Using UVC in Transportation For Mitigating Pathogen Exposure Risks for Passengers

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History

1895 – First use of UVC for water disinfection

1903 – Nobel Prize for Medicine & Physiology
- Awarded to Niels Finsen for his “contribution to the treatment of diseases with concentrated light (UV) radiation, whereby he has opened a new avenue for medical science".

1930 – UVC used to stop measles outbreak in schools

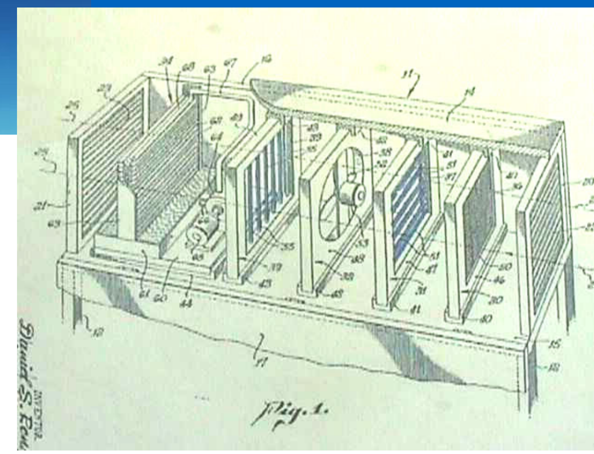
1941 – 1st Patent, UVC into HVAC

1963 – 1st Lumalier UVC fixtures manufactured in Memphis

2004 – Lancet Study– UVC in HVAC = facility-wide pathogen reduction

2008 – 1st ASHRAE UVC Handbook Chapter

2016 – CDC / Duke Infection Control Network (DICON) study confirms UVC reduces HAI rates



The History of UVC

Germicidal UVC: Renewed Interest in UVGI Technology

A resurgence of tuberculosis (TB) in the 1980's created a renewed interest in UVGI technology.

In 1980, Lumalier partnered with Dr. Paul Jenson from the CDC to work on improving the original upper air designs from the 1930's to help control tuberculous around the world.

By working with the CDC, the design was not patented so it could be used around the world.

Science of UVC

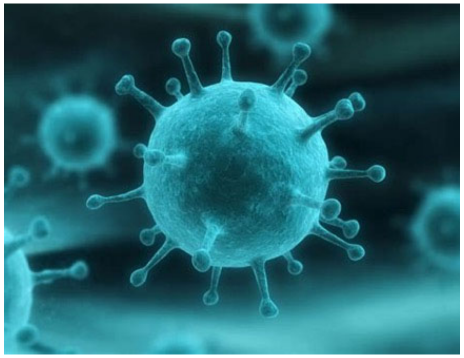
- Germicidal UVC
- Pathogens
- Textbook on UVC
- Pathogen “Kill” Rates

The Science of UVC

Pathogens: All Pathogens are not the same.

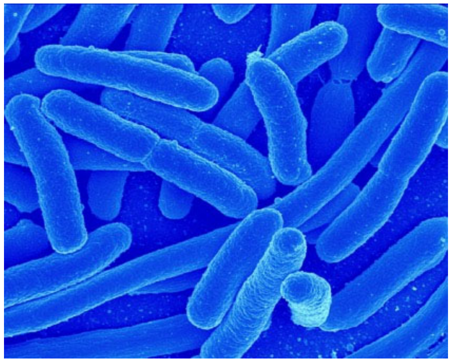
Having the correct strategy to address each is important to achieve the desired outcome.

Virus



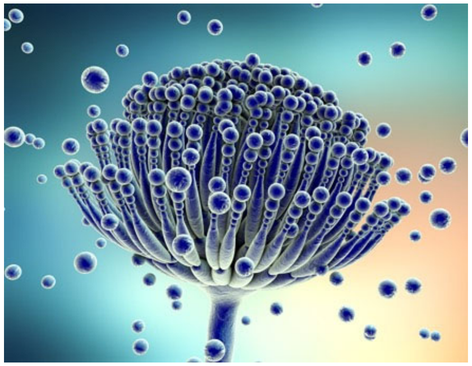
- ~0.001-0.3 microns in diameter
- No hard outer shell
- UV-C kills almost instantly

Bacteria



- ~0.2-2 microns in diameter
- Some species have shell
- Very susceptible to UV-C

