

Ultraviolet Dose Required for 99.9% Inactivation of Various Microbes ($\mu\text{W-sec}/\text{cm}^2$)



Pure, safe water.
Always:

Bacteria	UV Dose	Bacteria	UV Dose
Agrobacterium lumefaciens 5	8,500	Pseudomonas aeruginosa (Environ.Strain) 1,2,3,4,5,9	10,500
Bacillus anthracis 1,4,5,7,9 (anthrax veg.)	8,700	Pseudomonas aeruginosa (Lab. Strain) 5,7	3,900
Bacillus megatherium Sp. (veg) 4,5,9	2,500	Rhodospirillum rubrum 5	6,200
Bacillus megatherium Sp. (spores) 4,9	5,200	Salmonella enteritidis 3,4,5,9	7,600
Bacillus paratyphosus 4,9	6,100	Salmonella paratyphi (Enteric Fever) 5,7	6,100
Bacillus subtilis 3,4,5,6,9	11,000	Salmonella Species 4,7,9	15,200
Bacillus subtilis Spores 2,3,4,6,9	22,000	Salmonella typhimurium 4,5,9	15,200
Clostridium tetani	23,100	Salmonella typhi (Typhoid Fever) 7	7,000
Clostridium botulinum	11,200	Salmonella	10,500
Corynebacterium diphtheriae 1,4,5,7,8,9	6,500	Sarcina lutea 1,4,5,6,9	26,400
Dysentery bacilli 3,4,7,9	4,200	Serratia marcescens 1,4,6,9	6,160
Eberthella typhosa 1,4,9	4,100	Shigella dysenteriae - Dysentery 1,5,7,9	4,200
Escherichia coli 1,2,3,4,9	6,600	Shigella flexneri - Dysentery 5,7	3,400
Legionella bozemanii 5	3,500	Shigella paradysenteriae 4,9	3,400
Legionella dumoffii 5	5,500	Shigella sonnei 5	7,000
Legionella gormanii 5	4,900	Spirillum rubrum 1,4,6,9	6,160
Legionella micdadei 5	3,100	Staphylococcus albus 1,6,9	5,720
Legionella longbeachae 5	2,900	Staphylococcus aureus 3,4,6,9	6,600
Legionella pneumophila (Legionnaire's Disease)	12,300	Staphylococcus epidermidis 5,7	5,800
Leptospira canicola-Infectious Jaundice 1,9	6,000	Streptococcus faecalis 5,7,8	10,000
Leptospira interrogans 1,5,9	6,000	Streptococcus hemolyticus 1,3,4,5,6,9	5,500
Micrococcus candidus 4,9	12,300	Streptococcus lactis 1,3,4,5,6	8,800
Micrococcus sphaeroides 1,4,6,9	15,400	Streptococcus pyogenes	4,200
Mycobacterium tuberculosis 1,3,4,5,7,8,9	10,000	Streptococcus salivarius	4,200
Neisseria catarrhalis 1,4,5,9	8,500	Streptococcus viridans 3,4,5,9	3,800
Phytomonas tumefaciens 1,4,9	8,500	Vibrio comma (Cholera) 3,7	6,500
Proteus vulgaris 1,4,5,9	6,600	Vibrio cholerae 1,5,8,9	6,500
Molds	UV Dose	Molds	UV Dose
Aspergillus amstelodami	77,000	Oospora lactis 1,3,4,6,9	11,000
Aspergillus flavus 1,4,5,6,9	99,000	Penicillium chrysogenum	56,000
Aspergillus glaucus 4,5,6,9	88,000	Penicillium digitatum 4,5,6,9	88,000
Aspergillus niger (bread mold) 2,3,4,5,6,9	330,000	Penicillium expansum 1,4,5,6,9	22,000
Mucor mucedo	77,000	Penicillium roqueforti 1,2,3,4,5,6	26,400
Mucor racemosus (A & B) 1,3,4,6,9	35,200	Rhizopus nigricans (cheese mold) 3,4,5,6,9	220,000
Protozoa	UV Dose	Protozoa	UV Dose
Chlorella vulgaris (algae) 1,2,3,4,5,9	22,000	Giardia lamblia (cysts) 9,10	<20,000
Blue-green Algae	420,000	Nematode Eggs 6	40,000
E. histolytica	84,000	Cryptosporidium oocysts 9,10	<20,000
Virus	UV Dose	Virus	UV Dose
Adeno Virus Type III 3	4,500	Influenza 1,2,3,4,5,7,9	6,600
Bacteriophage 1,3,4,5,6,9	6,600	Rotavirus 5	24,000
Coxsackie	6,300	Tobacco Mosaic 2,4,5,6,9	440,000
Infectious Hepatitis 1,5,7,9	8,000		
Yeasts	UV Dose	Yeasts	UV Dose
Baker's Yeast 1,3,4,5,6,7,9	8,800	Saccharomyces cerevisiae 4,6,9	13,200
Brewer's Yeast 1,2,3,4,5,6,9	6,600	Saccharomyces ellipsoideus 4,5,6,9	13,200
Common Yeast Cake 1,4,5,6,9	13,200	Saccharomyces sp. 2,3,4,5,6,9	17,600

1. "The Use of Ultraviolet Light for Microbial Control", Ultrapure Water, April 1989.
2. William V. Collentro, "Treatment of Water with Ultraviolet Light - Part I", Ultrapure Water, July/August 1986.
3. James E. Cruver, Ph.D., "Spotlight on Ultraviolet Disinfection", Water Technology, June 1984.
4. Dr. Robert W. Legan, "Alternative Disinfection Methods-A Comparison of UV and Ozone", Industrial Water Engineering, Mar/Apr 1982.
5. Unknown
6. Rudolph Nagy, Research Report BL-R-6-1059-3023-1, Westinghouse Electric Corporation.
7. Myron Lupal, "UV Offers Reliable Disinfection", Water Conditioning & Purification, November 1993.
8. John Treij, "Ultraviolet Technology", Water Conditioning & Purification, December 1995.9. Bak Srikanth, "The Basic Benefits of Ultraviolet Technology", Water Conditioning & Purification, December 1995
9. Clancy, J.L., et al., "Using UV to Inactivate Cryptosporidium," Journal of American Water Works Association, 92 (9) 97-104, 2000.
10. Shin, G., et al., Low Pressure UV Inactivation of Cryptosporidium parvum and Giardia lamblia Based on Infectivity Assays and DNA Repair of UV-Irradiated Cryptosporidium parvum Oocysts, AWWA WQTC Conference, November 2000, Salt Lake City, 2000