

The Basic Benefits of Ultraviolet Technology

It is fast, effective, economical and won't harm the environment

by Bak Srikanth

Ultraviolet (UV) light treatment is a widely recognized and proven method of disinfection of water and has several advantages over other disinfection methods such as chlorination, ozonation, etc. UV light does not add anything to the water, such as undesirable color, odor, taste or flavor, nor does it generate harmful by-products. It adds only energy in the form of ultraviolet radiation. Also, UV disinfection requires only a fraction of the contact times required by other disinfection methods. It is fast, efficient, effective, economical and environmentally-friendly.

Light is electromagnetic radiation, or radiant energy traveling in the form of waves. UV energy is found in the electromagnetic spectrum between visible light and x-rays. The energy employed in UV water treatment is further categorized into two primary wavelengths- 254 nanometer (nm) and 185 nm. The 254 nm wavelength is also known as the germicidal wavelength due to its ability to destroy microorganisms. The 254 nm also has the ability to dissociate residual ozone in water. The 185 nm UV light is used for Total Organic Carbon (TOC) reduction to decompose organic molecules into carbon-dioxide and water.

All living organisms contain DNA (deoxyribonucleic acid). DNA provides the mechanism for all functions needed to sustain life. The 254

Ultraviolet light disinfection treatment, generated at a dosage of at least 30,000 microwatt-seconds, is more than sufficient to destroy most water borne microorganisms

nm UV light penetrates the outer cell membranes of microorganisms, passes through the cell body, reaches the DNA and permanently alters the genetic material. The microorganisms are thereby destroyed in a non-chemical manner. The units generate a UV dosage of at least 30,000 microwatt-seconds per square centimeter ($\mu\text{W}\cdot\text{s}/\text{cm}^2$), even at the end-of-lamp-life (EOL), which is more than sufficient to destroy most waterborne microorganisms, such as bacteria, yeasts, algae etc. (see Table A).

UV has been very widely used for several years in various industries such as pharmaceutical, semiconductor, power generation, food & beverage, cosmetics, aquaculture and health care, not only for disinfection but also for TOC reduction and ozone destruction applications.

The Aquafine RBE (Remote Ballast Enclosure) Series, which is Underwriters' Laboratories (UL®)-listed

and modified National Electrical Manufacturers' Association (NEMA) 4X-rated, is therefore compatible with harsh outdoor environments including rain and storm.

A UV unit essentially features UV lamps and quartz sleeves placed inside a cylindrical chamber through which the water flow occurs. The UV lamps are encased inside quartz sleeves with the water flowing over the sleeves. Optimized engineering of the lamp configuration within the cylinder allows for maximum transmission of UV light in every part of the cylinder.

In well-engineered systems, the lamps are securely held in place by a lamp-retainer assembly, designed to provide an intimate friction fit over the entire length of the lamp pin at all times. Units with this type of design also feature an optical sensor, which indicates the relative UV intensity generated and transmitted to the water stream by the lamps. This facilitates timely replacement of the lamps and monitors the scaling or other deposition on the quartz sleeves, which would reduce the effective transmission of the UV energy to the water stream.

This type of UV design incorporates a stainless steel inside surface chamber, passivated and electro-polished to specifications that meet or exceed those for Military Specification 5002D and Federal Specification QQ-P-35. The stainless steel in

this type of unit is sheared, fabricated, welded and then dye-checked for welding integrity. The process of passivation involves a series of steps including several hot nitric acid baths followed by hot DI water rinses, which render the material bright, clean and inert. When the equipment goes through an exacting electropolishing operation, 0.000050 inch to 0.0015 inch of the metal surface is removed. This removes impurities and improves the microfinish. The two processes render the surface free of scratches, weld marks, stains, and contamination and impart a homogenous metal surface finish. Salt spray tests (per ASTM B-117-90) have established that electropolished parts are four to five times more resistant to corrosion than untreated parts. This property makes them ideal for use in manufacturing water treatment equipment.

