PlasmaAir

Laboratory Research Summary
Plasma Air & Novaerus Products

Dozens of independent laboratory tests have shown Plasma Air HVAC devices and Novaerus portable units to safely and effectively reduce bacteria, viruses, allergens, volatile organic compounds, and particulate matter.

Influenza A Reduction

Laboratory Name:	**Kitasato Research Center for Environmental Science**
Laboratory Location:	**Kanagawa, Japan**
Date:	**September 27, 2011**
Device Tested:	**D5 needlepoint ionizer cartridge, used in the 7000 Series and the Plasma BAR**
Space Treated:	**0.2 m^3**

Objective

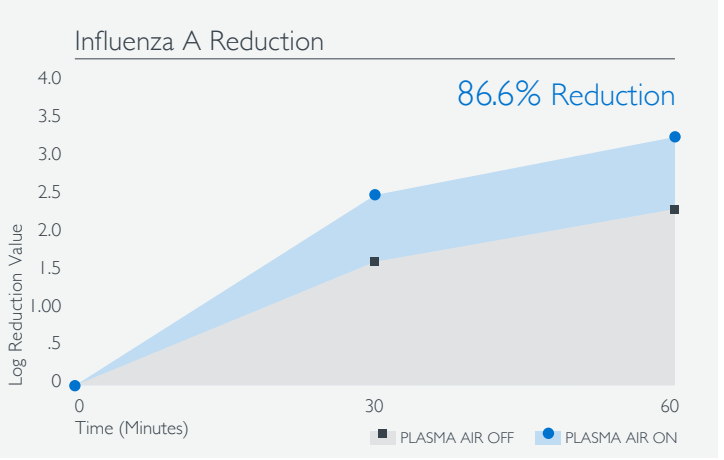
To evaluate the efficacy of the 7000 series and the Plasma BAR in reducing Influenza A (H1N1) virus.

Methodology

The 0.2 m^3 acrylic test chamber was put into a biological safety cabinet. The D5 device and fan were then placed in the test chamber. The virus suspensions were sprayed into the chamber using a compressor-type nebulizer NE-C16 (OMRON) into the test chamber for 5 minutes at an air flow ratio of approximately 0.2 mL/min.

Summary of Results

The device reduced 86.6% of Influenza A virus after one hour.



Airborne Bacteria and Bacteria Spore Reduction

Laboratory Name:	**Istanbul Faculty of Medicine, Department of Microbiology and Clinical Microbiology**
Laboratory Location:	**Istanbul, Turkey**
Date:	**January 20, 2011**
Device Tested:	**D5 needlepoint ionizer cartridge, used in the 7000 Series and the Plasma BAR**
Space Treated:	**1 m^3**

Objective

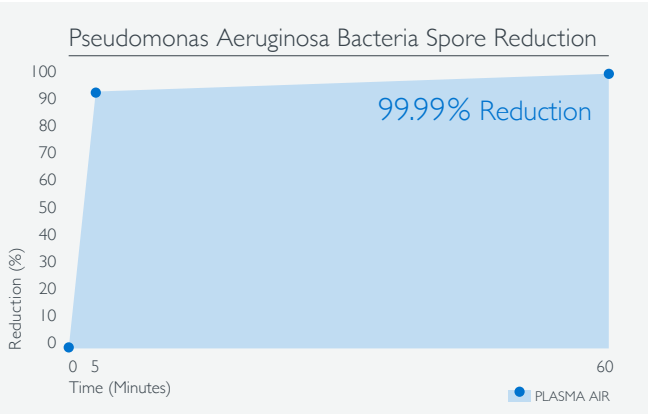
To evaluate the efficacy of the 7000 series and the Plasma BAR on reducing *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Escherichia coli,* and *Bacillus subtilis var. niger.*

Methodology

A 1 m^3 volumetric isolated test chamber was used for testing. One HVAC device was placed on the floor of the chamber. Airborne bacterial counts were measured before turning on the HVAC device.

Summary of Results

After one hour, testing showed 91.50% reduction of *Staphylococcus aureus*, 99.99% (no growth) reduction of *Pseudomonas aeruginosa*, 91.15% reduction *Escherichia coli*, and 89.30% reduction of *Bacillus subtilis var. niger.*



Staphylococcus epidermidis Bacteria Reduction

Laboratory Name:	**Aerosol Research and Engineering Laboratories**
Laboratory Location:	**Olathe, Kansas**
Date:	**November 22, 2016**
Device Tested:	**PA101D, PA201D**
Space Treated:	**563 ft^3**

Objective

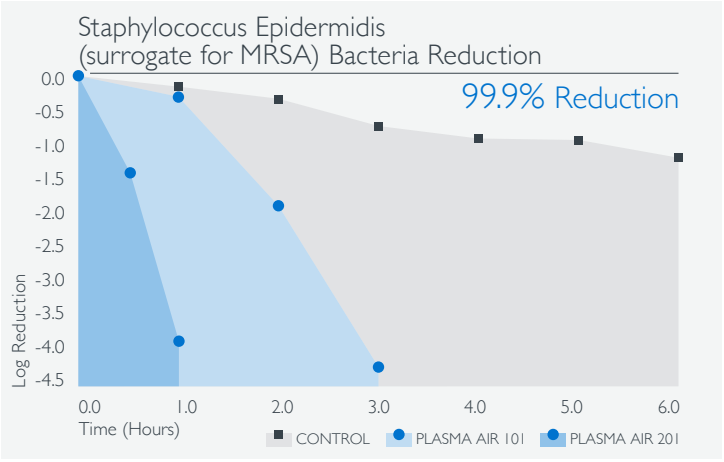
To evaluate the efficacy of the PA101D and PA201D on neutralizing airborne bacteria. The device was tested against aerosolized *Staphylococcus epidermidis*, a surrogate for methicillin-resistant *Staphylococcus aureus* (MRSA) bacteria.

