



A & L Laboratory Inc.

Environmental Consulting ~ Drinking Water Analysis ~ Radon Testing

Testing of SteriPEN™, a Portable Ultraviolet Light Water Purifier, Using MS-2 Coliphage at Different Speeds and Diameters of Stirring According to U.S.E.P.A. Protocol.

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**Research Conducted For:
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MAINE CERT #ME021

NH CERT #2501

Introduction

SteriPEN™ is a portable, handheld device designed to disinfect water by using a short wave germicidal ultraviolet (UV) light. The device, unlike traditional flow through UV water purifiers, treats batches of water up to 1 liter. Though the method of treatment is slightly different the concept is the same. The SteriPEN™ produces ultraviolet energy that is used to destroy microorganisms, without the use of chemicals. The SteriPEN™ is submerged in the water, where microorganisms are exposed to a dose of ultraviolet light in the 254-nanometer range. Ultraviolet light in this wavelength inactivates a wide range of microorganisms including bacteria, viruses and protozoan cysts. This inactivation occurs as the ultraviolet light disrupts the organism's DNA structure, making reproduction impossible. The intensity of the ultraviolet light and the microorganism's exposure time to the ultraviolet light are factors that influence which microorganisms are inactivated [6].

This study will examine the effects of the SteriPEN™ at varied diameters with different rates of stirring. Diameter testing was conducted on 1.5" and 2.5" circles. Stirring rates were examined on each diameter at rates of 1 revolution per second and 2 revolutions per second. {Figure #2 & #3}

Test Organism

MS2 Coliphage was chosen as a test subject for this study for several reasons. MS2 offers a high linear response over a wide range of UV dose levels, UV inactivation results are highly reproducible, it's easily propagated to high titers, and it is non-pathogenic to humans [9].

Studies on MS2 Coliphage have shown that a 99.5% inactivation (2.3 log reduction) of MS2 coliphage after UV treatment is equivalent or greater than a 99.9999% inactivation or a 6-log reduction of bacterial pathogens and a 99.99% percent inactivation or a 4-log reduction of viral pathogens [9]. The UV inactivation rate of MS2 coliphage has been compared to common microbial contaminants and pathogens (B. subtilis, Hepatitis A, Rotavirus SA-11, and Poliovirus type 1) [9]. Of all these organisms, MS2 coliphage was found to be the most resistant to UV radiation.

Test Procedure

Samples of general test water (EPA Test Water # 1) were used to compare the effects of the SteriPEN in two different types of containers. The general test water was created from laboratory reagent water. The required physical and chemical characteristics of the water are listed in **Table #1**. The water did not contain chlorine or any other disinfectant residuals. The pH of the water was measured by a Denver Instruments pH-ISE Meter model # 225. The pH was adjusted using a 1N solution of sodium hydroxide (NaOH) and/or hydrochloric acid (HCL). Total organic carbon (TOC) was analyzed on a Shimadzu TOC-V Combustion Analyzer. Measurements of turbidity were taken on a Hach 2100A Turbidimeter. Total dissolved solids, measured by a YSI Conductivity Meter, were increased to the appropriate concentrations by the use of sea salts. Proper water temperatures were monitored (Sper Scientific Infrared Thermometer 800048) and maintained throughout the entire experiment. Please refer to **Table #2** for the actual readings of each parameter used in the test.

Table #1. Required chemical and physical characteristics of test water per U.S.E.P.A. Guide Standard [7].

Parameter	General Test Water
Chlorine Residual	None
pH	6.5 - 8.5
Total Organic Carbon (TOC)	0.1 mg/L - 5.0 mg/L
Turbidity	0.1 NTU - 5 NTU
Temperature	20°C +/- 5°C
Total Dissolved Solids (TDS)	50 mg/L - 500 mg/L

Table #2. Actual chemical and physical characteristics of test water.

