



Application Note #12

Ultraviolet Light Disinfection Data Sheet

Εφαρμογές

Το υπεριώδες φως μπορεί να χρησιμοποιηθεί με ασφάλεια για πολλές εφαρμογές απολύμανσης. Διατίθενται συστήματα για την απολύμανση δωματίων και περιοχών υψηλής αφής, ασθενοφόρων και άλλων οχημάτων υπηρεσίας έκτακτης ανάγκης, αγωγών, εξοπλισμού εργαλείων μέσα σε θάλαμο απολύμανσης, συνεχούς μεταφορείς διέλευσης υπεριώδους ακτινοβολίας UV-C και πολλές άλλες εφαρμογές. Είναι από καιρό διαθέσιμο για απολύμανση ντουλαπιών βιολογικής ασφάλειας και επεξεργασία νερού στο σπίτι επίσης. Παρέχει μια μέθοδο απολύμανσης ηχομονωτικών υλικών χωρίς χημικά που είναι παραδοσιακά χημικά ασύμβατα.

Παράρτημα 1 – Ιστορική χρήση υπεριώδους φωτός για απολύμανση

Τα τελευταία 100 χρόνια η επιστήμη έχει αναγνωρίσει τα βακτηριοκτόνα αποτελέσματα της υπεριώδους περιοχής του ηλεκτρομαγνητικού φάσματος. Ακολουθούν ορισμένες βασικές συνεισφορές όλα αυτά τα χρόνια:

1855 Οι Arloing και Daclaux έδειξαν ότι το φως του ήλιου εξάλειψε τους *Bacillus anthracis* και *Tyrophthrix scaber*

1877 Οι Downes και Blunt ανέφεραν ότι τα βακτήρια απενεργοποιήθηκαν από το ηλιακό φως – το πιο αποτελεσματικό φάσμα του βιολετί μπλε

1889 Η Widmark επιβεβαίωσε ότι οι ακτίνες UV από λαμπτήρες τόξου ήταν υπεύθυνες για την αδρανοποίηση.

1903 Οι Banard και Morgan προσδιόρισαν ότι το φάσμα UV 226-328 nm είναι βιοκτόνο

1932 Οι Ehris και Noethling απομόνωσαν το βιοκτόνο φάσμα στα 253,7 nm

1957 Ο Riley αποδεικνύει αποτελεσματικότητα για τον έλεγχο της φυματίωσης

1994 Το CDC αναγνωρίζει την αποτελεσματικότητα της υπεριώδους ακτινοβολίας για τον έλεγχο της φυματίωσης

1999 Ο ΠΟΥ συνιστά την UVGI για τον έλεγχο της φυματίωσης

Παράρτημα 2 – Δοσολογία έκθεσης σε υπεριώδες φως

Ο βαθμός αδρανοποίησης από την υπεριώδη ακτινοβολία σχετίζεται άμεσα με τη δόση ακτινοβολίας UV που εφαρμόζεται. Η δόση UV είναι το γινόμενο της έντασης UV [I] (εκφρασμένη ως ενέργεια ανά μονάδα επιφάνειας) και του χρόνου έκθεσης [T].

Επομένως: $\Delta OSH = I \times T$

Αυτή η δόση, που μερικές φορές αναφέρεται ως όριο ροής, εκφράζεται συνήθως ως millijoule ανά τετραγωνικό εκατοστό (mJ/cm^2). Οι μονάδες " J/m^2 " χρησιμοποιούνται στα περισσότερα μέρη του κόσμου εκτός από τη Βόρεια Αμερική, όπου χρησιμοποιούνται " mJ/cm^2 ".

Η αναγωγή των μικροοργανισμών ταξινομείται με χρήση λογαριθμικής κλίμακας. Μια μονή μείωση κατά log είναι μείωση του 90 % των οργανισμών. Μια μείωση κατά δύο log είναι μια μείωση του 99 % των οργανισμών, ακολουθούμενη από μια μείωση κατά τρία log (99,9 %), κ.λπ. Η δόση έκθεσης σε υπεριώδη ακτινοβολία UV-C που απαιτείται για κάθε επίπεδο μείωσης εμφανίζεται στον πίνακα μαζί με τη δημοσιευμένη αναφορά από όπου προήλθαν τα δεδομένα.