Methodology

A large sealed aerosol test chamber was used to replicate a potentially contaminated room environment.

Summary of Results

The 101D achieved a 3.4 net log reduction and the 201D achieved a 3.5 net log reduction of *Staphylococcus epidermidis* (surrogate for MRSA) bacteria in 3 hours.



Airborne Bacteria, Mold and Yeast Reduction

Laboratory Name:	**EMSL Analytical, Inc.**
Laboratory Location:	**Cinnaminson, NJ**
Date:	**February 28, 2011**
Device Tested:	**D5 needlepoint ionizer cartridge, used in the 7000 Series and the Plasma BAR.**

Objective

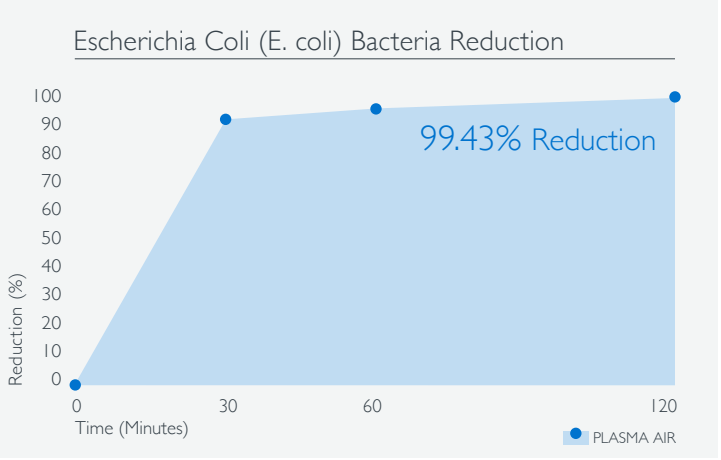
To evaluate the efficacy of the 7000 series and the Plasma BAR in reducing airborne bacteria: *Escherichia coli* and *Staphylococcus aureus*, mold: *Aspergillus niger* and *Cladosporium cladosporioides*, and yeast *Candida albicans*.

Methodology

An environmental chamber was set up for the testing. A nebulizer was connected to an air compressor with 1/4-inch plastic tubing and to the environmental test chamber through one of the openings.

Summary of Results

Testing showed a 99.43% reduction of *Escherichia coli*, an 81.67% reduction of *Staphylococcus aureus*, a 97.14% reduction of *Aspergillus niger*, a 97.69% reduction of *Candida albicans* and 36.27% reduction of *Cladosporium cladospoioides*.



VOC, Bacteria, and Smoke Particulate Reduction

Laboratory Name:	**LAWN Environmental Protection Ltd.**
Laboratory Location:	**Hong Kong, China**
Date:	**November 27, 2008**
Device Tested:	**PA102C**
Space Treated:	**1000 ft^3**

Objective

To evaluate the efficacy of the PA102C on reducing total volatile organic compounds (TVOC), formaldehyde (HCHO), airborne bacteria and cigarette smoke particulate.

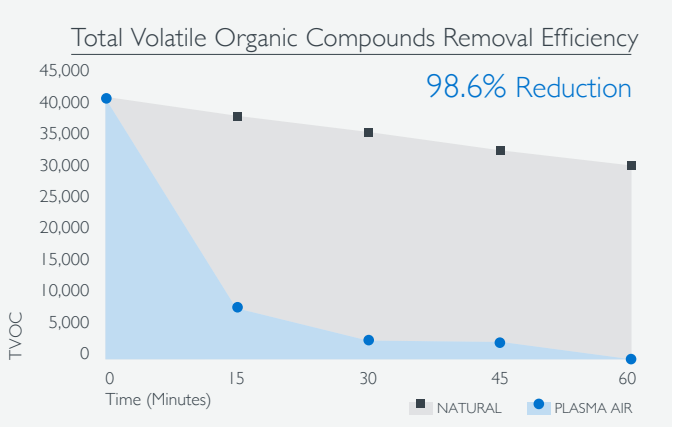
Methodology

The testing of the PA102C took place in a controlled room 1,000 ft^3 in size.

Summary of Results

The device reduced over 70% of TVOC, formaldehyde, airborne bacteria and cigarette smoke particulate (0.5µ – 5.0µ) within 15 minutes, over 80% within 30 minutes, and over 90% within 45 minutes.

Final results after one hour: 95.3% reduction of formaldehyde, 98.6% reduction of TVOC, 95.3% reduction of airborne bacteria, and 96.3% reduction of particulate.



