

# Effectiveness of UVC Light to Mitigate Coronavirus (COVID-19)

## What are Coronaviruses?

Coronaviruses (CoV) are a family of enveloped viruses that were first discovered in the 1960s. Coronaviruses are most commonly found in animals, including camels and bats, and are not typically transmitted between animals and humans. However, six strains of coronavirus were previously known to be capable of transmission from animals to humans, the most well-known being SARS-CoV (Severe Acute Respiratory Syndrome Coronavirus), responsible for a large outbreak in 2003, and MERS-CoV (Middle East Respiratory Syndrome Coronavirus), responsible for an outbreak in 2012. COVID-19 is caused by a coronavirus, which was initially named 2019-novel Coronavirus, or 2019-nCoV. On February 12, 2020, International Committee on Taxonomy of Viruses named the virus SARS-CoV-2, or Severe Acute Respiratory Syndrome Coronavirus-2. The Committee determined that this coronavirus was the same species as SARS-CoV, the virus that caused a global outbreak of a respiratory illness in 2003, but a different strain, hence the designation “2”.

Source: <https://www.cdc.gov/coronavirus/2019-ncov/faq.html>

## Government / Industry Recommendations for Airborne Infection Control

### CDC

Interim Infection Prevention and Control Recommendations for Patients with Confirmed Coronavirus Disease 2019 (COVID-19) or Persons Under Investigation for COVID-19 in Healthcare Settings.

[https://www.cdc.gov/coronavirus/2019-ncov/infection-control/control-recommendations.html?CDC\\_AA\\_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fhcp%2Finfection-control.html](https://www.cdc.gov/coronavirus/2019-ncov/infection-control/control-recommendations.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fhcp%2Finfection-control.html)

CDC recommends the use of Ultraviolet Germicidal Irradiation (UVGI) as one of the effective technologies to minimize the spread of airborne microorganisms.

### 7. Implement Environmental Infection Control

- Detailed information on environmental infection control in healthcare settings can be found in **CDC’s Guidelines for Environmental Infection Control in Health-Care Facilities** (<https://www.cdc.gov/mmwr/preview/mmwrhtml/rr5210a1.htm>) and **Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Healthcare Settings** [section IV.F. Care of the environment, <https://www.cdc.gov/infectioncontrol/guidelines/isolation/index.html>].

- <https://www.cdc.gov/infectioncontrol/pdf/guidelines/environmental-guidelines-P.pdf>

#### c. Ultraviolet Germicidal Irradiation (UVGI)

As a supplemental air-cleaning measure, UVGI is effective in reducing the transmission of airborne bacterial and viral infections in hospitals, military housing, and classrooms, but it has only a minimal inactivating effect on fungal spores.<sup>223-228</sup> UVGI is also used in air handling units to prevent or limit the growth of vegetative bacteria and fungi. Most commercially available UV lamps used for germicidal purposes are low-pressure mercury vapor lamps that emit radiant energy predominantly at a wave-length of 253.7 nm.<sup>229, 230</sup> Two systems of UVGI have been used in health-care settings – duct irradiation and upper-room air irradiation. In duct irradiation systems, UV lamps are placed inside ducts that remove air from rooms to disinfect the air before it is recirculated. When properly designed, installed, and maintained, high levels of UVGI can be attained in the ducts with little or no exposure of persons in the rooms.<sup>231, 232</sup> In upper-room air irradiation, UV lamps are either suspended from the ceiling or mounted on the wall.<sup>4</sup> Upper

Last update: July 2019

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## ASHRAE Guidance

ASHRAE has developed proactive guidance [ashrae.org/COVID19](https://www.ashrae.org/COVID19) to help address coronavirus concerns with respect to the operation and maintenance of HVAC systems. These include ASHRAE’s recently approved position document on airborne infectious diseases and links to the latest practical standards and guidelines.

ASHRAE recommends the following strategies of interest to address disease transmission: dilution ventilation, laminar and other in-room flow regimes, differential room pressurization, personalized ventilation, source capture ventilation, filtration (central or unitary), and **UVGI (upper room, in-room, and in the airstream)**.

## How Does UV Air Disinfection Help Combat Coronaviruses?

Coronavirus is highly susceptible to germicidal UV irradiation. The table below shows that the susceptibility of coronavirus to UV is greater than 3 times compared to the influenza (common cold) virus.

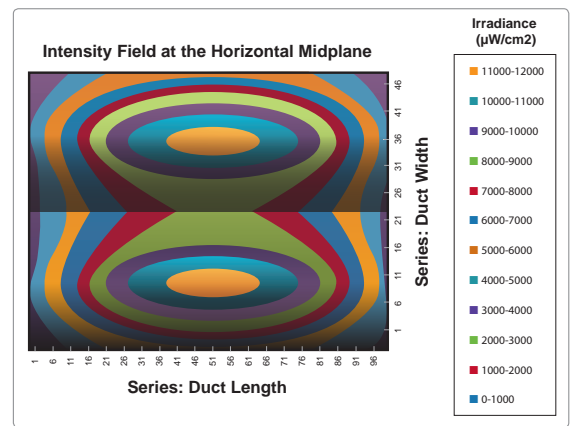
Airstream Disinfection			
Microbe	Type	Diameter	UV Dose for 90% Reduction
		µm	µJ/cm <sup>2</sup>
Coronavirus (incl. SARS)	ssRNA	0.11	<b>611</b>
Influenza A virus	ssRNA	0.098	<b>1935</b>

Ref: Walker, Chris & Ko, Gwangpyo. (2007). Effect of Ultraviolet Germicidal Irradiation on Viral Aerosols. Environmental science & technology. 41. 5460-5

## Delivering the Correct UV Dose for Coronavirus

The application challenge is to ensure the targeted organism is exposed to sufficient UV dose in the available space and time of UV exposure.