UV Dose (Fluence) (mJ/cm2) for a given Log Reduction without photo-reactivation

Spore	Lamp	1	2	3	4	5	6	7	Reference
	Type								
Bacillus anthracis spores - Anthrax spores	N/A	24.32	46.2						Light Sources Inc. 2014
Bacillus magaterium sp. (spores)	N/A	2.73	5.2						Light Sources Inc. 2014
Bacillus subtilis ATCC6633	N/A	36	48.6	61	78				Chang et al. 1985
Bacillus subtilis ATCC6633	LP	24	35	47	79				Mamane-Gravetz and Linden 2004
Bacillus subtilis ATCC6633	LP	22	38	>50					Sommer et al. 1998
Bacillus subtilis ATCC6633	LP	20	39	60	81				Sommer et al. 1999
Bacillus subtilis WN626	LP	0.4	0.9	1.3	2				Marshall et al., 2003
Bacillus subtilis spores	N/A	11.6	22.0						Light Sources Inc. 2014
Bacillus anthracis – Anthrax		4.52	9.04	13.56	18.08				UV-Light.co.UK
Bacillus anthracis spores – Anthrax spores		24.32	48.64	72.96	97.28				UV-Light.co.UK
Bacillus magaterium sp. (spores)		2.73	5.46	8.19	10.92				UV-Light.co.UK
Bacillus magaterium sp. (veg.)		1.3	2.6	3.9	5.2				UV-Light.co.UK
Bacillus paratyphus		3.2	6.4	9.6	12.8				UV-Light.co.UK
Bacillus subtilis spores		11.6	23.2	34.8	46.4				UV-Light.co.UK
Bacillus subtilis		5.8	11.6	17.4	23.2				UV-Light.co.UK
Clostridium difficile (C. difficile or C. diff)		6.0	12.0	18.0	24.0				UV-Light.co.UK
Clostridium tetani		13.0	26.0	39.0	52.0				UV-Light.co.UK
Bacterium									
Aeromonas salmonicida	LP	1.5	2.7	3.1	5.9				Liltved and Landfald 1996
Aeromonas hydrophila ATCC7966	LP	1.1	2.6	3.9	5	6.7	8.6		Wilson et al. 1992
Bacillus anthracis - Anthrax	N/A	4.52	8.7						Light Sources Inc. 2014
Bacillus magaterium sp. (veg.)	N/A	1.3	2.5						Light Sources Inc. 2014
Bacillus paratyphus	N/A	3.2	6.1						Light Sources Inc. 2014
Bacillus subtilis	N/A	5.8	11.0						Light Sources Inc. 2014
Campylobacter jejuni ATCC 43429	LP	1.6	3.4	4	4.6	5.9			Wilson et al. 1992
Citrobacter diversus	LP	5	7	9	11.5	13			Giese and Darby 2000
Citrobacter freundii	LP	5	9	13					Giese and Darby 2000
Clostridium tetani	N/A	13.0	22.0						Light Sources Inc. 2014
Corynebacterium diphtheriae	N/A	3.37	6.51						Light Sources Inc. 2014
Corynebacterium diphtheriae		3.37	6.74	10.11	13.48				UV-Light.co.UK
Ebertelia typhosa	N/A	2.14	4.1						Light Sources Inc. 2014V
Ebertelia typhosa		2.14	4.28	6.42	8.56				UV-Light.co.UK
Escherichia coli O157:H7 CCUG 29193	LP	3.5	4.7	5.5	7				Sommer et al. 2000
Escherichia coli O157:H7 CCUG 29197	LP	2.5	3	4.6	5	5.5			Sommer et al. 2000
Escherichia coli O157:H7 CCUG 29199	LP	0.4	0.7	1	1.1	1.3	1.4		Sommer et al. 2000
Escherichia coli O157:H7 ATCC 43894	LP	1.5	2.8	4.1	5.6	6.8			Wilson et al. 1992
Escherichia coli	N/A	3.0	6.6						Light Sources Inc. 2014
Escherichia coli ATCC 11229	N/A	2.5	3	3.5	5	10	15		Harris et al. 1987
Escherichia coli		3.00	6.0	9.0	12.0				UV-Light.co.UK
Escherichia coli ATCC 11229	N/A	3	4.8	6.7	8.4	10.5			Chang et al. 1985
Escherichia coli ATCC 11229	LP	<5	5.5	6.5	7.7	10			Zimmer et al. 2002
Escherichia coli ATCC 11229	MP	<3	<3	<3	<3	8			Zimmer et al. 2002
Escherichia coli ATCC 11229	LP	7	8	9	11	12			Hoyer 1998



