Phenomenal Aire

Cold Plasma Generator Technology

SUMMARY OF INDOOR AIR QUALITY TECHNOLOGY TESTING

Publication: August 18, 2020

Summary of Indoor Air Quality Technology Testing

In June of 2020, a prominent hotel management company participated in pilot programs to test advanced indoor air quality technology. The pilot programs were conducted at four hotels in Charlotte, NC. The pilot programs' intent was to formally demonstrate and document the performance of Cold Plasma Generator technology, known as Phenomenal Aire, and its ability to safely and effectively provide their properties with clean indoor air.

The Cold Plasma Generators (CPG) being tested utilize a process to clean indoor air referred to as bipolar ionization. The CPG technology manufacturer touts many benefits of its product, ranging from reducing airborne pollutants to the mitigation of harmful microorganisms.

Of the benefits stated by the manufacturer, is the technology's ability to increase the effectiveness of existing HVAC air filters. The company states the ability to increase the efficiency of a MERV8 filter to that of a MERV13. The relevance of a "MERV13" in current times is the documented performance of the filter at capturing sub-micron sized particulate matter and viruses from the airstream of an HVAC system.

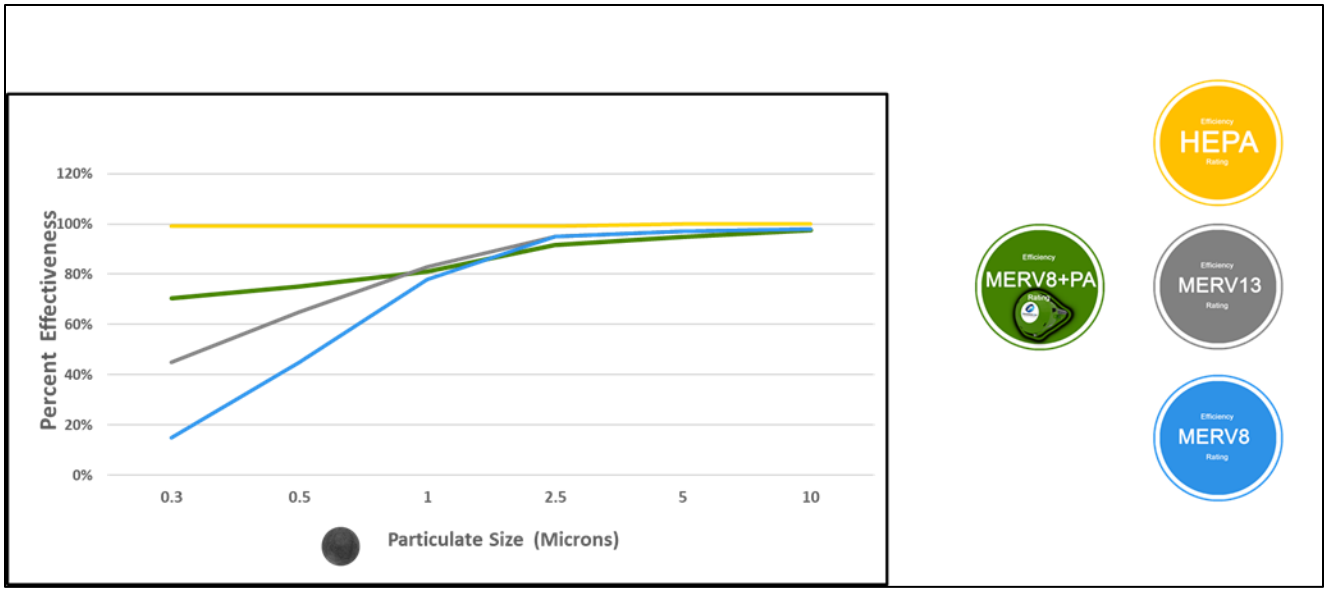
The pilot programs' basis would be a detailed comparison of the performance of a MERV8 filter paired with Phenomenal Aire to that of a MERV13 filter operating independently. The benchmark for success would be an analysis of performance at capturing particulate matter ranging in size from .3 microns to 10 microns.

Members of hotel's engineering and operations departments played key roles in the pilot programs by vetting the technology, providing review and oversight of the product installation, as well as oversight of testing procedures. Team members also provided detailed; site specific information necessary for an accurate financial analysis of deploying the technology.

On June 19th, detailed measurements of indoor air quality were recorded, and the CPG technology was installed. One June 25th post-installation measurements of indoor air were taken and recorded.

An aggregate of the recorded data from the individual test sites concluded that when capturing particulate .3 microns in size, a MERV8 filter paired with Phenomenal Aire performed at 70% efficiency vs. the documented industry standard of 20%. Graph 1. illustrates the aggregate data recorded during the pilot programs.

