Triangular Wave Technologies, Inc.
UV-Series–Ultra Violet Purifiers

Ultraviolet Sterilization Technology

Ultraviolet disinfection systems are mysterious to many people – how can "light" kill bacteria? But the truth is it can. Ultraviolet (UV) technology has been around for over 50 years, and its effectiveness has been well documented both scientifically and commercially. It is nature's own disinfection/purification method. With consumers becoming more concerned about chlorine and other chemical contamination of drinking water, more dealers are prescribing the ultraviolet solution suitable for both small flow residential applications as well as large flow commercial projects.

Ultraviolet is a means of killing or rendering harmless microorganisms in a dedicated environment. These microorganisms can range from bacteria and viruses to algae and protozoa. UV disinfections is used in air and water purification, sewage treatment protection of food and beverages, and many other disinfection and sterilization applications. A major advantage of UV treatment is that it is capable of disinfecting water faster than chlorine without cumbersome retention tanks and harmful chemicals. UV treatment systems are also extremely cost efficient!

What is UV and how does it work?

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 nanometers (nm) to 390 nanometers (nm). Optimum UV germicidal action occurs at 260 nm.

Since natural germicidal UV from the sun is screened out by the earth's atmosphere, we must look to alternative means of producing UV light. This is accomplished through the conversion of electrical energy in a low-pressure mercury vapor "hard glass" quartz lamp. Electrons flow through the ionized mercury vapor between the electrodes of the lamp, which then creates UV light.

As UV light penetrates through the cell wall and cytoplasmic membrane, it causes a molecular rearrangement of the microorganisms DNA, which prevents it from reproducing. If the cell cannot reproduce, it is considered dead.

Design and Dosage

The design of an ultraviolet sterilizer has an extremely important bearing on how the UV Dose is delivered and Dosage is the most critical function of UV disinfections. As individual UV lamps emit a set amount of ultraviolet energy, it is important that a system be sized correctly. Flow rates are the determining factor and must not be overstated. Contact time, which is the time the water is within the sterilization chamber, is directly proportional to Dosage, which is the amount of energy per unit area (calculated by dividing the output in watts by the surface area of the lamp), and thus the overall effectiveness of microbial destruction in the system. This product of intensity and time is known as the Dose and is expressed in microwatt seconds per centimeter squared (uWsec/cm2). **Divide by 1000 to express the dose in mJ/cm2, the preferred notation.**

$$\textbf{DOSE} = \frac{\text{time (sec) x output (watts)}}{\text{area (cm2)}}$$

TRIANGULARWAVE TECHNOLOGIES, INC.
Chemical-Free Water Treatment

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For maximum UV transmission a “hard glass” quartz sleeve is recommended for two main reasons. It isolates the lamp from the water to offer more uniform operating temperatures and allows for higher UV output into the water.

A variety of optional features may be added on to the UV sterilizers. They include UV monitoring devices that measure the actual UV output, solenoid shutoff devices that will stop the water flow in the event of a 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 to monitor excessive temperatures in the reactor chamber or control panel, and hour meters to monitor the running time of the UV lamps.

Advantages of UV Sterilization

Following are the advantages of UV sterilization:

- **Environmentally friendly, no dangerous chemicals to handle or store, no problem of overdosing (it’s impossible).**
- **Low initial capital cost as well as reduced operating expenses when compared with similar technologies such as ozone, chlorine, etc.**
- **Immediate treatment process, 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 (i.e. chlorine + organics = trihalomethanes).**
- **No change in taste, odor, pH or conductivity or 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 two water connections and a power connection.**
- **Compatible with all other water processes (i.e., RO, filtration, ion exchange, etc.)**

Factors Affecting UV

Because UV does not leave any measurable residual in the water it is recommended that the UV sterilizer be installed as the final step of treatment and located as close as possible to the final distribution system. Once the quality of your water source has been determined, you will need to look at things that will inhibit the UV from functioning properly (e.g., iron manganese, TDS, turbidity, and suspended solids).

Iron and Manganese will cause staining on the quartz sleeve and prevent the UV energy from transmitting into the water at levels as low as 0.03 ppm of iron and 0.05 ppm of manganese. Proper pretreatment is required to eliminate this staining problem.

Total Dissolved Solids (TDS) should not exceed approximately 500 ppm.There are many factors that make up this equation such as the particular make-up of the dissolved solids and how fast they absorb the sleeve, again impeding the UV energy from penetrating the water.

Turbidity is the inability of light to travel through water. Turbidity makes water cloudy and aesthetically unpleasant. In the case of UV, levels over 1 NTU can shield microorganisms from the UV energy, making the process ineffective.

Suspended Solids need to be reduced to a maximum of 5 microns in size. Larger solids have the potential of harboring or encompassing the microorganisms and preventing the necessary UV exposure. Pre-filtration is a must on all UV applications to effectively destroy microorganisms to a 99.9% kill rate.

Additional Factors affecting UV is temperature. The optimal operating temperature of a UV lamp must be near 40°C (104°F). UV levels fluctuate with temperature levels. Typically a quartz sleeve is installed to buffer direct lamp-water contact thereby reducing any temperature fluctuations.

UV Applications

One of the most common uses of ultraviolet sterilization is the disinfection of domestic water supplies due to contaminated wells. Coupled with appropriate pre-treatment equipment, UV provides an economical, efficient and user-friendly means of producing potable water.

