ULTRAVIOLET AIR PURIFICATION

A NATURAL PROCESS

EAGLE
AIR TREATMENT DIVISION

EAGLE PRODUCTS

- Manufactured in Canada since 1995
- Develops and Patents proprietary Ultraviolet Air Purification Systems
- Complete line of Ultraviolet Air Purification Systems
- Global Leader in Ultraviolet Air Purification


Patent No. 5,833,740

Dr. Normand Brais

UNITED STATES PATENT

The Commissioner of Patents and Trademarks has received an application for a new and useful invention. The requirements of law have been complied with, and it has been determined that a patent on the invention, known as

AIR PURIFIER

shall be granted under the laws of the United States of America. Therefore, this United States Patent grants to the person or persons having title to this patent the right to exclude others from making, using or selling the invention throughout the United States of America for the term of seventeen years from the date of this patent.

November 18, 1998
Date of Issue

M C Henry
Attesting Officer


Office de la propriété intellectuelle du Canada
Un organisme d'Industrie Canada

Canadian Intellectual Property Office
An Agency of Industry Canada

Brevet canadien / Canadian Patent

BREVET CANADIEN 2,221,944 CANADIAN PATENT

2004/04/13

1997/11/24

1998/05/26

Canada

AGENDA

1- Indoor Air Quality
2- Germicidal effect of UV
3- UV in natural outdoor environment
4 -UV Dosage inside Buildings
5- Eagle product line
6- Safety concerns
7- Results from independent studies

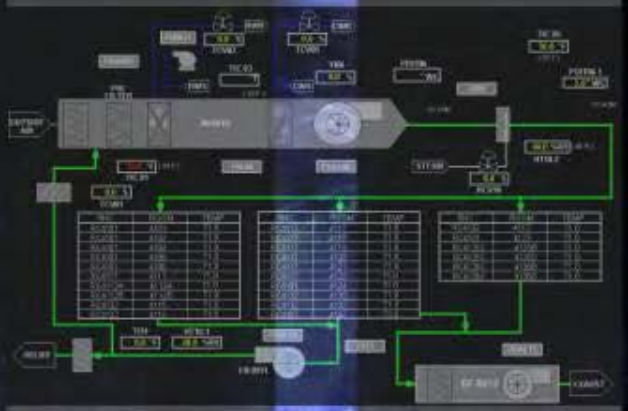
INDOOR AIR QUALITY

- **40 million people in North-America have respiratory problems**
- **50 million people in North-America have allergies**
- **31% of building occupants complain about bad odors**
- **23% of the population are smokers**
- **Buildings are more air tight**

Sources: 1.American Lung Association 2.American College of Allergies 3 &4 Honeywell Consumer Products 5. Center for Disease Control & Prevention

When designing for BUILDINGS :

ideal OUTDOOR conditions were used as the reference



Temperature

•Humidity

•Light

•Ventilation

INDOOR AIR QUALITY

Ventilation criteria: O_2-CO_2 balance

1 CFM per person

is sufficient for

Breathing

Sugar + O_2 → E_{TPA} + CO_2 + H_2O

VENTILATION HISTORICAL OVERVIEW

		CFM/pers
Tredgold (1824)	=	**3**
Billings (1893)	=	**30** (60 for TB)
21 State Code(1915)	=	**30**
ASHRAE (1973)	=	**10**
ASHRAE (1981)	=	**5** (60 for smokers)
ASHRAE (1989)	=	**15**

INDOOR AIR QUALITY

What is in the air?

Nitrogen = 78.1 %

Oxygen = 20.9%

Argon = 0.87 %

Water = 0 – 3.5%

Carbon Dioxide = 300 ppm (0.03 %)

INDOOR AIR QUALITY

What ELSE is in the air?

Solid: particulates, pollen, dust

Chemical : VOC, Solvents vapours, formaldehyde

Biological: Molds, viruses, bacteria

Indoor air contaminants

Particulates

Bacteria

Toxins

SOLIDS

BIOLOGICAL

CHEMICALS

Bacteria are sources of odors :

Two (too) well known examples:

1 - Sweat

2 - Bad breath

Prevention ⟶ Anti-bacteria products

Germicidal Effect of UV

Is it possible to control odors with more ventilation ?

Yes, but...

Given the exponential reproduction rate
of a colony of bacteria,
the required ventilation rate becomes quickly cost prohibitive
or simply unfeasible.

THE QUESTION?

How to control the concentration level of bacteria inside buildings ?

Which brings another QUESTION

What natural mechanism controls the level of bacteria in outdoor air ?

