MEDIXAIR™

CONTROL OF AIRBORNE PATHOGENS USING ULTRAVIOLET LIGHT

An innovative device for the disinfection of indoor air utilizing proven Ultraviolet Light technology

Medixair™ is engineered to ensure critical UV Light disinfection doses are achieved, creating a medically significant reduction of disease transmission by airborne bacterial, viral and fungal pathogens, and has been thoroughly tested in laboratory and clinical trials.

Medixair™ is safe for use in occupied areas, small, quiet and none invasive, and provides continuous operation without interruption of normal activities.

Medixair™ does not require dedicated operating staff, and does not require additions or alterations to existing HVAC equipment. Units are low cost, allowing flexible placement to meet varying needs, have small service times with low cost consumables, and do not require dedicated maintenance specialists.

Brandenburg
CREATING BETTER

Indoor Air Quality

Studies have found that bioaerosols (airborne microbes, their fragments, toxins and waste products) may account for up to one third of indoor airborne particulates. According to the American Medical Association, 50% of all illness is caused or aggravated by polluted indoor air. For example, the US Environmental Protection Agency (EPA) estimates that only 10% of all colds are caught outdoors, and 90% are caught indoors.

Activity	Approximate particle count	Units
Sneezing	40,000	Per sneeze
Bowel evacuation	20,000	Per event
Vomiting	1,000	Per event
Coughing	710	Per cough
Talking	36	Per 100 words

Droplet or airborne microorganisms released from various activities
Aerobiology and Its Role in the Transmission of Infectious Diseases

While the common cold may be considered mostly an inconvenience, colds and influenza outbreaks in commercial, professional sports and industrial facilities cause significant losses in performance and employee productivity, and have a major economic impact.

In healthcare environments, where there is significant potential for airborne transmission of nosocomial infection (sometimes referred to as "Health Care Associated Infection"), the effects are much more serious.

Medical Implications

All modern medical facilities employ extensive and rigorously enforced procedures for the microbial decontamination of contact surfaces and the prevention of microbial transfer through human interface. Other than personal protection (face masks), decontamination of airborne microorganisms is often implemented as a distant third.

Indoor air in a healthcare environment often contains a significant load of particulate matter, including microorganisms, dust, lint (from hospital linens and fabrics), and even pollen and animal dander brought in on the clothes of staff, patients and visitors.

Bacteria and viruses may float freely in the air, or are suspended on minute dust particles, and are continuously being disturbed by everyday activities such as:

- **Bed-making**
- **Cleaning**
- **The movement of equipment**
- **The movement of patients, medical staff, and visitors**
- **The delivery of food**
- **Air-conditioning**

Mortality in patients with a Health Care Associated Infection is estimated to be around seven times higher than in uninfected patients. According to the Centers for Disease Control (CDC), institution-acquired infections impact 99,000 lives and cost hospitals and nursing homes $30 billion a year.

A 2008 study carried out by Penn State University through the NIST CONTAM program suggests that an airborne pathogen such as tuberculosis will be carried through a typical office building ventilation system (conforming to the ASHRAE Standard 62-89 guidelines) and result in a person ten floors away from the source having a 33% risk of accumulating enough exposure to contract the disease after only 8 hours.

Medical practitioners agree that the airborne transmission of infectious diseases is a problem. However, the extent of the problem continues to be debated.

Currently, there is a wide range in the reported frequencies of airborne transmission in hospital acquired infections, from 10% to 33%.

Unfortunately, those responsible for infection control have been forced to use suboptimal, dated technologies to contain and eliminate airborne infection transmission - such as HEPA filtration systems, which were first developed in the 1940s.

Ultraviolet Light for Disinfection

The potential for interrupting transmission of airborne infection with ultraviolet light was first demonstrated by William F. Wells in the 1940s and 1950s. Wells showed that airborne droplet nuclei of tuberculosis and measles were the vehicles of airborne transmission, and that they were highly susceptible to inactivation by exposure to UV light. While most of the early attention was focused on measles and tuberculosis (because of their importance as airborne infections), many other infectious organisms were also found to be susceptible. However, difficulties in standardizing UV doses and repeating Wells' results, coupled with the growing availability and success of antibiotics that coincided with Wells' work, lead to the near abandonment of UV for air disinfection for many years.

Ultraviolet light has now become commonly used for many disinfection processes:

Drinking Water

UV light for drinking water disinfection dates back to the early part of the last century. Unlike chemical treatment, UV disinfection of water consists of a purely physical, non-corrosive process, and produces no known disinfection byproducts. Additionally, UV treatment is rapid and, in terms of primary energy use, approximately 20,000 times more efficient than boiling.