UV Dose (Fluence) (mJ/cm2) for a given Log Reduction without photo-reactivation

	Lamp Type	1	2	3	4	5	6	7	Reference
<i>Salmonella derby</i> (from human feces)	N/A	3.5	7.5						Tosa and Hirata 1998
<i>Salmonella enteritidis</i> (from human feces)	N/A	5	7	9	10				Tosa and Hirata 1998
<i>Salmonella infantis</i> (from human feces)	N/A	2	4	6					Tosa and Hirata 1998
<i>Salmonella spp.</i>	LP	<2	2	3.5	7	14	29		Yaun et al. 2003
<i>Salmonella typhi</i> ATCC 19430	LP	1.8	4.8	6.4	8.2				Wilson et al. 1992
<i>Salmonella typhi</i> ATCC 6539	N/A	2.7	4.1	5.5	7.1	8.5			Chang et al. 1985
<i>Salmonella typhimurium</i> (from human feces)	N/A	2	3.5	5	9				Tosa and Hirata 1998
<i>Salmonella typhimurium</i>	UVB	50	100	175	210	250			Joux et al. 1999
<i>Salmonella typhimurium</i> (in act. sludge)	LP	3	11.5	22	50				Maya et al. 2003
<i>Salmonella enteritidis</i>	N/A	4.0	7.6						Light Sources Inc. 2014
<i>Salmonella typhimurium</i>	N/A	8.0	15.2						Light Sources Inc. 2014
<i>Salmonella typhosa</i> - Typhoid fever	N/A	2.15	4.1						Light Sources Inc. 2014
<i>Salmonella enteritidis</i>		4.0	8.0	12.0	16.0				UV-Light.co.UK
<i>Salmonella paratyphi</i> – Enteric fever		3.2	6.4	9.6	12.8				UV-Light.co.UK
<i>Salmonella typhosa</i> – Typhoid fever		2.15	4.3	6.45	8.6				UV-Light.co.UK
<i>Salmonella typhimurium</i>		8.0	16.0	24.0	32.0				UV-Light.co.UK
<i>Sarcina lutea</i>	N/A	19.7	26.4						Light Sources Inc. 2014
<i>Sarcina lutea</i>		19.7	39.4	59.1	78.8				UV-Light.co.UK
<i>Serratia marcescens</i>	N/A	2.42	6.16						Light Sources Inc. 2014
<i>Serratia marcescens</i>		2.42	4.84	7.26	9.68				UV-Light.co.UK
<i>Shigella dysenteriae</i> ATCC29027	LP	0.5	1.2	2	3	4	5.1		Wilson et al. 1992
<i>Shigella dysenteriae</i> - Dysentery	N/A	2.2	4.2						Light Sources Inc. 2014
<i>Shigella flexneri</i> - Dysentery	N/A	1.7	3.4						Light Sources Inc. 2014
<i>Shigella paradysenteriae</i>	N/A	1.68	3.4						Light Sources Inc. 2014
<i>Shigella sonnei</i> ATCC9290	N/A	3.2	4.9	6.5	8.2				Chang et al. 1985
<i>Spirillum rubrum</i>	N/A	4.4	6.16						Light Sources Inc. 2014
<i>Spirillum rubrum</i>		4.4	8.8	13.2	17.6				UV-Light.co.UK
<i>Shigella dysenteriae</i> – Dysentery		2.2	4.4	6.6	8.8				UV-Light.co.UK
<i>Shigella flexneri</i> – Dysentery		1.7	3.4	5.1	6.8				UV-Light.co.UK
<i>Shigella paradysenteriae</i>		1.68	3.3	5.04	6.72				UV-Light.co.UK
<i>Staphylococcus aureus</i> ATCC25923	N/A	3.9	5.4	6.5	10.4				Chang et al. 1985
<i>Staphylococcus albus</i>	N/A	1.84	5.72						Light Sources Inc. 2014
<i>Staphylococcus albus</i>		1.84	3.68	5.52	7.36				UV-Light.co.UK
<i>Staphylococcus aureus</i>	N/A	2.6	6.6						Light Sources Inc. 2014
<i>Staphylococcus hemolyticus</i>	N/A	2.16	5.5						Light Sources Inc. 2014
<i>Staphylococcus lactis</i>	N/A	6.15	8.8						Light Sources Inc. 2014
<i>Staphylococcus aureus</i>		2.6	5.2	7.8	10.4				UV-Light.co.UK
<i>Staphylococcus hemolyticus</i>		2.16	4.32	6.48	8.64				UV-Light.co.UK
<i>Staphylococcus lactis</i>		6.15	12.3	18.45	24.6				UV-Light.co.UK
<i>Streptococcus viridans</i>		2.0	4.0	6.0	8.0				UV-Light.co.UK
<i>Streptococcus faecalis</i> (secondary effluent)	N/A	5.5	6.5	8	9	12			Harris et al. 1987
<i>Streptococcus faecalis</i> ATCC29212	N/A	6.6	8.8	9.9	11.2				Chang et al. 1985
<i>Streptococcus viridans</i>	N/A	2.0	3.8						Light Sources Inc. 2014
<i>Vibrio anguillarum</i>	LP	0.5	1.2	1.5	2				Lilved and Landfald 1996
<i>Vibrio cholerae</i> ATCC25872	LP	0.8	1.4	2.2	2.9	3.6	4.3		Wilson et al. 1992
<i>Vibrio comma</i> - Cholera	N/A	3.375	6.5						Light Sources Inc. 2014
<i>Vibrio natriegens</i>	UVB	37.5	75	100	130	150			Joux et al. 1999

