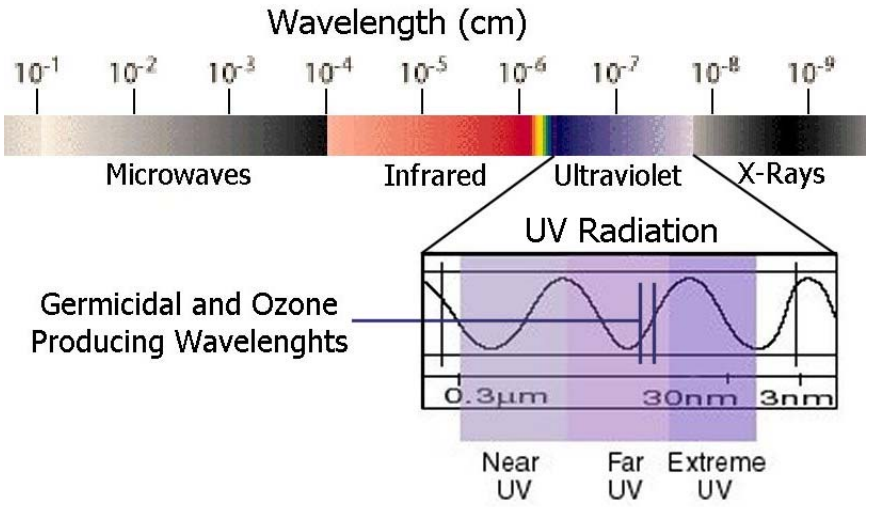
Ultraviolet (UV) Sterilization

Fact Sheet

Cal Water
Industrial Water Purification
(800) CAL-WATER

Electromagnetic Radiation
Electromagnetic waves (Electromagnetic Radiation) such as visible light are produced by the motion of electrically charged particles called photons. Photons with the shortest wavelengths have the highest energy.



Ultraviolet Radiation
Ultraviolet radiation of a specific wavelength is used to cause photochemical reaction to take place that damages DNA molecules in microorganisms so that cell division and reproduction can no longer occur. The most biologically disruptive frequencies in the EM spectrum are the shorter wavelengths within ultraviolet (UV) light known as the UV-C or Far UV spectrum. The wavelength of the EM spectrum most commonly used for this purpose is 254 nm, generated by Mercury vapor lamps.

Generating UV Radiation
A "UV" lamp is similar to a standard fluorescent bulb without the exterior phosphor coating to filter out UV light. The lamps are quartz tubes filled with a low pressure inert gas, typically argon, and a trace amount of mercury. High voltage electricity is applied across the electrodes, heating the gases and vaporizing the mercury. With a relatively small amount of Input power, (from 8 to 300 watts), a UV lamp produces substantial emissions at two distinct wavelengths within the UV spectrum of 185nm and 254nm.

Ultraviolet Sterilization (UV) is a simple way to destroy microorganisms in clear water. The sun keeps surface waters clear and pure with the ultraviolet rays that make it through the atmosphere. (Radiation from the Sun has become even more effective lately, because of the hole in the ozone layer.)

UV Applications

- Purification of drinking water from private wells. Cisterns, and Non-chlorinated municipal systems
- Following carbon filters
- Bacteria-free water for: (hospitals, kidney dialysis, breweries, dairies, bottling plants, cosmetics, pharmaceuticals, chemical, distilleries, etc.)
- Post-ion exchange because bacteria are a possible natural byproduct of this process.
- Pre-reverse osmosis to protect membranes that may be subject to biological degradation.
- Recirculation and/or reclamation systems (to prevent the recontamination of the water supply.)
- High-purity water systems after final polishing in a mixed bed, placed as close as possible to the final point of use and just prior to sub-micron filtration.
- Lake or pond water

Ultraviolet (UV) rays with a wavelength 254 nm will effectively kill bacteria, viruses, yeast, molds and algae. The UV radiation breaks through the outer membranes of the organisms, destroying or inactivating the DNA (Deoxyribonucleic Acid) thus preventing them from reproducing. This safely and effectively purifies water without changing its pH, color, taste, odor or temperature.

In practice, water enters a highly polished stainless steel chamber at a predetermined flow rate where it passes along one or more quartz sleeves containing ultraviolet radiation generating lamps. Improperly sized UV sterilizers, any common microorganisms present are exposed to 30,000 $\mu ws/cm^2$ of 254 nm UV energy, effectively killing them.