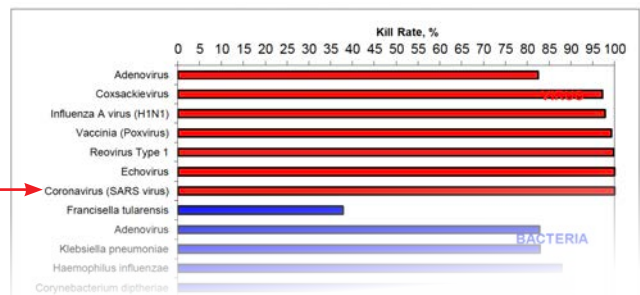
To ensure the proper dose is applied, our proprietary software is used to model the lamp quantity and system arrangement needed for the specific application. The output of this modeling produces a very detailed report showing intensity distribution and kill rates. Factors impacting dose include: spatial constraints, airflow volume, speed, temperature, and UV device geometry and intensity.



Output Example of Engineering Modeling Software

An example of the model output for a typical air handler is incorporated as reference within the "References-1.PDF" file titled "UVDI Airstream Model for Coronavirus.PDF".

**Coronavirus (SARS virus)**  
**> 99% Kill Rate!**



## Third-Party Validation of UVC Effectiveness

UVDI has also conducted independent third party validation of UV efficacy against airborne bacteria and viruses, where MS2 macrophage was used as a surrogate for all viruses.

	Test Organism		
	Spore bacteria (Bacillus atrophaeus)	Vegetative bacteria (Serratia. marcescens)	Virus (MS2 phage)
<b>Inactivation Efficiency</b>	<b>71%</b>	<b>&gt; 99.98%</b>	<b>98%</b>

Ref: Foarde, Karin & Koglin, Eric (2006). Biological Inactivation Efficiency by HVAC In-Duct Ultraviolet Light Systems, National Homeland Security Research Center.

# UVDI V-MAX™ Air Disinfection for HVAC Systems



## In-Duct Air Disinfection System

- Designed for duct-mounting parallel to the airstream providing optimum UV exposure
- Fixtures can be mounted internally or externally on the duct
- Configurable to meet airstream kill rates up to 99% - backed by computational models to ensure performance
- Prewired lamp connection reduces installation time
- Low power consumption with universal voltage input
- Available in 21", 33", 48" and 61" lamp lengths



## AHU Air Disinfection System

- Easy to install in both existing and new equipment
- Scalable design to fit any plenum size
- Lamps can be easily mounted on vertical supports
- Configurable to meet airstream kill rates up to 99% - backed by computational models to ensure performance
- Minimal space required for installation
- Negligible pressure drop
- Low power consumption with universal voltage input
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[Download Brochure](#)



# Indoor Air Quality Solutions

Ultraviolet technology for a healthier, safer, cleaner, and more energy efficient building environment

Advanced Technology for

- Improving Indoor Air Quality
- Promoting Sustainability
- Reducing Energy Consumption
- Instituting Green Building Solutions



Designed and Manufactured by UVDI in California, USA



ISO 9001:2015  
ISO 14001:2015



UVDI EPA Establishment  
Number 73542-CA-001



Intertek

# Bringing over 70 years of Experience in UV Technology



UVDI Headquarters - California, USA

## Trusted History

Spanning three generations, we are a family owned business that continues to look to the future.

Our mission is to make a cleaner, safer, and healthier world through advanced UV technologies.

## UVDI is an Established Leader in Innovative UV Solutions

### Air

Air disinfection and purification systems installed in thousands of facilities worldwide

### Surfaces

Mobile UV devices for infection control deployed in hundreds of hospitals globally

### Water

Providing millions of people worldwide with safe, clean water disinfected by UV

## Technology Leadership

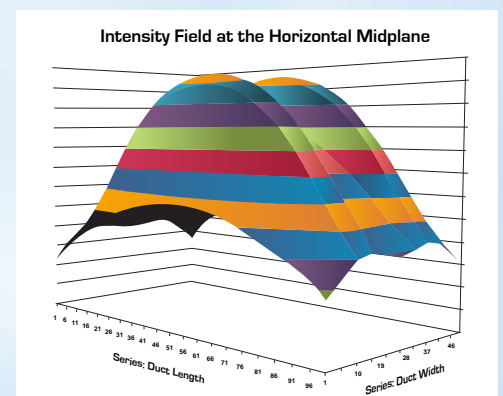
Our people, engineering experience, and R&D assets lead the industry with innovative UV solutions.



HVAC Duct System for Product Testing



UV Lamp Test Facility



Output Example of UVDI's Proprietary Engineering Modeling Software

# Delivering Solutions for a Broad Range of Industries

Schools/Universities



Airports



Government



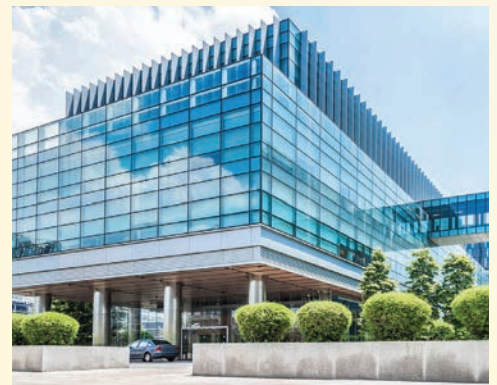
Healthcare



Gaming / Hospitality



Commercial/Offices



## Why is Indoor Air Quality Important?

Indoor Air Quality (IAQ) directly affects our wellbeing, productivity, and happiness, whether at school, work or during our leisure time. Healthy IAQ is essential as we may spend more than 90% of our time indoors.

A simple, yet very effective way to improve building IAQ is through the application of ultraviolet (UV) light technology. This energy efficient technology is a well proven solution for removing pollutants associated with poor indoor air quality such as bacteria, viruses, mold, VOCs (volatile organic compounds), and strong odors.