Dust Particle and *Aspergillus fumigatus* Mold Spore Reduction

Laboratory Name:	**Intertek**
Laboratory Location:	**Cortland, NY**
Date:	**January 26, 2005**
Device Tested:	**PA101C**
Space Treated:	**1000 ft^3**

Objective

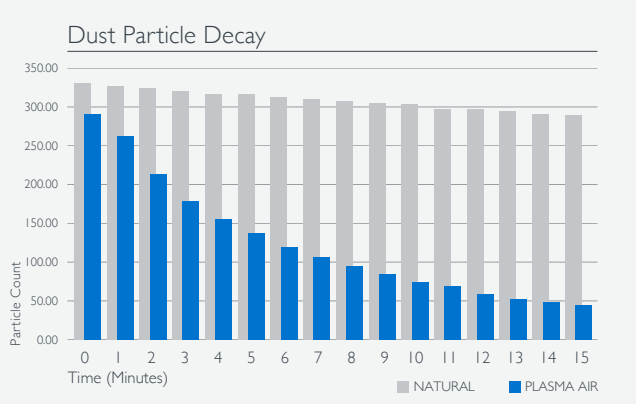
To evaluate the efficacy of the PA101C on reducing airborne dust particles and *Aspergillus fumigatus* mold spores.

Methodology

The tests were conducted in a closed room 10.5 × 12 × 8 ft equipped with an exhaust system to clean the room between tests. The room also had a ceiling fan to evenly spread the contaminants injected into the room. The PA101C was installed in a duct system which supplied a measured amount of purified air into the room.

Summary of Results

Over the fifteen-minute test period, the dust particles decayed naturally by 12.6%, while the PA101C produced a decay rate of 85.8%. The *Aspergillus fumigatus* mold spores decayed naturally at a rate of 67.1%, while the PA101C produced a decay rate of 91.1%.



Dust Particle Reduction Against Competitive Products

Laboratory Name:	**Intertek**
Laboratory Location:	**Cortland, NY**
Date:	**November 1, 2005**
Device Tested:	**PA101C**
Space Treated:	**1000 ft^3**

Objective

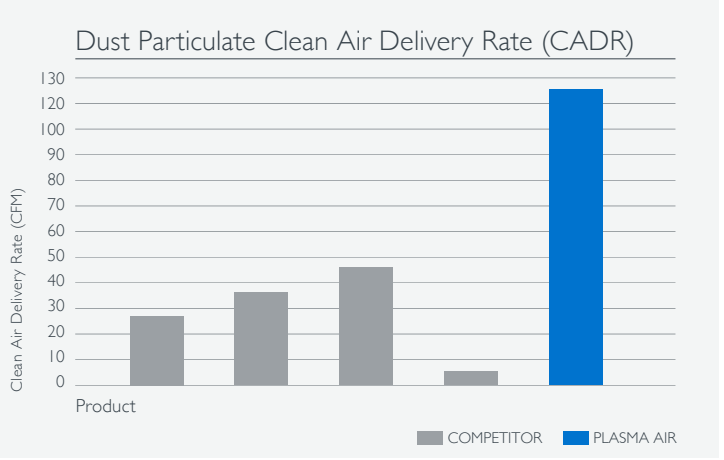
To evaluate the efficacy of the PA101C on reducing airborne dust particles against other competitive products on the market.

Methodology

The tests were conducted in a closed room 10.5 × 12 × 8 ft equipped with an exhaust system to clean the room between tests. The room also had a ceiling fan to evenly spread the contaminants injected into the room. The PA101C was installed in a duct system which supplied a measured amount of purified air into the room.

Summary of Results

The PA101C had the highest Clean Air Delivery Rate (CADR) among the five devices that were tested of 125.0 CFM.



Influenza A Reduction

Laboratory Name:	**Airmid Health Group Ltd.**
Laboratory Location:	**Dublin, Ireland**
Date:	**April 25, 2018**
Device Tested:	**Novaerus Defend 1050 (NV1050)**
Space Treated:	**28.5 m^3**

Objective

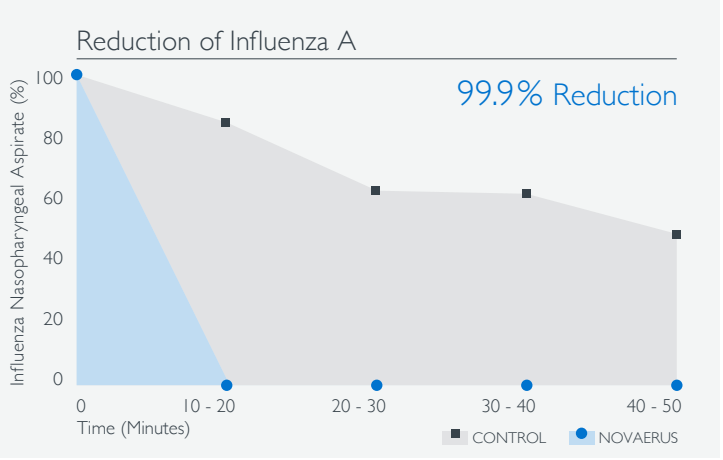
To evaluate the efficacy of the NV1050 on removing Influenza A.

Methodology

Testing of the NV1050 was conducted in a 28.5 m^3 environmental test chamber. The chamber was preconditioned to 20±3°C and 50±10% relative humidity prior to commencement of the tests. For the test runs, the NV1050 was placed on the floor in the centre of the chamber.