Parameter	General Test Water
Chlorine Residual	<0.10 mg/L
pH	7.9
Total Organic Carbon (TOC)	<1 mg/L
Turbidity	<1 NTU
Temperature	20°C
Total Dissolved Solids (TDS)	82 mg/L

Three SteriPENs™ were tested simultaneously. Each of the three SteriPENs™ was tested on 1 liter samples of the General Test Water at various speeds and rotation diameters. The general test water was spiked with test organism MS-2 coliphage (Escherichia coli bacteriophage ATCC® 15597-B1™). A control sample was removed from each liter of water. A single UV dose for one liter of water (90 seconds) was applied to each sample. The UV dose was administered according to the manufacturers instructions for treating between 0.5 -1.0 liter of water [5]. The on/off button was pushed once to begin the treatment of a one-liter sample. The green LED flashed indicating the SteriPEN™ was ready for use. The UV lamp end was then submerged into the sample contained in a 1000 ml Pyrex® beaker. The light illuminated, as the sensors came into contact with the water, indicating the 90-second dose had begun. The water was agitated by stirring the SteriPEN™ in a circular motion following on outline of 1.5" or 2.5" diameter circle. The SteriPEN™ was submerged so that the UV lamp assembly was halfway down the beaker. During the first test the speed of stirring was at the rate of one revolution per second for each diameter. Then each diameter was tested again at two revolutions per second. Upon completion of the treatment, an aliquot of water was removed from each container and several dilutions were plated according to the agar layer method described by Adams using E. coli host (Escherichia coli ATCC® 15597™) [1].

Results

Table #3. General Test Water MS2 coliphage Titer -logarithmic reductions and percent kill

	Control	General Test Water	Log Reduction	% Kill
1.5" Diameter with 1 Rotation Per Second	2.93E+05	5.70E+02	2.7108	99.8053869%
1.5" Diameter with 2 Rotations Per Second	2.80E+05	6.40E+02	2.6417	99.7717908%
2.5" Diameter with 1 Rotation Per Second	2.80E+05	5.70E+02	2.6916	99.7965900%
2.5" Diameter with 2 Rotations Per Second	3.30E+05	6.07E+02	2.7359	99.8162853%

Conclusion

The use of SteriPEN™ on the general test water at 1 rotation per second in both the 1.5" and 2.5" diameter circles resulted in a 2.71 and 2.70 log reduction (99.80554% and 99.7965%) of MS-2 coliphage after a single dose (90 seconds) respectively. The use of SteriPEN™ on the general test water at 2 rotations per second in both the 1.5" and 2.5" diameter circles resulted in a 2.64 and 2.73 log reduction (99.7718% and 99.8163%) of MS-2 coliphage after a single dose (90 seconds) respectively. Based on this data it appears that varying stir patterns and speeds have little effect if any on the reduction of MS-2.

The testing conducted on both the 1.5" and 2.5" diameter and at both rotation speeds indicates that SteriPEN™ meets the requirements set forth by the U.S.E.P.A. and is adequate for the inactivation of bacterial and viral contaminants in drinking water in various stirring patterns and speeds. The U.S. Environmental Protection Agency (EPA) Guide Standard and Protocol for Testing Microbiological Water Purifiers requires a minimum 6-log reduction/inactivation of bacteria, 4-log reduction/inactivation of viruses, and 3-log reduction/inactivation of protozoan cysts [7]. A 2.3 log reduction (99.5%) of MS-2 coliphage is considered to be equivalent to a 6- log reduction (99.9999%) of bacterial contaminants and a 4-log reduction (99.99%) of viral contaminants [9]. Generally, UV light is most effective at inactivating *Cryptosporidium* and *Giardia*, followed by bacteria and then viruses [8]. Given that protozoan cysts inactivation requires significantly lower UV doses, it can be expected that an adequate reduction of bacterial and viral contaminants would automatically imply a satisfactory reduction/inactivation of cysts.



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Figure #1

MS-2 Coliphage Logarithmic Reduction for General Test Water at Various Diameters and Stir Speeds.