The following list shows a few more areas where ultraviolet technology is currently in use:

surface water	**laboratories**	**bottled water plants**
ground water	**wineries**	**pharmaceuticals**
cisterns	**dairies**	**mortgage approvals**
breweries	**farms**	**electronics**
hospitals	**hydroponics**	**aquaria**
restaurants	**spas**	**boats and RV's**
vending	**canneries**	**printing**
cosmetics	**food products**	**butter processing**
bakeries	**distilleries**	**petro chemicals**
schools	**fish hatcheries**	**photography**
boiler feed water	**water softeners**	**swimming pools**

and much more…

Installation and Maintenance Guidelines

Once the application has been determined, you should find a location that offers easy access for service. You will need to have access to the pre-filters, to the UV chamber for annual lamp changes and regular maintenance on the quartz sleeve. You will want to locate near an electrical outlet. *Note: Using a UV system and a pump on the same electrical line may cause problems and shorten the life of the UV lamp and ballast. UV units should be installed on the cold water line before any branch lines and should be last point of treatment. All points of the distribution system after the sterilizer should be chemically "shocked" to ensure that the system is free from any downstream microbial contamination. Lamp changes should be done at least once every year. Filter changes are done according to the water conditions and use. If there is residue left, you may need to use a non-abrasive cleaner that does not scratch the surface and is formulated to remove iron and scale buildup. Do not leave fingerprints on the glass! It is imperative to follow the manufacturers 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 applications alike. Its simplistic design, ease of maintenance and low capital and operating costs make UV the number one choice in contaminated water situations. Health professionals and water specialists are becoming aware of possible side effects of chemical sterilizers and their resultant chemical by-products. Because of its advantages, UV irradiation should become a very popular choice for the disinfection of water supplies in the 21st century.

Next time, purify water "natures way"…use ultraviolet light.

UV Inactivation Chart1 (in mJ/cm2)

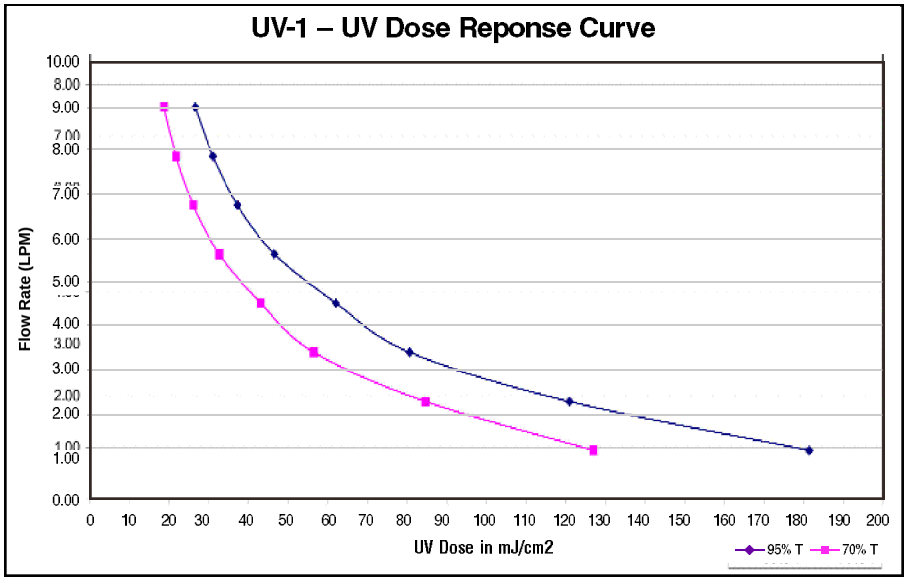
Typical (WY) UV systems produce UV doses of 38 – 60 mJ/cm2

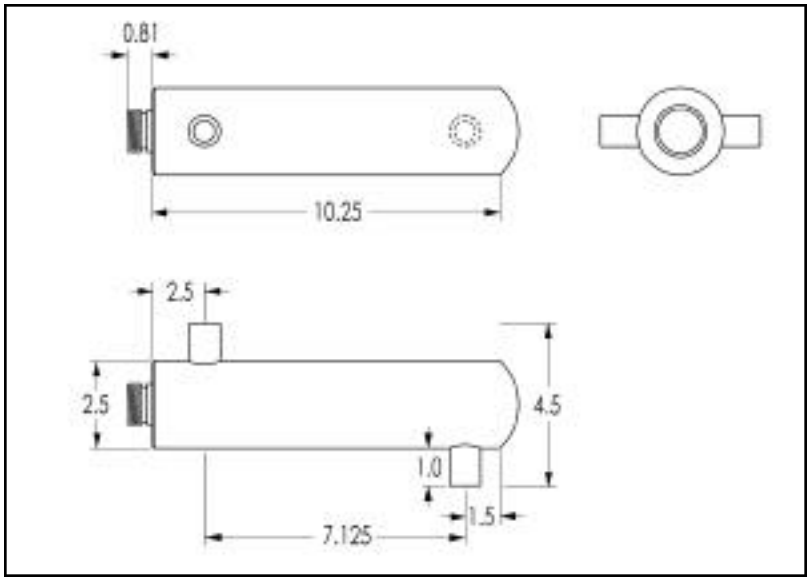
Organism	Type	Affiliated Disease, Contamination, Toxin	Dose log 3
Agrobacterium tumefaciens	Bacterium	Crown Gall disease in Dicotyledons (Grapes, Berries, Fruits, Nuts)	8.5
Aeromonas hydrophila	Bacterium	Tissue damage in humans (opportunistic pathogen)	3.9
Aspergillus flavus (yellow green)	Fungus (Mold Spore)	Aspergillosis of the lungs, corneal infections	99.0
A. glaucus (blue green)	Fungus (Mold Spore)	Allergenic	88.0
A. niger (black)	Fungus (Mold Spore)	Otomycosis, Black mold on fruits and vegetables	330.0
Adenoviridae	Virus	Upper respiratory infections	90.0
Bacillus anthracis	Bacterium	Anthrax	8.7
B. anthracis (spores)	Bacterium	Anthrax	46.2
B. megatherium (vegetable)	Bacterium	Infections, food poisoning	2.5
B. megatherium (spores)	Bacterium	Infections, food poisoning	52.0
B paratyphosus	Bacterium	non pathogenic	6.1
B. subtilis (vegetable)	Bacterium	Ropiness in bread dough, food contamination	11.0
B. subtilis (spores)	Bacterium	Ropiness in bread dough, food contamination	61.0
Campylobacter jejuni	Bacterium	Food poisoning, gastroenteritis	4.0
Chlorella vulgaris	Protist (algae)	Plant pathogen	22.0
Clostridium Tetani	Bacterium	Tetanus	23.1
C. botulinum	Bacterium	Produces Botulin toxin	11.2
Coliphage	Virus	Bacteriophage that infects E. coli	6.6
Corynebacterium diphtheriae	Bacterium	Diphtheria	6.5
Coxsackie A	Virus	Hand, foot & mouth disease, conjunctivitis, herpangina	6.9
Coxsackie B	Virus	Pericarditis, myocarditis, gastrointestinal distress	20.6
Cryptosporidium parvum	Protist	Cryptospiridiosis	10.0
Eberthella typhosa	Bacterium	Typhoid fever	4.1
Escherichia coli	Bacterium	Food poisoning, gastroenteritis, meiningitis	8.6
Giardia lamblia	Protist	Giardiasis	(cyst) 100
Hepatitis virus	Virus	Hepatitis, jaundice	8.0
Influenza virus	Virus	nfluenza, respiratory infections	6.6
Legionella bozemanii	Bacterium	Pneumonia	3.5
L. dumoffii	Bacterium	Pneumonia	5.5
L. gormanii	Bacterium	Pneumonia	4.9
L. longbeachae	Bacterium	Legionnaire's disease, pontiac fever	2.9
L. micdadei	Bacterium	Influenza, Pittsburgh pneumonia	3.1
L. pneumophila	Bacterium	Legionnaire's disease	3.8
Leptospira interrogans	Bacterium	Leptospirosis (Weil's disease, canicola fever, canefield fever, 7-day fever)	6.0
Micrococcus candidus	Bacterium		12.3
M. sphaeroides	Bacterium		15.4
Mycobacterium tuberculosis	Bacterium	Tuberculosis	10.0
Mucor racemosus A	Fungus (Mold Spore)	Fungal plant pathogen, zygomycosis and fungal sinusitis in humans	35.2

