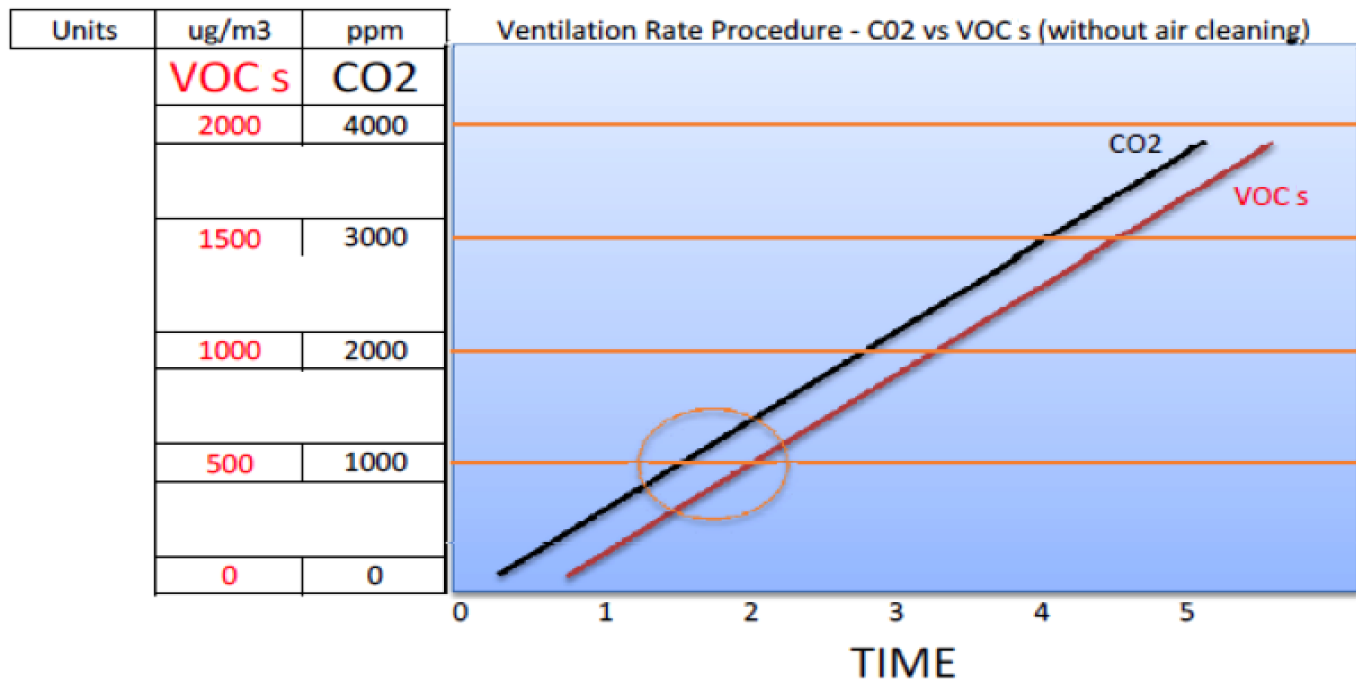
- a. Contaminant Source Analysis
- b. Contaminant Concentration Limit
- c. Cognizant Authority for Contaminant Limit
- d. Three Methods of Design:
  1. Mass Balance Analysis (Section 6.3.4.1)
  2. Subjective Evaluation (Section 6.3.4.2)
  3. Similar Zone (Section 6.3.4.3)

# OA Does Not Control IAQ Alone

Ventilation for VOC Control

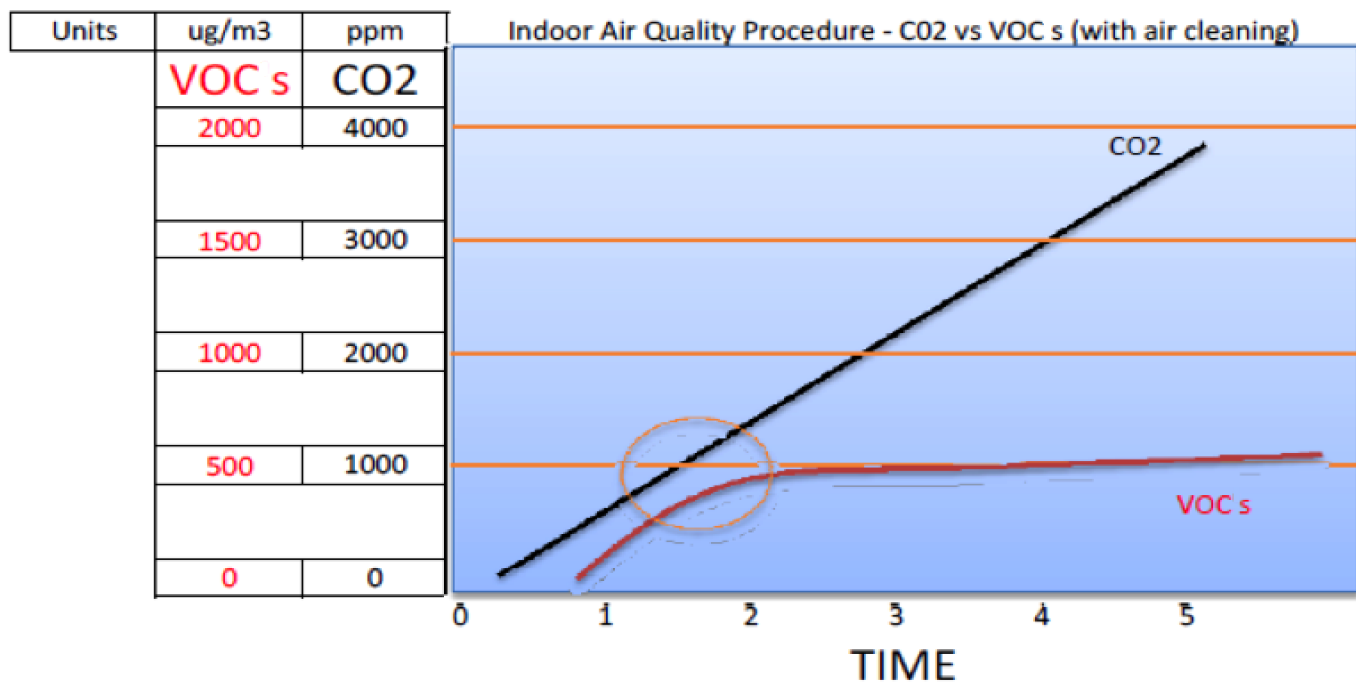


**Source:**  
National Institute of  
Standards & Technology



# C02 vs VOCs

ASHRAE 62 VRP  
Must maintain 700 PPM above outdoors



ASHRAE 62 IAQP  
Allows up to 5,000 PPM in accordance with OSHA & NIOSH PPM

**TABLE S-1 Comparison of Navy's Exposure Guidelines with Those Recommended by the Subcommittee**

Chemical	Exposure Level	U.S. Navy Values <sup>a</sup>		NRC Recommended Value <sup>a</sup>
		Current	Proposed	
Acrolein	1-h EEGL	0.05	0.07	0.1
	24-h EEGL	0.01	0.03	0.1
	90-day CEGL	0.01	0.01	0.02
Carbon dioxide	1-h EEGL	40,000	30,000	25,000
	24-h EEGL	40,000	15,000	25,000
	90-day CEGL	5,000	7,000	8,000
Carbon monoxide	1-h EEGL	400	55	180
	24-h EEGL	50	20	45
	90-day CEGL	20	10	9
Formaldehyde	1-h EEGL	3	0.4	2
	24-h EEGL	1	0.1	1
	90-day CEGL	0.5	0.04	0.3
Hydrazine	1-h EEGL	—	4	1
	24-h EEGL	—	0.3	1
	90-day CEGL	—	0.01	0.03
Methanol	1-h EEGL	200	200	600
	24-h EEGL	10	10	50
	90-day CEGL	10	7	10
Monoethanolamine	1-h EEGL	50	6	4
	24-h EEGL	3	3	4
	90-day CEGL	0.5	0.5	0.5
Nitric oxide <sup>b</sup>	1-h EEGL	—	—	130
	24-h EEGL	—	—	50
	90-day CEGL	—	—	3
Nitrogen dioxide	1-h EEGL	1	3	10
	24-h EEGL	1	1	2
	90-day CEGL	0.5	0.5	0.7
Oxygen (min.-max.)	1-h EEGL	130-220 mmHg	—	105 mmHg (min.)
	24-h EEGL	130-160 mmHg	—	127 mmHg (min.)
	90-day CEGL	130-160 mmHg	—	140 mmHg (min.)

<sup>a</sup>All values in parts per million (ppm) unless otherwise noted.

<sup>b</sup>Navy considers the guidance levels for nitrogen dioxide to be also protective of nitric oxide exposure.

## NAVY SUBMARINE STUDY

According to the National Research Council, CO<sub>2</sub> < 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.

# University of Denmark 2016 Study – Affects of CO<sub>2</sub> at 5,000 PPM

## \*\*Contradicts Harvard/Berkeley Study\*\*

ACCEPTED MANUSCRIPT

### Highlights

- 2.5-hour exposure to CO<sub>2</sub> up to 5,000 ppm did not decrease perceived air quality
- 2.5-hour exposure to CO<sub>2</sub> up to 5,000 ppm did not evoke acute health symptoms
- The examined CO<sub>2</sub> exposures did not affect performance of some cognitive tasks
- Discomfort and building related symptoms should not be attributed to CO<sub>2</sub>

# IS CO2 DCV OUTDATED?

<b>1 OA TVOCs</b> 0025502C Analog Input Outside air TVOCs at Roanoke, VA Office
<b>1134.31 TVOCs</b> Sensor
[No alert set]
<b>2nd FL Office TVOCs</b> 0025503C Ana
<b>589.74 TVOCs</b> Sensor
[No alert set]
<b>LAB R/A TVOCs</b> 00255038 Analog Inp
<b>693.53 TVOCs</b> Sensor
[No alert set]
<b>Lab SA Ion Levels</b> 00255034 Analog I
<b>475213.68 ions/cc</b> Sensor
[No alert set]

TVOCs Outside > Inside

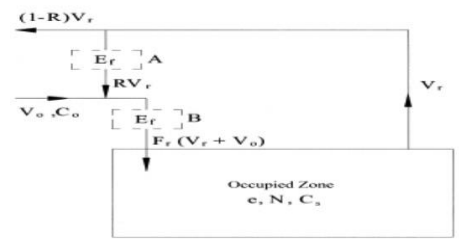
If Space CO2 is > CO2 Setpoint  
AND  
Space TVOCs are > than OA,  
Ventilate

<b>Lab T/H</b> 001690A8 Room Temp. & Humidity	
<b>68.79°F</b> Temperature	<b>56.63%</b> Humidity
Min: -148°F Max: 482°F	Min: 0% Max: 100%