Summary of Indoor Air Quality Technology Testing



- Graph 1. demonstrates the aggregate performance results (test data 3 sites) of Phenomenal Aire + Existing MERV8 filtration vs. industry performance data for MERV8, MERV13, and HEPA filters.
- Most notable performance enhancement occurred in the range of 0.3 – 1 microns.
- HEPA filtration products average 99.9% effective in all ranges. However, HEPA filtration is almost exclusively reserved for special application: clean rooms, operating rooms, etc.

Testing Parameters: Measurement of Particulate Matter in the air pre-installation & post-installation.

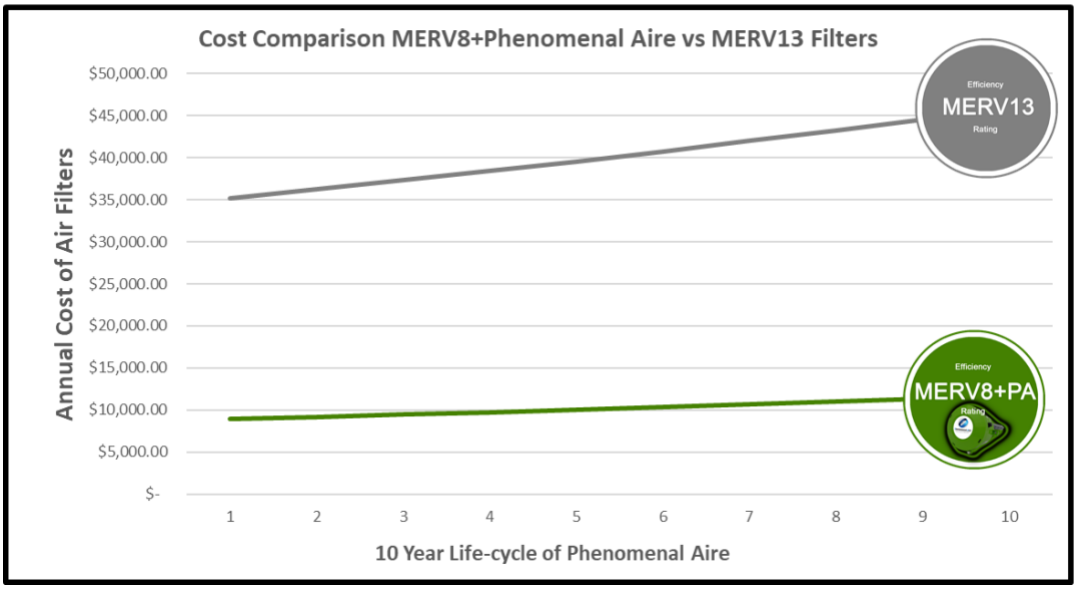
Testing Metrics: Measure efficiency gains of existing MERV8 air filters capturing Particulate Matter (.3 - 10 microns).

Testing Benchmarks: Measured data vs performance curve data for MERV8, MERV13, and HEPA filters.

Testing Outcome: Validation of measured data (aggregate 3 sites) demonstrates existing MERV8 filter + Phenomenal Aire performs at a 70% efficiency rate vs. the documented industry standard 20% (at particulate matter sized at .3 microns). Findings confirmed that a MERV8 filter + Phenomenal Aire is equal to or greater than a MERV13's performance.

The findings of the pilot program are further substantiated when comparing the documented outcome with that of other 3rd party test results. Findings of a 2017 IAQ test conducted by Blue Heaven Technologies mirrors that of the pilot program and is included within the technical documentation.

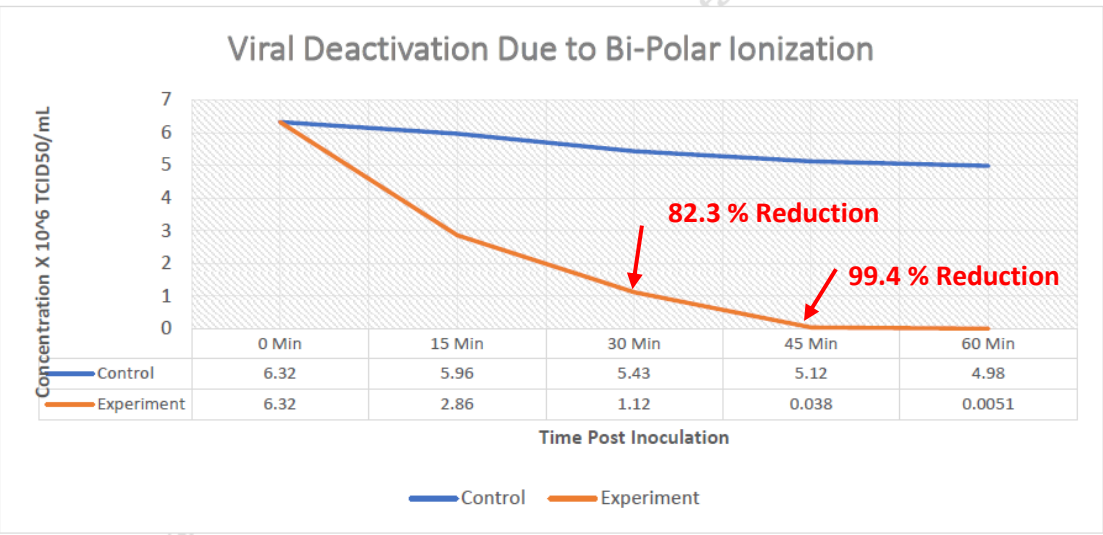
In addition to conducting the technical analysis of Phenomenal Aire, the hotel's team also conducted a financial analysis to determine what costs could be avoided by converting all existing MERV8 filters to MERV13. The hotel's procurement team provided real time data on the costs associated with making this change at a single location. Vendors were contacted to provide current quotes for both MERV8 and MERV13 filters. Chart 2. below illustrates an avoided cost of over $300,000 by pairing Phenomenal Aire with its existing MERV8 filters in a +400-room hotel.