Summary of Results

The NV1050 was effective in reducing airborne Influenza A aerosols in the test chamber, reaching 99.9% airborne virus reduction within the first 10 – 20 minutes of operation at max speed.



Bioaerosols Reduction

Laboratory Name:	**Aerosol Research and Engineering Laboratories**
Laboratory Location:	**Olathe, Kansas**
Date:	**December 7, 2016**
Device Tested:	**Novaerus Protect 800/900 (NV800/NV900)**
Space Treated:	**563 ft^3**

Objective

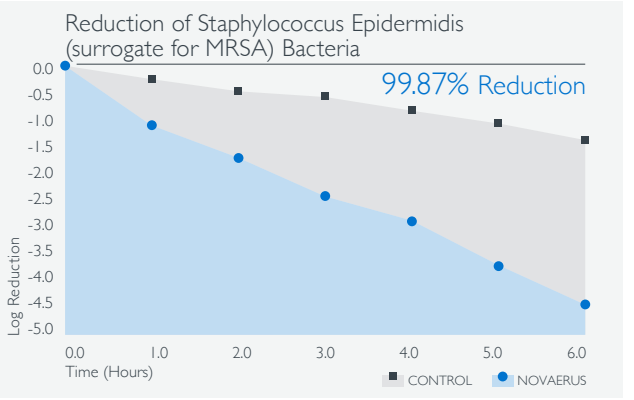
To evaluate the efficacy of the NV800/NV900 on neutralizing bioaerosols. The device was assessed on four aerosolized biologicals: *Staphylococcus epidermidis* (a surrogate for methicillin-resistant *Staphylococcus aureus* (MRSA)), MS2 bacteriophage (a surrogate for influenza and norovirus), *Aspergillus niger* fungus, and *Bacillus subtilis* endospores.

Methodology

A large sealed aerosol test chamber was used to replicate a potentially contaminated room environment and to contain any potential release of aerosols into the surrounding environment.

Summary of Results

Test results show the NV800/NV900 was extremely effective at reducing viability of bioaerosols in all conducted studies: a 99.87% reduction of *Staphylococcus epidermidis* (a surrogate for MRSA), a 99.99% reduction of MS2 (a surrogate for influenza and norovirus), a 98.85% reduction of *Aspergillus niger* mold, and an 86.5% reduction of *Bacillus subtilis* bacteria spores.



Clostridium difficile Bacteria Spore Reduction

Laboratory Name:	**Airmid Health Group Ltd.**
Laboratory Location:	**Dublin, Ireland**
Date:	**February 8, 2019**
Device Tested:	**Novaerus Defend 1050 (NV1050)**
Space Treated:	**28.5 m^3**

Objective

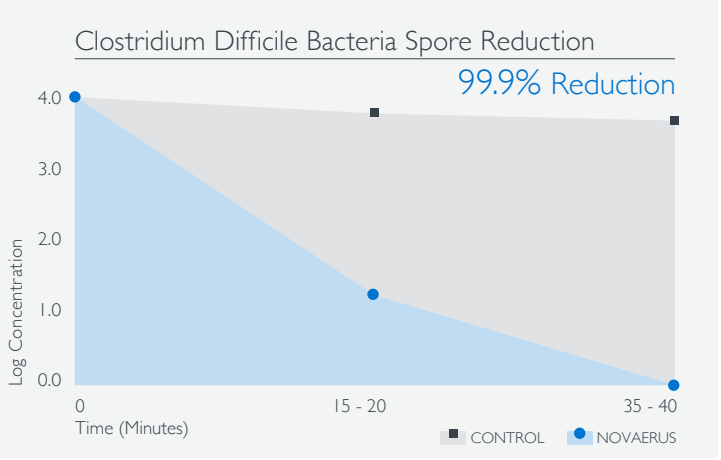
To assess the performance of the NV1050 in removing aerosolized *Clostridium difficile* spores.

Methodology

The impact of the NV1050 on aerosolised *C. difficile* spores was conducted in the 28.5 m^3 environmental test chamber. During the test runs the air purifier was placed in the centre of the test chamber and operated at full speed mode. The *C. difficile* spores were nebulised into the chamber for a fixed time and mixed with a ceiling fan. During the control runs the air purifier was switched off.

Summary of Results

The NV1050 demonstrated to be effective in reducing airborne *C. difficile* by 99.6% within the first 20 minutes. This increased to >99.9% after 40 minutes.



Mycobacterium tuberculosis Bacteria Reduction

Laboratory Name:	**Airmid Health Group Ltd.**
Laboratory Location:	**Dublin, Ireland**
Date:	**July 6, 2018**
Device Tested:	**Novaerus Defend 1050 (NV1050)**
Space Treated:	**30 m^3**

Objective

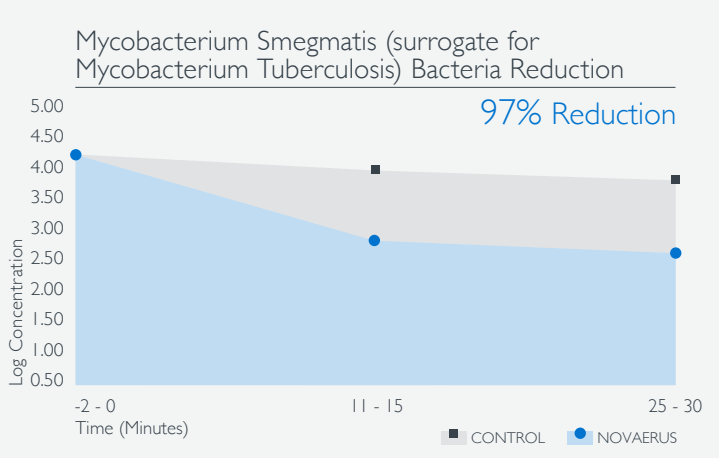
To assess the performance of the NV1050 in removing aerosolised *Mycobacterium smegmatis*, a surrogate for *Mycobacterium tuberculosis*.