Wastewater Treatment

UV light is replacing chlorination in the treatment of wastewater due to the chemical's toxic by-products. UV treatment compares favorably with other water disinfection systems in terms of cost, labor and the need for technically trained personnel for operation. Chlorine disinfection systems are expensive because of the need for special operator training and a steady supply of a potentially hazardous material.

Food, Drugs and Equipment

UV light surface disinfection systems are used to reduce microbial counts on all kinds of equipment and packaging, including glass and plastic bottles, cans, lids and foils. By treating the surfaces with UV prior to filling, spoilage organisms are eliminated, extending the shelf life of the product and reducing the risk of contamination.

Ultraviolet light is a range of the electromagnetic spectrum that is shorter in wavelength than visible light. Within the electromagnetic spectrum, photons (packets of light) of shorter wavelengths have more energy than those of longer wavelengths, and therefore have more potential to damage or disrupt microorganisms.

UVC light (in the 100-280 nm range) kills microorganisms by damaging their DNA. The UV light is absorbed by the DNA molecules and breaks the chemical bonds that hold them together.

The corrupted DNA causes the death of bacteria and fungi by interrupting vital cell functions, and renders viruses unable to replicate.

The effectiveness of germicidal UV depends on two primary factors: the dose of UV and the ability of the micro-organism to tolerate it. The dose is a product of the intensity of the light and the length of exposure.

Medixair™ Technology

Medixair™ offers a simple, compact, non-intrusive and cost effective solution to air disinfection, backed by both laboratory research and clinical trials. The patented design uses an enclosed chamber to contain the germicidal ultraviolet light (UVC) source, removing the potential for exposure by humans and animals present in the treated areas, and allowing continuous uninterrupted and unattended operation.

Each operating Medixair™ unit will disinfect 880 ft^3 (25 m^3) of air per hour continuously, enough to completely treat the air in an average hospital room over nine times every 24 hours.

Rigorous testing has demonstrated that Medixair™ is capable of achieving between 6.6 and 7.2 log cycles of kill over an eight hour period.

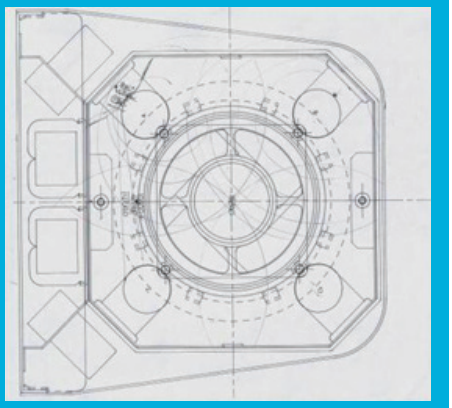
Safety

The ultraviolet light used by Medixair™ is non-ionizing and creates no ozone. No ultraviolet light is exposed outside the Medixair™ unit while it is in operation. Opening the unit's service access door, even while operating, will cause the unit to switch off.

The Environment

Medixair™ uses standard low pressure UV tubes that are manufactured with the same basic materials used in all commercially available fluorescent lights, and the units use electronic starters to minimize energy consumption and ensure high efficiency. As with all fluorescent lights, recycling of spent tubes is highly recommended.

Medixair™ Blueprint



The effectiveness of germicidal UV light depends on the "dose" or amount of energy absorbed by the microorganism. As the intensity of light is reduced exponentially with the distance from the source, air sanitization can only be achieved by a carefully managing this exposure.

The light chamber in the Medixair™ units is engineered to ensure that all the air passing through must pass within a defined maximum distance from the light source.

Coupled with the managed air flow rate, this ensures that all microorganisms present in the air will receive at least the target dose.

Medixair™ Results : Laboratory Trials

Laboratory Trials Carried out by Microsearch Laboratories Ltd. - an independent UKAS Accredited, DEFRA authorized contract laboratory, capable of handling up to Class II pathogens.

Contaminated Laboratory Waste Room

Organisms employed:

E.coli
S.areus
S.typhimurium
B.globigii
B.subtilus
B.megaterium

A reduction of 99.999 % with respect to each target organism was achieved over a 24 hour period in a real use situation.

Effectiveness Against Anthrax

Organisms employed:

Bacillus globigii (recommended anthrax spore surrogate)

Greater than 99.999 % kill rates with a 5 log reduction of contaminants over an 8 hour period.

Effectiveness Against MRSA

Organisms employed:

Staphylococcus aureus; NCTC 11939 (Epidemic methicillin resistant strain)
Staphylococcus aureus; NCTC 11940 (Epidemic methicillin resistant strain)
Staphylococcus aureus; NCTC 11962 (Associated with post operative toxic shock)

Achieved between 6.6 and 7.2 log cycles of kill over an 8 hour period.