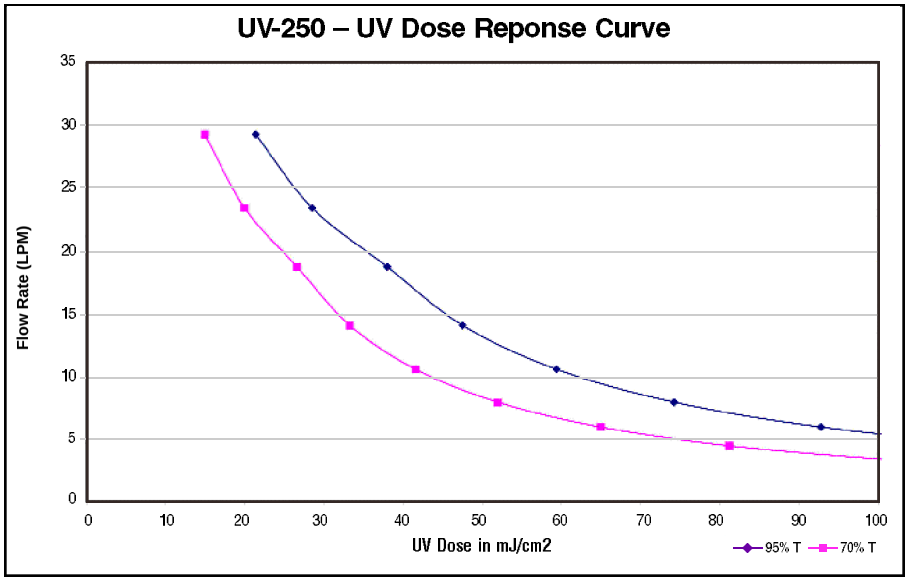
Organism	Type	Affiliated Disease, Contamination, Toxin	Dose log 3
Neisseria (Moraxella) catarrhalis	Bacterium	Otitis media, sinusitis, laryngitis	8.5
Nematode eggs (Roundworm)	Parasite	Ascariasis, Appendicitis, Loeffler's Syndrome	92.0
Oospora lactis	Fungus (Mold Spore)	Fruit rot (rapid decay of ripe fruits, potatoes), mold in dairy products	
Paramecium spp.	Protist		
Penicillum digitatum (olive)	Fungus (Mold Spore)	Fungal spoilage in fruits and vegetables	88.0
P. expansum (olive)	Fungus (Mold Spore)	Postharvest decay of stored apples	22.0
P. roqueforti (green)	Fungus (Mold Spore)	Producing harmful secondary metabolites (alkaloids and other mycotoxins)	26.4
Phytomonas tumefaciens	Bacterium	Crown Gall disease in Dicotyledons (Grapes, Berries, Fruits, Nuts)	8.5
Polio virus	Virus	Poliomyelitis (Polio)	29.0
Proteus vulgaris	Bacterium	Infections (esp. sinus and respiratory, urinary tract)	6.6
Pseudomonas aeruginosa (lab)	Bacterium	Hospital acquired infections, ear infection and dermatitis in pools & tubs	3.9
Pseudomonas aeruginosa (env.)	Bacterium	Hospital acquired infections, ear infection and dermatitis in pools & tubs	10.5
Rhizopus nigricans (black)	Fungus (Mold Spore)	Infections, allergetic reactions (known as breadmold)	220.0
Rhodospirillum rubrum	Bacterium		6.2
Rotavirus	Virus	Infections, severe diahorrea, gastroenteritis	26.0
Saccharomyces sp.	Yeast		13.2
Salmonella enteritidis	Bacterium	Egg-associated Salmonellosis (fever, abdominal cramps, diarrhoea)	7.6
S. paratyphi	Bacterium	Enteric fever	6.1
S. typhi	Bacterium	Typhoid fever	6.4
S. typhimurium	Bacterium		
Sarcina lutea	Bacterium		26.4
Serratia marcescens	Bacterium	Nosocomial (Hospital acquire)d infections	6.2
Shigella dysenteriae	Bacterium	Epidemic dysentery	4.2
S. flexneri	Bacterium	Shigellosis, dysentery	3.4
S. sonnei	Bacterium	Shigellosis	7.0
Staphylococcus aureus	Bacterium	Staph and nosocomical infections, toxic shock syndrome	7.0
S. epidermidis	Bacterium	Infections in catheters and prostheses	5.8
S faecalis	Bacterium		10.0
Streptococcus hemolyticus	Bacterium	Strep throat	5.5
S. faecalis	Bacterium	Endocarditis, bladder and prostate infection	8.0
S. lactis	Bacterium		8.8
S.pyogenes	Bacterium	Scarlet fever, toxic shock syndrome, flesh eating disease	8.8
S. viridans	Bacterium	Mouth or gingivial infections, endocarditis	3.8
Tobacco mosaic virus	Virus	Mottling and discoloration in plants	440.0
Vibrio cholerae	Bacterium	Cholera	2.2
Yersinia enterocolitica	Bacterium	Yersiniosis (fever, abdominal pain, diarrhoea	3.7