## UVDI's advanced solutions go beyond traditional HVAC filtration!

TECHNOLOGY	SOLUTIONS		BIOLOGICAL (Bacteria, Viruses, Mold)	GASEOUS (VOCs, Odors, Gases)
UV	COIL CLEANING	Page 6	✓	
UV	AIR DISINFECTION	Page 8	✓	
UV/PCO	AIR PURIFICATION	Page 10	✓	✓

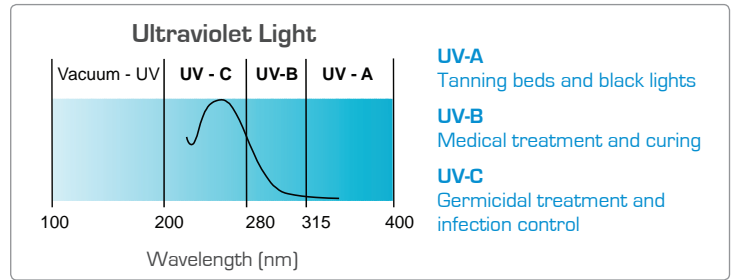
Traditional filtration alone does not eliminate all biological or gaseous contaminants.

# The Power of UV

## Ultraviolet Light is Lethal to Bacteria, Viruses, and Mold

Ultraviolet can be broken down into three bands:

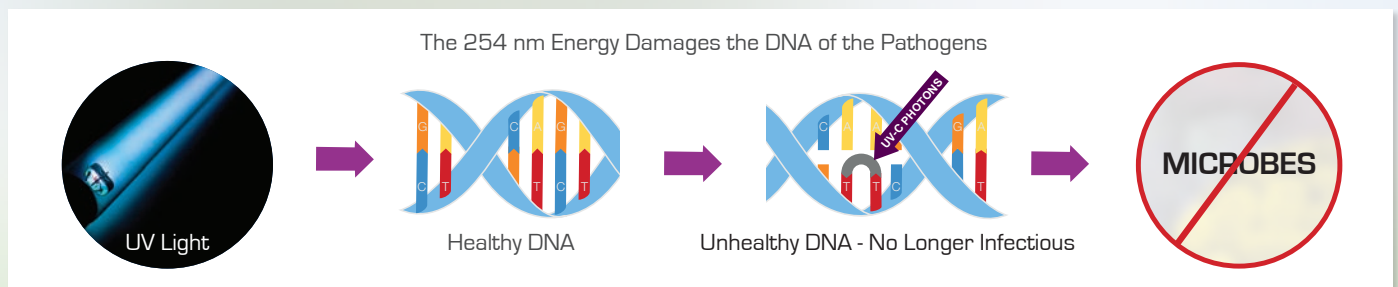
- UV-A — the most abundant in sunlight; responsible for skin tanning and wrinkles
- UV-B — primarily responsible for skin reddening and skin cancer; also used for medical treatments
- UV-C — naturally blocked by the earth's ozone layer and is the germicidal wavelength



UV-C has been safely used for disinfection of microorganisms for over 100 years.

## How Does UV Disinfect?

UV-C energy alters the DNA of microorganisms preventing them from reproducing and causing them to become non-pathogenic, or incapable of causing disease.



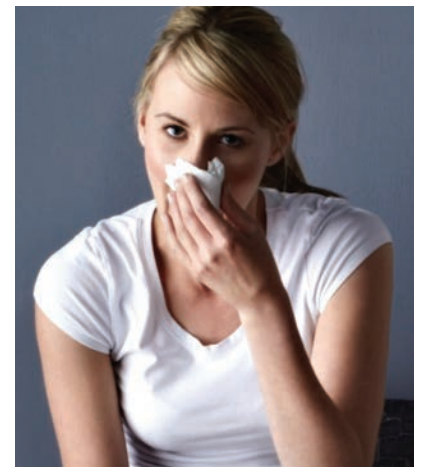
## Why UV?

### Because Even High Efficiency Filters Don't Remove Particles Smaller than 0.3 Microns!

HVAC filters are designed to only capture particles but not destroy the DNA of the microorganisms. Once captured, they can grow and thrive on the filter material. No other application is as effective as UV for the destruction of bacteria, viruses, and mold. These microorganisms profoundly impact HVAC system performance and building occupant safety and health.

### Did You Know?

"There are various methods of infectious disease transmission, including contact, transmission by large droplets, and inhalation of airborne particles containing infectious microorganisms. The practice of the HVAC professional in reducing disease transmission is focused primarily on those diseases transmitted by airborne particles." — Source: ASHRAE Position Document on Airborne Infectious Diseases, 2014

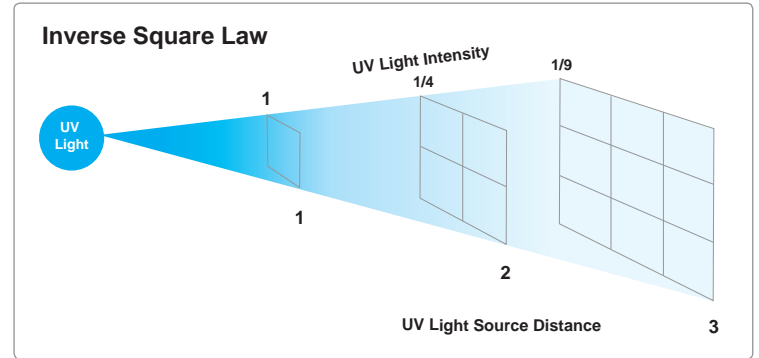


# UV Dose – Critical to System Efficacy

## Dose = Intensity x Time

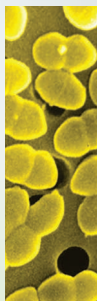
UV dose, typically expressed in mJ/cm<sup>2</sup>, J/m<sup>2</sup>, or μWs/cm<sup>2</sup>, is the total amount of UV intensity delivered over a period of time. UV intensity is a measure of UV energy delivered on a given surface. UV intensity obeys the inverse square law: It decreases as distance from the UV source increases.

$$\text{UV Dose (mJ/cm}^2\text{)} = \text{UV Intensity (}\mu\text{W/cm}^2\text{)} \times \text{Exposure Time (s)}$$



## Delivering the Correct Dose for a Specific Application

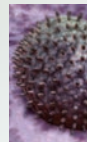
The dose required to kill biological pathogens is well documented. The application challenge is to insure the targeted organism is exposed to sufficient UV dose in the available space and time of UV exposure.