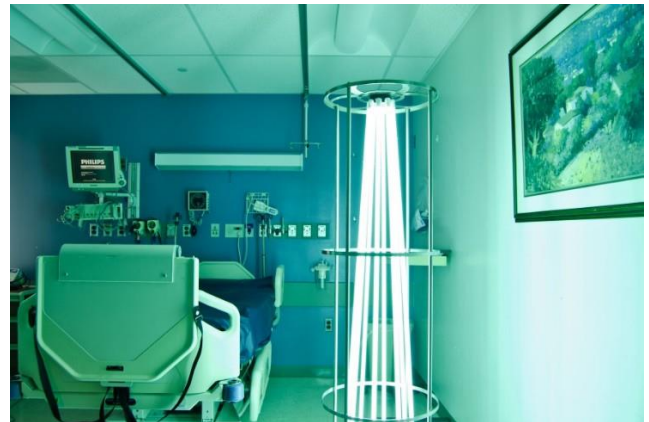


UV Dose (Fluence) (mJ/cm2) for a given Log Reduction without photo-reactivation

	Lamp Type	1	2	3	4	5	6	7	Reference
<i>Vibrio comma – Cholera</i>		3.375	6.75	10.125	13.5				UV-Light.co.UK
<i>Yersinia enterocolitica</i> ATCC27729	LP	1.7	2.8	3.7	4.6				Wilson et al. 1992
<i>Yersinia ruckeri</i>	LP	1	2	3	5				Liltved and Landfald 1996
Yeasts									
Brewers yeast	N/A	3.3	6.6						Light Sources Inc. 2014
Brewers yeast		3.3	6.6	9.9	13.2				UV-Light.co.UK
Common yeast cake	N/A	6.0	13.2						Light Sources Inc. 2014
Common yeast cake		6.0	12.0	18.0	24.0				UV-Light.co.UK
<i>Saccharomyces carevisiae</i>	N/A	6.0	13.2						Light Sources Inc. 2014
<i>Saccharomyces carevisiae</i>		6.0	12.0	18.0	24.0				UV-Light.co.UK
<i>Saccharomyces ellipsoideus</i>	N/A	6.0	13.2						Light Sources Inc. 2014
<i>Saccharomyces ellipsoideus</i>		6.0	12.0	18.0	24.0				UV-Light.co.UK
<i>Saccharomyces</i> spores	N/A	8.0	17.6						Light Sources Inc. 2014
<i>Saccharomyces</i> spores		8.0	16.0	24.0	32.0				UV-Light.co.UK
Molds									
<i>Aspergillus flavus</i>	N/A	60.0	99.0						Light Sources Inc. 2014
<i>Aspergillus flavus</i>		60.0	120.0	180.0	240.0				UV-Light.co.UK
<i>Aspergillus glaucus</i>	N/A	44.0	88.0						Light Sources Inc. 2014
<i>Aspergillus glaucus</i>		44.0	88.0	132.0	176.0				UV-Light.co.UK
<i>Aspergillus niger</i>	N/A	132.0	330.0						Light Sources Inc. 2014
<i>Aspergillus niger</i>		132.0	264.0	396.0	528.0				UV-Light.co.UK
<i>Mucor racemosus</i> A	N/A	17.0	35.2						Light Sources Inc. 2014
<i>Mucor racemosus</i> A		17.0	34.0	51.0	68.0				UV-Light.co.UK
<i>Mucor racemosus</i> B	N/A	17.0	35.2						Light Sources Inc. 2014