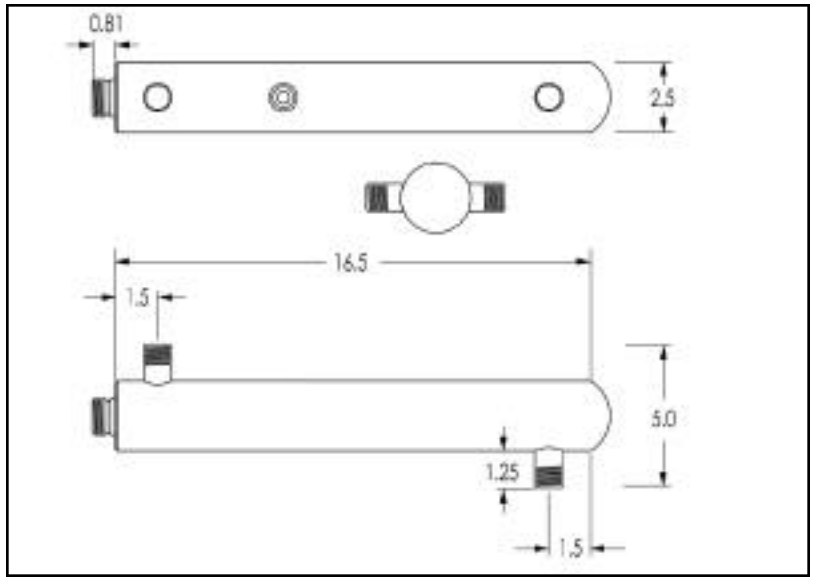
1 UV energy levels required at 254 nanometer wavelength for 99.9% destruction of organisms

UV Dosage & System Schematic – All Measrements in inches (1" = 25.4 mm
3.785 liters = 1 gallon









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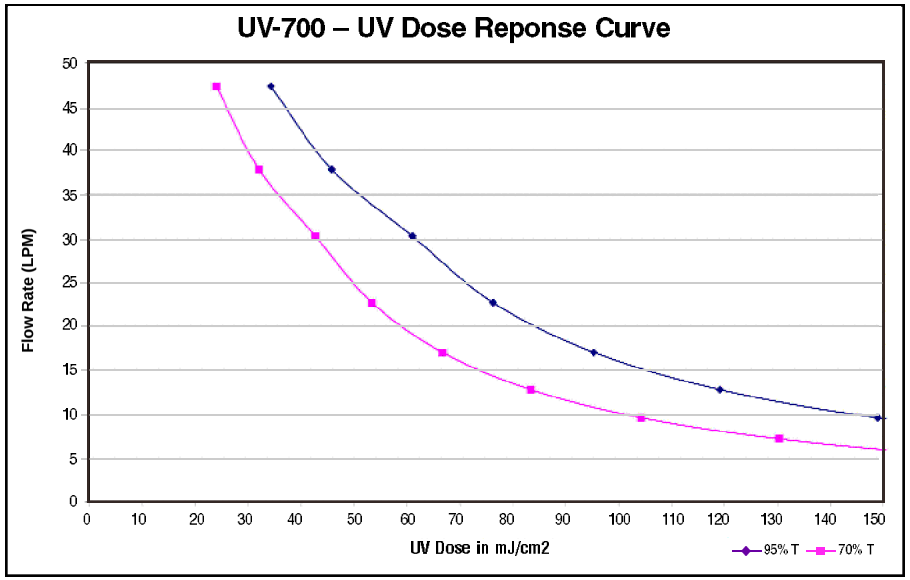