<b>OA T/H</b> 001690AC Room Temp. & Humidity	
<b>62.47°F</b> Temperature	<b>30.4%</b> Humidity
Min: -148°F Max: 482°F	Min: 0% Max: 100%

Zone Tag	Facility Type	Zone Use	Zone Floor Area (square ft) Az	Zone Max Occupancy Pz	Table 6.1 OA per Occupant Rp	Table 6.1 cfm/ft2 Ra	Pz * Rp Pz * Rp	Az * Ra Az * Ra	Table 6.2 Ventilation Effectiveness Ez	Outdoor Air to Zone (CFM) with Ez correction (Vbz/Ez)
Classrooms	Educational Facilities	Classrooms (AGE 9 +)	800.0	28.0	10.0	0.12	280	96	0.8	470
										OA required per VRP

Zone Height (feet)	9
Desired Outside Air (Vo) IAQP	140
Supply Air (Vs)	1,000
Return Air (Vr)	860
Recirc. Flow Factor (R)	0.86
Ventilation Effectiveness (Ez)	0.8
Level of Physical Activity	Standing (desk work)
Filter Location	B
HVAC Flow Type	Constant
Outdoor Air Flow Type	Constant

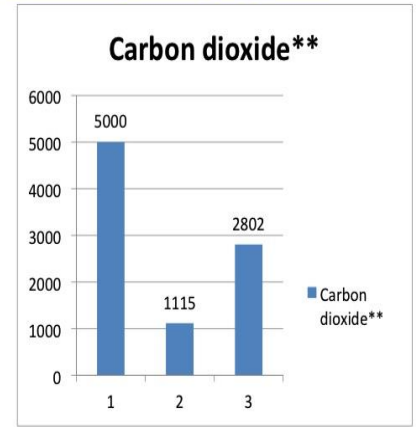


Air Changes Per Hour	8.3	VRP OA CFM per person	16.8
Outside Air Per VRP	470 CFM	IAQ OA CFM per person	5.0
Outside Air Per IAQ	140 CFM	Winter Heating Savings	
Outside Air Savings	330 CFM	OA Summer Drybulb	94.0
OA Summer Drybulb	94.0	OA Winter Design DB (F)	0
OA Summer Wetbulb	74.0	Supply Air DB Setpoint (F)	85
Coil Leaving Air Drybulb (F)	55.0	MBH Saved Winter	30.4
Coil Leaving Air Wetbulb (F)	54.0	KW Saved Winter	8.9
OA MBH Saved Summer*	27.1		
OA Tons Saved Summer*	2.3		

Indoor Contaminants Generated By People	Maximum Threshold Value (PPM)	Steady State Using the VRP* (Prescribed OA) Plasma Off	Steady State Using the IAQ Method (Reduced OA) Plasma On	Is Steady State Level Acceptable at Reduced OA Levels?	Contaminant Generation Rate (PPM)	Filtration Effectiveness	Cognizant Authority***
Acetaldehyde	100.0	0.01112	0.00139	Yes	0.00048	50%	OSHA
Acetone	250.0	0.00175	0.00102	Yes	0.00654	25%	NIOSH
Ammonia	25.00	0.01771	0.01339	Yes	0.21460	50%	NIOSH
Benzene	1.0000	0.00252	0.00092	Yes	0.00022	20%	OSHA
2- Butanone (MEK)	200.0	0.00020	0.00019	Yes	0.00133	20%	NIOSH
Carbon dioxide**	5000	1115	2802	Yes	441	0%	NIOSH
Chloroform	2.0000	0.00011	0.00001	Yes	0.00004	80%	NIOSH
Dioxane	100.0	0.00000	0.00000	Yes	0.00000	10%	OSHA
Hydrogen Sulfide	10.0	0.00000	0.00000	Yes	0.00000	25%	NIOSH
Methane	NA	1.68094	1.68094	Yes	0.00000	0%	NA
Methanol	200.0	0.00000	0.00000	Yes	0.00000	0%	NIOSH
Methylene Chloride	25.0	0.00078	0.00057	Yes	0.00121	10%	OSHA
Propane	1000.0	0.00998	0.00998	Yes	0.00000	0%	NIOSH
Tetrachloroethane	5.0000	0.00000	0.00000	Yes	0.00000	15%	OSHA
Tetrachloroethylene	100.0000	0.00037	0.00016	Yes	0.00001	15%	OSHA
Toluene	100.0000	0.00533	0.00134	Yes	0.00032	30%	NIOSH
1,1,1 - Trichloroethane	350.0000	0.00078	0.00013	Yes	0.00058	50%	NIOSH
Xylene	100.0000	0.00230	0.00057	Yes	0.00000	30%	OSHA

Indoor Contaminants Generated By People	Maximum Threshold Value (PPM)	Steady State Using the VRP* (Prescribed OA) Plasma Off	Steady State Using the IAQ Method (Reduced OA) Plasma On	Is Steady State Level Acceptable at Reduced OA Levels?	Contaminant Generation Rate (PPM)	Filtration Effectiveness	Cognizant Authority***
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Carbon dioxide**	5000	1115	2802	Yes	441	0%	NIOSH
Chloroform	2.0000	0.00011	0.00001	Yes	0.00004	80%	NIOSH
Dioxane	100.0	0.00000	0.00000	Yes	0.00000	10%	OSHA
Hydrogen Sulfide	10.0	0.00000	0.00000	Yes	0.00000	25%	NIOSH
Methane	NA	1.68094	1.68094	Yes	0.00000	0%	NA
Methanol	200.0	0.00000	0.00000	Yes	0.00000	0%	NIOSH
Methylene Chloride	25.0	0.00078	0.00057	Yes	0.00121	10%	OSHA
Propane	1000.0	0.00998	0.00998	Yes	0.00000	0%	NIOSH
Tetrachloroethane	5.0000	0.00000	0.00000	Yes	0.00000	15%	OSHA
Tetrachloroethylene	100.0000	0.00037	0.00016	Yes	0.00001	15%	OSHA
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Xylene	100.0000	0.00230	0.00057	Yes	0.00000	30%	OSHA

\*OA = Outside Air  
 \*\*\*OSHA, NIOSH & WHO most conservative values used  
<http://www.cdc.gov/niosh/npg/npgsyn-a.html>



1 = ASHRAE & NIOSH CO2 Limit  
 2 = CO2 Level at Ventilation Rate OA Flow Rate  
 3 = CO2 Level at IAQ Procedure OA Flow Rate

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

Is IAQ acceptable at reduced outside air levels?	Yes
--	-----

\*\*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.

Date	1/12/16
Job Name	-
Representative	-
Engineer	-
Contractor	-

IMC 2006 & later allows for ASHRAE 62 IAQP through the engineered exception found in Section 403.2  
 Exhaust flow rates may differ from Table 6.5 based on ASHRAE 62 IAQP via Section 6.5.2

# The Big Picture with IAQP

## School with 100K ft<sup>2</sup>

- Typical First Cost Savings = \$300k to \$400k  
or \$2.50/ft<sup>2</sup>\*
- Typical Annual Energy Savings = \$48,000  
or \$0.40/ft<sup>2</sup>\*\*

\*First cost savings analysis provided by Spurlock Consulting, ATL, GA

\*\*Energy savings provided by Gwinnett County Schools



## 2016 Best Public High Schools in Georgia

Explore the best public high schools in your area based on statistics, student and parent reviews, and expert insights. Ranking factors include state test scores, college readiness, graduation rates, SAT/ACT scores, [More](#)

- NBPI is in over 80% of the top 100 performing schools in Georgia, including the top 10.
- According to Columbia University Research on Ion Depletion, systems adding ions back to the space could contribute to students being more alert and performing better, even though the OA is decreased 50-75% due to the NBPI

<https://k12.niche.com/rankings/public-high-schools/best-overall/s/georgia/>

# ICC / IMC

- IMC 2006 & later includes a provision for engineered ventilation systems, i.e., (62.1 IAQP)
  - Section 403.2 – Exception

**403.2 Outdoor air required.** The minimum ventilation rate of outdoor air shall be determined in accordance with Section 403.3.

**Exception:** Where the registered design professional demonstrates that an engineered ventilation system design will prevent the maximum concentration of contaminants from exceeding that obtainable by the rate of outdoor air ventilation determined in accordance with Section 403.3, the minimum required rate of outdoor air shall be reduced in accordance with such engineered system design.

# Applications of Ionization



**Plasma displays**



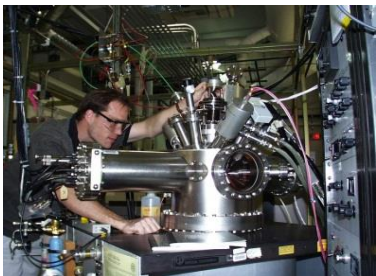
**Ion thrusters**



**Rocket exhaust**



**Fusion energy**



**Semi conductor  
fabrication**



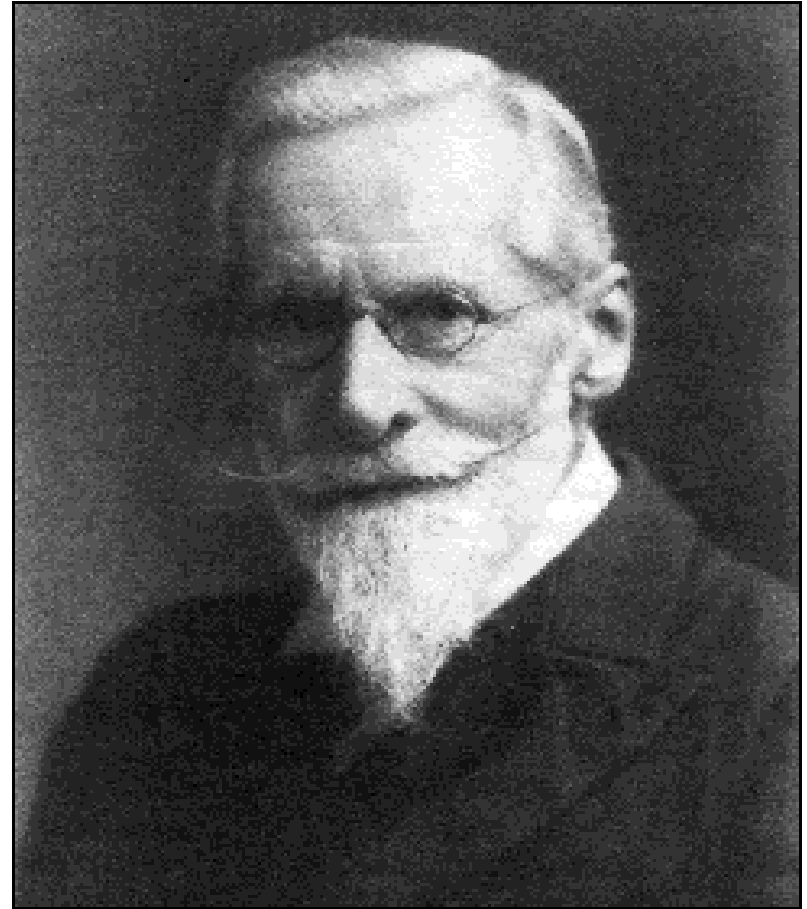
**Area in front of  
a space craft  
heat shield**



**Plasma torch**

# History of Air Ionization

Plasma was first identified in a Crookes 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 Crookes tube ( a thing moulded or formed).