<i>Mucor racemosus</i> B		17.0	34.0	51.0	68.0				UV-Light.co.UK
<i>Oospora lactis</i>	N/A	5.0	11.0						Light Sources Inc. 2014
<i>Oospora lactis</i>		5.0	10.0	15.0	20.0				UV-Light.co.UK
<i>Penicillium expansum</i>		13.0	26.0	39.0	52.0				UV-Light.co.UK
<i>Penicillium digitatum</i>	N/A	44.0	88.0						Light Sources Inc. 2014
<i>Penicillium digitatum</i>		44.0	88.0	132.0	176.0				UV-Light.co.UK
<i>Penicillium expansum</i>	N/A	13.0	22.0						Light Sources Inc. 2014
<i>Penicillium roqueforti</i>	N/A	13.0	26.4						Light Sources Inc. 2014
<i>Penicillium roqueforti</i>		13.0	26.0	39.0	52.0				UV-Light.co.UK
<i>Rhizopus nigricans</i>	N/A	111.0	220.0						Light Sources Inc. 2014
<i>Rhizopus nigricans</i>		111.0	222.0	333.0	444.0				UV-Light.co.UK
Protozoan									
<i>Chlorella Vulgaris</i>	N/A	13.0	22.0						Light Sources Inc. 2014
<i>Chlorella Vulgaris</i>		13.0	26.0	39.0	52.0				UV-Light.co.UK
<i>Cryptosporidium hominis</i>	LP & MP	3	5.8						Johnson et al. 2005
<i>Cryptosporidium parvum</i>	LP & MP	2.4	<5	5.2	9.5				Craik et al. 2001
<i>Cryptosporidium parvum</i>	MP	<5	<5	<5	~6				Amoah et al. 2005
<i>Cryptosporidium parvum</i>	MP	<10	<10	<10					Belosevic et al. 2001
<i>Cryptosporidium parvum</i>	LP	1	2	<5					Shin et al. 2001
<i>Cryptosporidium parvum</i>	MP	1	2	2.9	4				Bukhari et al. 2004
<i>Cryptosporidium parvum</i>	LP	<2	<2	<2	<4	<10			Clancy et al. 2004
<i>Cryptosporidium parvum</i>	MP	<3	<3	3-9	<11				Clancy et al. 2000
<i>Cryptosporidium parvum</i>	LP	<3	<3	3-6	<16				Clancy et al. 2000
<i>Cryptosporidium parvum</i>	LP	0.5	1	1.4	2.2				Morita et al. 2002
<i>Cryptosporidium parvum</i>	LP	2	<3	<3					Zimmer et al. 2003