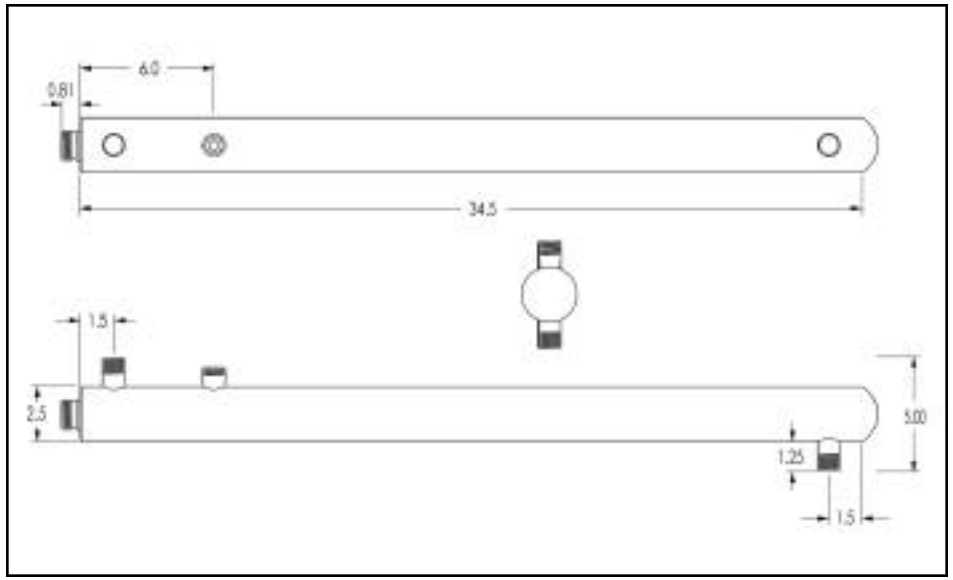

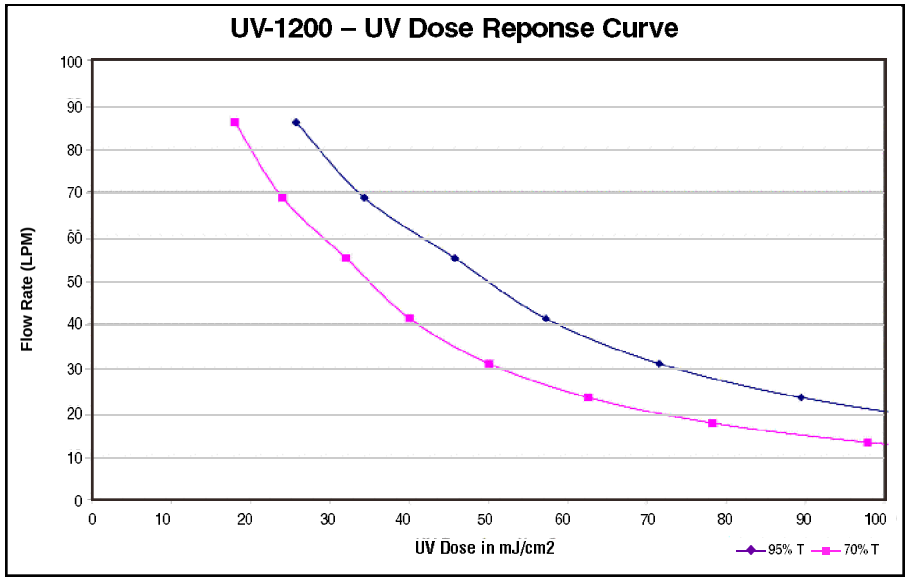

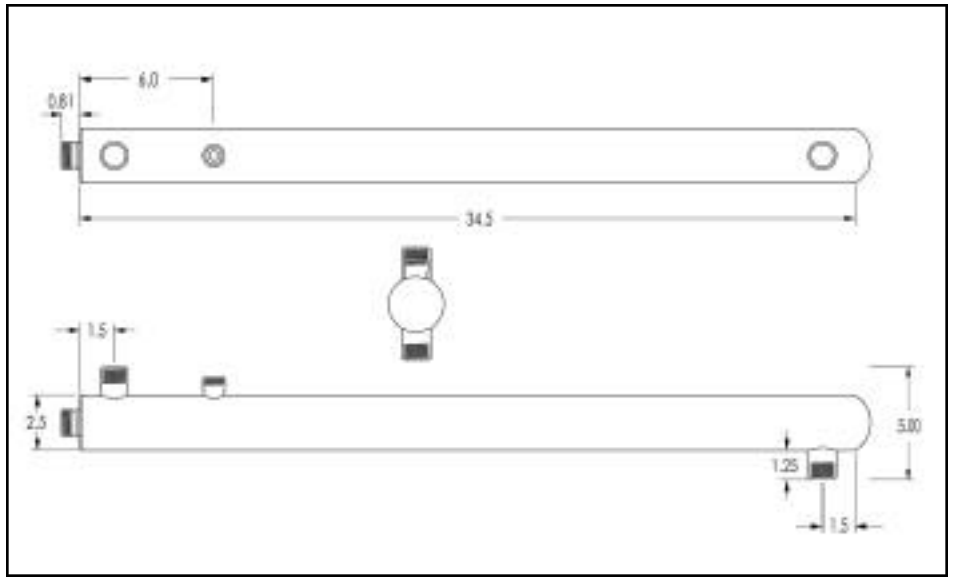

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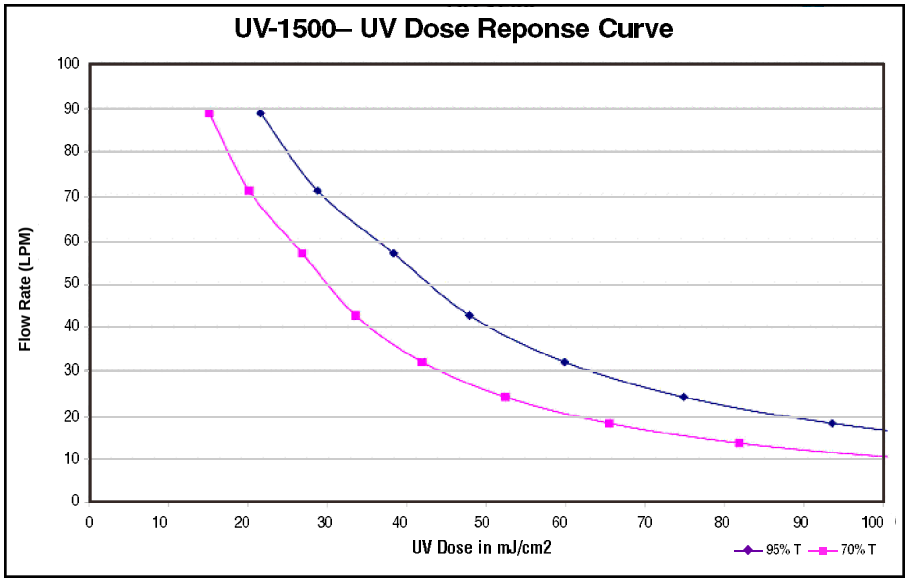