Methodology

The impact of NV1050 on aerosolised *M. smegmatis* was conducted in a 30 m^3 environmental testing chamber. The test chamber was preconditioned to 20 ± 3 °C and 55 ± 5% relative humidity. Prior to each run, the test chamber was decontaminated by scrubbing the walls and surfaces.

Summary of Results

The results achieved during the testing show that the NV1050 was able to reduce the concentration of *M. smegmatis* artificially aerosolised by 95% within the first 15 minutes and this rose to 97% after 30 minutes of A/C operation.



Methicillin-Resistant *Staphylococcus aureus* (MRSA) Bacteria Reduction

Laboratory Name:	**Microbac Laboratories, Inc.**
Laboratory Location:	**Wilson, NC**
Date:	**January 20, 2016**
Device Tested:	**Novaerus Protect 800/900 (NV800/NV900)**
Space Treated:	**1 m^3**

Objective

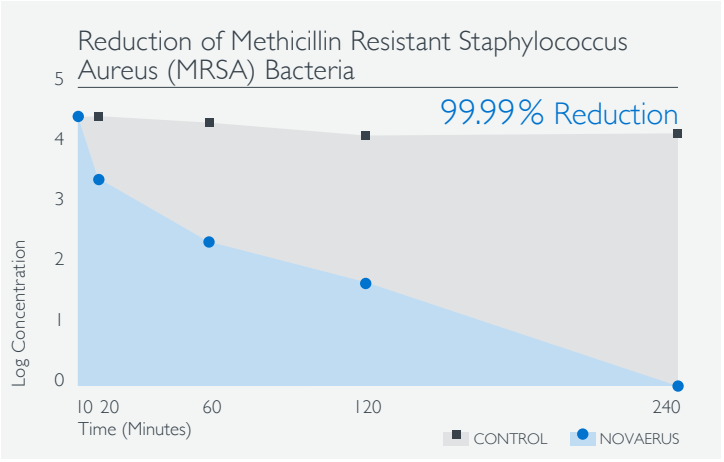
To evaluate the efficacy of the NV800/NV900 on reducing methicillin-resistant *Staphylococcus aureus* (MRSA).

Methodology

The challenge bacteria were aerosolized using a six-jet collision nebulizer under high pressure air and introduced into the chamber with the NV800/NV900.

Summary of Results

The NV800/NV900 reduced 99.99% of methicillin-resistant *Staphylococcus aureus* (MRSA) bacteria over the course of four hours.



Escherichia coli (E. coli) Deactivation

Laboratory Name:	**NASA Ames Research Center Universities Space Research Association**
Laboratory Location:	**Moffett Field, Mountain View, CA**
Date:	**February 2016**
Device Tested:	**Novaerus Protect 200 (NV200)**
Space Treated:	**18 ft^3**

Objective

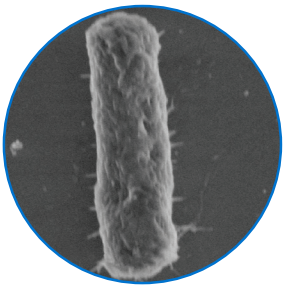
To explore the morphological and chemical modification of the cell structure of aerosolized *Escherichia coli (E. coli)* treated with a dielectric barrier discharge (DBD).

Methodology

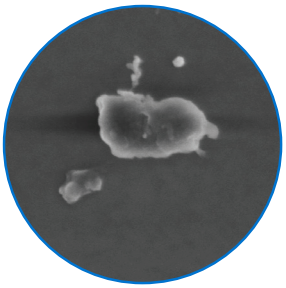
The NV200 was placed inside a biosafety cabinet, and a compressor nebulizer was attached to the input of the system in order to aerosolize the bacterial particles for testing.

Summary of Results

The bacteria underwent physical distortion to varying degrees, resulting in deformation of the bacterial structure. The electromagnetic field around the DBD coil caused severe damage to the cell structure, possibly resulting in leakage of vital cellular materials. The bacterial reculture experiments confirm inactivation of airborne *E. coli* upon treating with DBD.