Medixair™ Results : Clinical Trials

Clinical Trials Carried Out at Northwick Park Hospital, London, UK

Acute Ward MRSA Contamination (Meticillin-resistant Staphylococcus aureus)

MRSA hot-spots continued to prevail despite regular surface cleaning. In these areas, one in five patients became colonized with MRSA. Of that cohort, one in thirty further developed a blood stream infection (bacteraemia). In this group there was a mortality rate of 40%.

The replicated, controlled, and ethics committee approved trial aimed to intervene in the environmental transmission cycle of MRSA. Two identical side wards were employed in the trial to provide a control group and to permit replication of results.

Conclusions:

Medixair™ air sterilization made a positive impact, producing a significant reduction in the levels of environmental MRSA and colonization of patients within five days of implementation. A direct line correlation was identified between environmental MRSA contamination to patient colonization, wound infection and mortality.

Acute Orthopedic Trauma Ward **Clostridium difficile** Outbreak

Following the successful MRSA Study, Medixair™ units were successfully used as an intervention against an outbreak of **Clostridium difficile** in a trauma ward.

This trial achieved an 80% reduction over a period of 15 months, with almost all the subsequent infections occurring within the first quarter after the Medixair™ units were installed (with the last four quarters reporting either none or only one new case of CDI).

Conclusions:

During the study period the hospital had an active program against CDI. The program for the trauma ward was not distinct from the rest of the hospital apart from the installation of the air sterilization units. The hospital as a whole demonstrated a modest reduction of the total number of CDI cases, but not to the same degree as in the acute orthopedic trauma ward. Ultraviolet air sterilization seems to reduce the number of CDI outbreaks and the number of cases. It is hypothesized that the airborne mode of transmission plays a role in transmission of **Clostridium difficile.**

Medixair™ Results : Intervention Trial

Intervention Trial Carried Out at National Hospital for Neurology and Neurosurgery, University College London Hospitals, NHS Foundation Trust

Acute Ward MRSA Outbreak (Norovirus)

A serious infection outbreak caused the closure of several wards for two weeks. The outbreak was controlled within days of the installation of Medixair™ units.

Note: While the efficacy of Medixair™ has been demonstrated against all viral particles, this intervention was not a clinical study. Further managed hospital trials are currently in process.

Medixair™ - Clearing the Air

"The ongoing need for improved control of person-to-person airborne transmission of some respiratory infections, our increasing reliance on re-circulated air, and our growing understanding of where UV air disinfection is likely to work have prompted this review."

Richard L. Riley and Edward A. Nardell

Clearing the Air:
The Theory and Application of Ultraviolet Air Disinfection

Medixair™ has been selected as a breakthrough product by the British National Health Service, and is being implemented in showcase hospitals as part of its "Smart Solutions for HCAI" program.

How to Learn More

MEDIXAIR™

BRANDENBURG UK LIMITED

29 Navigation Drive
Hurst Business Park,
Brierley Hill, West Midlands
DY5 1UT, UK

Phone: +44 (0) 1384 472 900
Fax: +44 (0) 1384 472 911
Email: sales@b-one.com
Web: www.b-one.com

BRANDENBURG NORTH AMERICA

3780 Rider Trail South
Earth City
MO 63045, US

Phone: 314-567-4101
Email: sales@b-onena.com
Web: www.b-onena.com

Appendices

Medixair™ Specifications:

- Height: 27.3" (694 mm)
- Width: 7.9" (202 mm)
- Depth: 7.9" (202 mm)
- Weight: 17.6 lb (8 kg)
- Power Supply: 110-120 volt - 100 watts (230 volt version also available)
- Air Volume: 14.7 ft^3/min (25 m^3 per hour)
- UV Exposure Energy: 23,000 µW.sec/cm^2
- Noise: 35 dB @ 1metre (3.28ft)

Medixair™ Maintenance:

- The germicidal UVC tubes should be replaced every 6 months
- The germicidal UVC tubes should be cleaned quarterly (in the 2 quarters without tube replacement) following the bulb cleaning and handling instructions
- The air filter should be replaced quarterly (monthly in high dust environments)

Consumables are all low cost items. Service does not require specialist tools, equipment, or training, and the average service time per unit is less than 10 minutes.