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

# Changes in IAQ Caused By Corona Discharge Air Cleaner

BY TODD CRAWFORD; PATRICIA FRITZ, MEMBER ASHRAE; THOMAS WAINMAN

ASHRAE Standard 62.1 has long established that an occupied space requires an adequate supply of clean air to maintain acceptable indoor air quality (IAQ). The most common source of clean air—outside air—must be conditioned at a price; fans, filters, heating, cooling, and tempering are major capital, maintenance and operating expenses in buildings. Consequently, ventilation systems are designed to preserve as much of the conditioned air as possible by cleaning and recirculation. ASHRAE's IAQ Procedure<sup>1</sup> describes a method to reduce the proportion of outside air supply by treating (cleaning) and recirculating air. ASHRAE's IAQ Procedure is akin to the Exception in International Mechanical Code §403.2 (2010):

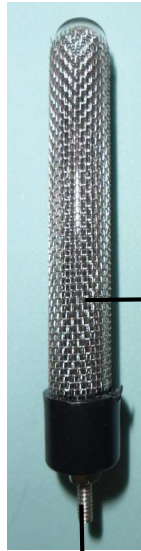
“Where the registered design professional demonstrates that an engineered ventilation system design will prevent the maximum concentration of contaminants from exceeding that obtainable by the rate of outdoor air ventilation...the minimum required rate of outdoor

Corona discharge (sometimes labeled: ionizing, negative ion, bipolar ionizing, activated oxygen, mountain fresh air, etc.) often is a proposed air cleaning technology to remove airborne contaminants. Corona discharge ionizes oxygen in air and generates an electrostatic field. The design of the corona discharge system can be modified to create mixtures of reactive oxygen species (ROS): ozone, hydroxyl radicals, and superoxide anions.<sup>2</sup> Ozone emissions from air cleaners are

regulated in California<sup>3</sup> and are generally discouraged in many states' guidance documents (see, for example: Connecticut, New York<sup>4</sup>); the manufacturer's marketing materials claim this air cleaner does not produce ozone. ROS initiate radical reactions that rapidly decay unsaturated volatile organic compounds (VOC) and generate particles. The radical reactions propagate, creating and destroying radicals and ROS until the reactants are transformed and the products do not react further.<sup>5</sup> For “air cleaning” the final reaction products would be carbon dioxide and water but in practice, corona discharge transforms airborne contaminants into myriad products that are not well-characterized for their chemical identities, yields or toxicities. We designed this study to evaluate the changes in IAQ caused by a corona

Todd Crawford, Patricia Fritz, and Thomas Wainman are research scientists at New York State Department of Health in Albany, N.Y.

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



GND

HV AC Input

Needlepoint systems can operate with precise power output, which prevents ionizing oxygen and ensures no ozone is produced

Ions leave tip based on polarity of voltage applied



HV Input

No Dielectric Barrier

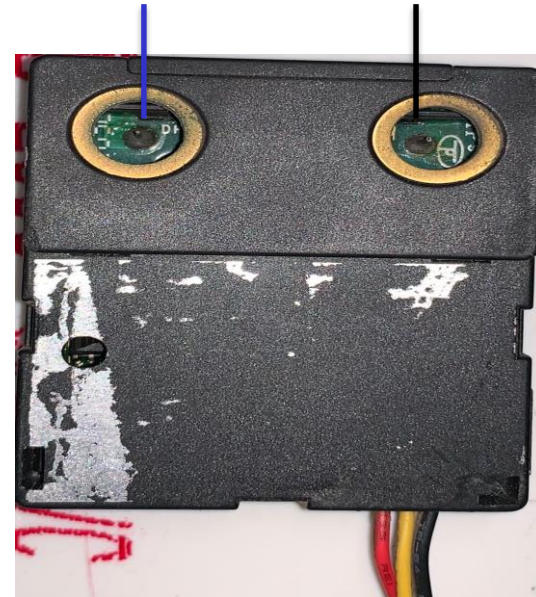
# Types of Needlepoint Bipolar Ionization

## 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

Positive Out

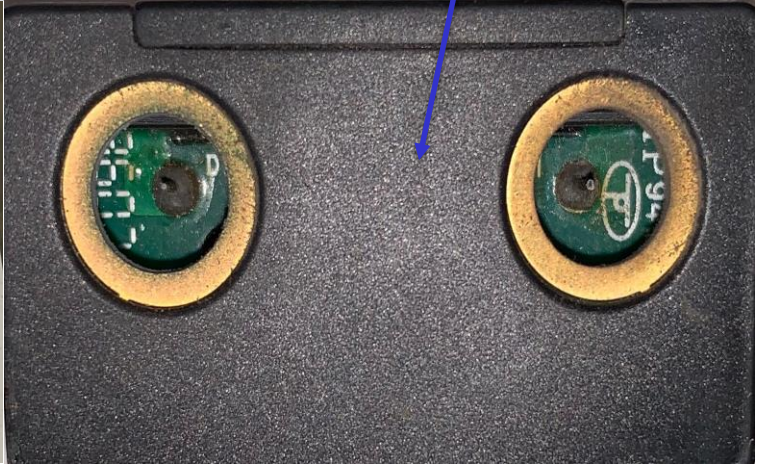
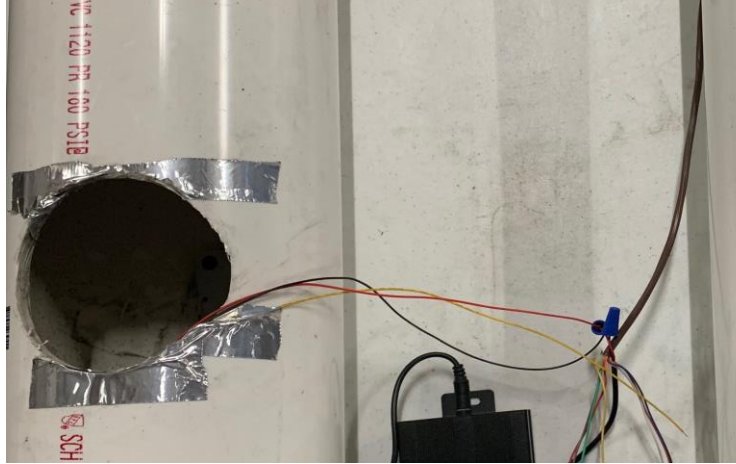
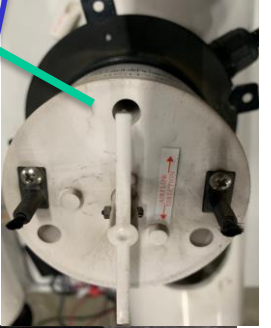
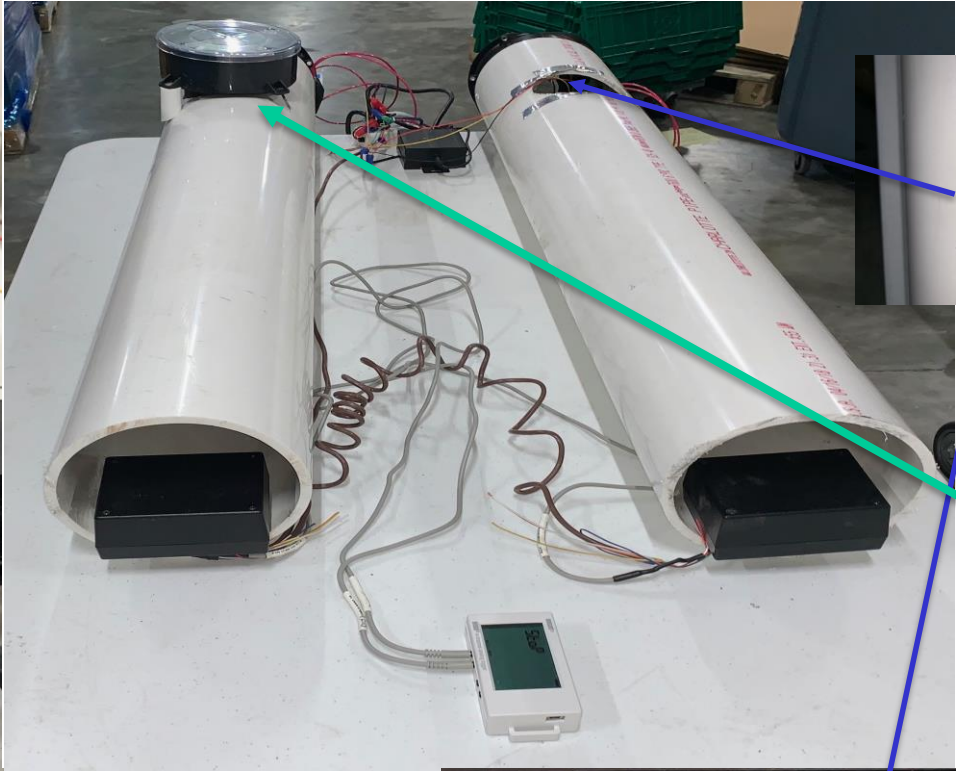
Negative Out