Healthy bacteria



Bacteria after DBD treatment

Staphylococcus epidermidis Bacteria Reduction

Laboratory Name:	**Novaerus Research and Development Labs**
Laboratory Location:	**Dublin, Ireland**
Date:	**June 27, 2018**
Device Tested:	**Novaerus Defend 1050 (NV1050)**
Space Treated:	**30 m^3**

Objective

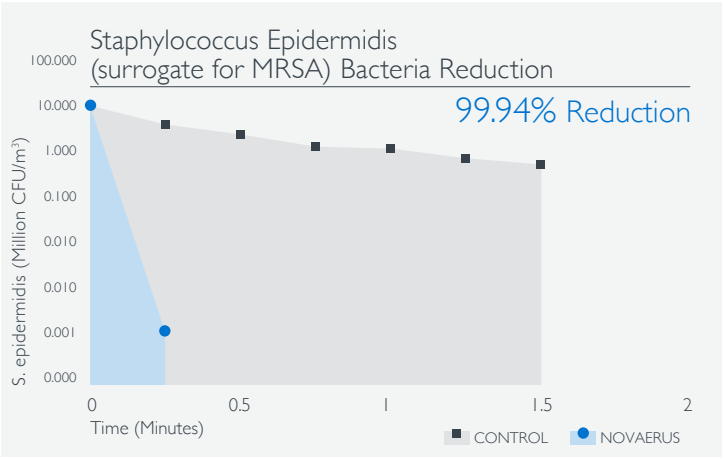
To evaluate the efficacy of the NV1050 on reducing airborne *Staphylococcus epidermidis*, a surrogate for methicillin-resistant *Staphylococcus aureus* (MRSA) bacteria.

Methodology

The test environment was a 30 m^3 test chamber, located in the Novaerus microbiology laboratory. During the testing, the NV1050 device was placed inside the chamber at the centre, with the air inlet facing towards the door of the chamber. The NV1050 device was tested at maximum airflow, speed setting 5. The test chamber was controlled for temperature and humidity at 25°C and 50% relative humidity.

Summary of Results

The NV1050 achieved a microbial cell reduction of 99.94% of *Staphylococcus epidermidis*, a surrogate for MRSA, within 15 minutes of operation.



Aspergillus niger Spore Reduction

Laboratory Name:	**Aerosol Research and Engineering Laboratories**
Laboratory Location:	**Olathe, Kansas**
Date:	**May 28, 2018**
Device Tested:	**Novaerus Defend 1050 (NV1050)**
Space Treated:	**562 ft^3**

Objective

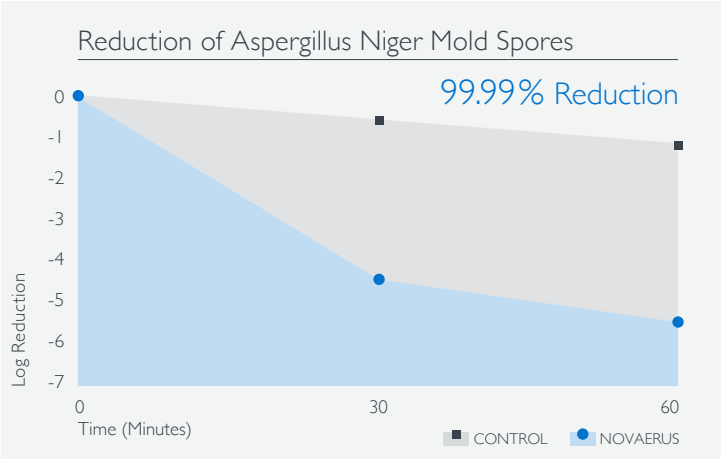
To evaluate the efficacy of the Novaerus NV1050 system against aerosolized *Aspergillus niger* spores.

Methodology

A. niger spores were aerosolized into a sealed bioaerosol chamber using a dry powder disseminator. AGI impingers were used to capture chamber bioaerosol concentrations.

Summary of Results

The average net log reduction of the NV1050 system at 30 minutes showed a 4.10 log. The net log reduction at 60 minutes showed a 4.28 log due to reaching detection limit. The actual log reduction is theoretically much higher at 60 minutes in a small room environment.



Formaldehyde Reduction

Laboratory Name:	**Aerosol Research & Engineering Laboratories**
Laboratory Location:	**Olathe, Kansas**
Date:	**July 27, 2018**
Device Tested:	**Novaerus Defend 1050 (NV1050)**
Space Treated:	**562 ft^3**

Objective

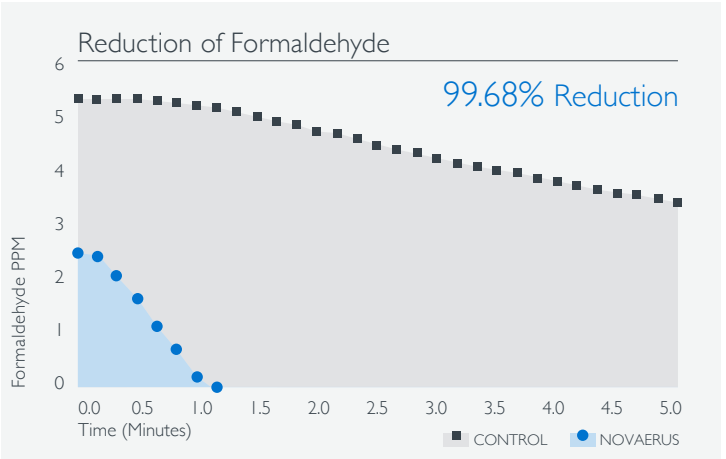
To evaluate the efficacy of the Novaerus NV1050 system on eliminating formaldehyde.

Methodology

Formaldehyde gas was released into a 562 ft^3 sealed chamber while the monitoring of concentration was logged with specialized detectors. For the control trial, the NV1050 remained outside the chamber, and the gas dissipated naturally over time.

