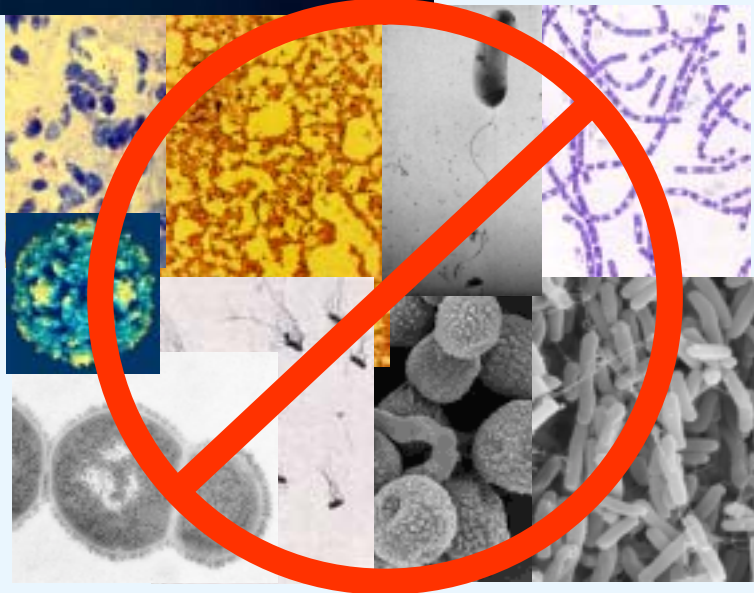


Disinfection of Aircraft Potable Water By Ultraviolet Light

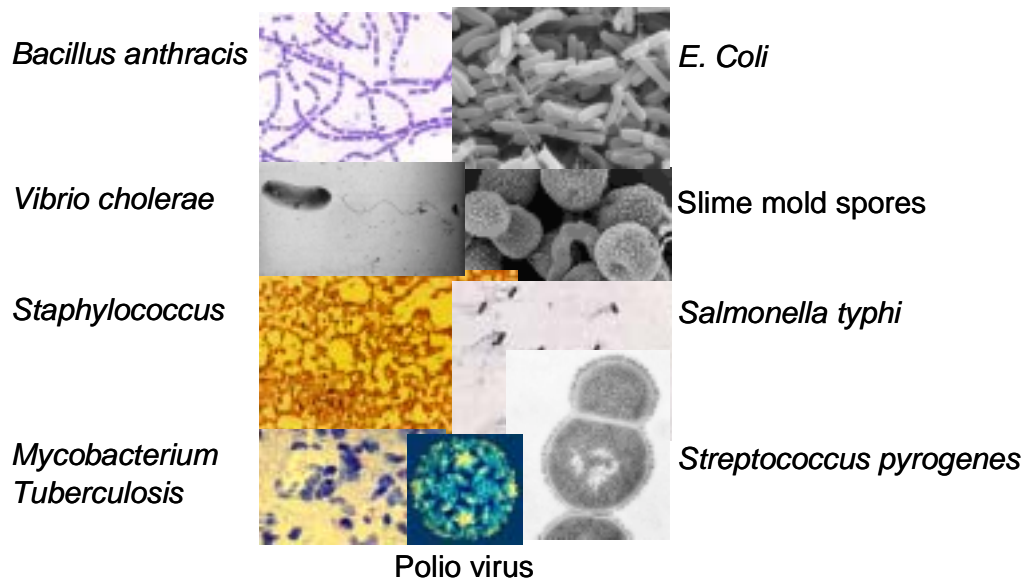


INTERNATIONAL
Water·Guard



Is Ultraviolet Disinfection of Aircraft Potable Water Really Necessary?

Water supplies the world over are increasingly becoming contaminated by harmful micro-organisms. This growing problem is not limited to third world countries, as recent outbreaks of waterborne disease in North America illustrate. Aircraft water systems are no less at risk, since water is typically loaded from the same municipal systems that are the source of the outbreaks.



In November of 2002, The Wall Street Journal published the results of an investigation into the quality of potable water on 14 commercial airlines. The airlines investigated were primarily U.S. carriers, but included one Mexican and one British airline. The results were far from flattering:

“We took samples of airline water from 14 flights and sent them to a prominent lab to test bacteria levels. We collected samples not only from lavatory taps but also from the galley. The reason: Though most airlines insist they serve only bottled water, flight attendant unions told us they use galley water when bottled water runs out. In all but two of the cases, bacteria levels exceeded the maximum level the federal government allows in municipal drinking water - 500 colonies per milliliter.”¹

¹The Wall Street Journal, Friday, November 1, 2002.

Japan's Ministry of Health, Labour and Welfare conducts annual potable water inspections of aircraft landing at Narita International Airport for compliance with the "Guidelines for Sanitary Control in the (Tokyo) Bay Area." The 1999 inspection disclosed some disturbing facts about the quality of water on aircraft not equipped with on-board disinfection devices:

*"All samples from the water supply trucks and water taps satisfied the guidelines. But unsatisfactory results were obtained from 150 samples (32.9%) of water taken from tanks in 63 aircraft, 5 samples (41.7%) of 12 samples of bottled water, and 1 sample out of 3 samples of water in containers."*¹

Britain's Chartered Institute of Environmental Health, Port Health Centre surveyed the quality of potable water being delivered to aircraft at UK airports. In its 2000 Annual Review, the Institute reported that:

*"During the year thirteen member authorities took part in a joint A.P.H./P.H.L.S survey on the microbiological quality of safety of (sic) water on aircraft. Results have shown that a need for enforcing authorities to pay particular attention to the adequacy of hygiene control of water supplies to aircraft."*²

In a recent study of U.S. bottled water, the Natural Resources Defense Council found that,

*"In sum, approximately one third of the tested bottled water (34 of 103, or 33%) violated an enforceable state standard or exceeded microbiological purity guidelines, or both, in at least one sample."*³

It should be noted that even if bottled water (of questionable quality) is served, passengers and crew may still be affected by waterborne disease from shower/lavatory water, or by drinking coffee, tea, or other beverages made with aircraft potable water.