### Organism UV Dose in Micro-watt sec/cm<sup>2</sup> for 99% kill factor

Organism	UV Dose in Micro-watt sec/cm <sup>2</sup> for 99% kill factor
<b>Bacteria</b>	<b>99%</b>
Bacillus anthracis spores	46,200
Escherichia coli	6,600
Legionella pneumophila	12,300
Mycobacterium tuberculosis	10,000
Staphylococcus aureus	6,458
Pseudomonas aeruginosa	3,597

This is only a partial listing of the organisms.



### Organism UV Dose in Micro-watt sec/cm<sup>2</sup> for 99% kill factor

Organism	UV Dose in Micro-watt sec/cm <sup>2</sup> for 99% kill factor
<b>Virus</b>	<b>99%</b>
Influenza A	4,558
Coronavirus (including MERS)	1,222



### Mold UV Dose in Micro-watt sec/cm<sup>2</sup> for 99% kill factor

<b>Mold</b>	<b>99%</b>
Aspergillus flavus	99,000
Aspergillus niger	330,000

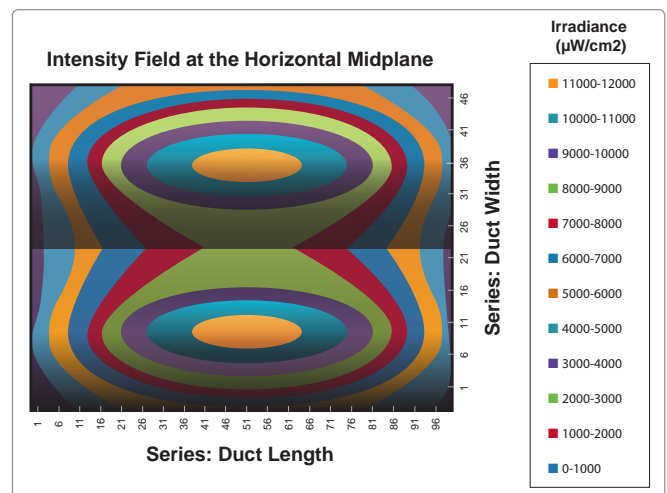
# How Does UVDI Validate the Correct Delivered Dose?

## Engineering Modeling Software

To ensure the proper dose is applied, our proprietary software is used to model the lamp quantity and system arrangement needed for the specific application. The output of this modeling produces a very detailed report showing intensity distribution and kill rates. Factors impacting dose include: spatial constraints, airflow volume, speed, temperature, and UV device geometry and intensity.

“ The results of the program have been **validated in a series of some 30 laboratory tests** sponsored by UVDI in which various microbes and UVGI systems were tested in two different laboratories. The results indicated **excellent accuracy**... ”

W.J. Kowalski, PE, PhD  
The Indoor Environment Center  
The Pennsylvania State University



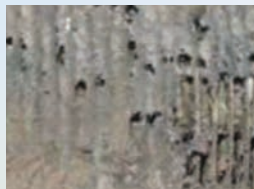
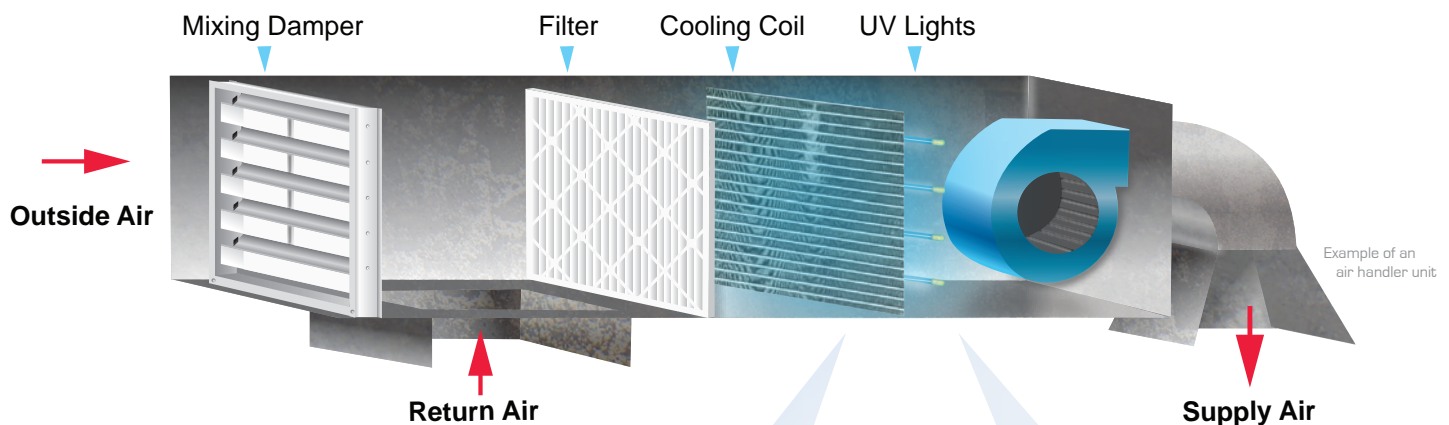
Output Example of Engineering Modeling Software



# Coil Cleaning

## Coil Cleaning Systems Save Energy and Money!

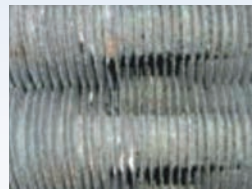
UV Destroys the Microbiological Biofilm that Thrives in the Moist Coil Environment



Clogged Coil



UV Destroys Biofilm



Clean Coil Post UV

UV coil systems are typically installed downstream of the evaporator coil to destroy bacteria, mold, and organic matter that grows and collects on cooling coils and surrounding areas.

## Benefits of Coil Cleaning

### Healthy Air Supply

UV energy destroys bacteria and mold that grow on the moist coil and drain pan surfaces eliminating “blow-off” of these into the air supply. This ensures that clean airflow is cooled by the coil without cross contamination.

### Better Comfort

Coil disinfection prevents biofilm accumulation on fins resulting in effective heat transfer with better temperature and humidity control.