Summary of Results

The NV1050 showed an average 99.68% reduction of formaldehyde in 1.1 minutes.



Nitrogen Dioxide Reduction

Laboratory Name:	**Aerosol Research & Engineering Laboratories**
Laboratory Location:	**Olathe, Kansas**
Date:	**July 27, 2018**
Device Tested:	**Novaerus Defend 1050 (NV1050)**
Space Treated:	**562 ft^3**

Objective

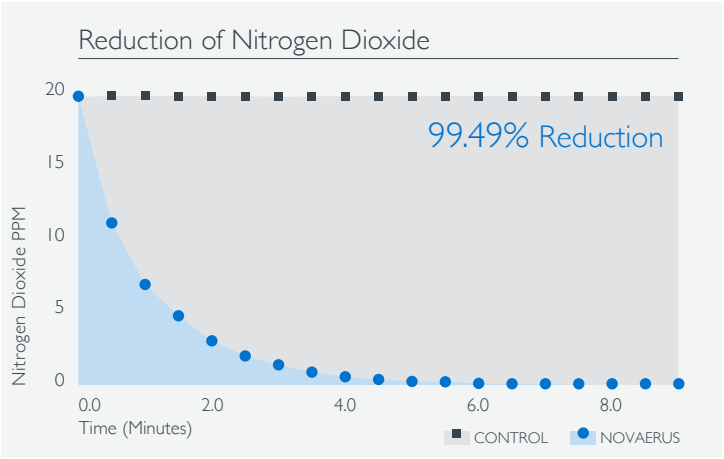
To evaluate the efficacy of the Novaerus NV1050 system on eliminating nitrogen dioxide (NO_2).

Methodology

NO_2 gas was released into a 562 ft^3 sealed chamber while the monitoring of the concentration was logged with specialized detectors. For the control trial, the NV1050 remained outside the chamber, and the gases were allowed to dissipate naturally over time.

Summary of Results

The NV1050 showed an average 99.49% reduction of NO_2 in 7.2 minutes.



Toluene VOC Reduction

Laboratory Name:	**Camfil Laboratories – Tech Center**
Laboratory Location:	**Trosa, Sweden**
Date:	**April 25, 2018**
Device Tested:	**Novaerus Defend 1050 (NV1050)**
Space Treated:	**19.72 m^3**

Objective

To evaluate the particulate and molecular efficiency of the NV1050 in a test chamber using Toluene, a volatile organic compound (VOC).

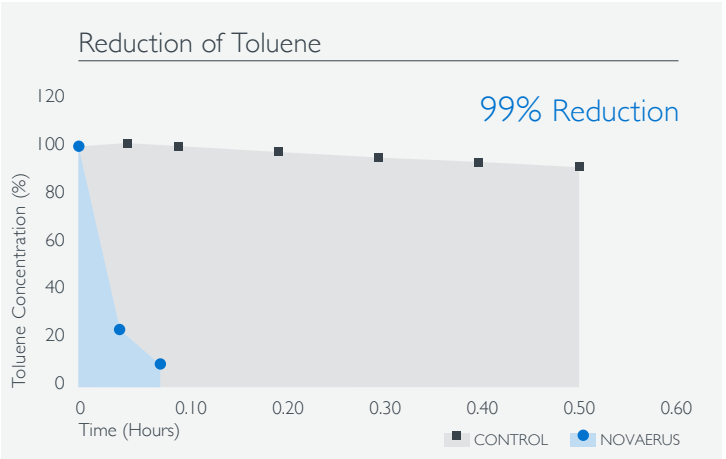
Methodology

Test method: CADR

Toluene was generated in the laskin nozzle and injected into a room until a pre-set concentration was achieved then the air cleaner was turned on. The results were then compared to the normal reduction of particles over time in the test chamber.

Summary of Results

The NV1050 produced a VOC CADR of 351 CFM. On the high speed, the NV1050 was shown to remove 90% of the toluene within 6 minutes and 99% within 9.1 minutes. On the low speed, the NV1050 was shown to remove 90% within 16 minutes.



Formaldehyde Reduction

Laboratory Name:	**Avomeen Analytical Services**
Laboratory Location:	**Ann Arbor, MI**
Date:	**May 27, 2014**
Device Tested:	**Novaerus Protect 800/900 (NV800/NV900)**
Space Treated:	**35 ft³**

Objective

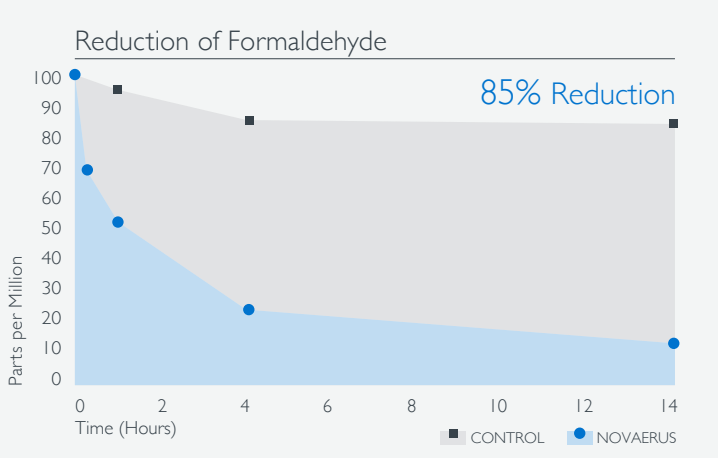
To evaluate the efficacy of the NV800/NV900 on reducing formaldehyde.