Germicidal Effect of UV

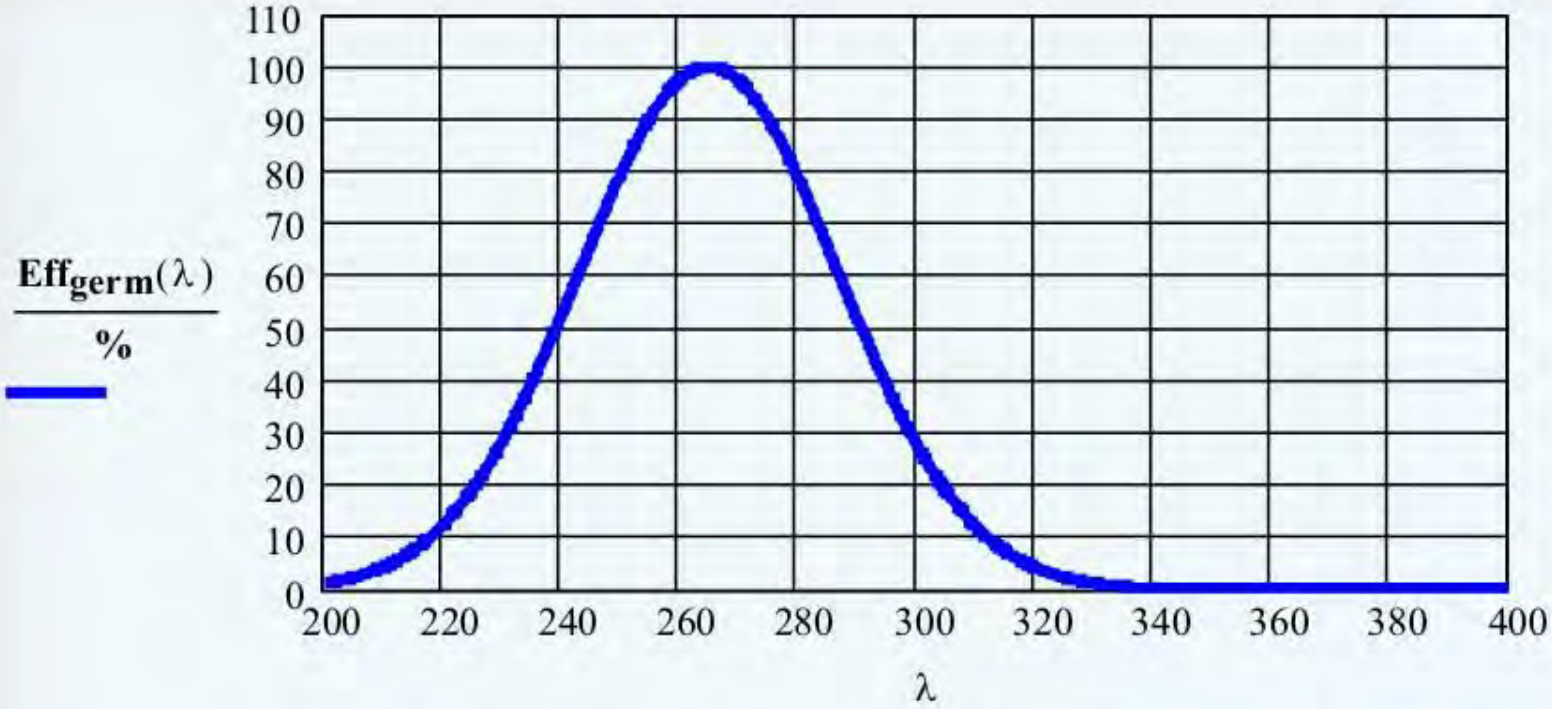
or…everything you always wanted to know about the sex life of bacteria but were always afraid to ask !

- **Short life span means that they need to reproduce fast : No time to fool around !**

- **Blue print required for reproduction: DNA**

Germicidal Effect of UV

DNA molecules are very sensitive to UV radiation in the range of 250 to 280 nm wavelength



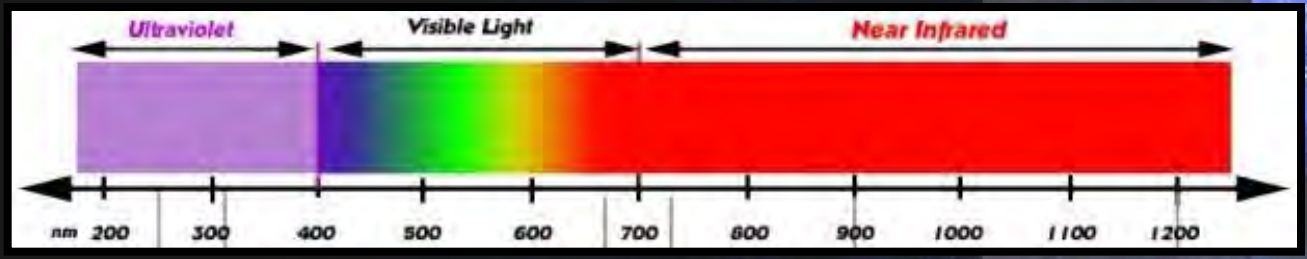
$$Avg_{germ\_eff} := \frac{1}{400 - 300} \cdot \int_{300}^{400} Eff_{germ}(\lambda)\, d\lambda \qquad Avg_{germ\_eff} = 3.03\,\%$$

UV radiation that reached the sea level are > 290 nm at p.93

source : Atmospheric Chemistry: Fundamentals and Experimental techniques, B.J. Finlayson-Pitts and J.N.Pitts, John-Wiley & Sons, 1986, 1098p.