Germicidal Dose

Germicidal UV dose is a measure of germicidal energy, multiplied by the exposure time, multiplied by the area within the treatment chamber, and adjusted for UV transmission. An example is $30mWsec/cm^2$, or $30,000\mu Wsec/cm^2$, in T-10 80% water. The amount of energy to reduce the viable population of individual pathogens by one log (90%) is commonly referred to as a D-10 value. A list of D-10 values is indicated on the Microorganism Table below. By doubling a pathogens D-10 value, another log reduction is achieved; i.e. 99%. Standard industrial disinfection commonly uses $30mWsec/cm^2$ for many applications.

Design & Operation

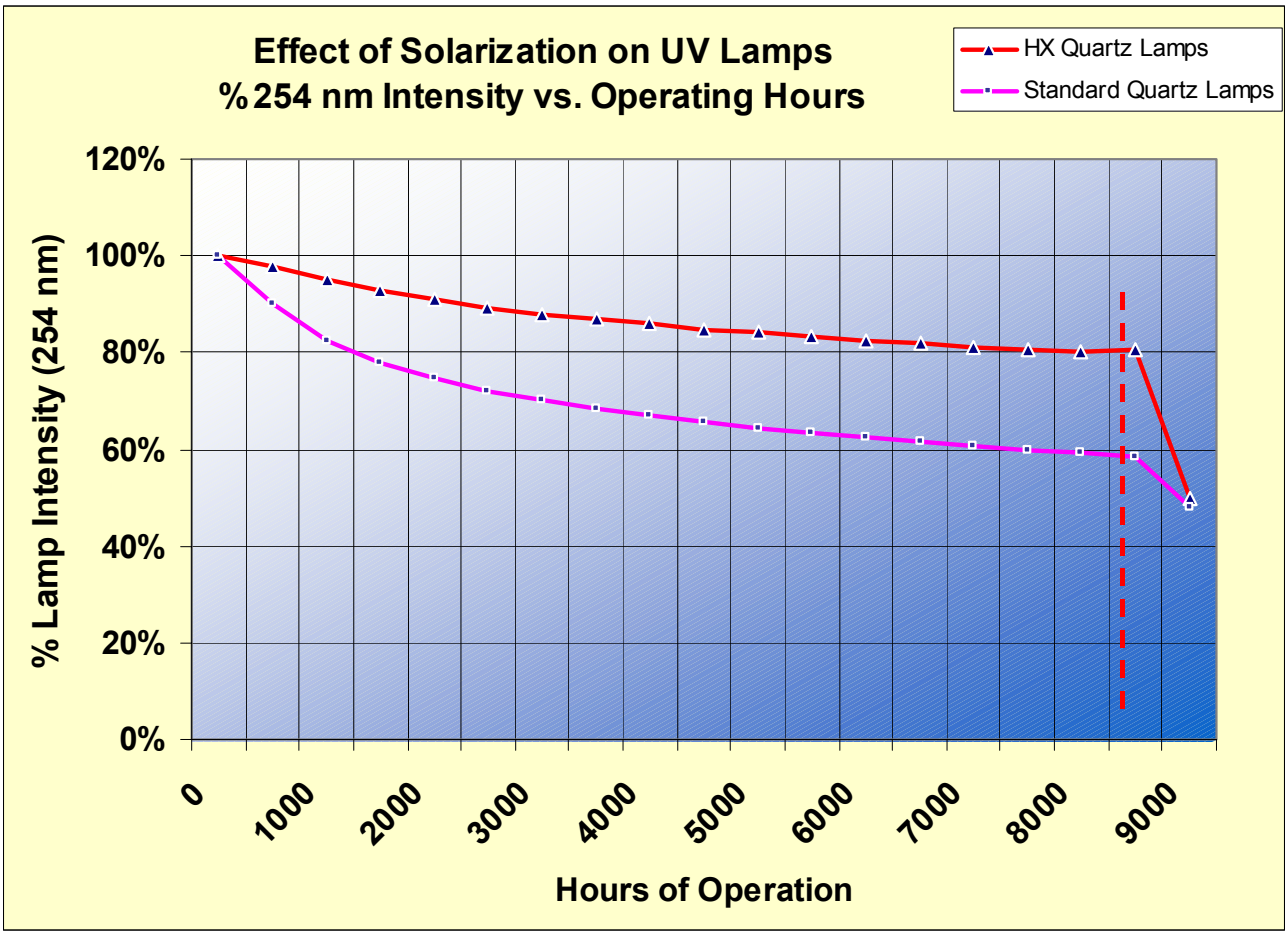
A typical UV sterilizer consists of a highly polished reflective treatment chamber and a separate power/control cabinet. The chamber can contain from one to dozens of lamps depending on the application. A UV sterilizer is best installed after filtration to clarify the water. A quartz sleeve is mounted in the chamber that acts as a housing for the UV lamp. NOTE: A UV lamp never comes in direct contact with the process fluid. The quartz sleeve also allows for easy replacement of the lamps due to the fact that the chamber does not need to be drained. The chamber should be drained, and the quartz sleeves replaced after approximately 25,000 hours of exposure to illumination.