### Energy Savings

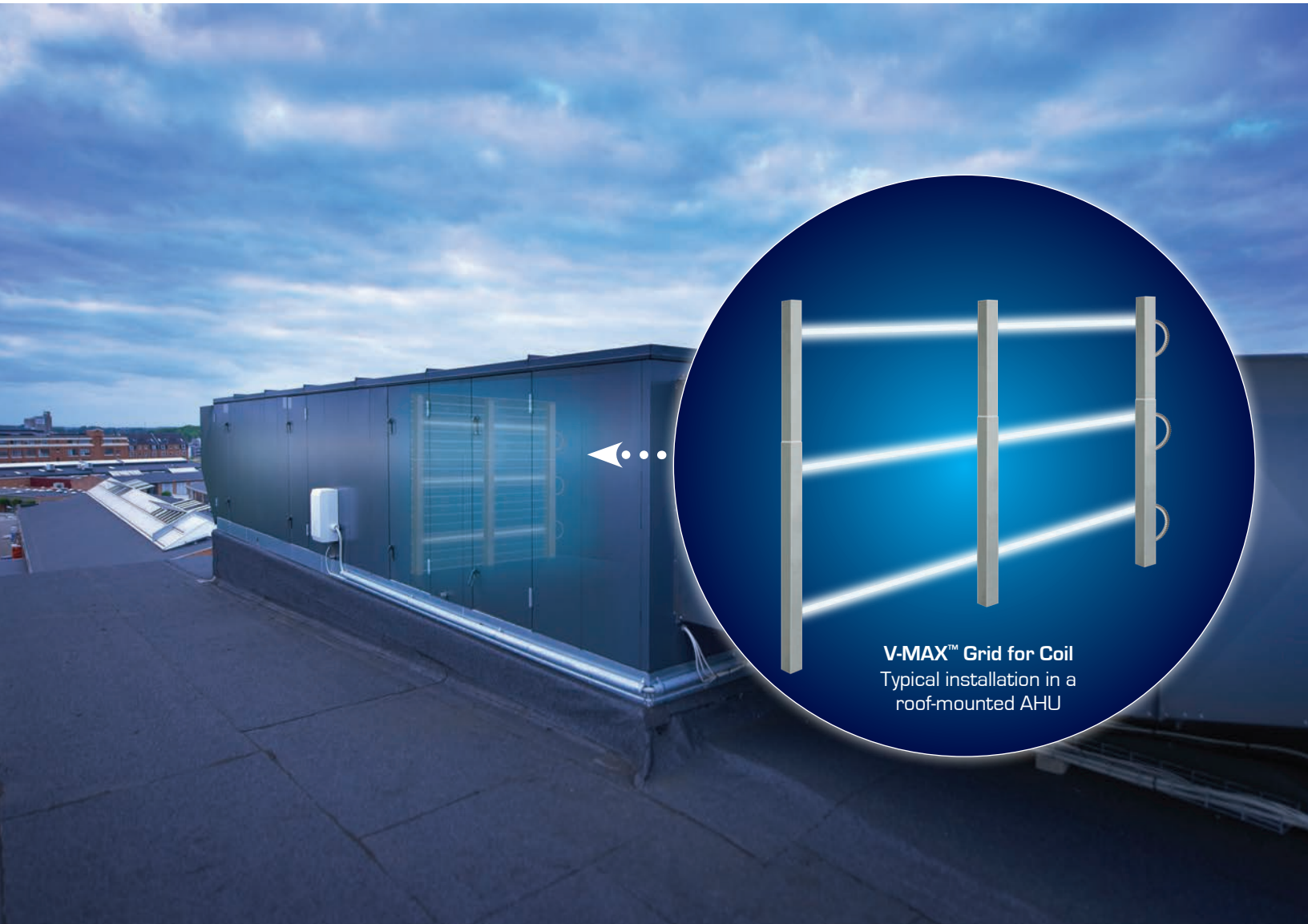
Maintaining a coil free of microbial growth will maximize coil heat transfer efficiency and reduce energy consumption up to 15% in some systems.

### Reduced Maintenance Cost and Less Downtime

UV energy ensures the cooling coil remains clean at all times, eliminating costly coil cleaning maintenance and reducing system downtime.

# V-MAX™ Coil Cleaning

Delivers Optimum UV Dose for Coil Cleaning and Maintenance



## V-MAX™ Coil Cleaning System Features

- Easy to install in both existing and new equipment
- Scalable design to fit any plenum size
- Fixtures can be mounted internally or externally
- Lamps can be easily mounted on vertical supports
- Negligible pressure drop
- Minimal space required for installation
- Low power consumption with universal voltage input
- Available in 21", 33", 48" and 61" lamp lengths



LVDI's coil cleaning systems are designed to meet or exceed ASHRAE Guidelines.

# Air Disinfection

## Air Disinfection Systems Kill Airborne Pathogens 24/7

Airborne Pathogens are Eliminated as Air Passes through High Intensity UV



- In facilities such as hospitals, schools, airports, and commercial buildings, airborne pathogens can spread through the air system threatening the health of occupants
- In-duct UV systems are designed to disinfect air as it passes through the HVAC system and irradiate the entire cross-section of a duct at high intensities

**Eliminates Viruses & Bacteria - up to 99% Kill Rate**



### United States Environmental Protection Agency (EPA) Test Results

These organisms were selected as reasonable surrogates for biological warfare agents (BWAs).



**Technology Evaluation Report:** Biological Inactivation Efficiency by HVAC In-Duct Ultraviolet Light Systems

ref: <http://nepis.epa.gov/> [enter: uvd1]

## Benefits of Air Disinfection

### Provide Healthy Indoor Air

UV disinfection reduces airborne infectious microorganisms that can cause the spread of illness and decreases instances of people becoming sick due to contamination by microorganisms such as viruses and bacteria.