- ***The current cost to purchase MERV8 filters is $8,920. The current cost for MERV13 is $35,158.***
- ***Graph 2. demonstrates the total cost differential for replacing air filters MERV8 vs MERV13 over a 10-year period.***
- ***The operational lifecycle of Phenomenal Aire is ten years.***
- ***A 3% rate of inflation was carried across the ten-year period.***

Phenomenal Aire™ SARS-CoV-2 Testing Results

Benefit of Virus Mitigation: Guest & Employee Health



Log Reduction at 15min: 0.34 30min: 0.75 45min: 2.22 60min: 3.1

In addition to controlling PM, Phenomenal Aire™ has a substantial benefit in contributing to virus mitigation strategies. A third-party laboratory recently confirmed Phenomenal Aire™ deactivates SARS-CoV-2 (COVID-19). Testing indicated a deactivation rate of 99.4%.

Technical Information Associated with the Pilot Programs:

Common Terminology

IAQ- Indoor Air Quality

Ion - An atom or molecule with a net electric charge due to the loss or gain of one or more electrons.

Agglomeration- Action or process of collecting mass.

Atom - The smallest part of an element.

Bipolar – Ions are electrically charged ... positive or negative.

Bipolar Ionization- An air cleaning process utilizing electrically charged ions that react with airborne contaminants ranging from particulate matter to viruses.

Element - A basic substance that is made of only one type of atom (oxygen, hydrogen, nitrogen)

HEPA- High Efficiency Particulate Air (filter)- The highest rated air filter (99% efficient) typical applications include use in HVAC systems serving clean rooms, operating rooms, manufacturing.

Molecule - Two or more atoms that are chemically joined (O_2, H_2O, etc...).

Ion Production - Positive and Negative Ions produced and emitted by needlepoint clusters that travel through the HVAC *plenum, ductwork & into the occupied space.*

MERV- Minimum Efficiency Rating Values, report a filter's ability to capture particles between 0.3 and 10 microns. Most common MERV filters: MERV8, MERV11, MERV13. The higher the rating the higher efficiency and higher restriction of air flow.

Ozone (O_3)- A colorless or blue gas that is formed when 3 oxygen atoms are combined. "Negative health effects" are associated with exposure to ozone and its reaction products.

Particulate Matter (PM)- Very small particles in air that are measured in micrometers made up of organic chemicals, dust, soot, smoke and metals. Testing incorporated PM ranging in size from 0.3-10 microns.

Plasma- A state of matter similar to gas in which a certain portion of the particles is ionized.

Plasma Field- Contains charged particles: positive electrons/ions and negative electrons/ions.

UL 867- Industry certification verifying ozone output from an air cleaner does not exceed 0.05 parts per million (ppm).

Summary of Indoor Air Quality Technology Testing

Testing Procedure

The process of measuring particulate matter in the indoor air was consistent for both pre-IAQ technology installation and post installation.

- 2 hours for each room/testing location
- 20 test samples within 2 hours
- Individual sample time of 6 minutes

Testing Equipment-

Greywolf PC-3016IAQ 6 Channel Particulate Counter

Meter Specifications

- Size Range: 0.3 - 25.0 µm+ (145 µm max into inlet)
- Channel Sizes: 0.3, 0.5, 1.0, 2.5, 5.0, 10.0 µm
- Flow Rate: 0.1 CFM (2.83 LPM)
- Counting Efficiency: 50% @ 0.3 µm; 100% for Particles >0.45 µm (per ISO 21501-4
- Zero Count Level: <1 Count/5 minutes (per ISO 21501-4)
- Concentration Limits: 8,000,000 Particles/ft^3 @ 10% Coincidence Loss

