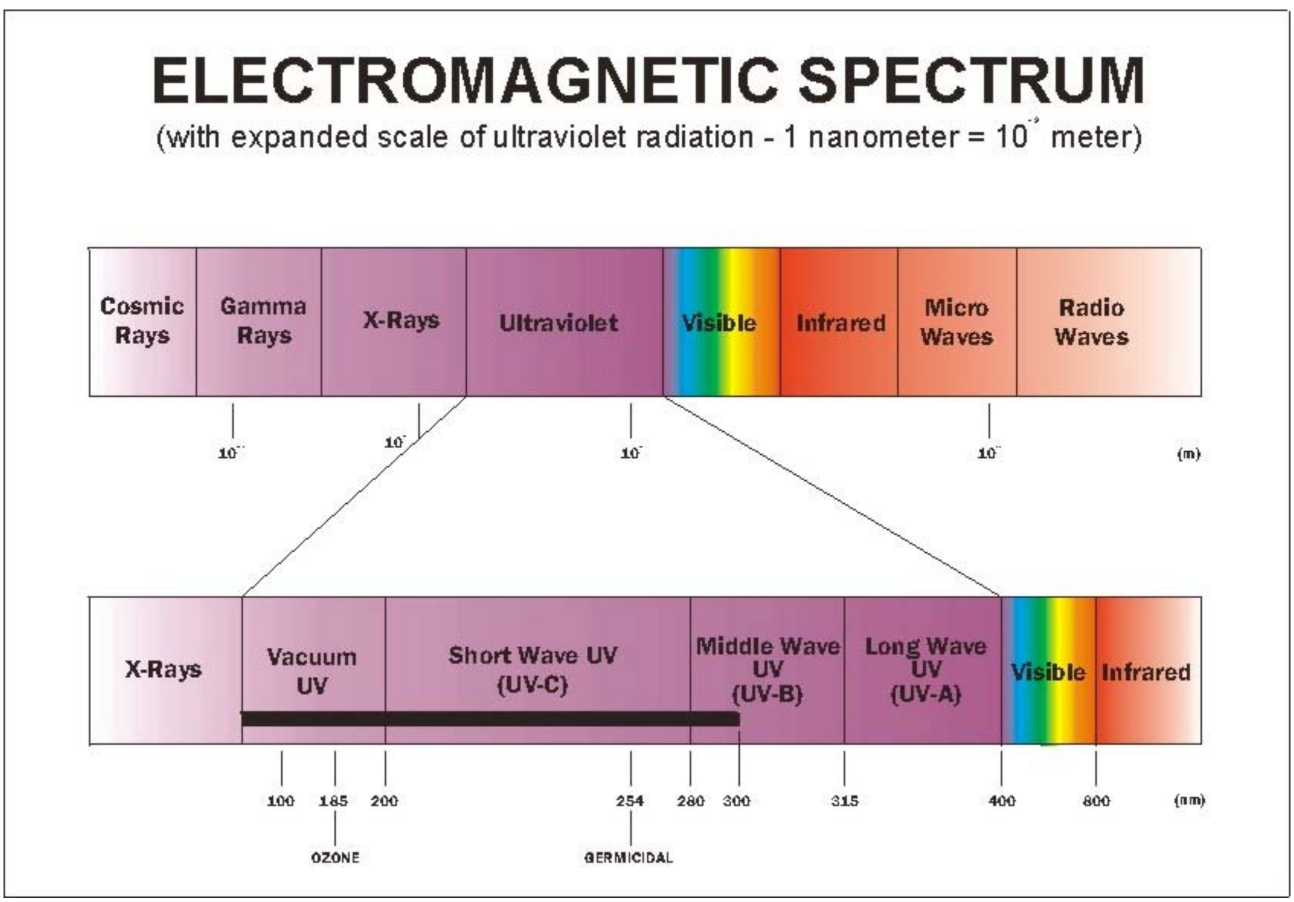
UV Offers
Reliable Disinfection

by Myron Lupal

The term ultraviolet or "UV" light, as it is commonly referred to is a proven means of addressing microbiologically contaminated waters. This simple, safe technology is suitable for both small flow residential applications as well as large flow commercial projects.

Disinfection, in its literal sense means free from infection. The U.S. Environmental Protection Agency (EPA) and world Health Organization (WHO) define water disinfection as having an absence of the indicator coliform bacteria. Sterilization implies complete destruction of all forms of life. For practical purposes the term sterilizer is used as a generic term to describe ultraviolet technology.

Ultraviolet is one energy region of the electromagnetic spectrum which lies between the x-ray region and the visible region. UV itself lies in the ranges of 200 nanometres (1 nanometer (nm) = 10-9 metre) to 390 nanometres. Since energy levels increase as the wavelength decreases, x-rays have more energy than UV and UV has more energy than the visible light spectrum.