## Alternating Current (AC) Output –

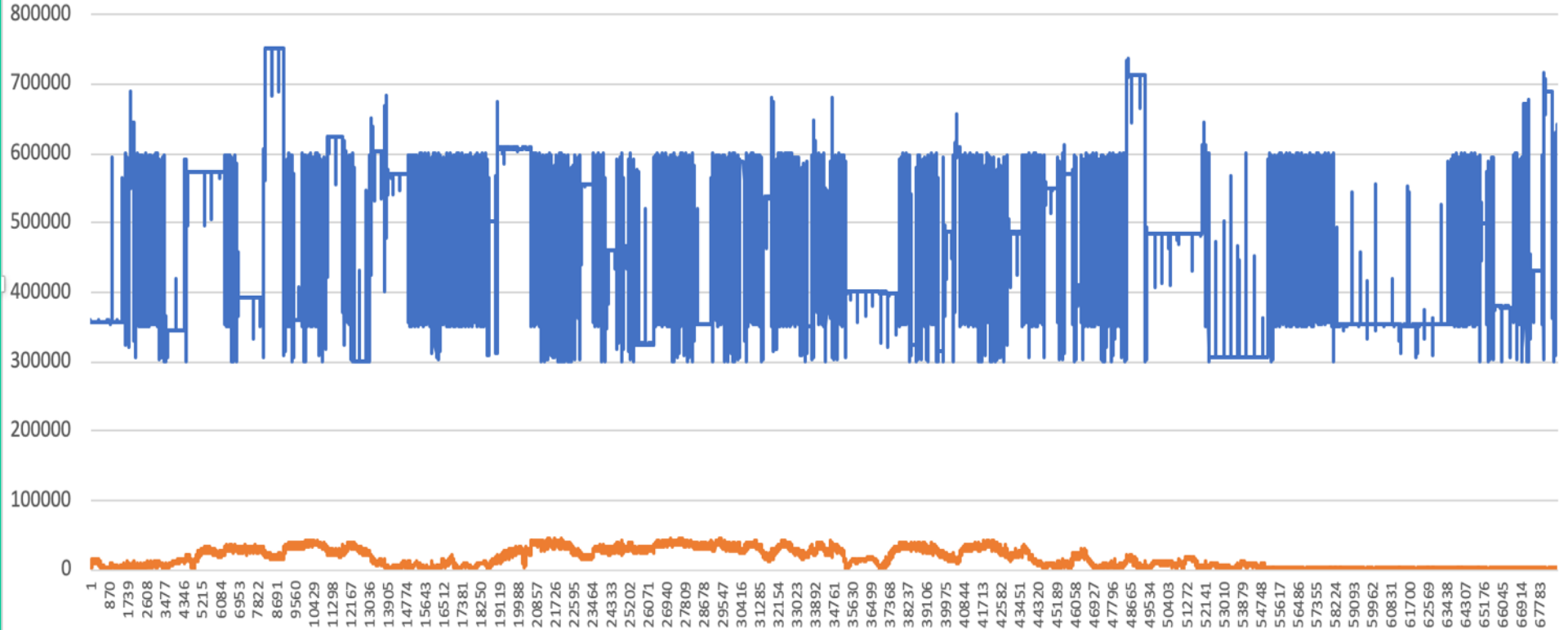
Each needle alternates between +/- at the frequency applied



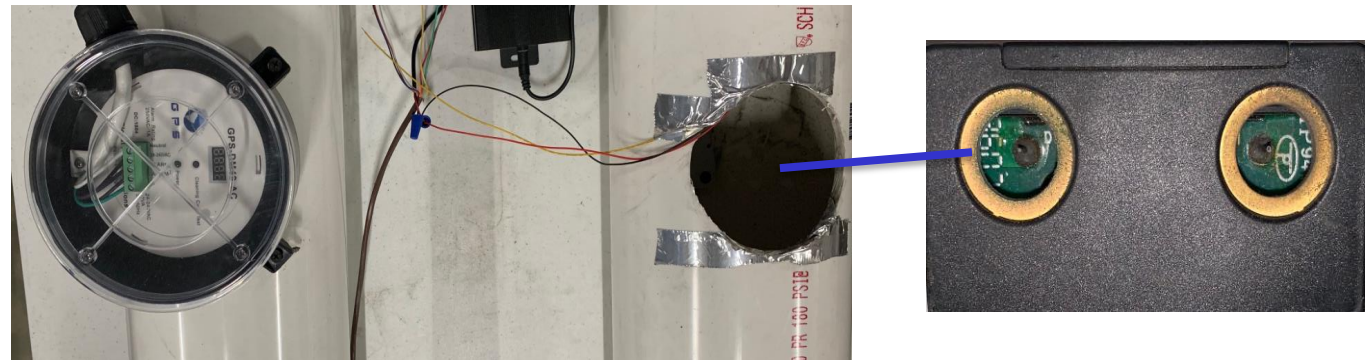


# Self-Cleaning Ionization Compared to Non-Self-Cleaning Ionization

Ions/cc



— Self-Cleaning — Not Self-Cleaning



# IONS ARE NATURALLY OCCURRING

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.

Units of Measure = Ions/cc

Waterfalls/Elevation – 5,000

City – 200

Inside Buildings - <100



# Ion Deficiency Issues

Few human activities lead to an increase in ions. Most activities cause a depletion.

According to research conducted by Columbia University, Ion depletion can cause sleepiness, attention deficit, discomfort and headaches

These effects can be controlled by artificially increasing ion levels using needlepoint bipolar ionization, which has been reported to reverse the issues.



# Applications for Needlepoint Bipolar Ionization

Item 1

Particle Control

Item 2

Odor Control

Item 3

Pathogen Control

Item 4

Energy and Cost Savings via  
Outside Air Reduction Using ASHRAE Standard 62, IAQP

Item 5

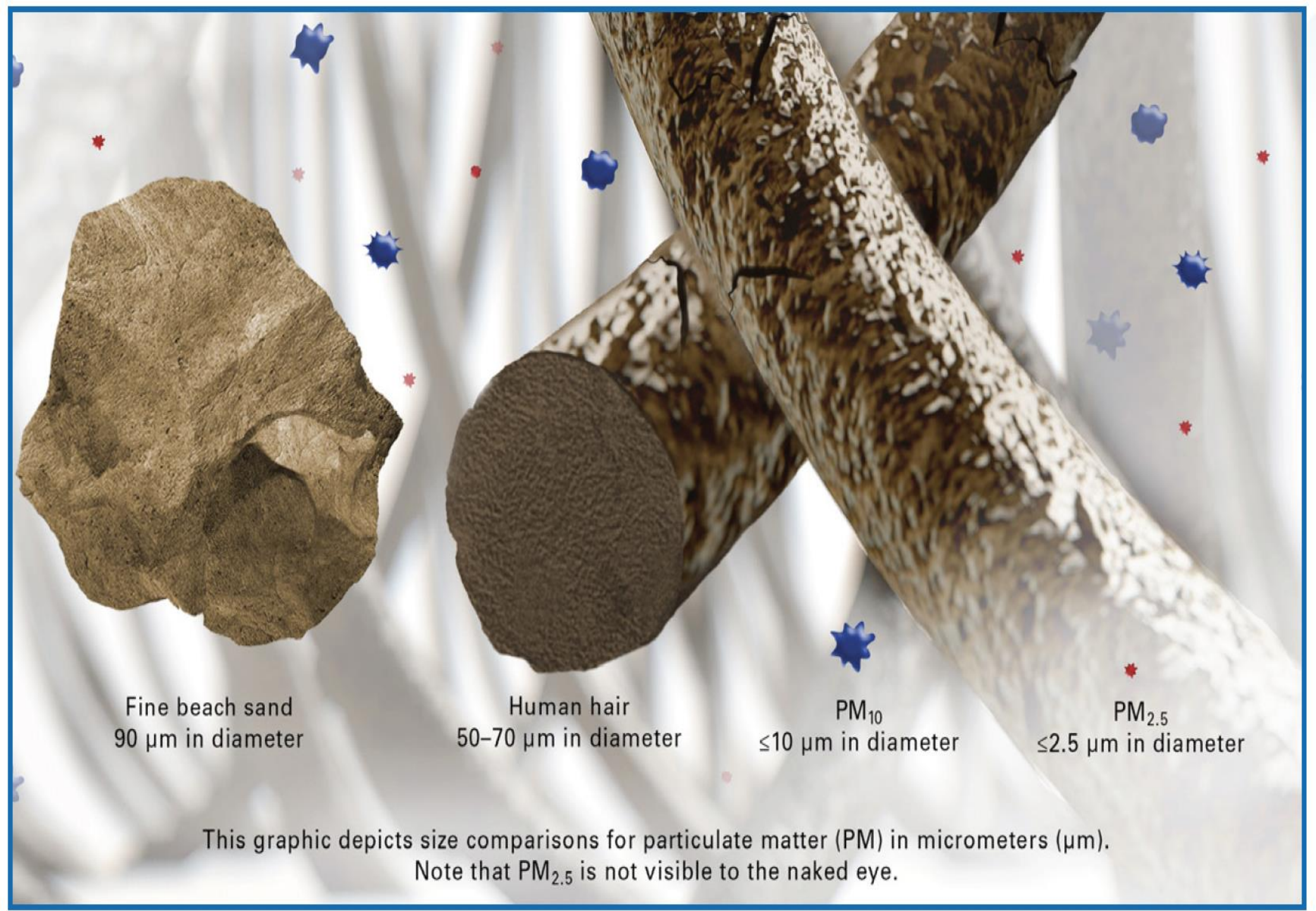
Clean Old Cooling Coils & Keep New Coils Clean

# 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 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





Fine beach sand  
90  $\mu\text{m}$  in diameter

Human hair  
50–70  $\mu\text{m}$  in diameter

PM<sub>10</sub>  
 $\leq 10$   $\mu\text{m}$  in diameter

PM<sub>2.5</sub>  
 $\leq 2.5$   $\mu\text{m}$  in diameter

This graphic depicts size comparisons for particulate matter (PM) in micrometers ( $\mu\text{m}$ ).  
Note that PM<sub>2.5</sub> is not visible to the naked eye.

# MERV 8 + Ionization = > MERV 13



2820 S. English Station Rd.  
 Louisville, Ky 40299  
 Tel: (502) 357-0132  
 Fax: (502) 267-8379

Date:	23-Oct-17
Report No.	17-618
MODIFIED CADR CHAMBER TEST	
TEST REPORT SUMMARY	
Chamber Smoke Concentration Decay Test	
MERV 13 vs. MERV 8 w/GPS Device	

## 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

Elapsed Time, Min.	Microns									# total Particles	#/cm3 Concentration
	0.30	0.40	0.55	0.70	1.00	1.30	1.60	2.20	2.20		
4	1805492	738537	144867	40941	865	153	96	3	2730958	2730	
34	636	101	25	23	8	5	2	5	808	0.81	

### MERV 8 Filter with Ion Technology

Elapsed Time, Min.	Microns									# total Particles	#/cm3 Concentration
	0.30	0.40	0.55	0.70	1.00	1.30	1.60	2.20	2.20		
5	1958081	1222632	332433	129698	2610	341	136	6	3645943	3645	
19	1876059	736434	117644	22892	116	11	20	5	2753181	2753	
16 hours	619	90	12	17	2	1	2	2	745	0.74	

# Needlepoint Bipolar Ionization for TVOC CONTROL

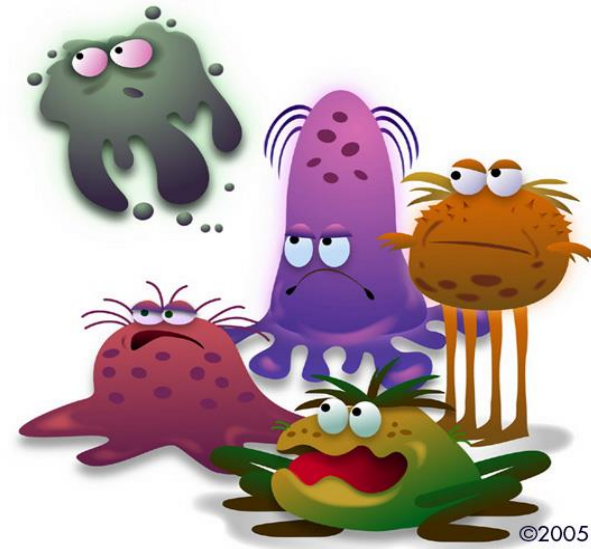
## What Are VOCs?