HVAC Equipment Included in Test

Location #1 Charlotte, NC

YORK model # XTI-05X096
Filter bank data: 12—20X24X2 4—16X20X2

Location #3 Charlotte, NC

York model# XTI 51X63
4-20X16X2 6—20X16X6 2—20X20X2

Location #2 Charlotte, NC

Carrier model #39T-26
Filter bank data: 15--16X20X2 5—16X25X2

Carrier model# 39T-13
Filter bank data: 3—16X25X2 6—16X20X2

Carrier model# 39T-26
Filter bank data: 5-16X25X2 15--16X20X2

Summary of Indoor Air Quality Technology Testing

HVAC Equipment Operations

- Air Handling Units (AHU) producing 7,000- 14,000 CFM
- 9 VAV boxes ranging from 240-2,330 CFM
- Outside Air set to 20%
- Operational Run Time 24/7
- Temperature Set-points 70°/71°

Environmental Conditions

The type and volume of Particulate Matter in indoor air is influenced directly or indirectly by any given number of factors including, temperature, humidity, activities like construction, even the number of occupants in a building. During the testing period, occupancy on June 19th was approximately 10% while occupancy on June 25th was at 16%.

Example: to demonstrate the relevance of occupancy/occupancy rates when collecting data, consider the following:

- A person sitting generates about 100,000 particles/cubic foot
- A person standing generates about 2,500,000 particles / cubic foot
- A person walking generates about 10,000,000 particles / cubic foot

June 19, 2020 Pre-installation Conditions

- High of 84° Low of 69°
- Precipitation 0.032”
- Humidity 80%
- Building Occupancy 10%

June 25, 2020 Post-Installation Test

- High of 87° Low of 69°
- Precipitation 0.033”
- Humidity 80%
- Building Occupancy 16%

*During the testing period construction activities were present outside of location #1 and location #3.

About the IAQ technology

Summary of Indoor Air Quality Technology Testing

Phenomenal Aire technology as described by the manufacturer, Top Product Innovations:

Phenomenal Aire™ Cold Plasma Generator (CPG) technology safely cleans the air inside commercial, institutional, and industrial buildings. Phenomenal Aire is designed for installation in a building's Heating Ventilation and Air Conditioning (HVAC) systems. The CPG Technology is ***Powered by Needlepoint Clusters™*** *and produces an electric field filled with billions of highly charged+ and - ions. The ions attach to pathogens, particles and gas molecules traveling in the airstream and act as a natural scrubbing agent. The scrubbing process, (ionization) inactivates harmful pathogens by breaking the microorganisms' molecular bonds and stealing away vital molecules like hydrogen.* ***The highly charged ions agglomerate sub-micron particulate matter (PM), making them easier to filter and capture****. The ions breakdown harmful Volatile Organic Compounds (VOCs) into harmless compounds like O_2, CO_2, N_2, and H_2O. The ions produced by Phenomenal Aire travel through the airstream of the HVAC system into the occupied space where they continue to clean the air as well as disable harmful pathogens on hard surfaces*

Supporting Documentation

Summary of Indoor Air Quality Technology Testing

Test Date: October 23, 2017
Modified CADR Chamber Test
Chamber Smoke Concentration Decay
Performance Testing MERV8+Bipolar Ionization vs MERV13

Filter Descriptions	MERV8	MERV13
Nominal Dimensions 24"X24"X1"	X	X
Pleated Panel	1"	1"
Rated Airflow, CFM	1200	1200

MERV13	Microns								Total Particle Count	#/cm3
Elapsed Time	**0.3**	**0.4**	**0.55**	**0.7**	**1**	**1.3**	**1.6**	**2.2**		
4 Minutes	1805492	738537	144867	40941	865	153	96	3	2730958	2730
34 Minutes	636	101	25	23	8	5	2	5	808	0.81
MERV8+ Bipolar ionization	Microns								Total Particle Count	#/cm3
Elapsed Time (Minutes)	**0.3**	**0.4**	**0.55**	**0.7**	**1**	**1.3**	**1.6**	**2.2**		
5 Minutes	1958081	1222632	332433	129698	2610	341	136	6	3645943	3645
19 Minutes	1876059	736434	117644	22892	116	11	20	5	2753181	2753
16 Hours	619	90	12	17	2	1	2	2	745	0.74

Test Description

- Comparative tests were conducted to compare the performance of a 1" MERV 13 Panel filter to that of a 1" MERV8 Panel Filter combined with bipolar ionization in cleaning a 1,000 FT3 room of cigarette smoke. Initial particle concentration approximately 3,000 particles per cm3.
- Finding 1- MERV13 Panel filter reduced particle count from 2,730,958 to 808 particles in a timeframe of 34 minutes.
- Finding 2- MERV8 Panel filter with bipolar ionization technology reduced particle count from 3,645,943 to 745 particles in a timeframe of 16 hours.
- Finding 3- MERV 8 Panel filter with bipolar ionization technology reduced particle count from 2,753,181 to 745 particles in a timeframe of 15 hours - 40 minutes in comparison to the MERV13 at 34 minutes.