The UV spectrum is divided into four regions, which are designated Vacuum UV, UV-A, UV-B, and UV-C. We are particularly concerned with the latter three.

UV-A or long-wave ultraviolet, which occurs between 325 - 390 nm band, is represented by naturally occurring sunlight. This range has little germicidal value.

UV-B or middle-wave ultraviolet occurs between 295 - 325 nm and is best known for its use in sun tanning lamps. These middle-waves may also be found in sunlight and provide some germicidal effect if exposure is sufficient.

UV-C or short-wave ultraviolet occurs between 200 - 295 nm and is where the most effective germicidal action occurs. The optimum UV germicidal action occurs at 265 nm.

Since short-wave ultraviolet is screened out by the earth's atmosphere, naturally occurring UV-C is rarely found on the earth's surface. For us to take advantage of the germicidal potential of UV-C, we must look to alternate means of producing UV light. Production of radiant UV energy must therefore be accomplished through the conversion of electrical energy. This conversion is accomplished with a low pressure mercury vapour lamp. UV light is produced as a result of the electron flow through the ionized mercury vapour between the electrodes of the lamp (it should be noted that the bluish glow given off by UV lamps is due to the starter gas inside the lamp and
has no germicidal action itself).

These UV lamps are similar in design to standard fluorescent lamps with a few notable exceptions. UV lamps are typically manufactured with "hard glass" quartz as opposed to "soft glass" found in fluorescent lamps. This quartz allows for a UV transmittance of over 90% of the radiated energy. Fluorescent lamps also contain a thin coating of phosphor inside the lamp which converts the UV to visible light.

Microorganisms encompass a wide variety of unique structures and can be grouped into five basic groups: bacteria, virus, fungi, protozoa, and algae. In simplistic terms, a microorganism is made up of the cell wall, cytoplasmic membrane and the cells genetic material, nucleic acid. It is this genetic material or DNA (deoxyribonucleic acid) which is the target for the UV light. As UV penetrates through the cell wall and cytoplasmic membrane it causes a molecular rearrangement of the microorganism's DNA which thus prevents it from reproducing. If a cell can not reproduce, it is considered dead.

Micro-Organism Destruction Levels

(ultraviolet energy at 253.7 nm wavelength required for 99.9% destruction of various microorganisms -- in μwsec/cm²)

Bacillus anthracis	8,700
Shigella dysentariae (dysentery)	4,200
Corynebacterium diphtheriae	6,500
Shigella flexneri (dysentery)	3,400
Dysentary bacilli (diarrhea)	4,200
Staphylococcus epidermidis	5,800
Escherichia coli (diarrhea)	7,000
Streptococcus faecalis	10,000
Legionella pneumophilia	3,800
Vibro commo (cholera)	6,500
Mycobacterium tuberculosis	10,000

Bacteriophage (E. Coli)	6,500
Pseudomonas aeruginosa	3,900
Hepatitis	8,000
Salmonella (food poisoning)	10,000
Influenza	6,600
Salmonella paratyphi (enteric fever)	6,100
Poliovirus (poliomyelitis)	7,000
Salmonella typhosa (typhoid fever)	7,000
Baker's yeast	8,800

Due to the individual cell make-up, different levels of ultraviolet energy are required for destruction. UV lamps emit about 90% of their radiated energy at 253.7 nm which by coincidence is very close to the peak germicidal effectiveness of 265nm

The degree of microbial destruction is a product of both time ; which is the actual residence, or contact time the water is within the sterilization chamber, and intensity ; which is the amount of energy per unit area (calculated by dividing the output in watts by the surface area of the lamp). This product of intensity and time is known as the Dose and is expressed in micro watt seconds per centimeter squared (μwsec/cm^2).

Design

The design of an ultraviolet sterilizer is extremely important on how the UV Dose is delivered. As individual UV lamps emit a set amount of ultraviolet energy, it is extremely important that a system be sized correctly. Flow rates are the determining factor and must not be overstated. The size of the reactor chamber is also of extreme importance since the delivered intensity decreases as per the square of the distance from the lamp. Ballast selection must coincide with the correct operating current of the lamp as a loss in UV intensity will occur if the lamp is not driven at the correct output. Optional solid state ballasts offer the advantage of cooler operating temperatures, smaller space requirements, and less weight all with consistent power delivery. Quartz sleeves shield the actual water flow from the lamp and offer more uniform operating temperatures as well as allowing for higher energy transmissability into the water. A variety of optional features may be built into the sterilizers including; UV monitoring devices which measure the actual UV output at 253.7 nm, solenoid shut-off devices that will stop water flow in the event of system failure , flow control devices to properly limit the water flow in the units, audible and visual alarms (both local and remote) to warn of lamp failures, high temperature sensors which monitor excessive temperatures in the reactor chamber or control panel, and hour meters to monitor the running time of the UV lamps.