### Better Patient Outcomes in Hospitals

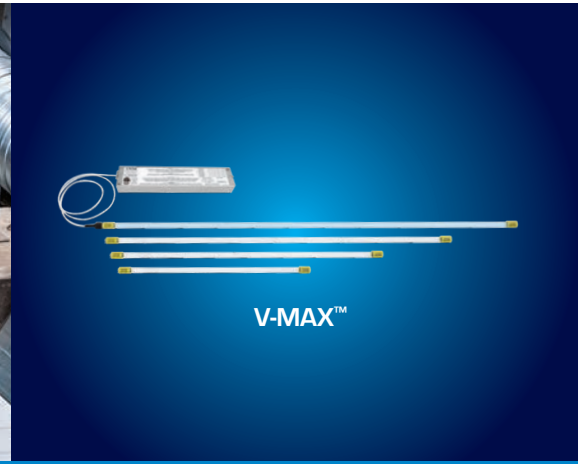
Assists in reducing HAIs (Hospital-Acquired Infections) when air disinfection and surface disinfection systems are used together.

### Reduced Sick Days

Healthy indoor air helps minimize absenteeism and increases employee comfort and productivity.

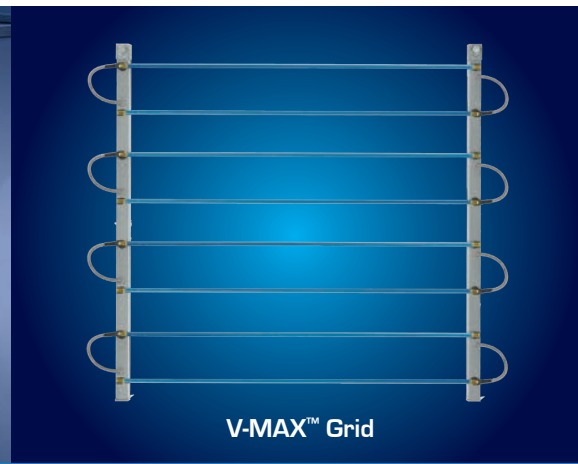
# V-MAX™ Air Disinfection

Delivers Optimum UV Dose for Eliminating Airborne Pathogens



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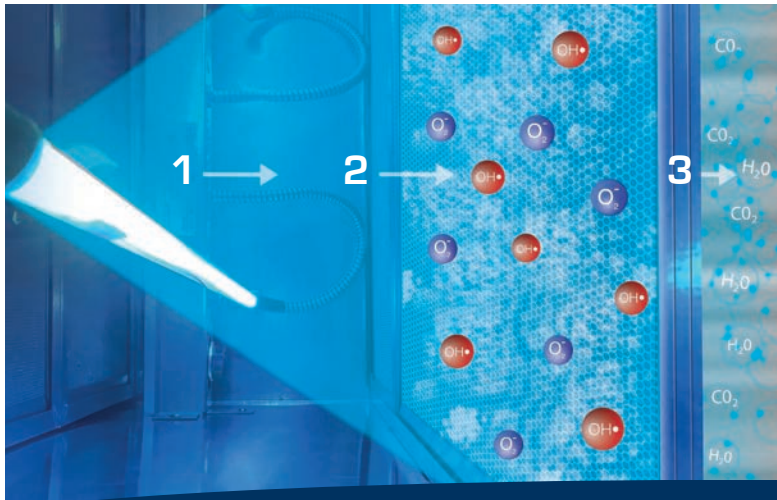
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# Air Purification

## V-PAC™ - The Next Generation of Air Purification

Sustainable and More Effective than Typical Filtration



- 1) When UV light illuminates our titanium di-oxide (TiO<sub>2</sub>) coated photocatalytic oxidation (PCO) panel, an activation process begins.
- 2) The activation generates highly reactive hydroxyl radicals and super-oxide ions resulting in a strong chemical “oxidizing” reaction between the supercharged ions and gaseous pollutants such as VOCs and odor molecules.
- 3) This breaks the pollutant down into harmless carbon dioxide and water molecules, making the **air more purified!**

**Eliminates VOCs & Odors**



## Benefits of Air Purification

### Positive Impact on Occupant Health

Removes interior and exterior gaseous pollution sources such as tobacco smoke, cleaning solvents, off-gassing from building materials, human metabolic by-products, vehicle exhaust, jet fumes, manufacturing process emissions, and agriculture process emissions that cause illnesses.

### Saves Energy

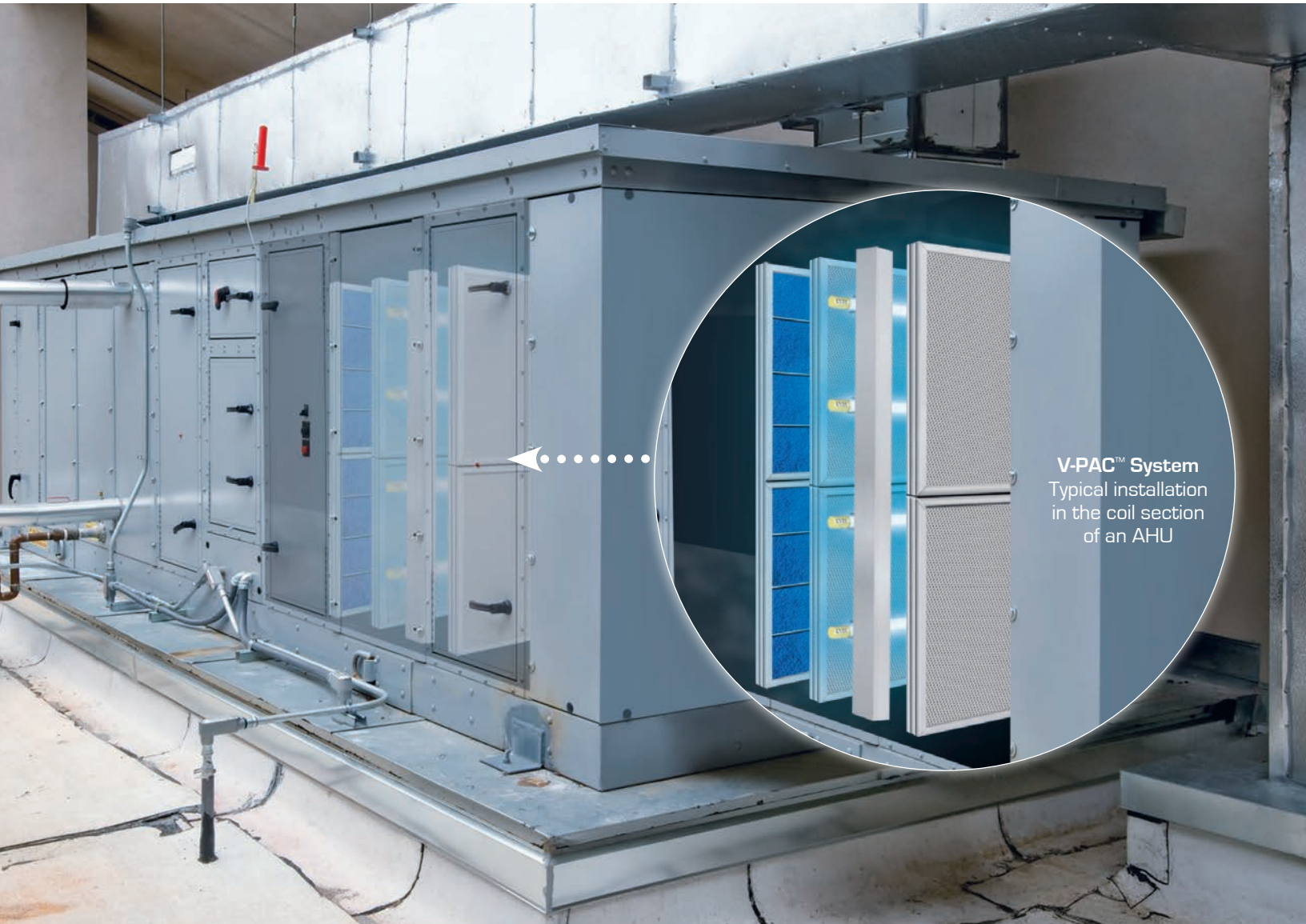
Reduces make-up air requirements for dilution and has low power consumption.

