Considerations for UVC Efficacy Test Standard of UV Devices in Healthcare Settings

UV for Whole Room Surface Disinfection

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presented by

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Current Status of Standards or Efficacy Claims for Whole Room UV Disinfection Devices

- Currently, no industry standards for characterizing efficacy of whole room UVC disinfection devices
- EPA regulated UV devices as pesticidal device, nut unlike pesticidal devices, they do not require product registration. Only requirement is of the facility to be EPA registered. Manufacturer is expected to have proof of whatever claims are being made for their device.
- Example marketing claims
  - …. Destroys (..or kills) bacteria in xxx minutes
  - … disinfects whole room in xxx minutes
  - … reduce infection rates by xxx %
  - … deactivates endospores in less than 5 minute
  - ….xxx % reduction of endospores in xxx minutes
  - …achieves minimum xxx log reduction in xxx minutes at xx feet distance

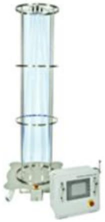
Variations of Portable UV Devices for Room Disinfection









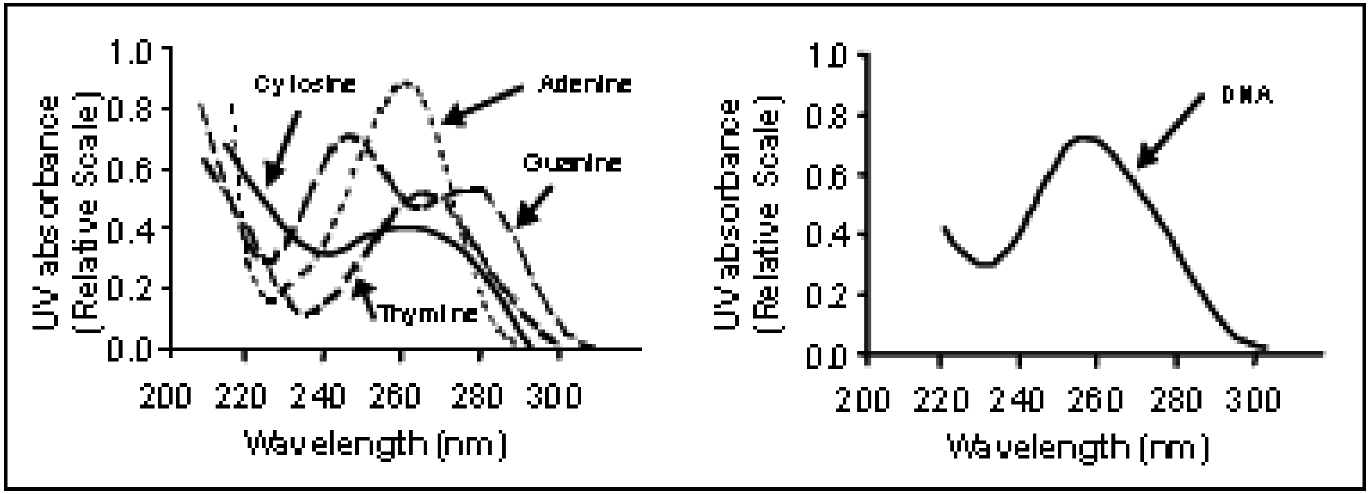





- **Fixed – Ceiling Mounted Devices available**
- **Various Object (phones, tablets, keypads, pens) disinfection also being introduced**

Variations of Portable UV Devices for Room Disinfection

- Different form factors and features such as user interface, safety, software, data reporting
- Different UV wavelengths employed:
  - UVC (254 nm)
  - Far UV 222 nm
  - UV LEDs 254 nm, 270+ nm
  - pulsed xenon (200-315nm)
  - Visible 405 nm (reactive oxygen species)