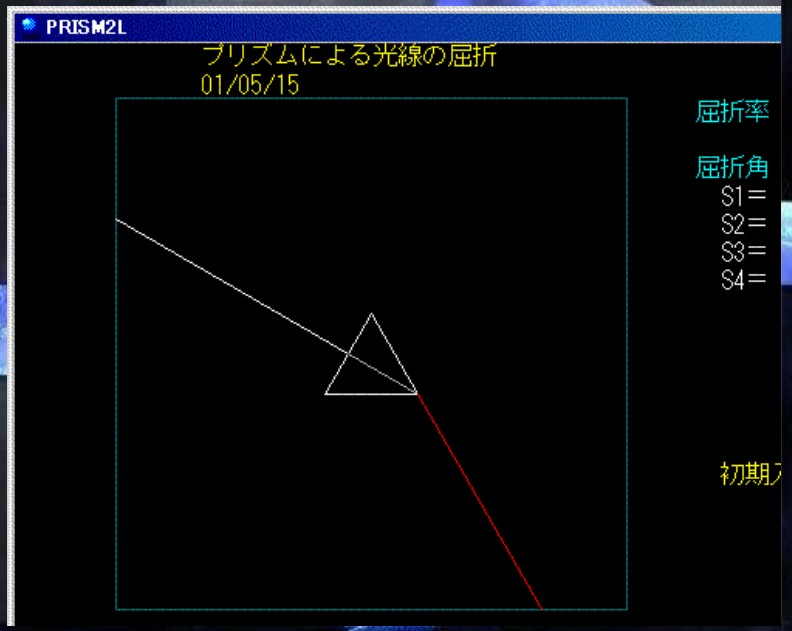
Germicidal Effect of UV

- Infra-red → > 700 nm
- Visible light → 400 – 700 nm
- Ultraviolet → < 400 nm



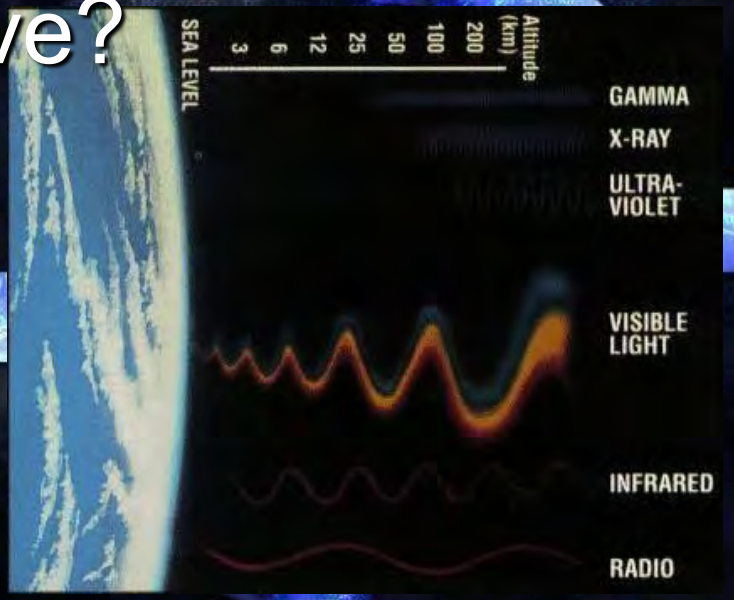
Basic UV Refresher

Ultraviolet	Wavelength
UV - A	315 to 400 nm
UV - B	280 to 315 nm
UV - C	200 to 280 nm
UV - V	100 to 200 nm



Natural UV Source : The Sun

WHAT DOSE
OF UV Germicidal Energy
does bacteria living
OUTDOORS receive?



$$\mathbf{DOSE_{outdoor}} := \frac{1}{400 - 300} \cdot \int_{0 \cdot \mathbf{hr}}^{12 \cdot \mathbf{hr}} \int_{300}^{400} \mathbf{Eff_{germ}}(\lambda) \cdot \mathbf{UV}(\lambda)\, d\lambda\, dt$$

Total Daily Natural Outdoor UV Dose : $\mathbf{DOSE_{outdoor}} = 19189 \frac{\mathbf{microwatt\,sec}}{\mathbf{cm}^2}$