**Volatile:** Vapor at Room Temperature

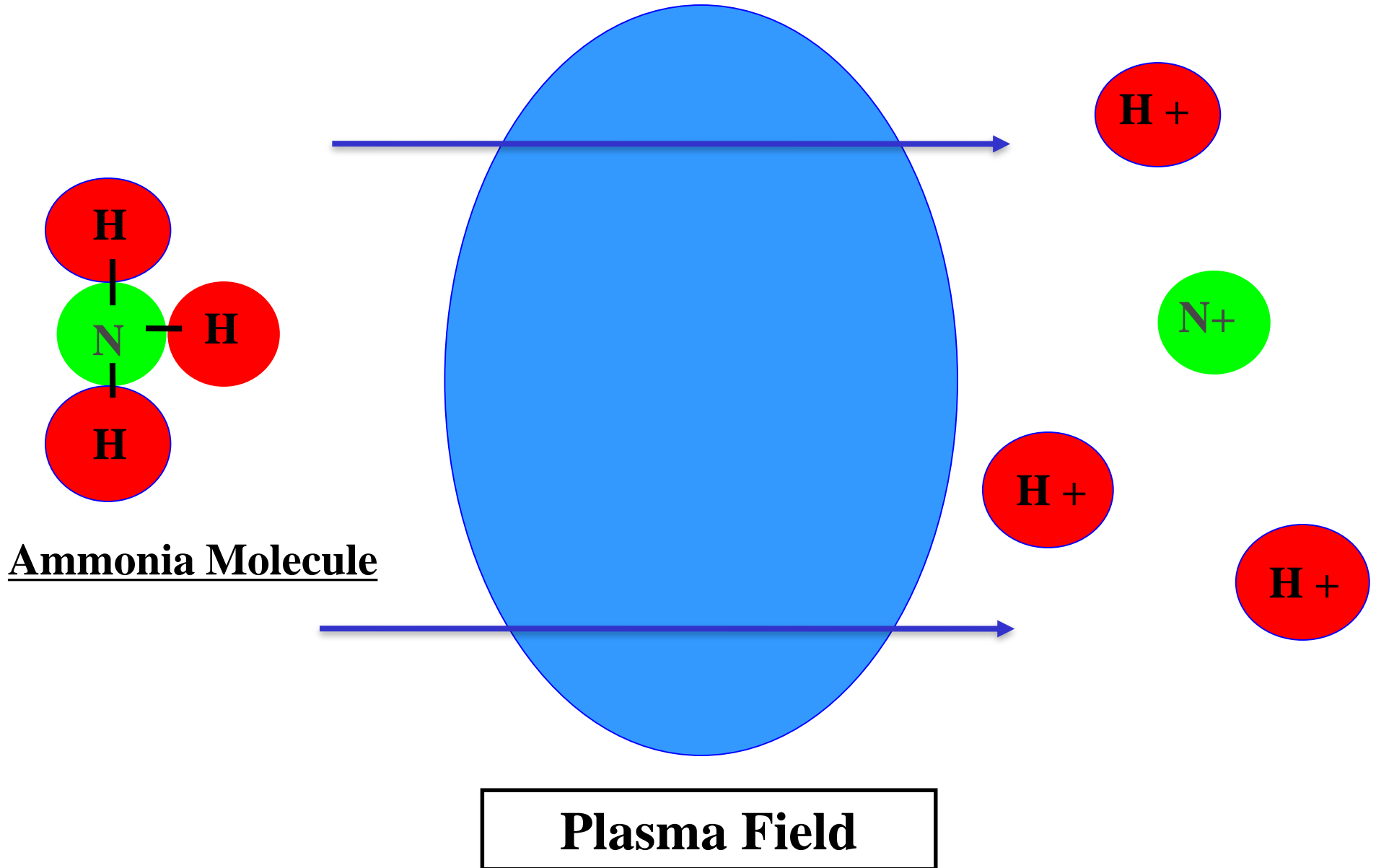
**Organic:** Contains Hydrogen & Carbon

**Compounds:** More than one gas

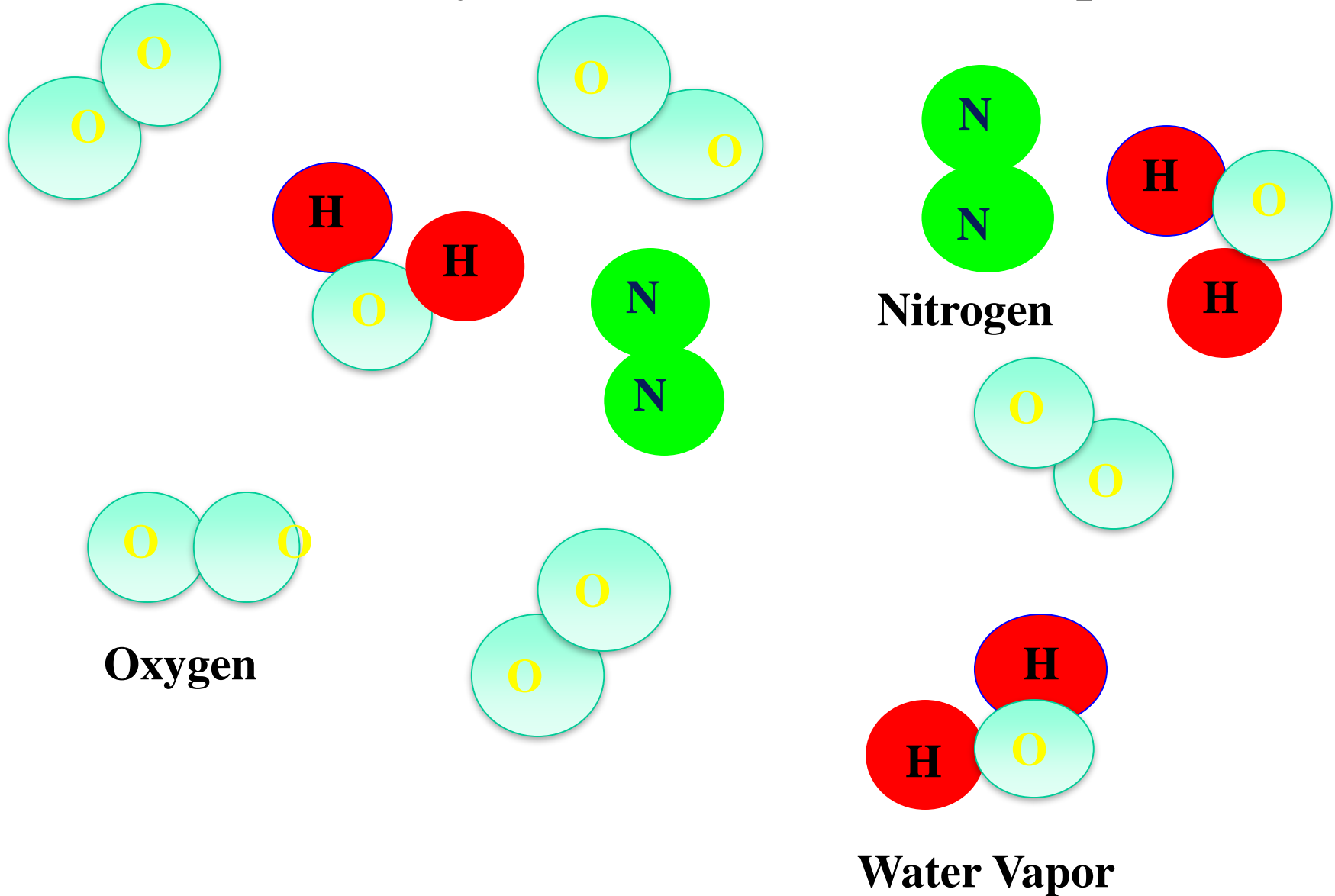
- Natural & Man-Made
- We Come in Contact w/100's Each Day
- Human & Non-Human Sources




# Plasma Breaks Down Gases To Less Objectionable Forms



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



# Chemical Compounds Ionization Can Easily Control

<b>CHEMICAL</b>	<b>FORMULA</b>	<b>Electron Volt</b>
Xylene*	C <sub>8</sub> H <sub>10</sub>	7.89
Styrene*	C <sub>8</sub> H <sub>8</sub>	8.46
Methyl Ethyl Ketone*	C <sub>3</sub> H <sub>8</sub> O	9.52
Ammonia*	NH <sub>3</sub>	10.07
Acetaldehyde*	CH <sub>3</sub> CHO	10.23
Ethyl Alcohol*	C <sub>2</sub> H <sub>5</sub> OH	10.48
Formaldehyde*	CH <sub>2</sub> O	10.88
<b>Oxygen</b>	<b>O<sub>2</sub></b>	<b>12.07</b>
<b>Glass tubes require &gt;12.07 to break down the dielectric</b>		

- \* Typical contaminants of concern as contained within ASHRAE 62.1
- Electron Volt Energy greater than 12Ev, creates ozone (O<sub>3</sub>)



## Standard 62 IAQ Procedure Reduced Outdoor Air For Auditorium

By Peter F. Johnson, Member ASHRAE

If you don't use the air purification option in the IAQ Procedure in ANSI/ASHRAE Standard 62.1-2004, *Ventilation for Acceptable Indoor Air Quality*, you may miss out on a non-traditional but cost-effective design that reduces heating, cooling loads, duct sizes and first costs.

The IAQ design option results in outdoor air (OA) reductions for most commercial spaces down to 5 cfm (2.4 L/s) OA per person, and are based at full occupancy 24/7. When gas cleaning technology is used with high-efficiency filters, you use less energy and have a healthy and more comfortable space.

In Ohio, Brunswick School officials were planning a new auditorium in 1998 and wanted the best IAQ with reduced OA. They also required the air-handling systems use the least amount

of energy for heating and cooling the space.

In 1999 the air-handling system's design was based on the ANSI/ASHRAE Standard 62-1999, *Ventilation for Accept-*

*able Indoor Air Quality*, IAQ procedure that combined the use of gas-phase cleaning and high-efficiency particulate filters for reduced OA. For greatest savings, an energy recovery unit (wheel) was added for energy recovery of the exhaust air.

This project was designed as an architectural showcase. It is a one-story insulated brick building with a built-up insulated metal deck roof with single ply membrane and rooftop units.

The Ohio Building Code (OBC) Section 403.2, "Mechanical Ventilation," requires designers to use Standard 62. The code has the option to use 15 cfm/person (7 L/s per person) of OA to be supplied per the standard's Ventilation Rate Procedure. Or, you may use Standard 62 to calculate the required outside air with air-cleaning systems to clean gasses, vapors and improve the job of removing particulates. In 1999,

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#### About the Author

Peter F. Johnson is sales/service manager for PIER Associates in Akron, Ohio.