UV Dose (Fluence) (mJ/cm²) for a given Log Reduction without photo-reactivation

	Lamp Type	1	2	3	4	5	6	7	Reference
<i>Cryptosporidium parvum</i>	MP	<1	<1	<1					Zimmer et al. 2003
<i>Cryptosporidium parvum</i> , oocysts, tissue culture assay	N/A	1.3	2.3	3.2					Shin et al. 2000
<i>Encephalitozoon cuniculi</i> , microsporidia	LP	4	9	13					Marshall et al. 2003
<i>Encephalitozoon hellem</i> , microsporidia	LP	8	12	18					Marshall et al. 2003
<i>Encephalitozoon intestinalis</i> , microsporidia	LP & MP	<3	3	<6	6				Huffman et al. 2002
<i>Encephalitozoon intestinalis</i> , microsporidia	LP	3	5	6					Marshall et al. 2003
<i>G. muris</i> , cysts	MP	<5	<5	5					Amoah et al. 2005
<i>G. muris</i> , cysts, mouse infectivity assay	N/A	<2	<6	10 + tailing					Craik et al. 2000
<i>Giardia lamblia</i>	LP	<10	~10	<20					Campbell et al. 2002
<i>Giardia lamblia</i>	LP	<2	<2	<4					Mofidi et al. 2002
<i>Giardia lamblia</i> , gerbil infectivity assay	LP	<0.5	<0.5	<0.5	<1				Linden et al. 2002b
<i>Giardia lamblia</i> , excystation assay	N/A	40	180						Karanis et al. 1992
<i>Giardia lamblia</i> , excystation assay	N/A	> 63							Rice and Hoff 1981
<i>Giardia muris</i>	MP	1	4.5	28 + tailing					Craik et al. 2000
<i>Giardia muris</i>	MP	<10	<10	<25	~60				Belosevic et al. 2001
<i>Giardia muris</i>	LP	<1.9	<1.9	~2	~2.3				Hayes et al. 2003
<i>Giardia muris</i>	LP	<2	<2	<4					Mofidi et al. 2002
<i>Giardia muris</i> , excystation assay	N/A	77	110						Carlson et al. 1985
Nematode Eggs	N/A	45.0	92.0						Light Sources Inc. 2014
Nematode Eggs		45.0	90.0	135.0	180.0				UV-Light.co.UK
Paramecium	N/A	11.0	20.0						Light Sources Inc. 2014
Paramecium		11.0	22.0	33.0	44.0				UV-Light.co.UK





The following table shows the required UV-C exposure dosages necessary for various log reductions of viruses.