Minimum Germicidal UV output power requirement per square foot of indoor floor assuming 24/24 continuous use :

$$\mathbf{Spec_{sqft\_output}} := \frac{\mathbf{DOSE_{outdoor}}}{24 \cdot \mathbf{hr}} \qquad \mathbf{Spec_{sqft\_output}} = 206 \frac{\mathbf{microwatt}}{\mathbf{ft}^2}$$

3- Effect of natural UV on OUTDOOR air

UV Type	Effects	Operating Mode
UV - C (254 nm)	Germicidal Sterilisation	Acts on **DNA** Inhibits Reproduction
UV - V (185 nm)	Photo-Oxidation (hydroxyl radicals)	$UVV + O_2 \longrightarrow O^* + O^*$ $O^* + H_2O \longrightarrow OH^* + OH^*$
Oxidation of organic chemicals in the upper atmosphere		$CO + 2OH^* \longrightarrow CO_2 + H_2O$

Natural UV Source : The Sun

DAILY germicidal UV DOSE received by bacteria living in OUTDOOR AIR:

19,189 microwatt.sec/cm^2

Dosage of UV-C for complete destruction (uW-sec/cm^2)

BACTERIA			
Agrobacterium Lumefaciens^	8,500	Streptococcus Lactis*	8,800
Bacillus Anthracis*(**Anthrax**)	8,700	Streptococcus Pyrogenes^	4,200
Bacillus Anthracis ***Spores***^(**Anthrax**)	46,200	Streptococcus Salivarius^	4,200
BaciHus Megatherium Sp. (Veg)*	2,500	Streptococcus Viridans*	3,800
Bacillus Megatherium Sp. (Spores)*	5,200	Typhoid Fever^	4,100
Bacillus Paratyphosus*	6,100	Vibrio Comma (Cholera)^	6,500
Bacillus Subtilis*	11,000	Vibrio Cholerae^	6,500
Bacillus Subtilis Spores*	22,000	**MOLDS**	
Clostridium Tetani^	23,100	Aspergillus Amstelodami^	77,000
Clostridium Botulinum^	11,200	Aspergillus Flavus*	99,000
Corynebacterium Diphtheriae*	6,500	Aspergillus Glaucus*	88,000
Dysentery Bacilli*	4,200	Aspergillus Niger (bread mold)*	330,000
Eberthella Typhosa*	4,100	Mucor Mucedo^	77,000
Escerichia Coll*	8,600	Mucor Racemosus (A & B)*	35,200
Legionella Bozemanii^	3,500	Oospora Lactis*	11,000
Legionella Dumoffill^	5,500	Penicillium Chrysogenum^	56,000
Legionella Gormanil^	4,900	Penicillium Digitatum*	88,000
Legionella Micdadei^	3,100	Penicillium Expansum*	22,000
LegioneHa Longbeachae^	2,900	Penicillium Roqueforti*	26,400
Leglonella Pneumophfla		Rhizopus Nigricans (cheese mold)*	220,000
(Legionnaire's Disease)	2,760	**VIRUS**	
Leptospiracanicola-		Adeno Virus Type III^	4,500
Infectious Jaundice^	6,000	Bacterlophage (E.Coli)*	6,600
Leptospira Interrogans^	8,000	Coxsackie A2^	6,300
Micrococcus Candidus*	12,300	Infectious Hepatitis^	8,000
Micrococcus Sphaeroides*	15,400	Influenza*	3,400
Mycobacterlum Tuberculosis^	10,000	Rotavirus^	24,000
Neisseria Catarrhalis*	8,500	Poliovirus^	21,000
Phytomonas Tumefaciens*	10,500	Variola** (**Smallpox**)	24,000

4 – Air Purification Techniques : Where does UV Fit In?

Pollutant Type	Examples	Remediation Technology
Solids	Dust	Filters
Chemicals	Solvents Formaldehyde VOC	Absorption on activated charcoal Thermal oxidation **UV-Photo-oxidation**
Biological	Fungi Molds Bacteria	Germicidal chemical products **UVSterilisation of DNA**

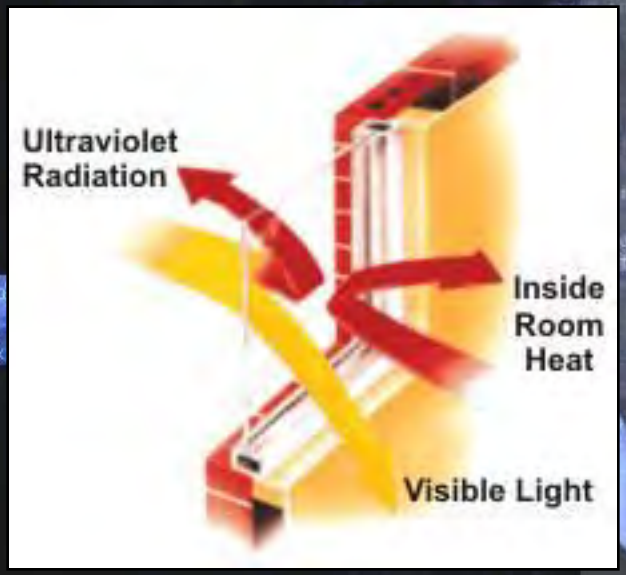
4 – Air Purification Techniques

WHY is there no UV INSIDE BUILDINGS ?