### Environmentally-friendly

Chemical-free and, unlike other air purification technologies, does not produce ozone.

# V-PAC™

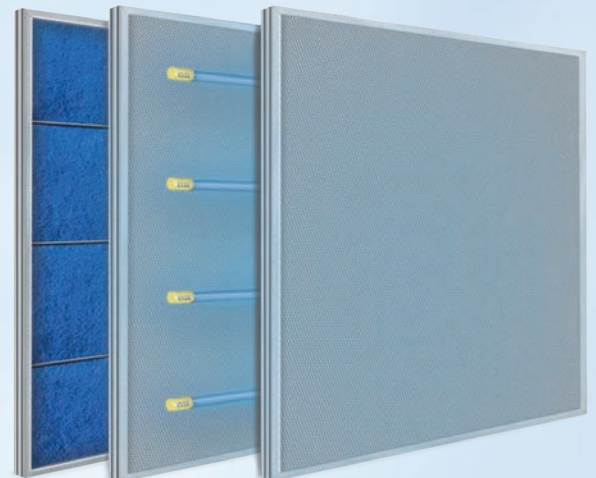
V-PAC™ Air Purification System Purifies and Disinfects Your Air



V-PAC™ System  
Typical installation  
in the coil section  
of an AHU

## V-PAC™ System Features

- Easy to install in both existing and new equipment
- Scalable design to fit any plenum size
- Photocatalytic Panels (PCO) and BPS™ Lite Activated Carbon Panels are designed for installation in standard filter tracks
- Utilizes V-MAX™ high output lamp systems
- Negligible pressure drop
- Complete system will fit in an airflow length that is as little as 9"
- Virus and bacteria reduction



BPS™ Lite  
Activated  
Carbon Panel

PCO  
Panel

UV  
Lights

PCO  
Panel

# Our Ultraviolet Solutions Extend Globally

UVDI's mission is to make a cleaner, safer, and healthier world through advanced UV technologies