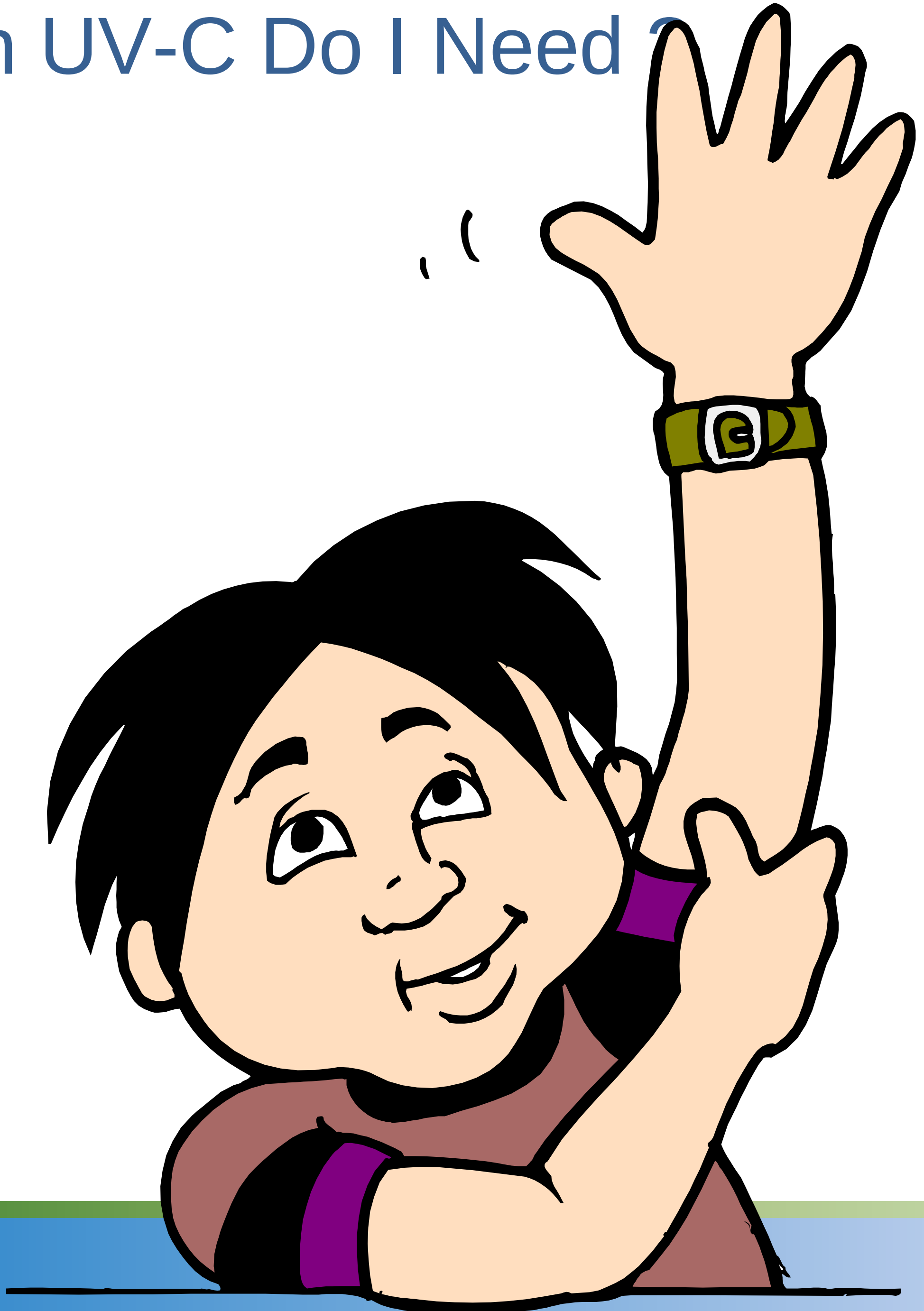


Source: Adapted from Jagger (1967)

Variations of Portable UV Devices for Room Disinfection

- Variation in treatment protocols: total room treatment time varies from 10 mins to 50 mins (except continuous 405 nm)
  - Total device output as a fn of # lamps, height, intensity, configuration, reflectors etc.
  - Device location / proximity to target surfaces
  - Single placement versus multiple placements
  - Automated cycle times based on room size mapping; reflected dose measurements, measured dose on surfaces
  - Clinical lab studies- variation in study set-up (no standard)
    - Strain of microorganism, carrier type & size, prep of inoculum, type of soiling, inoculation of carrier, distance/orientation of carrier w.r.t device etc. *(now addressed by new ASTM E 3135 standard)*
  - Inconsistent dose assumptions used by different manufacturers

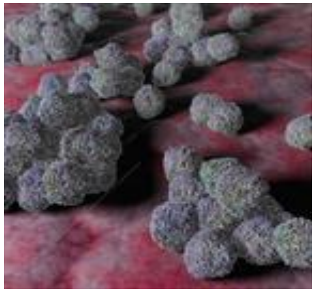
How Much UV-C Do I Need ?