UV Dose (Fluence) (mJ/cm ²) for a given Log Reduction without photo-reactivation									
Virus	Host	Lamp	1	2	3	4	5	6	
Adenovirus type 15	A549 cell line (ATCC CCL-185)	LP	40	80	122	165	210		Thompson et al. 2003
Adenovirus type 2	A549 cell line	LP	20	45	80	110			Shin et al. 2005
Adenovirus type 2	Human lung cell line	LP	35	55	75	100			Ballester and Malley 2004
Adenovirus type 2	PLC / PRF / 5 cell line	LP	40	78	119	160	195	235	Gerba et al.
Adenovirus type	PLC / PRF / 5 cell	LP	55	105	155				ston-Enriquez
Adenovirus type	PLC / PRF / 5 cell	LP	30	ND	ND	124			Meng and Gerba
Adenovirus type	PLC / PRF / 5 cell	LP	23.6	ND	ND	111.8			Meng and Gerba
B40-8 (Phage)	B. Fragilis	LP	11	17	23	29	35	41	Sommer et al.
B40-8 (Phage)	B. fragilis HSP-40	LP	12	18	23	28			Sommer et al
Bacteriophage - E. Coli	N/A	N/A	2.6	6.6					Light Sources Inc.
Bacteriophage – E. Coli			2.6	5.2	7.8	104.0			UV-Light.co.UK
Calicivirus canine	MDCK cell line	LP	7	15	22	30	36		Husman et al.
Calicivirus feline	CRFK cell line	LP	7	16	25				Husman et al.
Calicivirus feline	CRFK cell line	N/A	4	9	14				Tree et al. 2005
Calicivirus feline	CRFK cell line	LP	5	15	23	30	39		ston-Enriquez et al. 2003
Coxsackievirus B3	BGM cell line	LP	8	16	24.5	32.5			Gerba et al.
Coxsackievirus B5	Buffalo Green Monkey cell line	N/A	6.9	13.7	20.6				Battigelli et al. 1993
Coxsackievirus B5	BGM cell line	LP	9.5	18	27	36			Gerba et al.
Echovirus I	BGM cell line	LP	8	16.5	25	33			Gerba et al.
Echovirus II	BGM cell line	LP	7	14	20.5	28			Gerba et al.
Hepatitis A	HAV/HFS/GBM	N/A	5.5	9.8	15	21			Wiedenmann et
Hepatitis A HM175	FRhK-4 cell	LP	5.1	13.7	22	29.6			Wilson et al.
Hepatitis A HM175	FRhK-4 cell	N/A	4.1	8.2	12.3	16.4			Battigelli et al.
Infectious Hepatitis	N/A	N/A	5.8	8.0					Light Sources Inc.
Infectious Hepatitis			5.8	11.6	17.4	232.0			UV-Light.co.UK
Influenza	N/A	N/A	3.4	6.6					Light Sources Inc.
Influenza			3.4	6.8	10.2	136.0			UV-Light.co.UK
MS2 (Phage)	Sal monella typhimurium WG49	N/A	16.3	35	57	83	114	152	Nieuwstad and Havelaar
MS2 (Phage)	E. coli K-12 Hfr	LP	21	36					Sommer et al.
MS2 (Phage)	E. coli CR63	N/A	16.9	33.8					Rauth 1965
MS2 (Phage)	E. coli 15977	N/A	13.4	28.6	44.8	61.9	80.1		Meng and Gerba
MS2 (Phage)	E. coli C3000	N/A	35						Battigelli et al.
MS2 (Phage)	E. coli ATCC 15597	N/A	19	40	61				Oppenheimer et
MS2 (Phage)	E. coli C3000	LP	20	42	69	92			Batch et al. 2004
MS2 (Phage)	E. coli ATCC 15597	LP	20	42	70	98	133		Lazarova and