Medixair™ Benefits:

- Medixair™ units provide continuous unattended operation without the need for dedicated specialist staff
- Medixair™ units are discreet, non-intrusive, and whisper quiet, allowing all normal activities to proceed without interruption
- Medixair™ units are available as fixed wall-mounted for permanent locations, or free standing to allow for more flexible response to changing conditions
- Medixair™ units offer a very affordable, proven solution for controlling airborne pathogens, allowing more widespread usage within the same budgetary constraints

UV Energy Required to Destroy Bacteria and Viruses (as μW.s/cm²)

Bacteria	Energy	Medixair™ %	Bacteria	Energy	Medixair™ %
Agrobacterium tumefaciens	4,200	547 %	Phytomonas tumefaciens	4,400	522 %
Bacillus anthracis	4,500	511 %	Proteus vulgaris	3,000	766 %
Bacillus aegaterium (spore)	9,070	253 %	Pseudomonas aeruginosa	5,500	418 %
Bacillus aegaterium	3,750	613 %	Pseudomonas fluorescens	3,500	657 %
Bacillus subtilis (spore)	12,000	191 %	Salmonella enteritidis	7,600	303 %
Bacillus subtilis	7,100	323 %	Salmonella paratyphi	6,100	377 %
Bacillus paratyphosus	3,200	718 %	Salmonella typhimurium	8,000	287 %
Bacillus enteritidis	4,000	575 %	Samonella typhosa	6,000	383 %
Coryneb acterium diphteriae	3,750	613 %	Sarcina lutea	19,700	116 %
Clostridium tetani	4,900	469 %	Serratia marcesens	2,420	950 %
Clostridium botulinium	12,000	191 %	Salmonella paratyphi	6,100	377 %
Dysentery bacilli	2,200	1045 %	Salmonella typhimurium	8,000	287 %
Eberthella typhosa	2,140	1074 %	Samonella typhosa	6,000	383 %
Escherichia coli	5,400	425 %	Sarcina lutea	19,700	116 %
Leptospira spp (Infectious Jaundice)	3,000	766 %	Serratia marcesens	2,420	950 %
Legionella pneumophila	2,040	1127 %	Shighella dysenteriae	4,200	547 %
Legionella bozemanii	1,800	1277 %	Shigella paradysenterea	1,680	1369 %
Legionella dumoffii	3,000	766 %	Shigella flexneri	1,700	1352 %
Legionella gormanii	2,500	920 %	Shigella sonnei	2,100	1095 %
Legionella micdadei	1,500	1533 %	Spirillium rubsum	4,400	522 %
Legionella longbeachae	1,500	1533 %	Staphylococcus albus	1,840	1250 %
Listeria monocytogenes	3,400	676 %	Staphylococcus aureus	2,600	884 %
Listeria monocytogenes	3,400	676 %	Streptococcus haemolyticus(A)	6,700	343 %
Micrococcus candidus	6,050	380 %	Streptococcus haemolyticus(D)	9,500	242 %
Micrococcus sphaeroides	10,000	230 %	Streptococcus lactis	6,150	373 %
Mycobacterrium tuberculosis	6,200	370 %	Streptococcus viridans	2,000	1150 %
Neisseria catarrhalis	4,400	522 %	Streptococcus pyrogenes	2,160	1064 %

Virus	Energy	Medixair™ %	Virus	Energy	Medixair™ %
Adenovirus	1,500	1533 %	Infectious hepatitis virus	8,000	287 %
Bacteriophage (E.Coli virus)	3,000	766 %	Influenza	3,400	676 %
Coxsackie virus A9	12,000	191 %	Poliovirus 1	11,000	209 %
Coxsackie virus B1	15,500	148 %	Poliovirus 2	12,000	191 %
Echovirus 1	11,000	209 %	Poliovirus 3	10,000	230 %
Echovirus 2	12,000	191 %	Reovirus 1	15,400	149 %
Hepatitis A	11,000	209 %	Rotavirus SA11	7,800	294 %

References

Aerobiology and Its Role in the Transmission of Infectious Diseases

Aaron Fernstrom and Michael Goldblatt
Journal of Pathogens
Volume 2013 (2013), Article ID 493960

Spread of Disease in Office Buildings

The Pennsylvania State University
Indoor Environment Center

Managing water in the home: accelerated health gains from improved water supply

The World Health Organization
WHO/SDE/WSH/02.07
Prepared by Professor Mark D. Sobsey
School of Public Health
University of North Carolina
Chapel Hill
USA

Clearing the Air: The Theory and Application of Ultraviolet Air Disinfection

Richard L. Riley and Edward A. Nardell

American Review of Respiratory Disease, Vol. 139, No. 5 (1989), pp. 1286-1294.

International Ultraviolet Association

www.iuva.org