Methodology

A plexiglass chamber was built for formaldehyde testing of the NV800/NV900. This chamber was also equipped for proper ventilation and interior air circulation. A calculated amount of formaldehyde solution was evaporated in an aluminum pan heated to 120 degrees Celsius with a constant temperture hot plate.

Summary of Results

The NV800/NV900 reduced formaldehyde from 100 ppm to around 13 ppm during a 14-hour testing experiment, an 85% reduction.



PM1 and PM2.5 Reduction

Laboratory Name:	**Camfil Laboratories – Tech Center**
Laboratory Location:	**Trosa, Sweden**
Date:	**April 25, 2018**
Device Tested:	**Novaerus Defend 1050 (NV1050)**
Space Treated:	**19.72 m^3**

Objective

To evaluate the particulate and molecular efficiency of the NV1050 in a test chamber using DEHS.

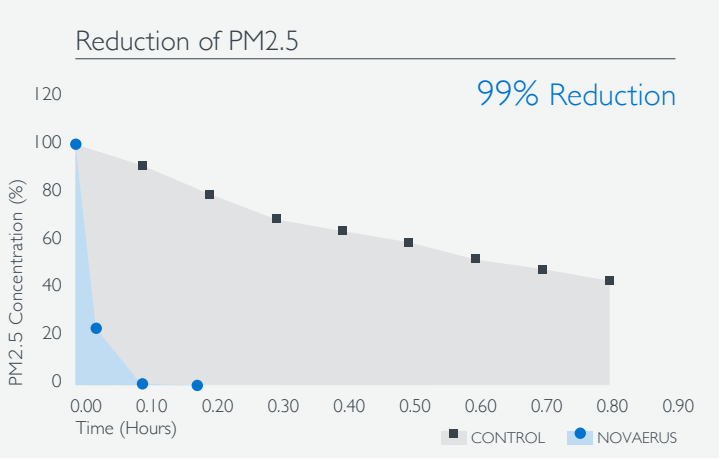
Methodology

Test method: CADR

DEHS was generated in the laskin nozzle and injected into a room until a pre-set concentration was achieved then the air cleaner was turned on. The results were then compared to the normal reduction of particles over time in the test chamber.

Summary of Results

The NV1050 produced a CADR of 513 CFM against PM2.5 and a CADR of 507 CFM against PM1. It removed 99% of PM2.5 within 6.26 minutes and 99% of PM1 within 6.33 minutes.



Allergens Reduction

Laboratory Name:	**Indoor Biotechnologies Ltd.**
Laboratory Location:	**Cardiff, UK**
Date:	**September 9, 2016**
Device Tested:	**Novaerus Protect 800/900 (NV800/NV900)**
Space Treated:	**1 m^3**

Objective

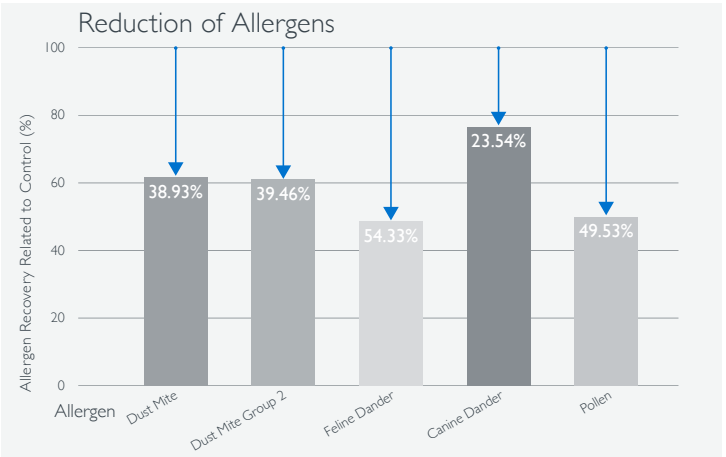
To evaluate the efficacy of the NV800/NV900 on reducing airborne allergens.

Methodology

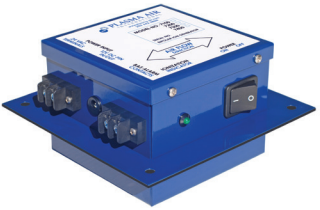
Testing was performed with the NV800/NV900 placed in a closed, thoroughly cleaned experimental chamber measuring approximately 1 m^3.

Summary of Results

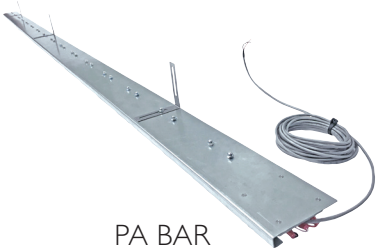
The NV800/NV900 produced an overall allergen reduction of 41.16%, with a 38.93% reduction of house dust mites, a 39.46% reduction of house dust mites (group 2), a 54.33% reduction of feline dander, a 23.54% reduction of canine dander, and a 49.53% reduction of pollen.



PA 100/200 Series



PA 7000 Series



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Protect 800/900
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