WINDOWS are UV filters

VISIBLE LIGHT goes through

But not UV light



4 – Air Purification Techniques

BASIC CONCEPT:
Add UV source inside buildings

1- UV irradiation of INDOOR AIR

- Destruction of Bio-contaminants (bacteria, molds, etc)
- Elimination of their associated odours

2- UV irradiation of surfaces (objects)

- Sterilisation of heating and cooling coils

Two Factors in achieving a kill using Ultraviolet Light

TIME : The greater the exposure time (contact time between the contaminant & the UV source) the more UV energy can be delivered to the contaminant resulting in a greater Kill Rate.

INTENSITY : The greater the intensity (strength of the UV source) the more UV energy can be delivered to the contaminant resulting in a greater Kill Rate.

*This is true for all types of UV glass & Lamps. This is a fundamental principl of UV Light.

4 - UV DOSAGE INSIDE BUILDINGS

UV dose = INTENSITY X Time

(Joule/cm^2) (watt/cm^2) (sec)

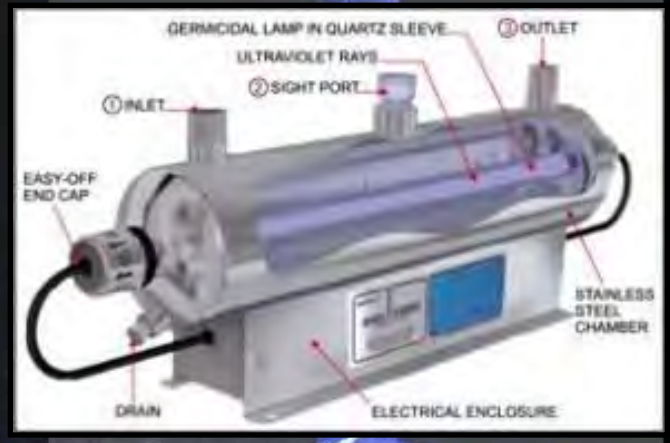
If UV dose > LETHAL dose

→ reproduction is stopped

NOTE: ***process similar to pasteurisation :***
Temperature x Time

Familiar With UV?

- Our Sun produces UV energy which naturally destroys biological contaminants in the atmosphere.
- UV-C Light attacks microorganisms on a molecular level mutating the DNA of the cell.
- UV Has been used for many years in water treatment.
- If you are familiar with UV Water Treatment, the principles for treating moving air are the same.



Example of a UV Water Purifier

UV Air Purifiers on the Market

- You may be familiar with UV Air Purifiers on the market.
- They appear to be very similar.
- They may vary in number of lamps. Some have 1, 2 even 4 UV Lamps.
- Excellent Object Purifiers but NOT very effective Air Purifiers.

Two Types of Ultraviolet Purifiers

AIR PURIFIER : Designed to treat the air-stream, destroying biological & chemical contaminants.
High Intensity x Short exposure Time

OBJECT PURIFIER : Designed to treat a stationary object destroying and preventing microbial growth.
Intensity x Long exposure Time

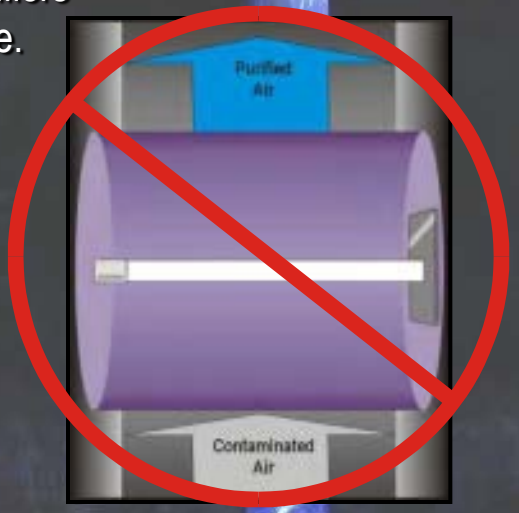
The Two Inch Rule

- Some manufacturers promote that their one and two lamp Probe purifiers will treat the entire volume of air passing through the duct at one time.

- Unfortunately, that could not be farther from the truth. According to the Lamp Manufacturers, efficiencies DROP very quickly the further from the Lamp surface you move.

- **At just 2" from the surface of the glass, the UV efficiency has already dropped 80% and the decline is exponential.**

- This is true for all types of UV Lamps, from cold cathode to hot cathode, soft glass to quartz glass.