**Denver Center for Performing Arts**  
UVDI Coil Cleaning



United Arab Emirates  
Saudi Arabia  
Qatar



Japan  
China  
Korea



**Qatar - Ministry of Interior**  
UVDI Air Disinfection



**Cleveland Clinic Abu Dhabi**  
UVDI Surface & Room Disinfection



Mexico  
Italy  
France

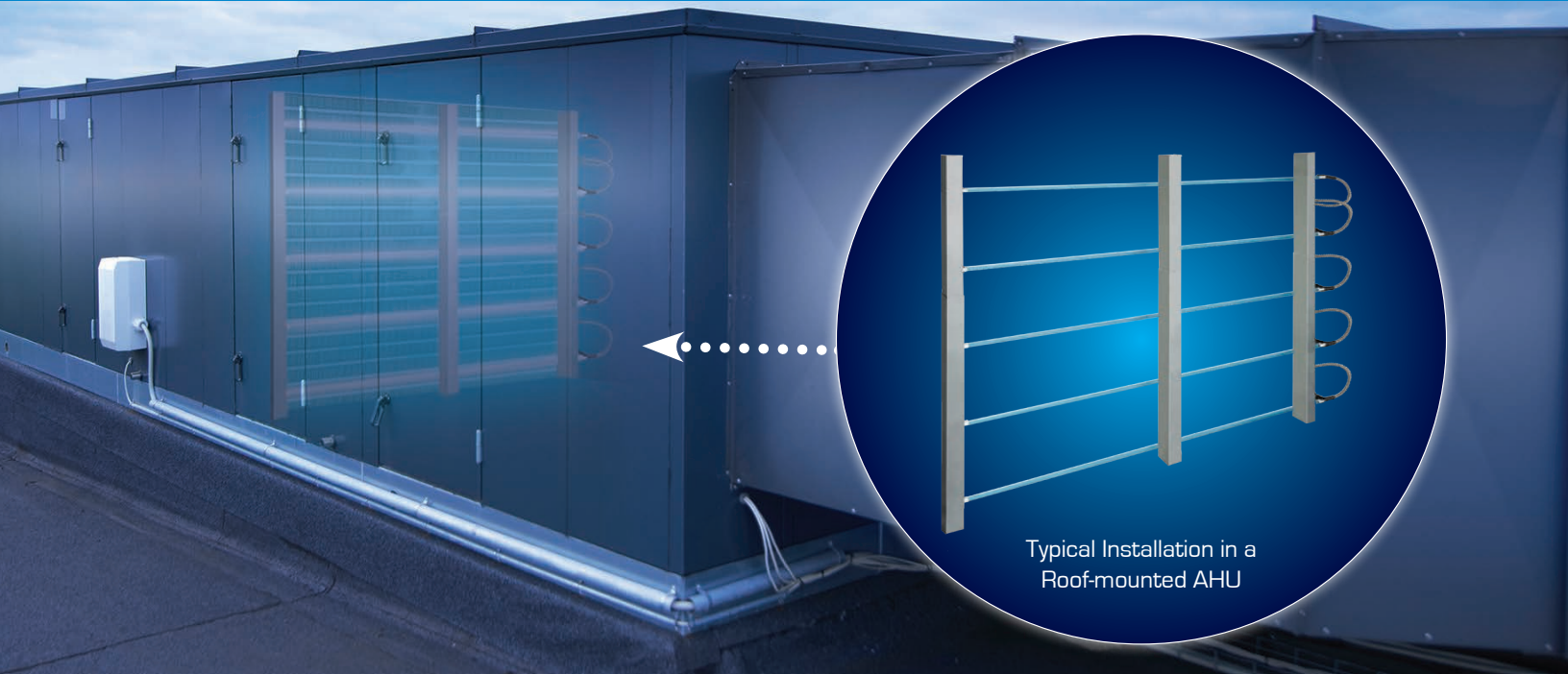


USA  
Canada



**Los Angeles International Airport**  
UVDI Air Purification

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### Provides Healthy Indoor Air

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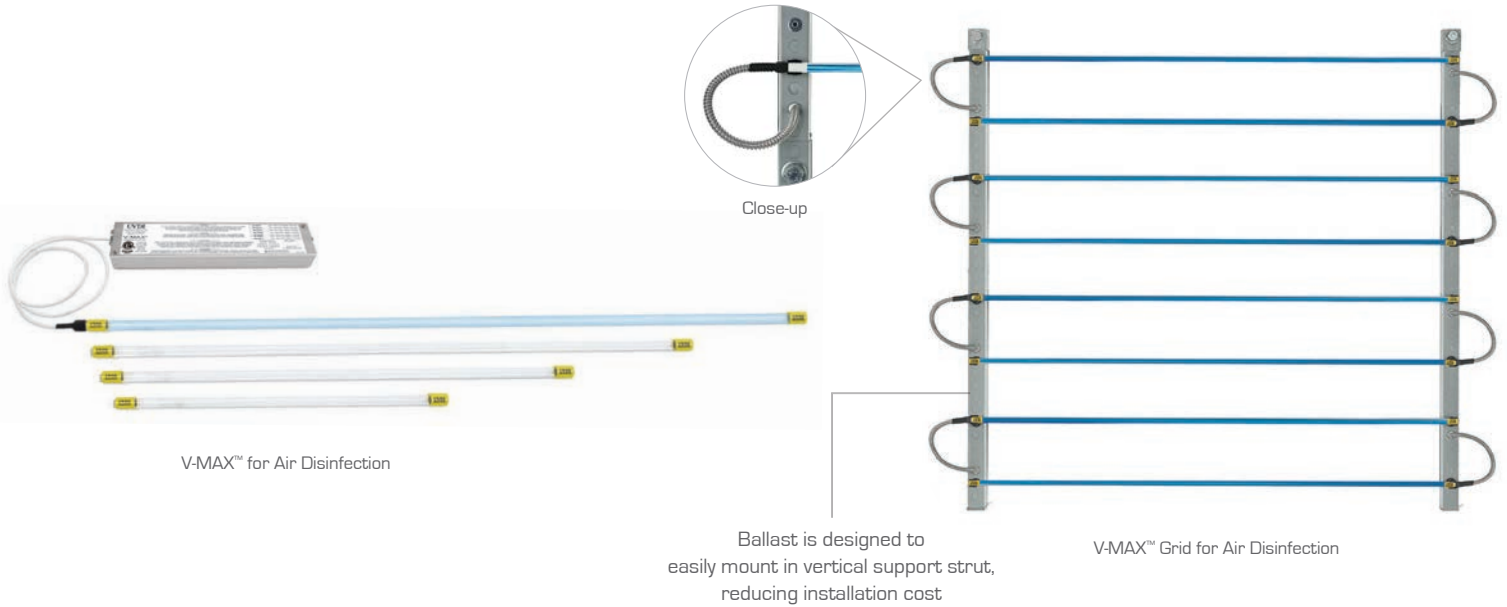
*Eliminates viruses and bacteria — up to 99% Kill Rate!*



# V-MAX™ Air Disinfection

## Delivers Optimum UV Dose for Eliminating Airborne Pathogens

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- Scalable design to fit any plenum size
- Fixtures can be mounted internally or externally
- Lamps can be easily mounted on vertical supports
- Negligible pressure drop
- Minimal space required for installation
- Low power consumption with universal voltage input





**Lamps**

Rated for 9,000 hrs. of lamp life and provide maximum UV-C irradiance



**V-MAX™ Magnetic Mounting Clips**

Easily attach onto lamp ends



**V-MAX™ Grid Mounting Clips**

Easily snap into support strut and attach onto either lamp ends or bulbs

## Tech Specs

Input Voltage	Lamp Configuration					
	21" (53.34 cm)	Dual 21" (Dual 53.34 cm)	33" (83.82 cm)	Dual 33" (Dual 83.82 cm)	48" (121.92 cm)	61" (154.94 cm)
120	0.45	0.90	0.75	1.45	1.24	1.3
208	0.30	0.60	0.45	0.90	0.75	0.80
240	0.25	0.50	0.40	0.80	0.65	0.70

Designed for use with 120, 208, and 240 VAC input. Approximate current draw (in Amps).

- Rated for temperature 30°F - 135°F (-1°C - 57°C)
- RH: up to 95% non condensing

### Regulatory Approvals

ETL listed to UL/Canadian standards:

- UL 1598/CSA 22.2 250
- UL 1995/CSA 22.2 236
- UL 153/CSA 22.2 12