Information on Ozone

1. Ozone (O_3) is a colorless or blue gas that is formed when 3 oxygen atoms are combined. Ozone is commonly found in outdoor air — & as the EPA says, “Good Up High Bad Nearby”. Ground-level or "bad" ozone is not emitted directly into the air but is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOC) in the presence of sunlight. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources of NOx and VOC. At ground level, ozone is a harmful pollutant. Ozone pollution is a concern during the summer months because strong sunlight and hot weather result in harmful ozone concentrations in the air we breathe. Many urban and suburban areas throughout the United States have high levels of "bad" ozone. But many rural areas of the country are also subject to high ozone levels as winds carry emissions hundreds of miles away from their original sources. Ozone is also created by electrical devices in homes and commercial buildings. Computers and printers produce minimal levels of ozone when in operation.

Side effects of Exposure to High Levels of Ozone

Routes of exposure: inhalation, eyes, skin (Safety Data Sheet Information)

i. **Health effects code(s):** HE7, HE10, HE11, HE14
ii. Breathing ozone can trigger a variety of health problems including chest pain, coughing, and throat irritation. It can worsen bronchitis, emphysema, and asthma. "Bad" ozone also can reduce lung function and inflame the linings of the lungs. Repeated exposure may permanently scar lung tissue. Healthy people also experience difficulty breathing when exposed to ozone pollution. Because ozone forms in hot weather, anyone who spends time outdoors in the summer may be affected, particularly children, older people, outdoor workers and people exercising. Millions of Americans live in areas where the national ozone health standards are exceeded.

What are recommended levels of ozone?

Recommended limit in indoor spaces for any electronic device producing ozone is 50 parts per billion.

b. ASHRAE Position Document: “Any ozone emission (beyond a trivial amount that any electrical device can emit) should be seen as a negative, and use of an ozone-emitting air cleaner, even though the ozone is an unintentional by-product of operation, may represent a net negative impact on indoor air quality and thus should be used with caution. If possible, non-ozone-emitting alternatives should be used.”

Summary of Indoor Air Quality Technology Testing

Indoor Air Cleaners that use ozone as primary means to clean the air

c. Many air purifiers produce high levels of Ozone in combination with other reactive oxygen species (ROS). This has an adverse effect on the long-term health of inhabitants of these buildings. Many manufacturers of these devices claim that the ozone never reaches the environment or space. This is simply not true. The half-life of Ozone in the air is in excess of 8 hours. Half-life is the measure of the time it takes the concentration of ozone molecules to decay to half the concentration. However, with air purifiers that produce high levels of ozone, they are constantly producing the ozone and the concentration only increases to a level where the decay rate and production rate equilibrate.
d. ASHRAE Position Document "Negative health effects arise from exposure to ozone and its reaction products. Consequently, devices that use the reactivity of ozone for cleaning the air should not be used in occupied spaces. Extreme caution is warranted when using devices in which ozone is not used for the purpose of air cleaning but is emitted unintentionally during the air-cleaning process as a by-product of their operation."
e. ASHRAE Position Document UV Lamps "There is also the potential of an incomplete oxidizing process, which produces by-products of reaction that can be more toxic or harmful than the original constituents (e.g., formaldehyde). The catalysts can be contaminated (poisoned) by airborne reagents and/or products of oxidation, which results in reduced or total efficiency failure of the process. Incomplete decomposition of some organic contaminants and net production of formaldehyde, acetaldehyde, formic acid, and acetic acid"

UL Certifications

f. According to UL 867 certification, ozone output from an air cleaner should not exceed 0.05 ppm.
    i. Done in a sealed chamber 2.0" away from the output of the device.
    ii. Takes place in a sealed chamber test to confirm that ozone does not build up over time.
g. The UL 2998 validation certifies that the electrostatic air cleaner produces zero emissions-measured ozone.

TABLE B-1 Comparison of Regulations and Guidelines Pertinent to Indoor Environments[a]

(The user of any value in this table should take into account the purpose for which it was adopted and the means by which it was developed.)