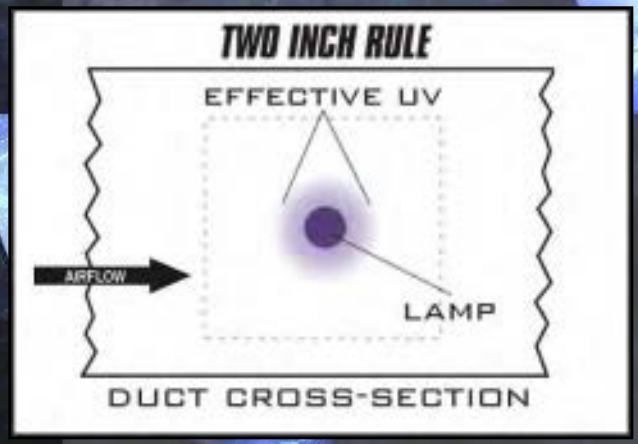


This is an example of a competitors suggested treatment area.

- Manufacturers who promote that their one and two Lamp Probe Purifiers will purify the entire duct are in reality only TREATING A VERY NARROW BAND OF AIR that travels by the Lamp.

- As will be discussed, even that narrow band of air is not being treated adequately because the air is moving much too fast in the duct to receive the proper UV dosage.

**The 2" Rule is the reason why the "J" Lamp is mounted inside the Aluminum Reflector Tube. The purifier will maximize the UV Energy which would otherwise be lost in the duct-work.

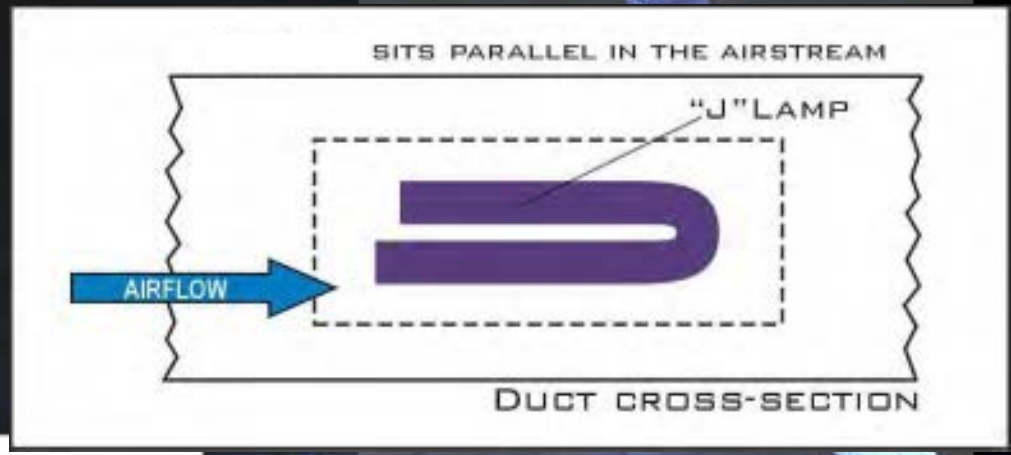


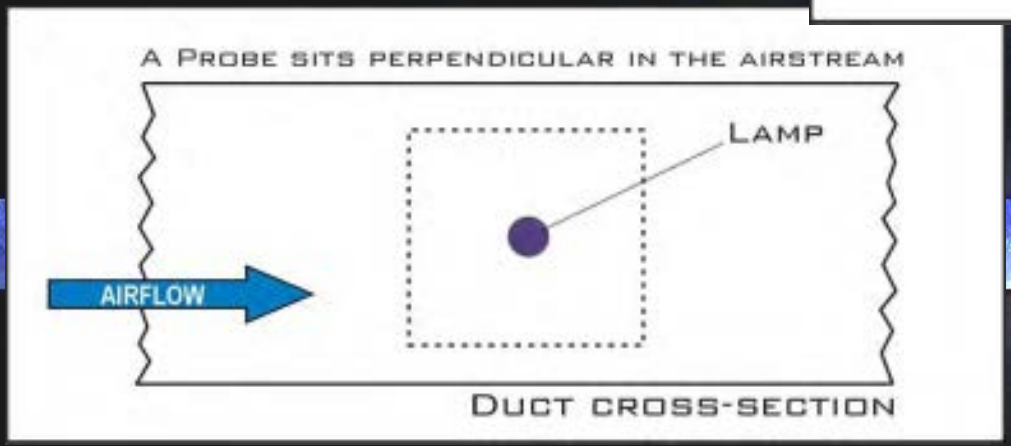
Dwell Time

- Finally, to increase the dwell time (the time the contaminant is in contact with the UV Energy), the purifier is mounted parallel to the air-stream not perpendicular, maximizing the time the contaminant is in contact with the UV lamp.

