White Paper

Comprehensive Ultra-Violet Protection for HVAC Systems in High-Threat Buildings

For building professionals, ensuring safe, clean, and breathable air for building occupants is one of the most central and fundamental tasks. Doing so is usually just a matter of following basic indoor air quality principles to properly maintain the Heating, Ventilation, and Cooling (HVAC) system.

However, providing acceptable air quality can be much more challenging in buildings at risk of airborne biological threats, such as SARS, bird flu, and anthrax. An airborne contaminant could spread quickly through the building's HVAC system and cause serious harm to occupants.

In high-threat buildings, professionals need a way to protect occupants from the potentially devastating effects of airborne biological contaminants. BioProtector™ from Novatron, Inc. uses extremely high intensity UV light to provide comprehensive protection for HVAC systems in high-threat buildings by neutralizing the full range of airborne biological hazards.

This white paper examines the challenges associated with providing comprehensive protection for HVAC systems. It discusses the limitations of air-cleaning systems based on the leading technologies, and shows how BioProtector from Novatron, Inc. is the superior choice to deliver comprehensive protection for HVAC systems.

Unprotected HVAC Systems and the Dangers of Airborne Biological Contaminants

The vast majority of airborne hazards can be avoided by implementing basic indoor air quality principles, as outlined by the U.S. Environmental Protection Agency (EPA). However, for facilities in which there is significant concern about airborne biological contaminants, additional measures may be necessary to protect building occupants.

High-threat buildings may include military, diplomatic, research, healthcare, and other related sites

For these high-threat buildings, it is important to protect the HVAC systems against airborne biological contaminants. The harmful impact of an airborne pathogen is greatly increased if it is allowed to circulate through an unprotected HVAC system.

Brief Overview of the Leading Air-Cleaning Technologies for HVAC Systems

The leading air-cleaning technologies for HVAC systems are High Efficiency Particulate (**HEPA**) filters and Ultraviolet Germicidal Irradiation (**UVGI**) systems.

Though research and development continues on new air-cleaning technologies, these two have been the most widely deployed.

Other promising but unproven technologies include Sorption-based Gaseous Air Cleaning and Photocatalytic Oxidation Air Cleaning (PCO)

Systems based on HEPA filters remove airborne biological contaminants by trapping them. Particle filtration efficiency is measured on the Minimum Efficiency Reporting Value (MERV) scale, which ranges from 1 to 20. The HEPA designation is reserved for the higher efficiency filters, rated MERV 17 and above.

Systems relying on UVGI kill or otherwise neutralize biological contaminants by exposing the air stream in the HVAC ducts to UV light. This application differs considerably from the use of low intensity UV light to kill biological contaminants on surfaces, such as dirty cooling coils.

The primary distinction between the HEPA and UVGI technologies is whether airborne biological contaminants are trapped, as with HEPA filters, or neutralized, as with UVGI systems. The impact of this distinction is crucial when choosing an air-cleaning system.

The Challenge of Choosing the Appropriate Air-Cleaning System

Before selecting an air-cleaning system, building professionals with responsibility for high-threat buildings should first understand the level of protection needed for the HVAC system. Next, they should carefully evaluate potential air-cleaning systems to understand whether the systems could provide the desired level of protection. Finally, they should consider other important factors such as operating cost, installation challenges, and ongoing maintenance.

Determining How Much Protection is Needed

If even a tiny amount of a dangerous biological organism were to gain access into the HVAC system, the consequences for building occupants could be very serious. For high-threat buildings, experts generally recommend that air-cleaning measures in the HVAC system should provide a removal rate of 99.9999% against all airborne biological organisms.

The removal rate indicates what percentage of an airborne biological release would be prevented by the air-cleaning system from continuing through the HVAC system and thus potentially reaching the building occupants. Removal

rate is often expressed on a logarithmic scale. A removal rate of 99.9999% is equivalent to 6 logs of removal, which indicates 6 orders of magnitude, or 1 million times, reduction of the original contamination level.

Understanding the Limitations of HEPA Filters

HEPA filters are perhaps the best-known technology for reducing exposure to airborne biological organisms. The effectiveness of these filters depends on a number of factors, including particle diameter of the biological organism, filter efficiency at that diameter, airflow rate through the filter, level of filter maintenance, and the location of the filter relative to both the contaminant source and the building occupants.

A typical HEPA filter has a removal efficiency of 99.97%, or approximately 3.5 logs. The highest efficiency HEPA filters, known as ULPA filters, have efficiencies of 99.9995% (5.3 logs) or higher.