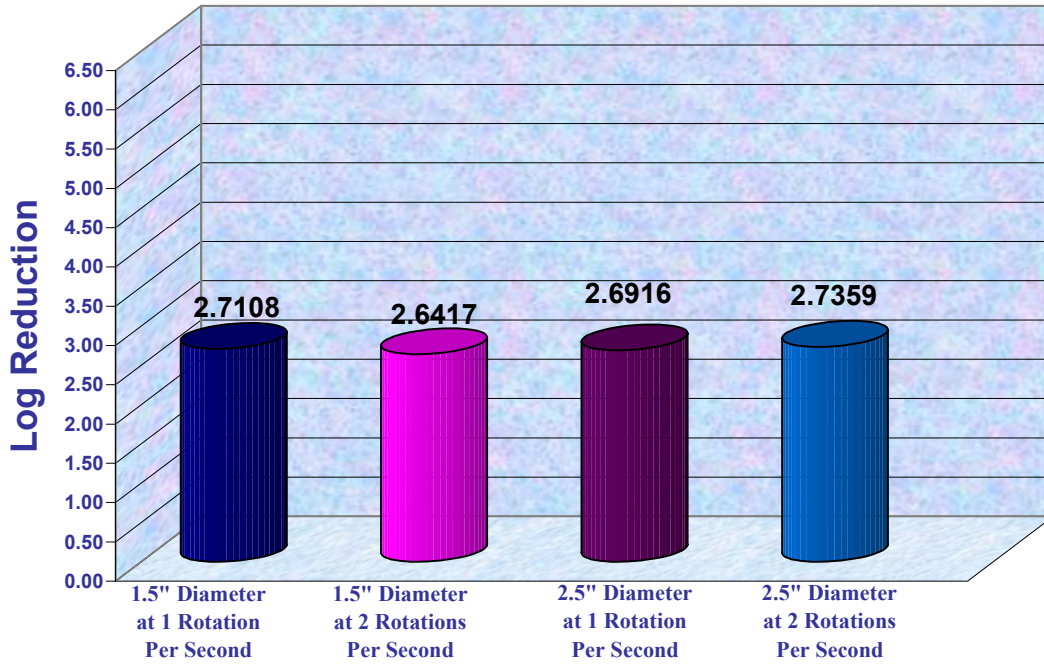


Figure #2

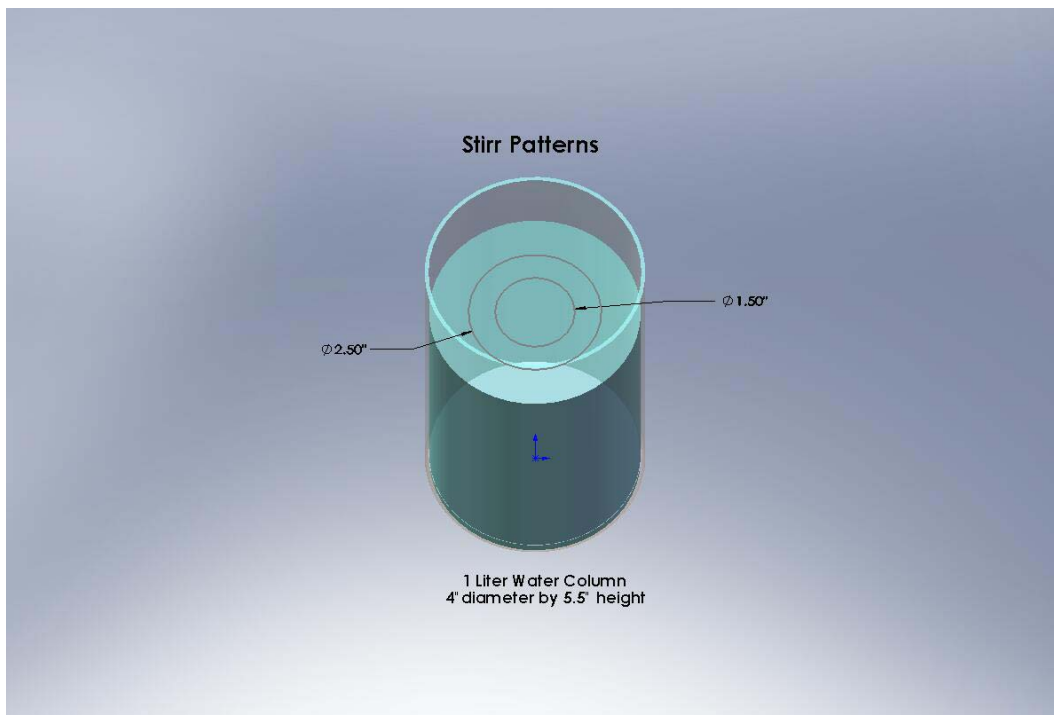
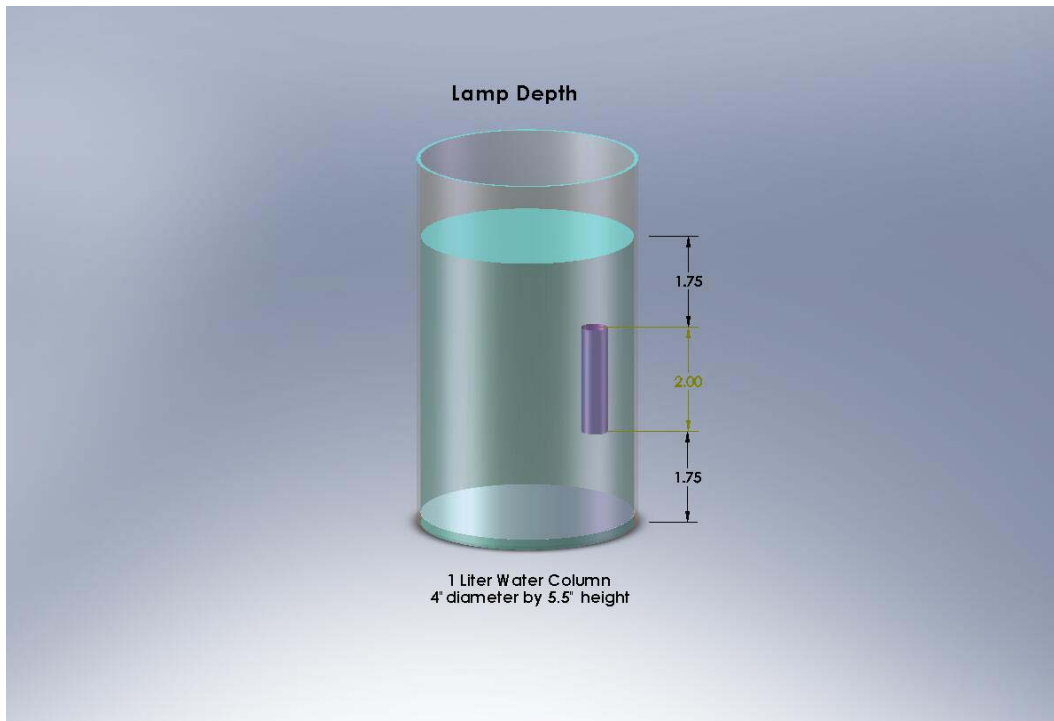