UVC Efficacy

- **UVC Dose to achieve a specific log reduction varies from one micro-organism to another**

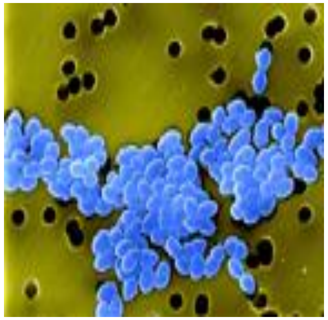
UVC Dose Values for 99% Disinfection (2 Log Reduction)



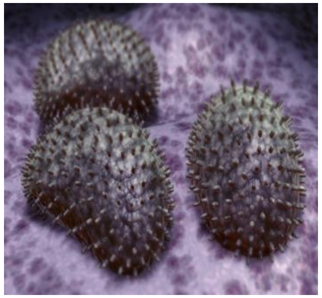
MRSA
7,106 μW-sec/cm²

Clostridium difficile
38,500 μW-sec/cm²

Acinetobacter Baumannii
6,600 μW-sec/cm²



VRE
12,600 μW-sec/cm²



Influenza A
4,558 μW-sec/cm²

Aspergillus Niger
330,000 μW-sec/cm²

Understanding UVC Dose vs Efficacy

- Level of disinfection is measured in terms of % disinfection or log reduction

  Log 1 (90%)   Log 2 (99%)   Log 3 (99.9%)   Log 4 (99.99%).....

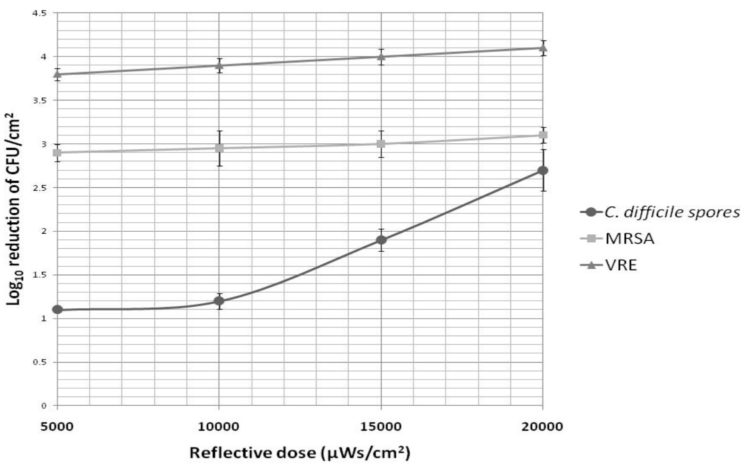
- Log reduction achieved on a target micro-organism is a function of applied UVC dose

- **Total Applied Dosage** = UVC Intensity at target x Time

- **Example: Clostridium Difficile (C-Diff)**
- *99% Disinfection (2 Log Reduction)*
- Dose required for 99% disinfection: 60,00 µw cm^2-sec
- Assume Device intensity on surface: 100µw/cm^2
- Total Time required : 60,000/100 = 600 secs (10 mins) !

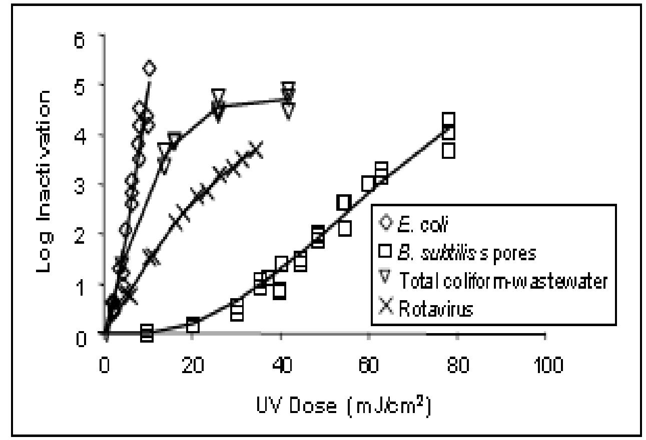
- *99.99% Disinfection (4 Log Reduction)*
- Theoretical Dose required for 99.99% disinfection: 120,000 µw secs/cm^2
- Total Time required : 120,000/100 = 1200 secs (20 mins) ! **IS THAT TRUE?**