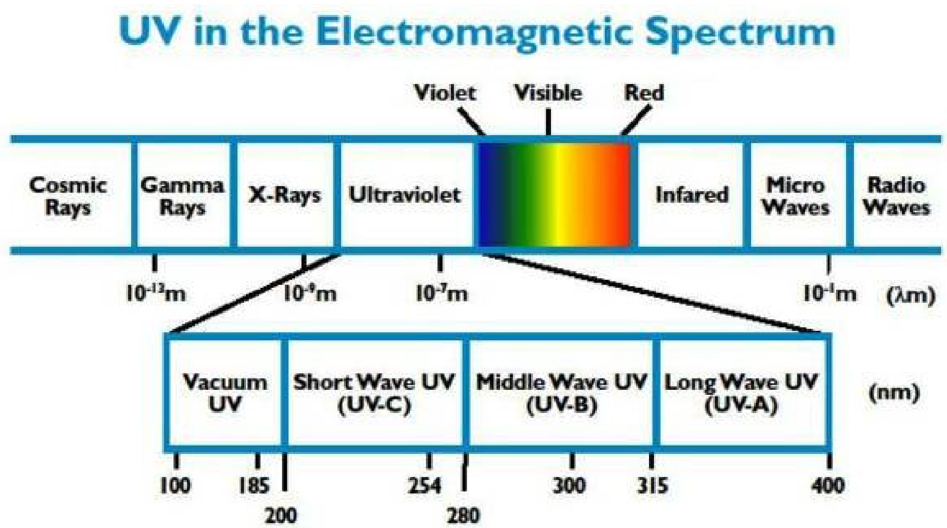
Spores

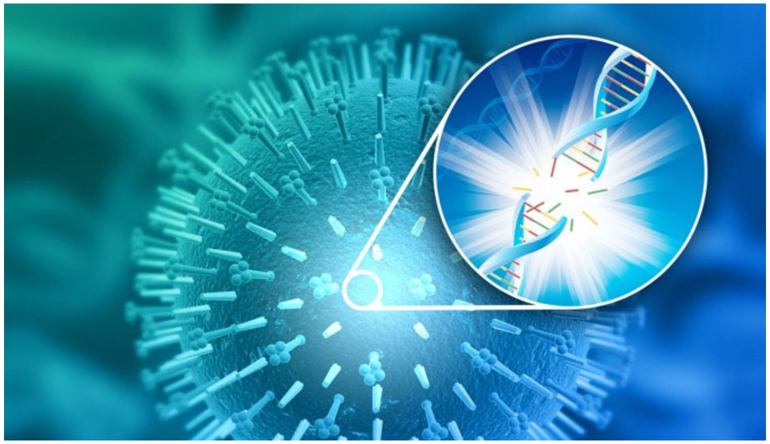


- ~3-10 microns in diameter
- Usually has a shell
- Needs higher dose of UV-C

The Science of UVC Germicidal UVC

- **Lumalier UV Germicidal Disinfection Solutions Provide Up to a 99.9% Pathogen Reduction Rate**.
- UVC germicidal light energy is generated at a 254 nm, a wavelength that disrupts the DNA of infectious pathogens, rendering the cell incapable of reproduction, colonization or harm to humans.





UV Products

Renewed Interest in UVGI Technology

Humans are constantly off-gassing pathogens. We are continually exposed to bacteria and viruses.

- One sneeze can produce over *10 million* microscopic particles.
- One cough can spew *100,000* droplets laden with bacteria and viruses.
- Even talking produces *10,000* particles.

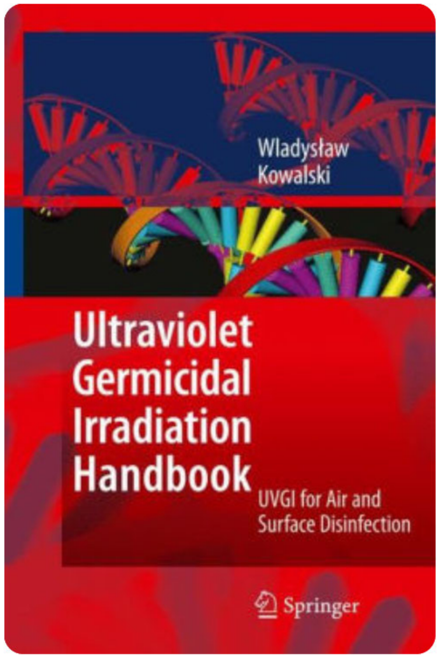
The Science of UVC

The Respected Handbook of the UV-C industry

Dr. Wladyslaw Kowalski (Wally)