Lamp Life
The useful life of Mercury vapor (UV) lamps is limited by the degradation of the electrode material. The decrease in UV radiation is caused by the deposit of evaporated electrode material on the inner surface of the lamp tube.

Frequent ignition accelerates electrode wear and reduces lamp life. UV lamps are most effective if left on continuously.

UV technology is used for a wide range of applications, from disinfection to oxidizing organics.

Oxidizer Destruction
UV is also used to destroy oxidizers such as ozone and free chlorine in water. It should be noted that the amount of energy to perform this process is dependent on the concentration of the oxidizer.



UV Efficiency Lost to Solarization

UV efficiency is lost because of the cumulative effect of **solarization** of the quartz UV lamps themselves. Solarization is the photochemical ageing process that naturally occurs in the presence of high ultraviolet radiation over time. While the above curve shows radiation being produced past 9500 hours, mercury vapor lamps become unreliable after about 8,000 hours of operation. UV lamps must be replaced on a routine basis to prevent a sterilizer from becoming just an expensive piece of pipe.

Because lamp output degrades over its life it is important to size a system for sufficient performance at the End-Of-Lamp life (EOLL). Doing so will insure that throughout the life of the lamp you will actually achieve a higher UV dose.

UV sterilizer sizing considerations:

- Flow rate, peak and variability
- Water Clarity
- Water temperature.
- Microorganism species.
- Projected UV Lamp replacement frequency. (Please see **Solarization** above.)

The flow rates listed in **Sizing and Selection** are based on an ultraviolet radiation dosage of 30,000 μws/cm2/sec. Organisms commonly found in city water are killed at this dosage. In certain specialized applications, different species are encountered that require more or less radiation to kill.

Microorganism Table

D-10 (90% kil)l by standard dosage of 30,000 mws/cm2*
UV Radiation at 254 nm

Microorganism	mws/cm2	Microorganism	mws/cm2
B. Megatherium sp. (veg.)	2,500	Neisseris catarrhalis	8,500
Streptococcus viridans	3,800	Phytomonas tumefaciens	8,500
Eberthelia typosa	4,100	Bacillus anthracis	8,700
Salmonella typhosa (Typhoid fever)	4,100	Streptococcus lactis	8,800
Dysentery bacilli	4,200	Baker's Yeast	8,800
Bacillus megatherium	5,200	Mycobacterium tuberculosis	10,000
Streptoccus hemolyticus	5,500	Pseudomonas aeruginosa	10,500
Leptospria Spp. (Infectious Jaundice)	6,000	Bacillus subtilis	11,000
Poliovirus (Poliomyelitis)	6,000	Oospora lactis (white)	11,000
Bacillus paratyphosus	6,100	Micrococcus candidus	12,300
Salmonella paratyphi (Enteric fever)	6,100	Saccharomyces elliposideus	13,200
Corynebacterium diphtheria	6,500	S. typhimurium	15,200
Vibrio comma (Cholera)	6,500	Microcroccus sphaeroides	15,400
Escherichlia coli	6,600	Saccharomyces sp.	17,600
Proteus vulgaris	6,600	Bacillus subtilis spores	22,000
Pseudomonas fluorescens	6,600	Clostridium tetani	22,000
Bacteriophase (E. coli)	6,600	Penicillium expensum	22,000
Influenza	6,600	Chlorella vulgaris (algae)	22,000
S. enteritidis	7,600	Sarcina lutea	26,400
Virus of Infectious Hepatitis	8,000	Penicillium roqueforti (green)	26,400

Additional Sterilization Required
(Sub-micron filtration - oxidizer - additional UV)

Microorganism	mws/cm2	Microorganism	mws/cm2
Mucor racemosus A (white gray)	35,200	Aspergillus flavus	99,000
Mucor racemosus B (white gray)	35,200	Paramecium	200,000
Aspergillus glaucus (bluish green)	88,000	Rhisopus nigricans	220,000
Penicillium digitatum (olive)	88,000	Aspergillus niger	330,000
Nematode eggs	92,000	Tobacco mosaic	440,000

For More Information Please Call
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