Log Reduction as a function of UV Dose



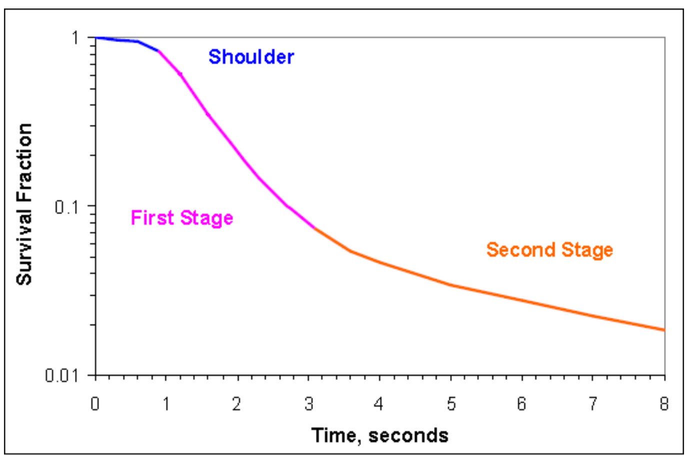
Nerandzic *et al. BMC Infectious Diseases* 2010, 10:197

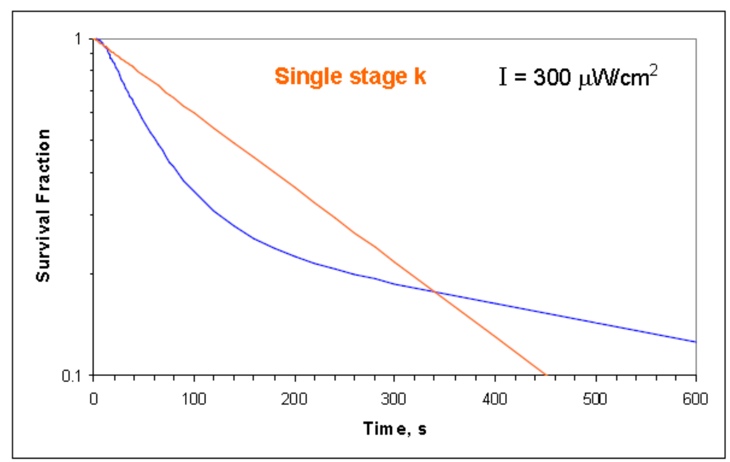
Figure 2.8. Shapes of UV Dose-Response Curves



Source: Adapted from Chang et al. (1985)

Multistage Microbial Response

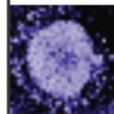
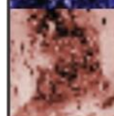
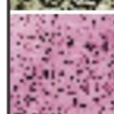




UV Rate Constants

<u>Factors affecting UV rate constants</u>

- Microbial species
  - Vegetative bacteria
  - Bacterial spore
  - Virus
  - Fungal cells & yeast
  - Fungal spores
- UV wavelength
- UV intensity
- Relative humidity
- Media type
  - Water
  - Air Surface

	AIRBORNE PATHOGEN	GROUP	SHAPE	DIA microns
	Rhinovirus	VIRUS	icosahedral	0.023
	Orthomyxovirus - Influenza	VIRUS	helical	0.10
	Coronavirus	VIRUS	helical	0.11
	Pseudomonas aeruginosa	BACTERIA	rods	0.57
	Staphylococcus aureus	BACTERIA	spherical	0.90 0.95 0.95
	Bacillus anthracis	BACTERIA	spores	1.13
	Aspergillus niger	FUNGI	spores	3.50
	Candida albicans	FUNGI	spores	5.00
	Stachybotris chartarum	FUNGI	spores	5.65

UV Rate Constants and Dose

Microbe	Type	Water		Surface		Air-Lo RH		Air –High RH	
		K (m2/J)	D_{90} (J/m^2)	K (m2/J)	D_{90} (J/m^2)	K (m2/J)	D_{90} (J/m^2)	K (m2/J)	D_{90} (J/m^2)
Bacteria	Veg	0.08463	27	0.14045	16	0.38887	6	0.07384	31
Viruses	All	0.05798	40	0.03156	73	0.39985	6	0.29050	8
Bacterial spores	Spores	0.01439	160	0.01823	126	0.02566	90	0.02600	89
Fungal cells/yeast	Veg	0.01008	229	0.00700	329	0.09986	23	-	-
Fungal spores	Spores	0.00916	251	0.00789	292	0.00730	315	0.00472	488

Ref: Ultraviolet Germicidal Irradiation Handbook, W. Kowalski, 2009