Figure #3



References

1. Adams, M. H. 1959. *Bacteriophages*. Interscience Publishers, New York
2. Enriquez, C. and Gerba, c. 2001. *Evaluation of the Steri-Pen® Water Treatment System According to the US Environmental Protection Agency Guide Standard And Protocol For Testing of Microbiological Water Purifiers*.
3. Hanson, Anne 2000. *Testing of Steri-Pen, a Hand-held Ultraviolet Water Treatment Device using MS2 Coliphage*.
4. Hanson, Anne 2001. *Testing of Steri-Pen, a Hand-held Ultraviolet Water Treatment Device using MS2 Coliphage on Visually Turbid Natural Water*.
5. Hydro-Photon, Inc., 2005 *SteriPEN™ Users Guide*, Blue Hill, Maine <http://www.hydro-photon.com/PDF/SteriPENEnglish.pdf>
6. *Ultraviolet Light Disinfection Technology In Drinking Water Application - An Overview*. United States Environmental Protection Agency, Office of Water. EPA 811-R-96-002. September, 1996
7. U.S.E.P.A. - Task Force Report, 1987. *Guide Standard and Protocol for Testing Microbiological Water Purifiers*. United States Environmental Protection Agency, Registration Division, Office of Pesticide Programs and Criteria and Standards Division, Office of Drinking Water, Washington, DC
8. U.S. Army Center for Health Promotion and Preventive Medicine, 2005. *Technical Information Paper; Ultraviolet Light Disinfection in the Use of Individual Water Purification Devices*, Aberdeen Proving Ground, MD.
9. Wilson, B.R.P.F. Roessler, E. Van Dellen, M. Abbaszadegan and C.P. Gerba. *Coliphage MS2 as a UV Water Disinfection Efficacy Test Surrogate for Bacterial and Viral Pathogens*. University of Arizona, Tucson, AZ