Textbook on UV-C: Handbook covers all calculations to determine effective disinfection rates and levels for:

- Air/ HVAC
- Water
- Upper air
- Surface



The Science of UVC

Pathogen “Kill” Rates

- Pathogen “Kill” rates are a known, published, constant.
- There are no known pathogens resistant to a lethal dose of UVC energy.

Bacteria	Dose	k
Bacilus anthracis	45.2	0.051
B.megatherium sp. (spores)	27.3	0.084
B.megatherium sp. (veg.)	13.0	0.178
B.parathyphosus	32.0	0.072
B. suptilis	71.0	0.032
B. suptilis spores	120.0	0.019
Campylobacter jejuni	11.0	0.209
Clostridium tetani	120.0	0.019
Corynebacterium diphteriae	33.7	0.069
Dysentery bacilli	22.0	0.105
Eberthella typhosa	21.4	0.108
Escherichia coli	30.0	0.077
Klebsiella terrifani	26.0	0.089
Legionella pneumophila	9.0	0.256
Micrococcus candidus	60.5	0.038
Micrococcus sphaeroides	100.0	0.023
Mycobacterium tuberculosis	60.0	0.038
Neisseria catarrhalis	44.0	0.053
Phytomonas tumefaciens	44.0	0.053
Pseudomonas aeruginosa	55.0	0.042
Pseudomonas fluorescens	35.0	0.065
Proteus vulgaris	26.4	0.086
Salmonella enteritidis	40.0	0.058
Salmonella paratyphi	32.0	0.072
Salmonella typhimurium	80.0	0.029
Sarcina lutea	197.0	0.012
Seratia marcescens	24.2	0.095
Shigella paradysenteriae	16.3	0.141
Shigella sonnei	30.0	0.077
Spirillum rubrum	44.0	0.053
Staphylococcus albus	18.4	0.126
Staphylococcus aureus	26.0	0.086
Streptococcus faecalis	44.0	0.052
Streptococcus hemoluticus	21.6	0.106
Streptococcus lactus	61.5	0.037
Streptococcus viridans	20.0	0.115
S.enteritidis	40.0	0.057
Vibrio chlolerae (V.comma)	35.0	0.066
Yersinia enterocoltica	11.0	0.209

Yeasts	Dose	k
Bakers' yeast	39	0.060
Brewers' yeast	33	0.070
Common yeast cake	60	0.038
Saccharomyces cerevisiae	60	0.038
Saccharomyces ellipsoideus	60	0.038
Saccharomyces sp.	80	0.029
Mould spores		
Aspergilus flavus	600	0.003
Aspergilus glaucus	440	0.004
Aspergilus niger	1320	0.0014
Mucor racemosus A	170	0.013
Mucor racemosus B	170	0.013
Oospora lactis	50	0.046
Penicillum digitatum	440	0.004
Penicillum expansum	130	0.018
Penicillum roqueforti	130	0.018
Rhizopus nigricans	1110	0.002
Virus		
Hepatitis A	73	0.032
Influenza virus	36	0.064
MS-2 Coliphase	186	0.012
Polio virus	58	0.040
Rotavirus	81	0.028
Protozoa		
Cryptosporidium parvum	25	0.092
Giardia lamblia	11	0.209
Algae		
Blue Green	3000	0.0008
Chlorella vulgaris	120	0.019

UV Products

Disinfection Rates by Distance

Disinfection rates at different distances

how long does the unit need to operate in order to achieve a 99.99% disinfection rate within a space?

This table shows reduction rates for a variety of common pathogens of concern.