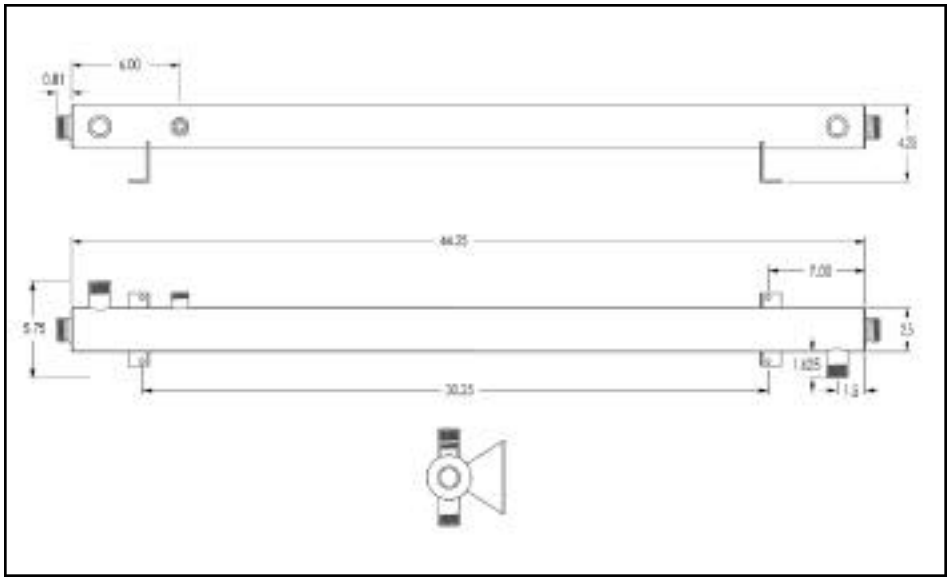

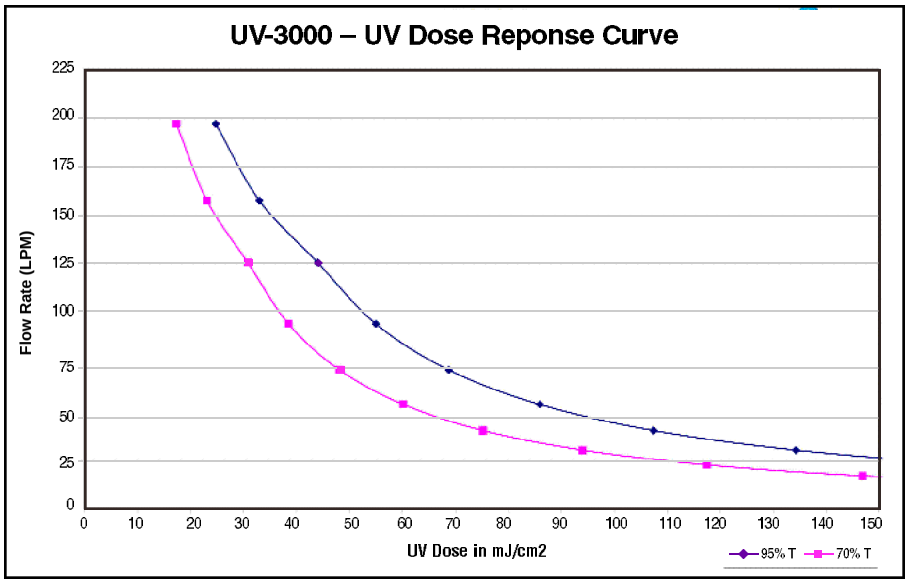

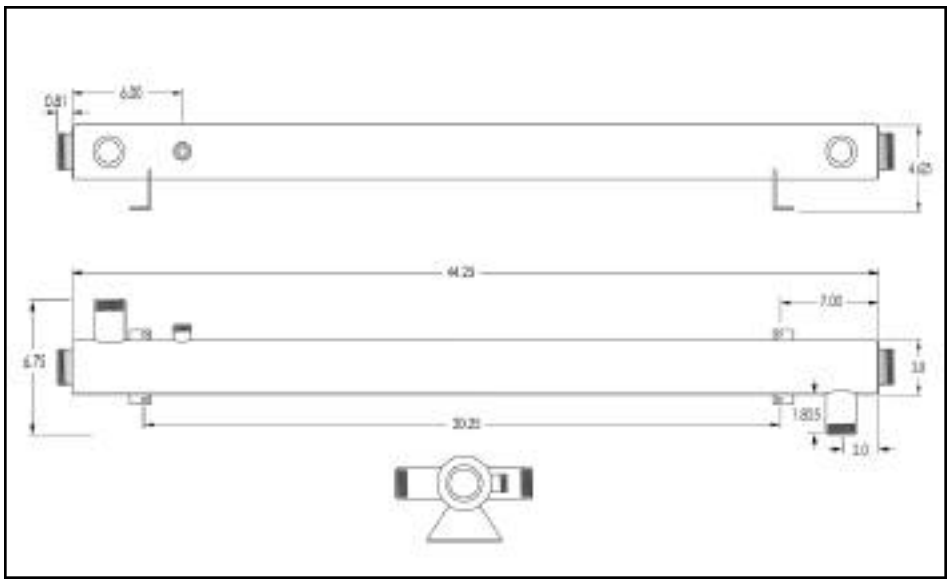

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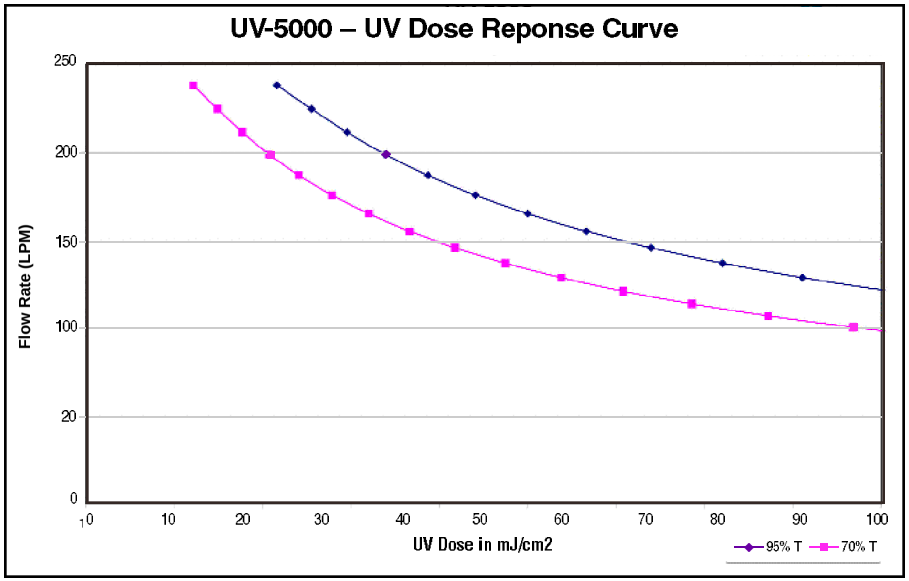
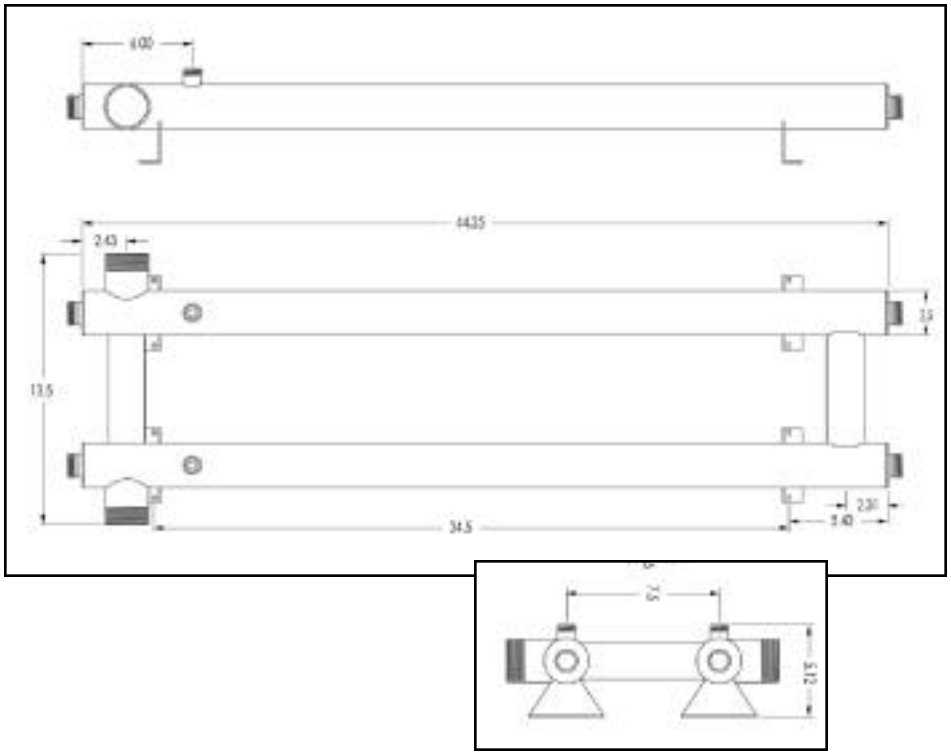




Note: For tech support and dose information on higher volume (GPM) units and/or integrated systems, contact TWT, Inc. at info@triangularwave.com

We the team at Triangularwave Technologies, Inc. provide tech support (consulting) for our customers before, during and after all sales and installations of our products/systems.

Thank you

Triangularwave Technologies, Inc. (TWT®)

TWT Patented Deposit Control Technologies and Ultraviolet Disinfection & Purification Treatment System. Suggested Product integration for Enhanced Results! End-To-End Solutions!

Control Scale Deposits / Bacteria / Corrosion / Algae / Colloids In All Fluid Based Systems