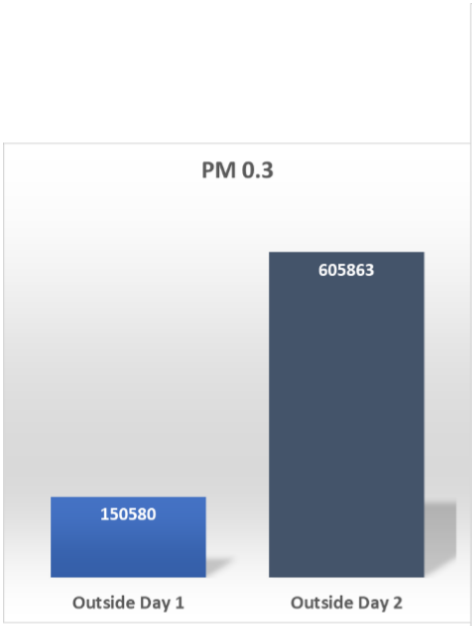
	Enforceable and/or Regulatory Levels			Non-Enforced Guidelines and Reference Levels			
	NAAQS/EPA (Ref. B-4)	OSHA (Ref. B-5)	MAK (Ref. B-2)	Canadian (Ref. B-8)	WHO/Europe (Ref. B-11)	NIOSH (Ref. B-13)	ACGIH (Ref. B-1)
Carbon dioxide		5000 ppm	5000 ppm 10,000 ppm [1 h]	3500 ppm [L]		5000 ppm 30,000 ppm [15 min]	5000 ppm 30,000 ppm [15 min]
Carbon monoxide[c]	9 ppm [g] 35 ppm [1 h] [g]	50 ppm	30 ppm 60 ppm [30 min]	11 ppm [8 h] 25 ppm [1 h]	90 ppm [15 min] 50 ppm [30 min] 25 ppm [1 h] 10 ppm [8 h]	35 ppm 200 ppm [C]	25 ppm
Formaldehyde[h]		0.75 ppm 2 ppm [15 min]	0.3 ppm 1 ppm[i]	0.1 ppm [L] 0.05 ppm [L] [b]	0.1 mg/m^3 (0.081 ppm) [30 min][p]	0.016 ppm 0.1 ppm [15 min]	0.3 ppm [C]
Lead	1.5 µg/m^3 [3 months]	0.05 mg/m^3	0.1 mg/m^3 1 mg/m^3 [30 min]	Minimize exposure	0.5 µg/m^3 [1 yr]	0.050 mg/m^3	0.05 mg/m^3
Nitrogen dioxide	0.05 ppm [1 yr]	5 ppm [C]	5 ppm 10 ppm [5 min]	0.05 ppm 0.25 ppm [1 h]	0.1 ppm[1 h] 0.02 ppm [1 yr]	1 ppm [15 min]	3 ppm 5 ppm [15 min]
Ozone	0.12 ppm [1 h][g] 0.08 ppm	0.1 ppm	j	0.12 ppm [1 h]	0.064 ppm (120 µg/m^3) [8 h]	0.1 ppm [C]	0.05 ppm[k] 0.08 ppm[l] 0.1 ppm[m] 0.2 ppm[n]
Particles[e] <2.5 µm MMAD[d]	15 µg/m^3[1 yr][o] 35 µg/m^3 [24 h][o]	5 mg/m^3	1.5 mg/m^3 for <4 µm	0.1 mg/m^3 [1 h] 0.040 mg/m^3 [L]			3 mg/m^3 [C]
Particles[e] <10 µm MMAD[d]	150 µg/m^3 [24 h][o]		4 mg/m^3				10 mg/m^3 [C]
Radon				800 Bq/m^3 [1 yr]			
Sulfur dioxide	0.03 ppm [1 yr] 0.14 ppm [24 h][g]	5 ppm	0.5 ppm 1 ppm [i]	0.38 ppm [5 min] 0.019 ppm	0.048 ppm [24 h] 0.012 ppm [1 yr]	2 ppm 5 ppm [15 min]	2 ppm 5 ppm [15 min]
Total Particles[e]		15 mg/m^3					