- If properly delivered, UV Irradiation can be a very efficient method for air purification. The use of the Turbulator, Aluminum Reflector Tube, "J" Lamp and placing the unit parallel to the air-stream are the "tools" needed to maximize the UV Energy.

The air spends 2400% MORE TIME in Contact with the UV Energy than does a Probe Purifier.





Parallel = Increased Dwell Time

Perpendicular = a fraction of Dwell Time

EAGLE Air Purification system

Contaminated air enters parallel to the UV lamp increasing contact time with UV energy

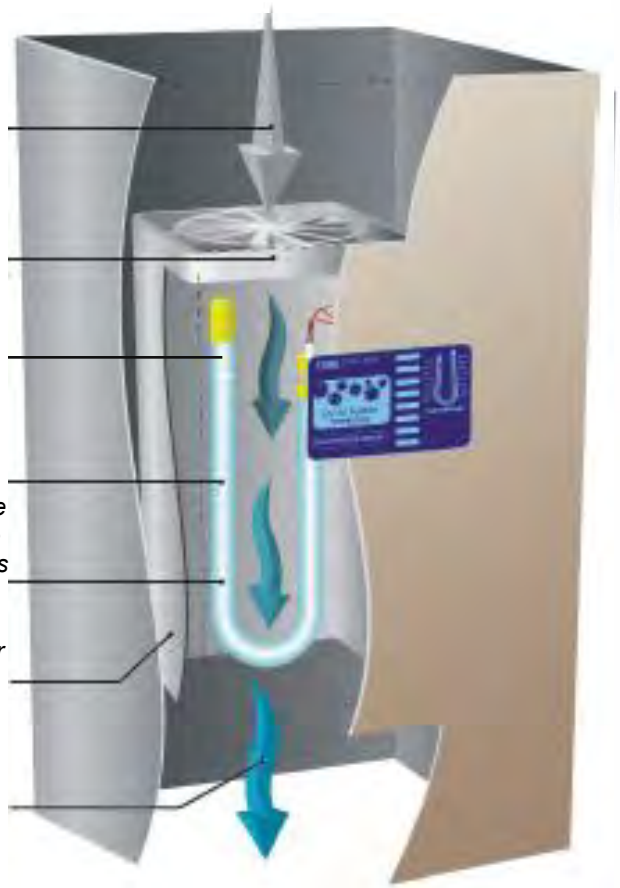
The turbulator spins and mix the air around the UV "J" lamp

The UVV Oxidizing section of the lamp destroys chemicals and odors

The UVC section of the lamp then destroys the biological contaminants

The aluminum reflector chamber directs the UV energy for optimal purification

The treated air then recirculates through the home



Ventilation Duct

- Whole-Home Air Treatment
- Dual-Zone UVC / UVV Lamp
- Biological Destruction
- Chemical Oxidation
- Patented Process
- 3" Status Display
- 3 Year Replacement Warranty incl. UV Lamp
- Leader in Indoor Air Quality
- Tested & Published results

EAGLE Air Purification units

EA+

E+

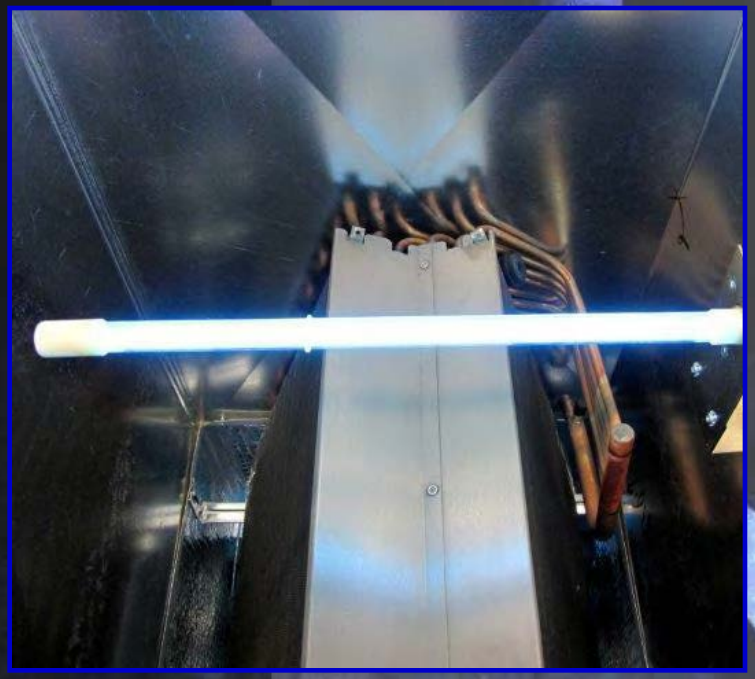
Whole home EA+ and E+

-Easy to install, self diagnosis

-3 years « no question » warranty

ELITE

EAGLE Object- coil Purification



STAR - 24/110V

- 16" UVC Coil Cleaner destroys mold & their associated odors on coil
- Improve energy efficiency
- 3" LCD Display provides important user information
- 1 year warranty including UV Lamp
- Optional Remote Kit available