Factors Affecting UV

The effectiveness of a UV system in eliminating microbiological contamination is directly dependant on the physical qualities of the influent water supply.

Suspended Solids or particulate matter cause a shielding problem in which a microbe may pass through the sterilizer without actually having any direct UV penetration. This shielding can be reduced by the correct mechanical filtration of at least five microns in size.

Iron / Manganese will cause staining on the lamp or quartz sleeve at levels as low as 0.3 ppm of iron and 0.05 ppm of manganese. Proper pretreatment is required to eliminate this staining problem.

Calcium / Magnesium hardness will allow scale formation on the lamp or quartz sleeve. This problem will be especially magnified during low flow (or no flow) times when the calcium and magnesium ions tie-up with carbonates and sulfates to form hard scale build-up inside the sterilizer chamber and be deposited on the lamp or sleeve.

Other Absorbing Compounds such as humic and fumic acids as well as tannins will reduce the amount of UV energy available to penetrate through the water to affect the genetic material, DNA of the molecule.

Additional Factors Affecting UV

Temperature is a determining factor. The optimal operating temperature of the UV lamp must be near 40°C (104° F). UV levels will fluctuate with excessively high or low temperature levels. A quartz sleeve is typically employed to buffer direct lamp - water contact thereby reducing any temperature fluctuations. A typical method employed in a system without a quartz sleeve is to engineer the system to take into account these fluctuations and typically de-rate the regular flow rate by the corresponding amount.

Advantages Of UV Lights

Advantages of UV lights include:

- Environmentally friendly, no dangerous chemicals to handle or store, no problems of overdosing.
- Low initial capital cost as well as reduced operating expenses when compared with similar technologies such as ozone, chlorine, etc.
- Immediate treatment process works, no need for holding tanks, long retention times, etc.
- Extremely economical, hundreds of gallons may be treated for each penny of operating cost.
- No chemicals added to the water supply - no by-products (ie. chlorine + organics = trihalomethanes).
- No change in taste, odour, pH, or conductivity nor the general chemistry of the water.
- Automatic operation without special attention or measurement, operator friendly.
- Simplicity and ease of maintenance, periodic cleaning (if applicable) and annual lamp replacement, no moving parts to wear out.
- No handling of toxic chemicals, no need for specialized storage requirements, no WHMIS requirements.
- Easy installation, only a two water connections and a power connection.
- More effective against viruses than chlorine.
- Compatible with all other water processes (ie. RO, filtration, ion exchange, etc.)

Applications

UV technology is currently used in a vast array of applications from basic home drinking water protection due to a contaminated well to use as a final, germ-free rinse agent for cleaning electronic parts. The following list shows a few areas where ultraviolet technology is currently in use :

surface water	laboratories	bottled water plants
ground water	pharmaceuticals	cisterns
wineries	hospitals	breweries
dairies	farms	electronics
mortgage approvals	hydroponics	marine
aquaria	recreational vehicles	restaurants
vending machines	canneries	printing
cosmetics	food products	butter processing
bakeries	distilleries	petro chemical
schools	fish hatcheries	photography

Installation Guidelines

Once the application has been determined, placement of the UV unit should be given considerations. The sterilizer should be placed as close to the dispersion point as possible. Since UV is a physical process and has no residual value, it is imperative that all points of the distribution system after the sterilizer be chemically "shocked" to ensure that the system is free from any downstream microbial contamination.

UV units should be installed on the cold water line before any branch lines. A typical household distribution system will typically have a 5 gpm flow rate, however if the flow rate is in question, the UV unit should be oversized rather than undersized. As an added safety precaution, a flow regulating device should be installed on any sterilizer to ensure that the manufacturers recommended rated flow is not exceeded.

The UV sterilizer should be the last point of treatment. Any pretreatment products should precede the sterilizer. If the water supply contains Giardia Lamblia (or other cysts), an alternate mechanical filtration unit (check NSF St. 53 for applicable units) should be installed at the point-of-use after the UV unit.

The only positive way to determine if the sterilizer is indeed operating as designed is to obtain microbiological testing on the water supply. Even though the lamp is lit and appears to be functioning, factors such as water quality, lamp life, and actual UV transmission may be affecting the actual UV output. It is recommended to have the water tested periodically to ensure you are receiving bacteriologically safe water. It is also imperative to follow the manufacturer's guidelines on water quality and operational procedures.

Summary

The need for ultraviolet sterilization products can be found in virtually all areas in both residential and commercial water applications alike. UV's physical process makes it the ideal system component for those multiple water problems. Its simplistic design, ease of maintenance and low capital and operating costs make UV the number one choice in contaminated water situations. Next time, purify your water natures way.....use ultraviolet light.

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