UV Dose (Fluence) (mJ/cm²) for a given Log Reduction without photo-reactivation

Virus	Host	Lamp	1	2	3	4	5	6	
MS2 (Phage)	<i>E. coli</i> ATCC 15977	LP	20	50	85	120			Thurston-Enriquez et al., 2003
MS2 (Phage)	<i>E. coli</i> HS(pFamp)R	LP		45	75	100	125	155	Thompson et al.
MS2 (Phage)	<i>E. coli</i> C3000	LP	20	42	68	90			Linden et al.
MS2 (Phage)	<i>E. coli</i> K-12	LP	18.5	36	55				Sommer et al.
MS2 (Phage)	<i>E. coli</i> NCIMB 9481	N/A	14						Tree et al. 2005
MS2 ATCC 15977-B1 (Phage)	<i>E. coli</i> ATCC 15977-B1	LP	15.9	34	52	71	90	109	Wilson et al. 1992
MS2 DSM 5694 (Phage)	<i>E. coli</i> NCIB 9481	N/A	4	16	38	68	110		Wiedenmann et al 1993
MS2 NCIMB 10108 (Phage)	<i>Salmonella typhimurium</i> WG49	N/A	12.1	30.1					Tree et al. 1997
PHI X 174 (Phage)	<i>E. coli</i> WG5	LP	2.2	5.3	7.3	10.5			Sommer et al.
PHI X 174 (Phage)	<i>E. coli</i> C3000	N/A	2.1	4.2	6.4	8.5	10.6	12.7	Battigelli et al.
PHI X 174 (Phage)	<i>E. coli</i> ATCC15597	N/A	4	8	12				Oppenheimer et
PHI X 174 (Phage)	<i>E. coli</i> WG 5	LP	3	5	7.5	10	12.5	15	Sommer et al.
PHI X 174 (Phage)	<i>E. coli</i> ATCC 13706	LP	2	3.5	5	7			Giese and Darby
Poliovirus - Poliomyelitis	N/A	N/A	3.15	6.6					Light Sources Inc.
Poliovirus – Poliomyelitis			3.15	6.3	9.45	126.0			UV-Light.co.UK
Poliovirus 1	BGM cell line	N/A	5	11	18	27			Tree et al. 2005
Poliovirus 1	CaCo2 cell-line (ATCC HTB37)	LP	7	17	28	37			Thompson et al. 2003
Poliovirus 1	BGM cell line	LP	8	15.5	23	31			Gerba et al.
Poliovirus Type Mahoney	Monkey kidney cell line Vero	LP	3	7	14	40			Sommer et al. 1989
Poliovirus Type 1 ATCC Mahoney	N/A	N/A	6	14	23	30			Harris et al. 1987
Poliovirus Type 1 LSc2ab ()	MA104 cell	N/A	5.6	11	16.5	21.5			Chang et al. 1985
Poliovirus Type 1 LSc2ab	BGM cell	LP	5.7	11	17.6	23.3	32	41	Wilson et al. 1992
PRD-1 (Phage)	<i>S. typhimurium</i> Lt2	N/A	9.9	17.2	23.5	30.1			Meng and Gerba
Reovirus Type 1 Lang strain	N/A	N/A	16	36					Harris et al. 1987
Reovirus-3	Mouse L-60	N/A	11.2	22.4					Rauth 1965
Rotavirus	MA104 cells	LP	20	80	140	200			Caballero et al.
Rotavirus SA-11	Monkey kidney cell line MA 104	LP	8	15	27	38			Sommer et al. 1989
Rotavirus SA-11	MA-104 cell line	N/A	7.6	15.3	23				Battigelli et al.
Rotavirus SA-11	MA-104 cell line	N/A	7.1	14.8	25				Chang et al.
Rotavirus SA-11	MA-104 cell line	LP	9.1	19	26	36	48		Wilson et al.
Staphylococcus aureus phage A 994	<i>aphylococcus aureus</i> 994	LP	8	17	25	36	47		Sommer et al. 1989
Tobacco mosaic	N/A	N/A	240.0	440.0					Light Sources Inc.



Appendix 3 – Persistence of Bacteria (As compiled via a Google Search)

Persistence of Clinically Relevant Bacteria on Dry Inanimate Surfaces ¹	
Organism	Persistence
Acinetobacter spp.	3 days to 5 months
Bordetella pertussis	3-5 days
Campylobacter jejuni	Up to 6 days
Clostridium difficile (spores)	5 months
Chlamydia pneumoniae	Up to 30 hours
Chlamydia psittaci	15 days
Corynebacterium diphtheria	7 days – 6 months
Corynebacterium pseudotuberculosis	1-8 days
Escherichia coli	1.5 hours – 16 months
Enterococcus spp. including VRE and VSE	5 days – 4 months
Haemophilus influenza	12 days
Helicobacter pylori	Up to 90 minutes
Klebsiella spp.	2 hours – 30 months
Listeria spp.	1 day – 4 months
Mycobacterium bovis	Up to 2 months
Mycobacterium tuberculosis	1 day – 4 months
Neisseria gonorrhoeae	1-3 days
Proteus vulgaris	1-2 days
Pseudomonas aeruginosa	6 hours – 16 months; 5 weeks on dry floor
Salmonella typhi	6 hours – 4 weeks
Salmonella typhimurium	10 days – 4.2 years
Salmonella spp.	1 day
Serratia marcescens	3 days – 2 months; 5 weeks on dry floor
Shigella spp.	2 days – 5 months
Staphylococcus aureus, including MRSA	7 days – 7 months
Streptococcus pneumoniae	1-20 days
Streptococcus pyogenes	3 days – 6.5 months
Vibrio cholera	1-7 days

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