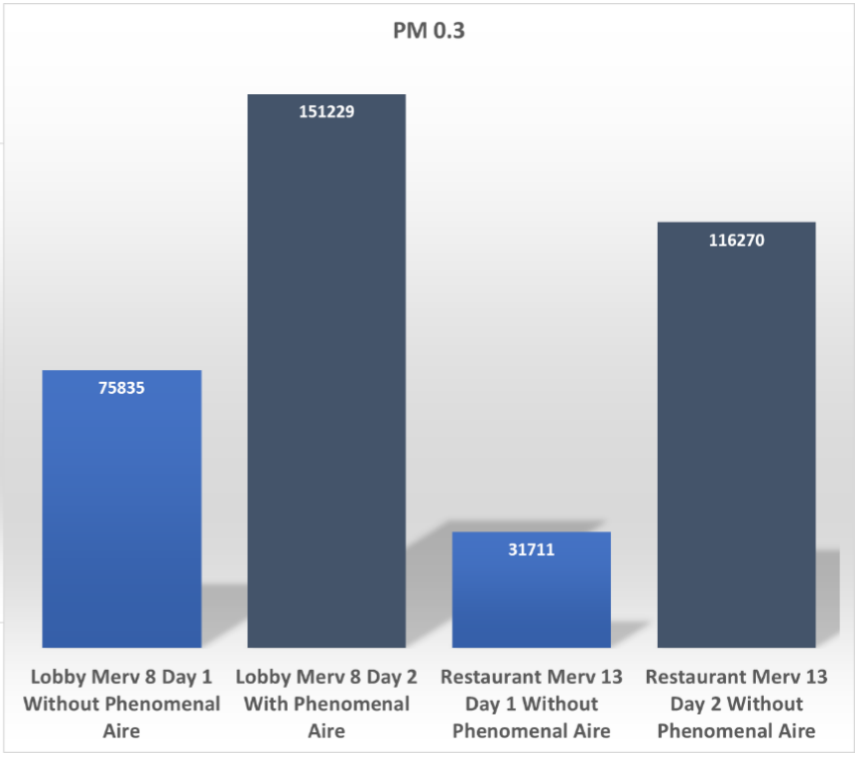
References

https://cfpub.epa.gov/airnow/index.cfm?action=gooduphigh.index

Supplemental Data Charts

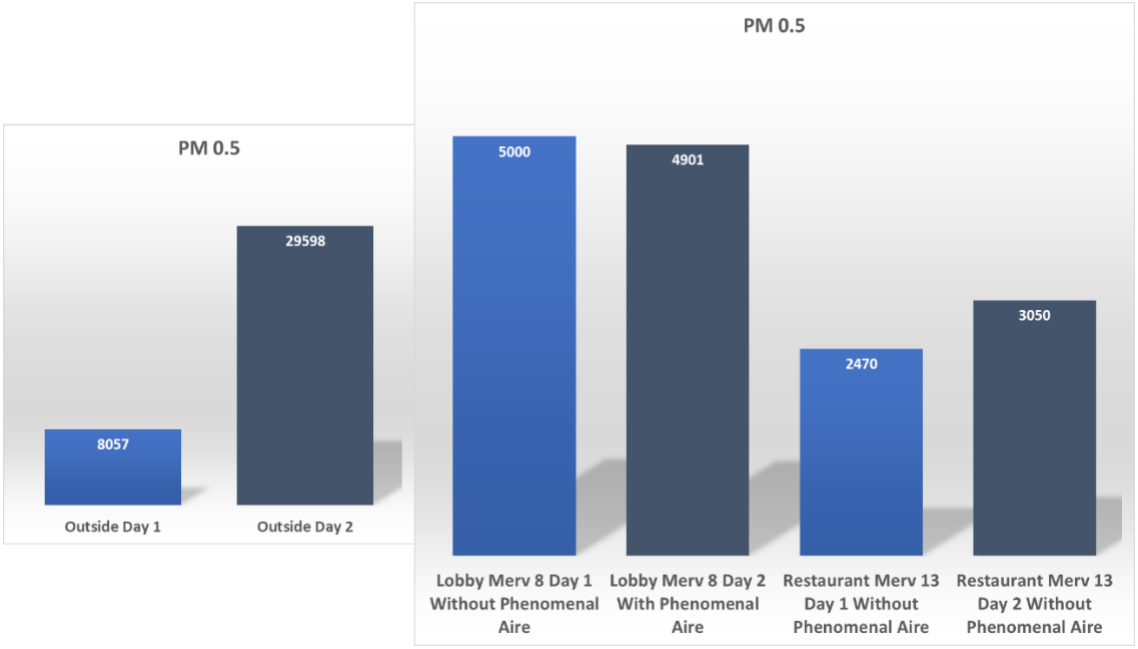
PM0.3 Testing





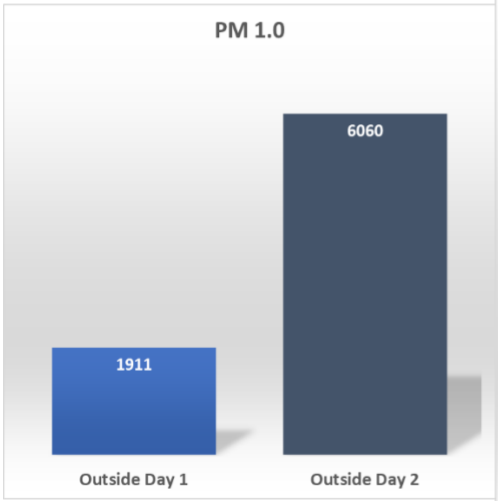
Supplemental Data Charts