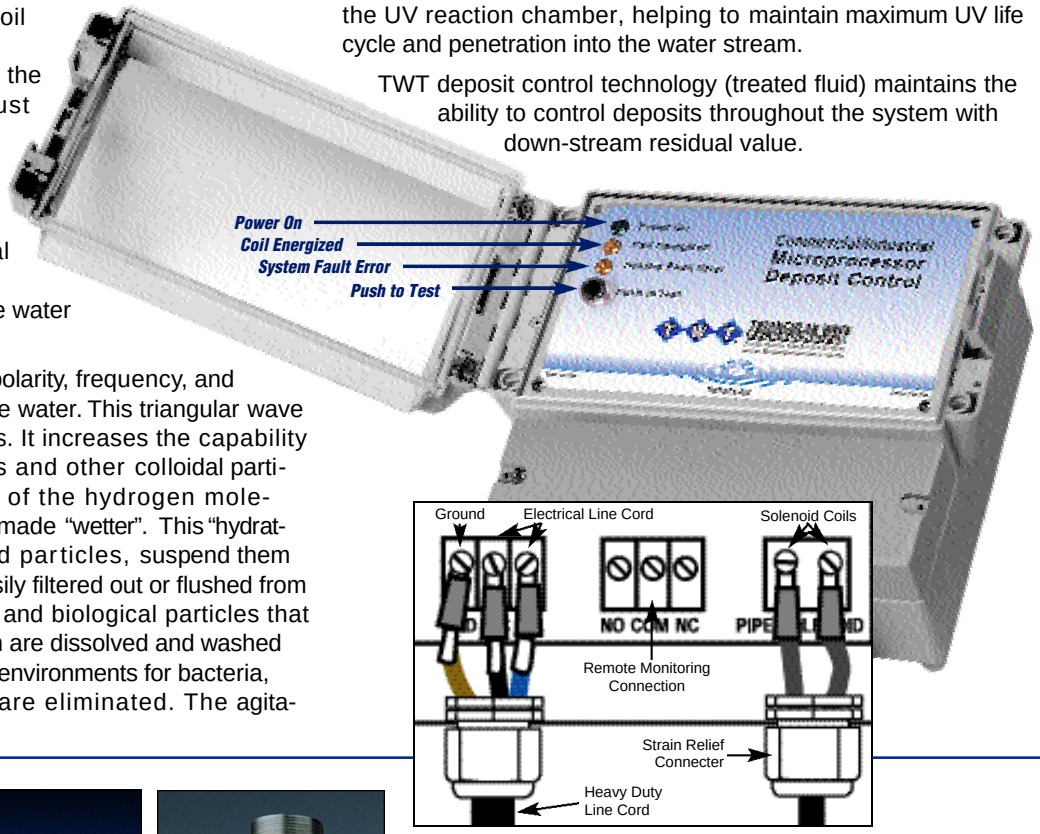
TWT, Inc. offers a full range of products & systems designed to address fluid problems wherever fluid flows.

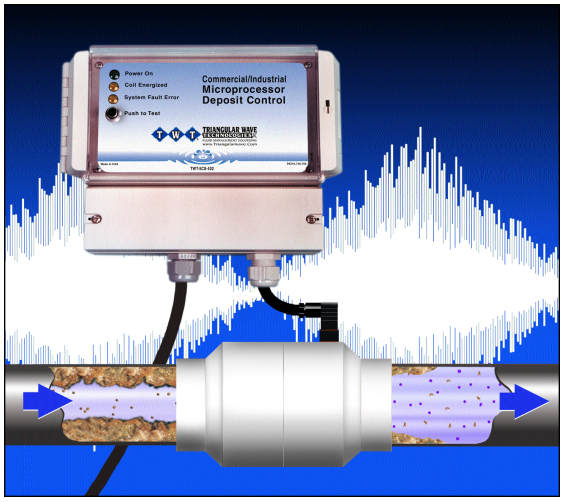
TWT® Patented Deposit Control Technology

The basic component in the TWT systems is the deposit controller. It is comprised of a microprocessor, solenoid coil wrap and/or a reaction chamber. The microprocessor is a patented controller that functions like a small computer to relay a continuous electrical power supply to the solenoid coil and/or reaction chamber. The reaction chamber is plumbed into the main water in-take line and/or just before each piece of vital processing equipment, and provides a factory wrapped wire coil forming a solenoid.The solenoid conveys the triangular wave signal at the appropriate power level (as allowed by the model chosen) to the water passing through the chamber.

This signal constantly changes the polarity, frequency, and amplitude of the current entering the water. This triangular wave treatment produces several benefits. It increases the capability of the water to hydrate scale ions and other colloidal particles. In effect, the surface charge of the hydrogen molecules is enhanced and the water is made "wetter". This "hydrated" water can dissolve unwanted particles, suspend them in solution, and allow them to be easily filtered out or flushed from the system. Accordingly, the mineral and biological particles that cause scale, deposits, and corrosion are dissolved and washed away. This means that the breeding environments for bacteria, such as bio-film and corrosion, are eliminated. The agitation created in the reaction chamber also disrupts the conditions essential for the normal reproduction of bacteria and they die, thus allowing them to be harmlessly flushed out of the system. If left untreated, scale build-up inside the reaction chamber and on the quartz sleeve containing the UV lamps may rapidly diminish the UV disinfection effectiveness by reducing the amount of UV light which is absorbed into the water stream. The TWT Deposit Control System will further condition the water stream so as to prevent this scale build-up inside the UV reaction chamber, helping to maintain maximum UV life cycle and penetration into the water stream.

TWT deposit control technology (treated fluid) maintains the ability to control deposits throughout the system with down-stream residual value.





TWT® Reaction Chambers

To use in conjunction with the TWT Deposit Control Systems when required, Triangular Wave Technologies, Inc. has developed a line of factory-wrapped wire Reaction Chambers to address magnetic pipe environments. Typically, wire coil cannot be installed on any magnetic pipe, such as steel, galvanized steel, ductile iron, or cast iron. The TWT Reaction Chambers solve this problem by providing an easily installed section of non-magnetic pipe to provide the proper pipe material for the Deposit Control System to work as designed. The TWT Reaction Chambers are fully sealed, protecting their two layers of factory-wrapped coil. The PVC, Stainless Steel and the Industrial Reaction Chamber systems are designed and manufactured to meet the highest quality specifications.

TWT® Deposit Control Technology, Ultraviolet Lamp Protection (cleaning) with Down-Stream Residual Benefits.

MADE IN U.S.A.

TRIANGULARWAVE TECHNOLOGIES, INC.
Chemical-Free Water Treatment

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