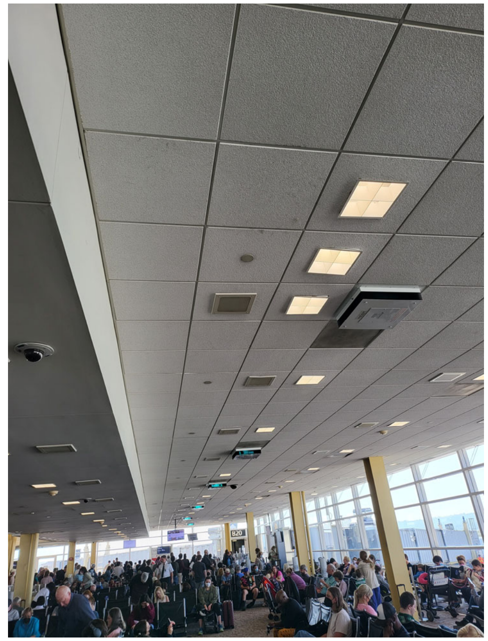
Pathogen reduction rates for EDU-495, 99.99% in seconds

Common name	UVGI K m^2/J	µw/cm^2	Nominal UVC lamp wattage	UVC intensity in microwatts @60" (5')	UVC intensity in microwatts @120"(10')	UVC intensity in microwatts @ 180" (15')	number of seconds to achieve 4-log reduction @ 60"	% pathogen reduction @ 60"	number of seconds to achieve 4-log reduction @ 120"	% pathogen reduction @ 120"	number of seconds to achieve 4-log reduction @ 180"	% pathogen reduction @ 180"
Strep	0.81100	0.00811	380w	387µ / sec.	99µ / sec.	39µ / sec.	3	99.992	12	99.993	29	99.990
Pneumonia	0.57210	0.005721	380w	387µ / sec.	99µ / sec.	39µ / sec.	5	99.998	17	99.993	42	99.991
Tuberculosis / TB	0.47210	0.004721	380w	387µ / sec.	99µ / sec.	39µ / sec.	6	99.998	20	99.991	50	99.990
Coronavirus	0.37700	0.00377	380w	387µ / sec.	99µ / sec.	39µ / sec.	7	99.996	25	99.991	63	99.991
Flu	0.11900	0.00119	380w	387µ / sec.	99µ / sec.	39µ / sec.	20	99.990	78	99.990	199	99.990
Staph / MRSA	0.11300	0.00113	380w	387µ / sec.	99µ / sec.	39µ / sec.	21	99.990	82	99.990	210	99.990
Measles	0.10510	0.001051	380w	387µ / sec.	99µ / sec.	39µ / sec.	23	99.991	89	99.990	225	99.990
Chicken Pox	0.10500	0.00105	380w	387µ / sec.	99µ / sec.	39µ / sec.	23	99.991	89	99.990	226	99.990
Meningitis (Viral)	0.03550	0.000355	380w	387µ / sec.	99µ / sec.	39µ / sec.	70	99.993	263	99.990	665	99.990
Meningitis (Fungal)	0.00822	0.0000822	380w	387µ / sec.	99µ / sec.	39µ / sec.	289	99.990	1130	99.990	2860	99.990
C.diff	0.00770	0.000077	380w	387µ / sec.	99µ / sec.	39µ / sec.	309	99.990	1210	99.990	3060	99.990
Meningitis (Bacterial)	0.00492	0.0000492	380w	387µ / sec.	99µ / sec.	39µ / sec.	486	99.990	1900	99.990	4800	99.990

UV Products

In-Duct In-AHU
Upper-Air
Surface

UVC Air Disinfection technology in transit



UVC Waiting Areas and Terminals

UV Products

Upper-Air

Upper air UV disinfects contaminated air using the natural process of convection.

- Contagious droplet nuclei is expelled when an infected person speaks, coughs or sneezes.
- Warmed droplets are carried on rising air currents.
- Pathogens are neutralized as they pass through the cleansing germicidal energy field.
- Cleaner, healthier air is naturally circulated throughout the space.
- A human body generates ~ 400btu / hour, enough convection heat energy to create about 20 air turns per hour without fans or ventilation.

Surface UV-C Disinfection in Transit

Emerging Technologies

LEDs

Air disinfection

Emerging UV Products for Transit

LEDs

- Pro
  - More efficient, less power consumption
  - Safer
  - Applies in smaller, more compact spaces
- Cons
  - Less output and UVC energy
  - Expensive to replace

Alternative Wavelengths

- UV- A & B: Non-Germicidal
- 222 nm
  - Pros: Reportedly safer for human exposure
  - Cons: Still yet untested

Thank you!

Questions?