FREE SECOND UV LAMP INCLUDED

6 – SAFETY CONCERNS

- Installed as per specifications, EAGLE units are safe and approved by CSA/ULC/ETL

- There is only one safety concern and it is written on each unit :

CAUTION : ***"Do not expose eye or skin directly to the ultraviolet lamp."***

6 – Results from Studies

Montreal, Canada – In a study published in The Lancet Medical Journal, McGill University scientists found that shining proprietary Ultraviolet Purifiers on the air conditioning coil reduces over all sickness by 20%, reduces respiratory symptoms by 40% and has resulted in a 99% reduction of microbial and endotoxin concentrations on irradiated surfaces within the ventilation system.

McGill
McGill University Health Center

A two year Double Blind Study on Sick Building Syndrome using Ultraviolet Purifiers Published in The Lancet Medical Journal.

Department of Epidemiology and Bio-statistics of McGill University


Effect of ultraviolet germicidal lights installed in office ventilation systems on workers' health and wellbeing: double-blind multiple crossover trial

Dick Menzies MD MSc1, Julia Popa BEng MEng, James A Hanley PhD, Thomas Rand PhD, Don Milton MD DrPH.

EPA United States Environmental Protection Agency

United States Environmental Protection Agency | Office of Research and Development Washington, D.C. 20460 | EPA 600-06-xxx June 2006 www.epa.gov/nhsrc

TECHNOLOGY EVALUATION REPORT

Biological Inactivation Efficiency by HVAC In-Duct Ultraviolet Light Systems

UV Bio-Wall 50 Outwardly Projecting Air Purifier

Office of Research and Development
National Homeland Security
Research Center

Notice

The U.S. Environmental Protection Agency (EPA), through its Office of Research and Development's National Homeland Security Research Center (NHSRC), funded and managed this technology evaluation through a Blanket Purchase Agreement (BPA) under General Services Administration contract number GS23F0011L-3 with Battelle, with RTI under subcontract to Battelle. This report has been peer and administratively reviewed and has been approved for publication as an EPA document.

Executive Summary

The U.S. Environmental Protection Agency's (EPA's) National Homeland Security Research Center (NHSRC) Technology Testing and Evaluation Program (TTEP) is helping to protect human health and the environment from adverse impacts resulting from acts of terror by carrying out performance tests on homeland security technologies. Under TTEP, RTI recently evaluated the performance of the Technologies Inc. UV Bio-Wall Outwardly Projecting Air Purifier. The objective of testing the device was to evaluate its bioaerosol inactivation efficiency as a heating, ventilation and air-conditioning (HVAC) in-duct ultraviolet light system.

The product was tested using a test plan approved by EPA, *Test/QA Plan for Biological Inactivation Efficiency by HVAC In-Duct Ultraviolet Light Air Cleaners*. (1) The tests were conducted using three organisms, two bacteria *Bacillus atrophaeus (surrogate for anthrax spore)* and *Serratia marcescens* and one bacterial virus (MS2). These organisms were selected because their sizes, shapes and susceptibility to UV inactivation make them reasonable surrogates for biological warfare agents (BWAs). Generally, vegetative bacteria are readily killed and bacterial spores are more difficult. To model use in an HVAC system, RTI used a test duct designed for testing filtration and inactivation efficiencies of aerosol, bioaerosol, and chemical challenges.

Figure 2-1. Bellow box installed on the outside of the test rig.

Figure 2-2. Device installed inside the test rig. There are 5 lamps. A reflective surface was placed in the duct.

The bioaerosol inactivation efficiencies calculated for the three organisms were 93% on *one pass for *B. atrophaeus* (surrogate for anthrax spore), >99.97% *on one pass for *S. marcescens* (bacteria) and 99% *on one pass for *MS2* (bacterial virus). The irradiance was measured as 1200 μW/cm² at 133 cm (52.4 in.) upstream from the closest glass part of the lamps with an airflow of 0.93 m³/sec (1970 cfm). The system had five lamps that were burned in for 100 hours prior to measurements.

* *One pass inactivation with no re-circulation by the UV System.*

The researcher team chose to test a cross-section of contaminants, they chose a bacterial spore (surrogate for anthrax spore) and the UV Bio-Wall 50" achieved a 93% destruction on one pass, a viral bacteria (MS2) which the Bio-Wall achieved a 99% destruction at one pass and a bacteria which we achieved >99.97% destruction at one pass.

CONCLUSION:
emulating outdoor conditions to design healthier buildings

Ventilation
has been used to control
the concentration of CO_2

Ultraviolet sources
will be used to control
the growth of bio-contaminants
and their odors generating toxins