There are three primary types of particulate air filters: mechanical, electrostatically charged, and electronic

Though upgrading to HEPA filters is often seen as the easiest way to reduce the risk of exposure to airborne biological contaminants, professionals who seek a system that would provide 6 logs of removal for high-threat buildings may experience considerable drawbacks:

- *Large pressure drop may require significant system modifications*

  As filter efficiencies are increased in order to provide the necessary level of protection, the pressure drop through the HVAC system also increases. The pressure drop due to HEPA filters may require replacement and upgrades of fans, motors and air ducts.

- *Filter leakage and bypass effects could undermine performance*

  If HEPA filters are poorly sealed in their frames, either initially or as the seals deteriorate over time, the resulting leakage and bypass may cause considerable performance degradation. Extensive ongoing maintenance is often necessary to ensure filters continue to work as intended.

- *Dangerous biological contaminants are trapped rather than killed*

  Because HEPA filters trap contaminants, the follow-up decontamination effort after an incident may still be a difficult and dangerous task, requiring specialized tools and skills.

Understanding the Challenges of Standard UVGI Systems

When installed in the ductwork of a building, UVGI systems neutralize airborne biological contaminants - including viruses, bacteria, and both bacterial and fungal spores - through the use of UV light. Though UVGI systems are best known in the healthcare industry, they have gained ground in other commercial, manufacturing, and defense applications.

The effectiveness of UVGI systems is primarily a function of the geometry of the device, intensity of the light source, resistance of the biological contaminant, and the residence time of the contaminant in the field of irradiation. The challenges for professionals who seek a system that would provide 6 logs of removal for high-threat buildings include the following:

- *Lack of industry standards to rate UVGI systems*

  While the primary factors that relate to UVGI effectiveness are understood, the industry has not adopted an established metric – along the lines of the MERV scale for filters - to report system effectiveness. Potential buyers often face the challenge of comparing between effectiveness claims that are not based on equivalent, "apples-to-apples" measurements. Only effectiveness claims based on the results of real-world, flowing-air tests that were performed by reputable organizations should be considered.

- *Insufficient UV dosage to provide necessary HVAC protection*

  UV dosage is a function of UV intensity and exposure time. Lower intensity UV has been used for antimicrobial purposes since the mid-20th century, most often for applications in which the low intensity UV light is applied over a relatively long period of time. Examples of such an approach include the treatment of drinking water in a holding tank or the treatment of air circulating near the ceiling of a hospital room. These lower intensity UV systems may only reduce microorganism levels by 1 log or less.

  Significantly higher dosage of UV light is required fully sterilize the air flowing through an HVAC system. The situation is complicated by the fact that the air within the HVAC system spends only a brief amount of time in the irradiating field. As a result, higher UV intensity is needed to deliver the necessary dosage. Many UVGI systems cannot deliver sufficient UV intensity to provide complete protection of building occupants.

UVGI has been used for antimicrobial purposes since the mid-20th century, but only more recently for air sterilization in HVAC systems

- *Vulnerability to UV-resistant biological organisms*

  Microorganisms vary considerably in their response to UV light. Generally, vegetative bacteria and viruses are most readily neutralized, while spore-forming bacteria require much higher dosage of UV to be killed. Many dangerous biological contaminants, including anthrax, are of the spore-forming bacteria variety.

  Claims to the effectiveness of UVGI systems should include the "worst-case scenario" of spore-forming bacteria. Care should be taken to determine whether the quoted reduction levels are for UV-resistant spores or for other, less-resistant organisms, as there can often be orders of magnitude differences in effectiveness depending on the type of test organism.

Introducing the BioProtector Solution

BioProtector products from Novatron, Inc. provide comprehensive protection for HVAC systems in high-threat buildings. By selecting BioProtector, building professionals avoid the limitations of HEPA filters while overcoming the challenges common to standard UVGI systems.

BioProtector uses high-intensity, Advanced UV System (AUVS) technology to rapidly and effectively destroy airborne biological contaminants. When inserted into an HVAC air duct, BioProtector has been proven to deliver a removal rate of 6 logs or higher against the full range of biological organisms, including UV-resistant spore-forming bacteria.

Benefits of BioProtector

BioProtector was designed specifically for use in high-threat buildings that require complete protection against the full-range of airborne biological organisms. The benefits of BioProtector include:

- *Delivering 6-logs of neutralization against the full range of biological contaminants*

  The US Army conducted tests in 2007 to replicate a flowing-air HVAC system. They used this setup to measure the effectiveness of a BioProtector unit. The BioProtector system was shown to deliver a neutralization rate of better than 6 logs (>99.9999%) for viruses, vegetative bacteria, and both singlet and agglomerated UV-resistant spore-forming bacteria. [US Army Research, Development, and Engineering Command (RDECOM) Collective Protection Technology Readiness Evaluation Report, August 2007]

  By providing such a high level of effectiveness against UV-resistant spore-forming bacteria, building professionals can be confident that BioProtector will deliver complete protection against the full range of airborne biological contaminants.