# Mold, Virus & Bacteria Control

The Positive and Negative Ions Attack DNA/RNA Cell Structure of Single Cell Organisms & Removes Hydrogen

Plasma  
Source

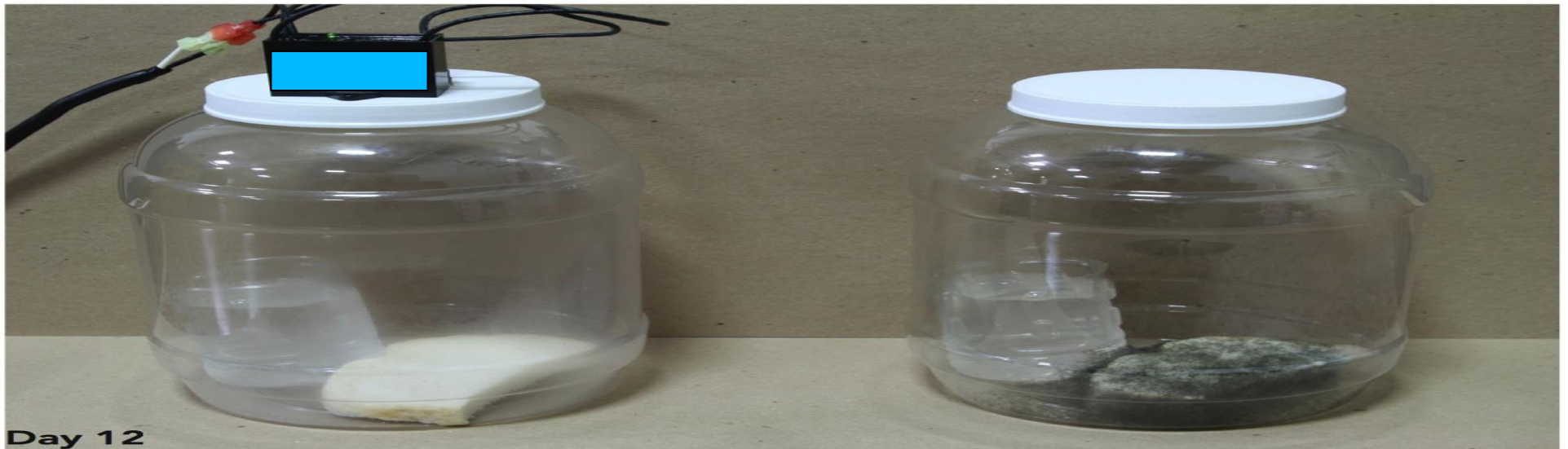


# Independent Testing by CDC Affiliate EMSL Labs & ATS Labs

**10' x 10' x 10' cube at 6 Air Changes Per Hour**

<b>Pathogen</b>	<b>Time Exposed</b>	<b>Kill Rate</b>
E.coli	15 minutes	99.68%
MRSA	30 minutes	96.24%
Legionella	30 minutes	99.98%
Noro Virus	30 minutes	93.50%

# Mold Test (with & without NBPI)



KSU ASHRAE STUDENT PROJECT

# NPBI as Replacement to UVC

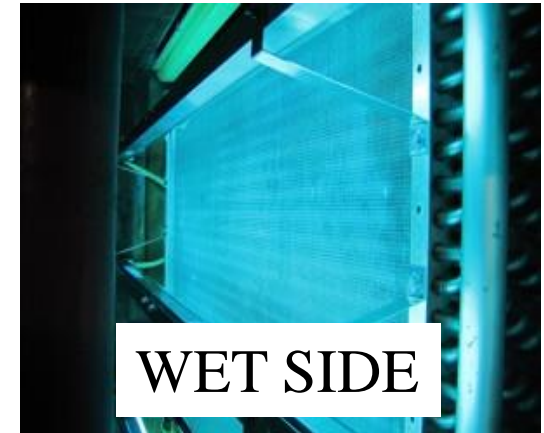
## Needlepoint Bi-Polar Ionization v/s UVC

CHEMICAL	Bi-polar Ionization	UVC Light
Replacement Interval?	None ★	Annually
Produces Detectable Ozone?	No	No
Kill Mold, Bacteria and Virus?	Yes	Yes
Kills Pathogens in the Space?	Yes ★	No
Controls Odors?	Yes ★	No
Reduces Particulates?	Yes ★	No
Contains Mercury?	No ★	Yes
Electrodes Fragile?	No ★	Yes
Shock Resistant	Yes ★	No

Hazardous Disposal Req'd

No

Yes



*Note: Cleans entire coil depth, not just "line of sight".*

# Needlepoint Ionization vs UVC

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

# Valencia College – Won 3 Green Globes

Independent  
Testing Results:

0 Bacteria  
0 Fungi

Throughout  
Entire Depth  
Of Cooling Coil

**Indoor VOCs < OA VOCs!**

Designed at 5 CFM/pp  
No DCV, E/A or Relief Fans



# Ionization Products

- Sizes and capacity vary based on the manufacturer
- Request Ion Density Output (Ions per Cubic Centimeter) at a given distance, ~ 1” or 2” away
- Confirm products have passed the UL 867-2007 ozone chamber test – NOTE: a loop hole in UL 867 does NOT require ozone testing if products are duct mounted – only if they are space mounted
- UL 2998 – New UL Claim validation certification & now required per ASHRAE 62.1-2019

# Ion Density Output Matters!

## BRAND "A" Data

<u>Model</u>	<u>Ion Output</u>	<u>Published Capacity</u>
Product 1	200M ions/cc	4,800 CFM
Product 2	720M ions/cc per foot of bar	(cleans coil)

## BRAND "B & C" Data

Product 1	60M ions/cc	6,000 CFM
Product 2	40M ions/cc per foot of bar	(does not clean coil)

Brand B/C IOM states not to mount in high humidity environments, such as downstream of cooling coil – confirm mounting location is agreeable to manufacturer!

# Flexible Ionization Strip



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

*Figure 6*



Affix iFlex power pack to back of cabinet.

Affix iFlex to the top of coil on plastic strip (or top of fins) to treat coil, blower and living space.

# SELF-CLEANING ION GENERATOR

12”L X 2”W x 3”H



# Ion Bar Installation



# Ion Bar Installation



# 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

3

System Tons

Scale Thickness	% Loss	Added Tons	Added Annual Cost
0.006	16%	0.48	\$86.40
0.012	20%	0.6	\$108.00
0.024	27%	0.81	\$145.80
0.036	33%	0.99	\$178.20

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**

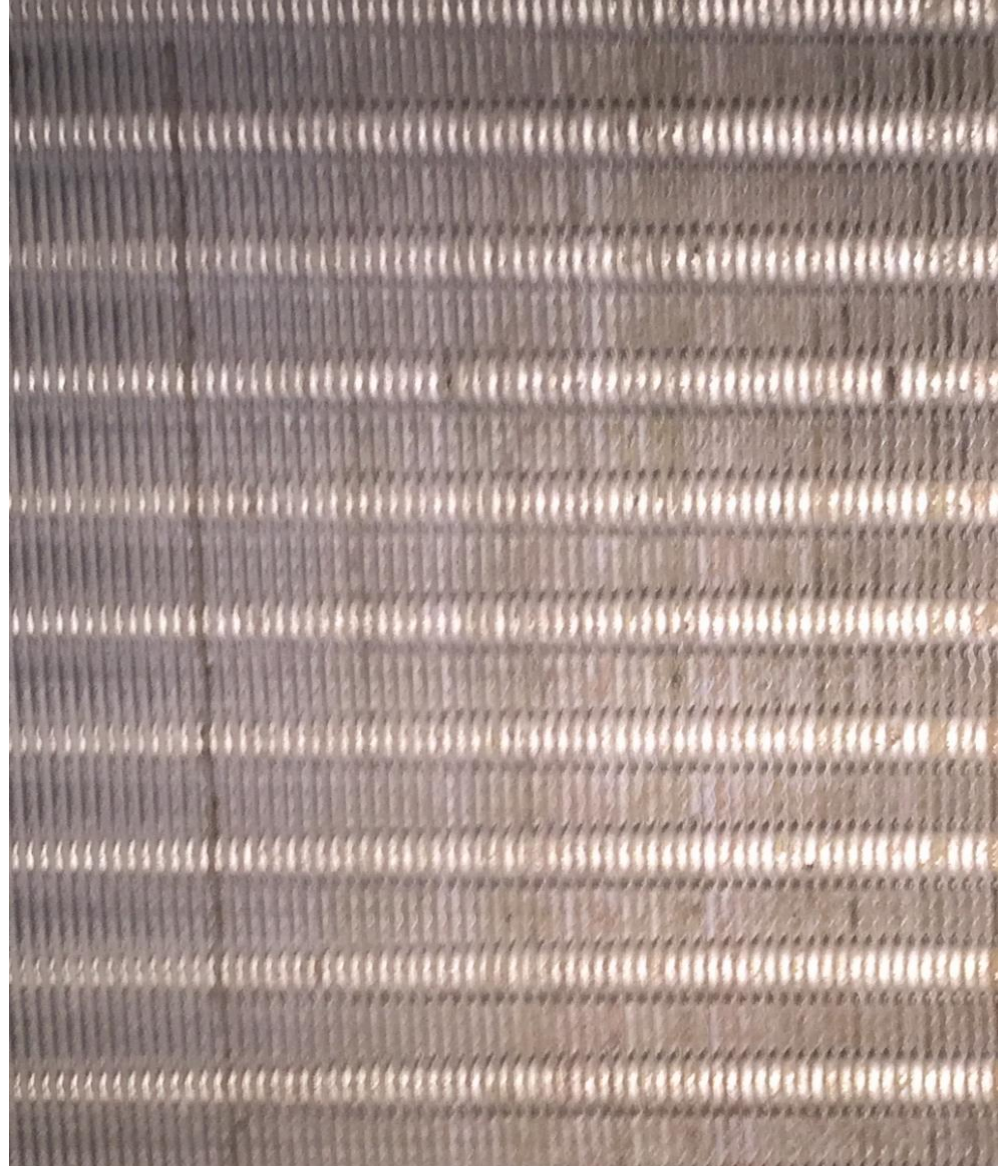
**Operational Hours = 2000** (typical school annual hours)

**Total Savings = \$37.28 Per 1,000 CFM @ 1” Static**

**Dirty Coil Surfaces Affect Heat  
Transfer By Imposing More  
Load on System**



**BEFORE IONIZATION**



**THREE WEEKS LATER**

**GREENSBORO, NC HOSPITAL – Ionization Bar Utilized**

# Alabama Hospital

11/25/2014 17:00:00 - 12/18/2014 13:16:00 (EST)  
11/30 12/05 12/10 12/15

<b>Pressure (In W.C.):</b> 0.254 In W.C.	
<b>Ion Sensor (Ions):</b> 16,310 Ions/cc	
<b>Temperature (SAT):</b> 50.05 °F	
<b>Battery:</b> 4.36 V	