PM 0.5 Testing



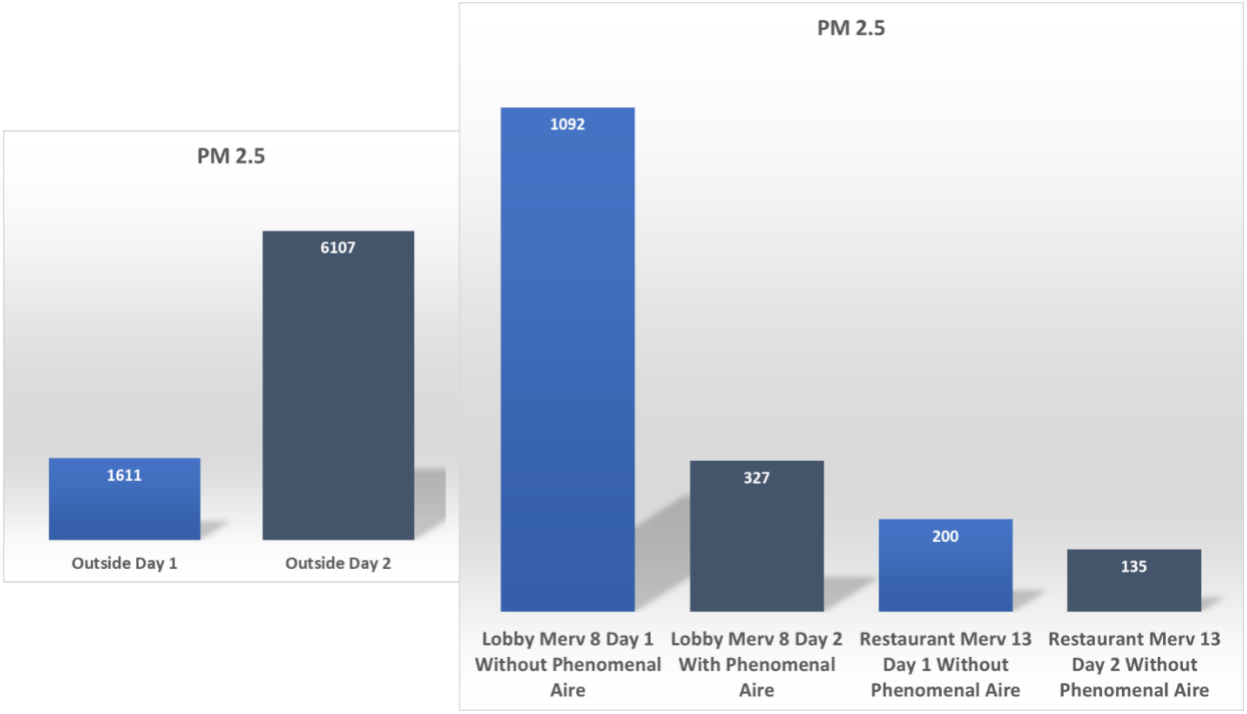
Supplemental Data Charts

PM 1.0 Testing



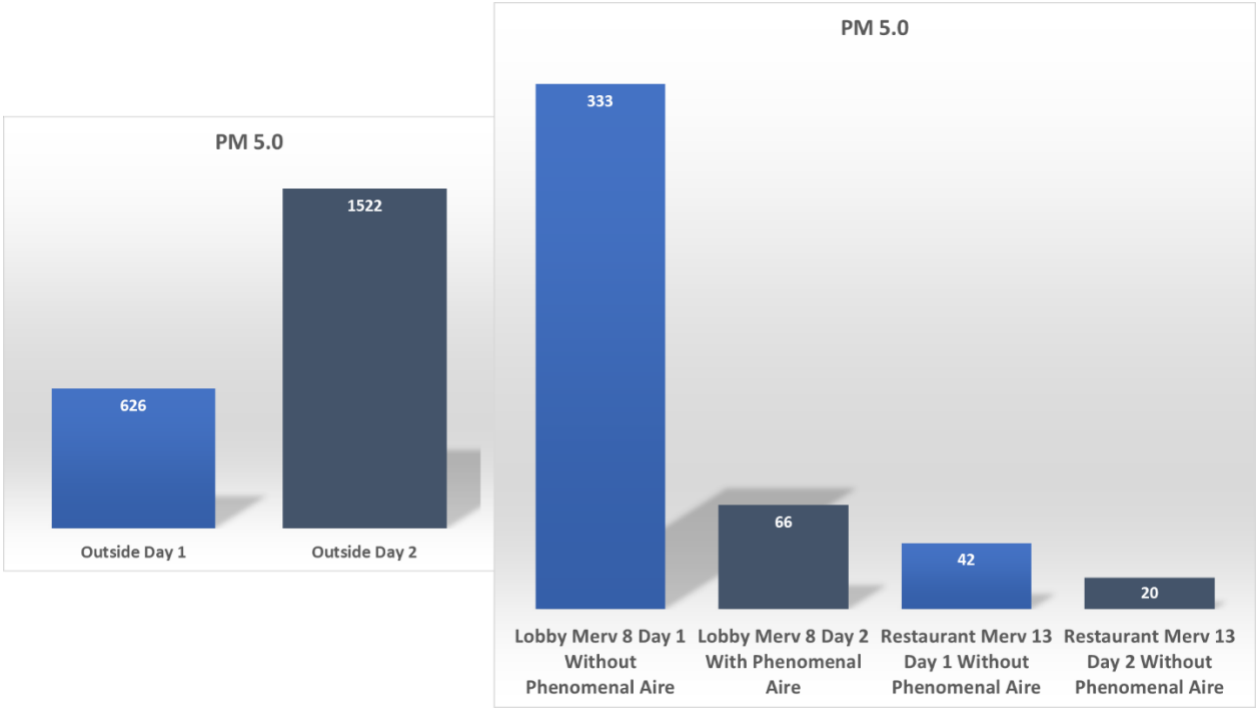
Supplemental Data Charts

PM 2.5 Testing



Supplemental Data Charts

PM 5 Testing



Supplemental Data Charts

PM 10 Testing