- *Not requiring supplemental protection by HEPA filters*

  Standard UVGI systems cannot deliver 6 logs of neutralization against most biological organisms, especially spore-forming bacteria. As a result, supplemental protective measures, such as HEPA filters, are generally needed in order to provide full protection.

  Because BioProtector delivers such a high degree of effectiveness against the full range of biological contaminants, supplemental protective measures are not needed in order to provide sufficient protection for building occupants. This results in simpler installation, as well as streamlined operations and maintenance.

- *Not exposing occupants to the risk of filter leakage or bypass effects*

  Since BioProtector does not rely on HEPA filters, the risk of filter leakage or bypass is eliminated and the effort required for operating and maintaining the system is reduced. The only components of BioProtector that require routine maintenance are the UV lamps, which are designed to operate continuously for nearly two years between servicings.

- *Delivering extremely high UV dosage in a device of manageable size that consumes a moderate level of power*

  As mentioned earlier, standard UVGI systems do not deliver sufficient UV dosage to provide complete protection for building occupants against the full range of biological contaminants.

BioProtector provides significant benefits over both HEPA filters and standard UVGI systems

  BioProtector uses an innovative enhancement technique to allow relatively low-power UV sources to achieve very high levels of UV intensity. As a result, significantly higher dosage of UV can be delivered at a fraction of the size and cost than would be necessary in a standard UVGI system.

- *Incurring a moderate pressure drop*

  Because the BioProtector system works by neutralizing microorganisms in moving air, the resulting pressure drop is considerably less than that of most HEPA-based systems. As a result, the need to upgrade fans, motors and other system components can almost always be avoided. BioProtector is thus an especially attractive option for those who are considering retrofitting an existing HVAC system.

How BioProtector Works

BioProtector is a standalone device that is inserted in-line with the air duct of the HVAC system. Air flows into BioProtector, which uses high intensity, Advanced UV System (AUVS) technology to rapidly and effectively destroy any biological organisms that may be present, and then continues through the air duct.

BioProtector achieves such high intensity UV by directing the air stream through a reflective cavity. In an approach analogous to that of a microwave cavity, the reflective cavity allows the UV photons to make many transits and the UV intensity is significantly increased.

Though other UVGI-based air-cleaning systems utilize reflectors, BioProtector distinguishes itself by the use of a unique cavity technology that produces higher reflectivity in the ultraviolet range. As a result, the UV within the reflective cavity is very intense and uniform. This innovation enables greater neutralization of airborne biological contaminants without increasing the power, size and cost of the system.

Applications of BioProtector

BioProtector provides comprehensive UVGI-based protection for rooms, buildings, hospitals, and shelters. Because of its moderate power consumption, pressure drop, and size, it is an especially good option for those who are considering retrofits to protect high-threat buildings.

The BioProtector product is scalable from small sizes, suitable for servicing areas of a few hundred square feet, to much larger units, which are capable of protecting hundreds of thousands of square feet. While system efficiency increases as system size increases, even relatively small systems are very energy efficient. The largest unit built to date treats 60,000 cfm of air at the Pentagon in Washington, D.C.

BioProtector Key Features

BioProtector was originally developed under sponsorship of the US Department of Defense (DoD) / Defense Advanced Research Projects Agency (DARPA)

- >6 logs removal (>99.9999%) for UV-resistant spore-forming bacteria
- Even higher removal rate for vegetative bacteria and viruses
- 100 to >1 million times more effective than standard HEPA filters
- Very low pressure drop
- Reliable 24/7 operation with low power
- Proprietary system design and intense UV technology
- 16,000 hour service interval for UV source
- Wide selection of sizes

BioProtector BP 246i

Examples of BioProtector Products

Product / Model Number	BP 114	BP 246	BP 458
Nominal Air Flow (cfm)	500	3500	10,000
Typical Air Flow Range (cfm)	250 - 1,000	2,000 - 7,000	7,000 - 20,000
Width (feet)	1	2	4
Height (feet)	1	4	5
Length (feet)	4	6	8
Number of Lamps*	6	8	20
Electrical Power (watts)*	1200	3200	8000
Lamp Life (hours)	16,000	16,000	16,000
Pressure Drop (iwg)*	<0.3	<0.3	<0.3

** At Nominal Flow Rate*

About Novatron, Inc

Novatron was founded in April of 2000 and has become an important innovator in the field of air sterilization. Novatron is led by President and CEO, Wayne Clark, Ph.D., a senior executive and scientist with extensive experience and a distinguished management record in high technology environments. He has published more than 25 technical papers and has been inventor or co-inventor on 15 patents. Dr. Clark has expertise in intense UV source technology and the use of UV technology for commercial, industrial, and defense applications.

To learn more about Novatron or BioProtector, contact Dr. Wayne Clark at (858) 638-7101 for a free consultation, or visit www.novatroninc.com.