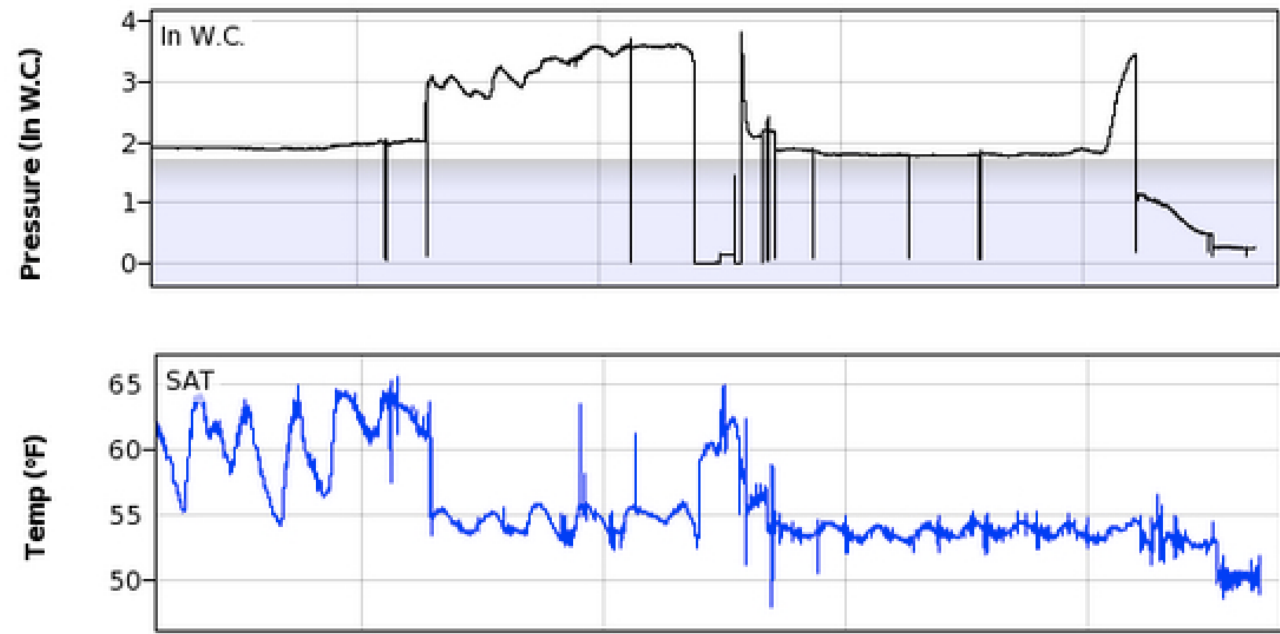
Latest Connections	
Next connection expected moments from now	
Today at 13:16 EST	
Today at 13:01 EST	
Today at 12:46 EST	
Today at 12:31 EST	
Today at 12:16 EST	

[Full Log](#)

## Device Information

**General** | Communications

<b>Status:</b> Logging every 01 min
<b>Memory:</b> 55%
<b>Battery Level:</b> 100%
<b>Nickname:</b> GPS Data Logger
<b>Serial Number (SN):</b> 10634515
<b>Model:</b> HOBO U30 Station - GSM-UDP
<b>Firmware Version:</b> 2.009



## Ion Bar Installed 11/25/2014

- Initial Wet Coil Pressure Drop: ~4.0" W.C.
- Initial Dry Coil Pressure Drop: ~2.0" W.C.
- Pressure Drop After GPS Dry: 0.24" W.C.
- Pressure Drop After GPS Wet: 0.55" W.C.

MOBILE, AL HOSPITAL

6 ROW COOLING COIL > 10 YEARS OLD

# Maintenance / Life

1. NBPI products require little maintenance
2. NBPI products require no replacement parts
3. NBPI products are usually designed to last the life of the associated air handling system. Life expectancy is greater than 10 years\*

\*Carbon Fiber Brushes Required

# Ion Sensing Solutions

Hand Held Air Ion Counters



Duct Mount Ion Detectors

Wall & Duct Mount Air Ion Counters



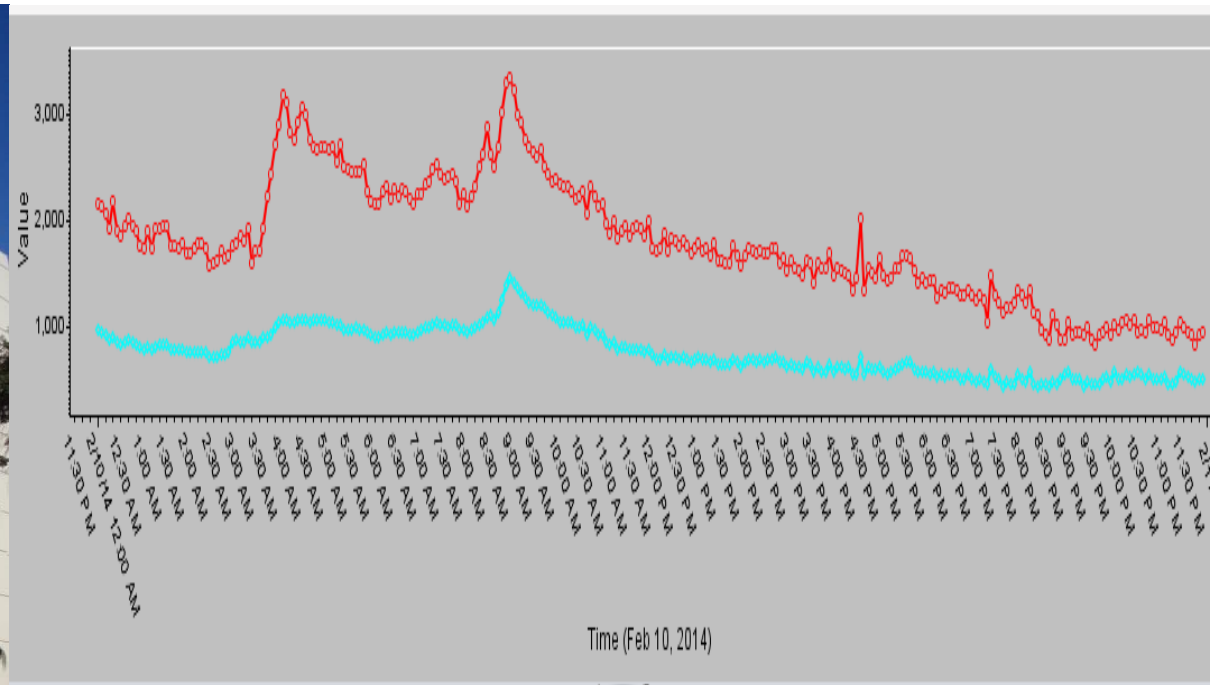
TVOC Sensors



VOC Sensors

# Houston Methodist Hospital

## NBPI as Substitute to Carbon

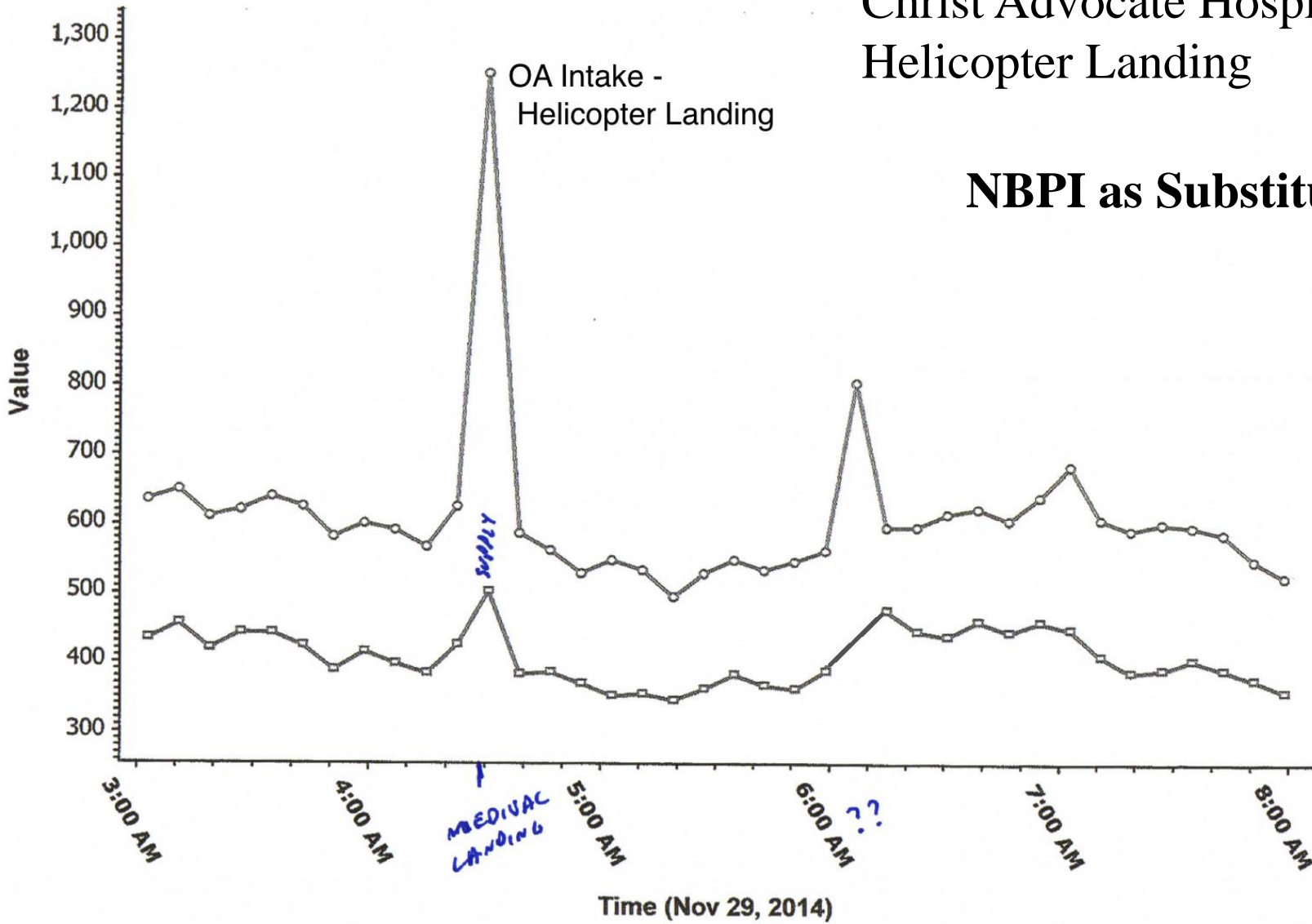


Sh...	Marker	Name	Reference
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<input type="checkbox"/>		OA-VOC.AHU B580.OA-VOC	HHIAPPJHSNP01.NAEF5-02/FC-1.AHU B580.OA-VOC.Trend3
<input checked="" type="checkbox"/>		VOC-1.Trend - Present Value	HHIAPPJHSNP01.NAEF5-02/FC-1.AHU B580.VOC-1.Trend1
<input type="checkbox"/>		VOC-1.Trend - Present Value	HHIAPPJHSNP01.NAEF5-02/FC-1.AHU B580.VOC-1.Trend2