The quartz sleeves run through helical baffles, designed to promote turbulent flow which enhances the contact and increases residence time, thereby resulting in increased dosage and absorption of UV light. The intensity of the lamps declines over time, therefore the lamps need to be replaced in most units about every 8,000 to 9,000 hours for optimum unit performance. The UV units also feature sample ports to facilitate the collection of water samples for microbiological/chemical analysis.

There are two kinds of UV lamps, low-pressure and medium-pressure. The medium-pressure lamps generate energy throughout the entire UV spectrum, which runs from 100 nm through 400 nm. The low-pressure lamps, on the other hand, have a more focused distribution with a predominant energy output in the germicidal (254 nm) wavelength. Therefore, although the medium-pressure lamps generate higher outputs than low-pressure lamps, a lot of the UV energy is wasted in the non-germicidal wavelengths.

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5. U.S. Government Federal specification, QQ-P-35.
6. U.S. Government Military specification, MIL-S-5002D, 1989.

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Table A

Ultraviolet Dosage Required For Destruction of Various Organisms

($\mu\text{W-s cm}^2$)

Bacteria	Mold Spores
<i>Bacillus anthracis</i> 8,700	<i>Aspergillus flavus</i> 99,000
<i>S. enteritidis</i> 7,600	<i>Aspergillus glaucus</i> 88,000
<i>B. Megatherium sp. (veg.)</i> 2,500	<i>Aspergillus niger</i> 330,000
<i>B. Megatherium sp. (spores)</i> ... 5,200	<i>Mucor racemosus A</i> 35,200
<i>B. paratyphosus</i> 6,100	<i>Mucor racemosus B</i> 35,200
<i>B. subtilis</i> 11,000	<i>Oospora lactis</i> 11,000
<i>B. subtilis spores</i> 22,000	<i>Penicillium digitatum</i> 88,000
<i>Clostridium tetani</i> 22,000	<i>Penicillium expansum</i> 22,000
<i>Corynebacterium diphtheria</i> ... 6,500	<i>Rhizopus nigricans</i> 220,000
<i>Eberthella typhosa</i> 4,100	
<i>Escherichia coli</i> 6,600	
<i>Leptospira</i> 6,000	
<i>Micrococcus candidus</i> 12,300	
<i>Micrococcus sphaeroides</i> 15,400	
<i>Mycobacterium tuberculosis</i> .. 10,000	
<i>Neisseria catarrhalis</i> 8,500	
<i>Phytomonas tumefaciens</i> 8,500	
<i>Proteus vulgaris</i> 6,600	
<i>Pseudomonas aeruginosa</i> 10,500	
<i>Pseudomonas Fluorescens</i> 6,600	
<i>S. typhimurium</i> 15,200	
<i>Salmonella</i> 10,000	
<i>Salmonella typhosa</i> 4,100	
<i>Sarcina lutea</i> 26,400	
<i>Serratia marcescens</i> 6,160	
<i>Dysentery bacilli</i> 4,200	
<i>Shigella dysenteriae</i> 4,200	
<i>Shigella paradysenteriae</i> 3,400	
<i>Spirillum rubrum</i> 6,160	
<i>Staphylococcus albus</i> 5,720	
<i>Staphylococcus aureus</i> 6,600	
<i>Streptococcus hemolyticus</i> 5,500	
<i>Streptococcus viridans</i> 3,800	
<i>Vibrio cholerae</i> 6,500	
	Protozoa
	<i>Chlorella vulgaris</i> (algae) 22,000
	Nematode eggs 92,000
	<i>Paramecium</i> 200,000
	Virus
	Bacteriophage (E. coli) 6,600
	Influenza 6,600
	Polio virus 6,000
	Tobacco mosaic 440,000
	Virus of Infectious Hepatitis 8,000
	Yeast
	Bakers' yeast 8,800
	Brewers' yeast 6,600
	Common yeast cake 13,200
	<i>Saccharomyces cerevisiae</i> 13,200
	<i>Saccharomyces ellipsoideus</i> . 13,200
	<i>Saccharomyces sp.</i> 17,600