# AHU 6

Christ Advocate Hospital, Chicago  
Helicopter Landing

**NBPI as Substitute to Carbon**



Printed on 12/18/2014 08:39:08 AM

Show	Marker	Name	Reference
<input checked="" type="checkbox"/>	○	Hospital.Surgery Pavilion.AHU-6.VOC-MA.Hospital.Surgery Pavilion.AHU-6 VOC-MA	JCI-ADX-NAE-2/N2-2.UNT0202049.VOC-MA.Trend1
<input checked="" type="checkbox"/>	□	Hospital.Surgery Pavilion.AHU-6.VOC-DA.Hospital.Surgery Pavilion.AHU-6 VOC-DA	JCI-ADX-NAE-2/N2-2.UNT0202049.VOC-DA.Trend1

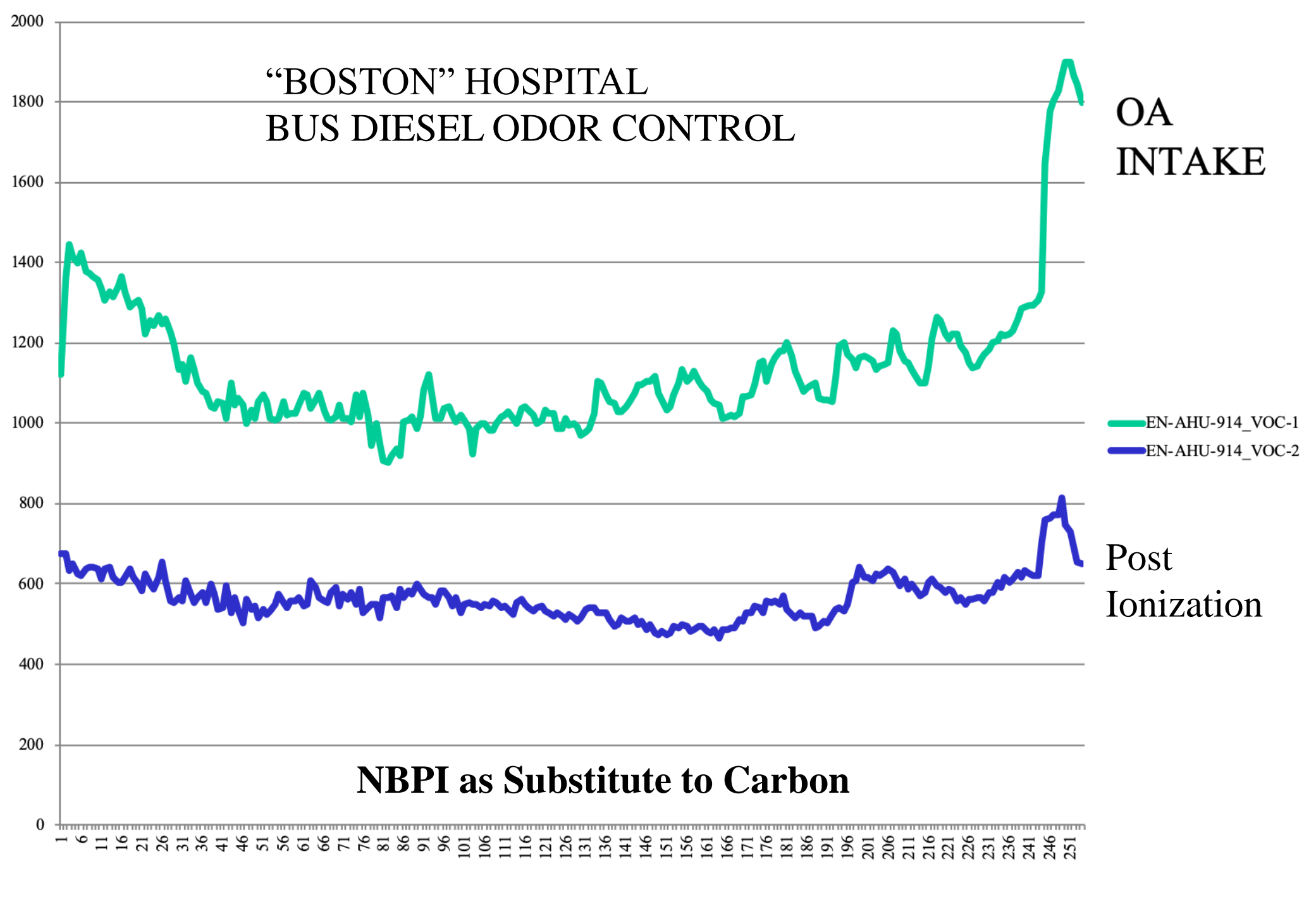
# “BOSTON” HOSPITAL BUS DIESEL ODOR CONTROL

OA  
INTAKE

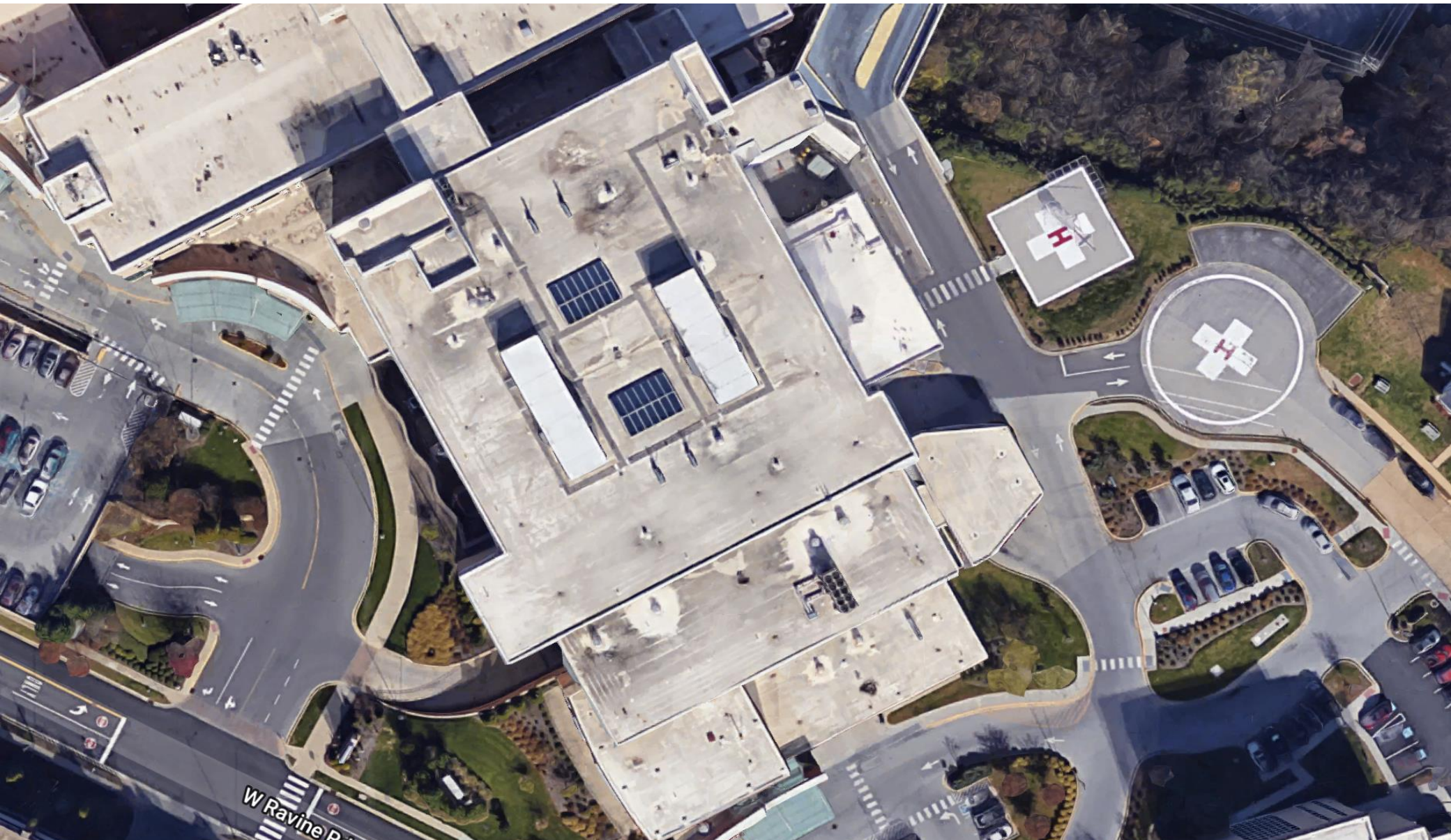
EN-AHU-914\_VOC-1  
EN-AHU-914\_VOC-2

Post  
Ionization

**NBPI as Substitute to Carbon**



Helicopter Odor Control – New Pad = New Complaints  
**NBPI as Substitute to Carbon**



# FL Hospital

## NBPI as Substitute to Carbon

Name	Before Ion Bar	After Ion Bar	
DeviceAddress	1	1	
Hub Id	942900003	942900005	
Device Name	Sarasota Hospital IAQ In	Sarasota Hospital IAQ Out	
Device Model	Tongdy Air Quality Sensor	Tongdy Air Quality Sensor	
Read-in time	8/24/2019 7:23	8/24/2019 7:23	
TVOC	3.575	0.849	76.3%
CO2 Level	451	442	
Particles with $\phi < 2.5\text{nm}$	0.7	0	100.0%
Particles with $\phi < 10.0\text{nm}$	1.4	0	100.0%
Humidity	98.65	90.33	
Temperature, °F	67.2	47.5	

## TAMPA BAY ARENA CASE STUDY

Year Built:	1996
Year Renovated:	2011
Size:	670,000 square feet
Occupancy:	21,500 Occupants
OA Reduction:	94,274 CFM
Capacity Saved:	700 Tons
Equipment:	12 – 40,000 AHU's with Needlepoint Equip.
Renovation \$ Saved:	> \$1 million
Annual Energy \$:	>\$115,000
C02 Reduction:	> 1.25 millions pounds C02 annually
Environment Impact:	Equivalent to planting > 3,000 trees
Engineer:	Smith Seckman & Reid (SSR Nashville)
Contractor:	Tappouni Mechanical, Tampa, FL

# Building Rating Programs

Providing compliance path for IAQP

- **LEED – Leadership in Energy & Environmental Design**  
(Alternate Compliance Path allows IAQP)
- **ENERGY STAR**
- **GREEN GLOBES**

# Needlepoint Bipolar Ionization

- Saves on First & Renovation Construction Costs
  - Rule of Thumb – 5 CFM per person of Outside Air
- Saves Energy
- Reduces Maintenance
- Reduces Construction Costs
- Provides Pathogen, Particle & Odor Control