Ultraviolet disinfection is a time-proven method of eliminating the threat of microbiological contamination of aircraft potable water supplies. More than 900 of IWG's water treatment units are currently flying in aircraft ranging from business jets like the Gulfstream G-IV to head-of-state airliner conversions.

²Excerpted translation from "Gyomu Hokokusho" produced annually in Japanese by Narita International Airport's Quarantine Office of the Ministry of Health, Labour and Welfare (1999).

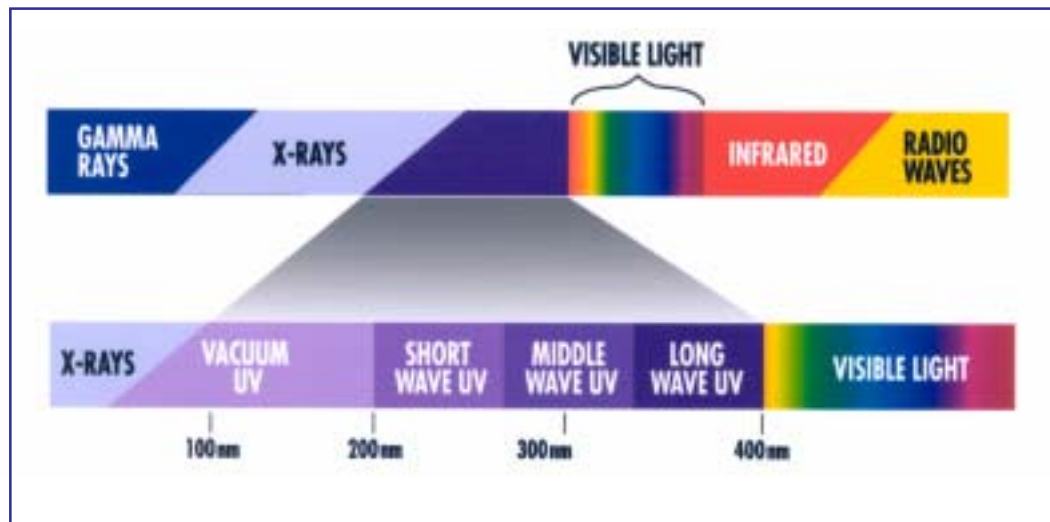
³Natural Resources Defense Council, February, 1999, "Bottled Water: Pure Drink or Pure Hype?" Principal Author: Erik D. Olson, J.D., with Diane Poling, J.D., and Gina Solomon, M.D., M.P.H., Page viii.

How Does Ultraviolet Light Disinfect Water?

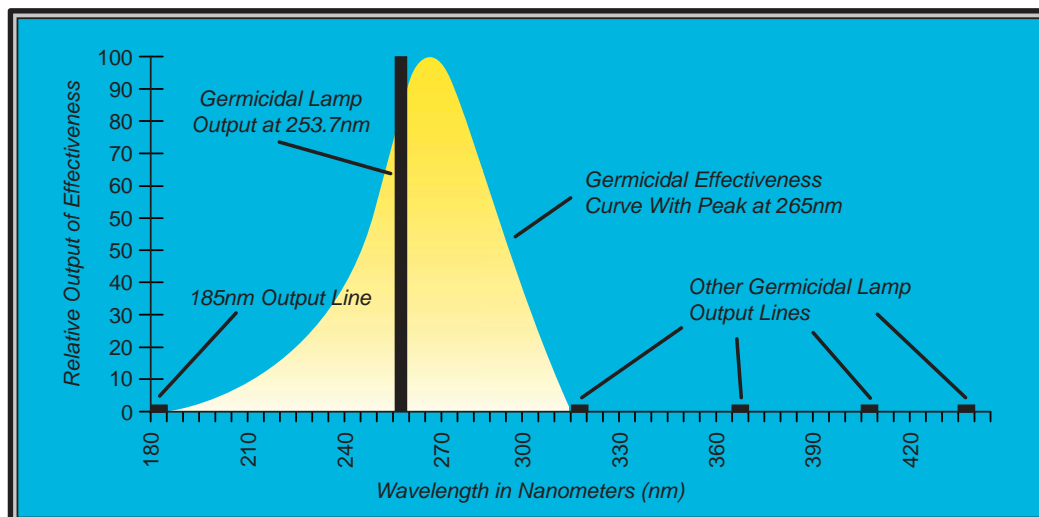
Scientists have known for nearly a century that ultraviolet light of certain wavelengths is an effective germicidal agent. Over the past thirty years, extensive experimental work has been carried out by researchers seeking to determine lethal ultraviolet dosages for a variety of micro-organisms. Pathogenic microbes were generally the number one target. As a result of this research, it is now possible to design ultraviolet irradiation equipment to meet virtually any disinfection requirement.

THE MECHANICS OF DISINFECTION

Ultraviolet radiation is actually high energy light. The wavelengths in the ultraviolet spectrum are too short for the human eye to resolve and ultraviolet light is therefore invisible. The ultraviolet spectrum ranges from 40 to 400 Nanometers (nm), with the most effective spectral region for germicidal purposes being between 250 and 265 nm. At the proper level of intensity, ultraviolet light is fatal to all micro-organisms known to inhabit water.

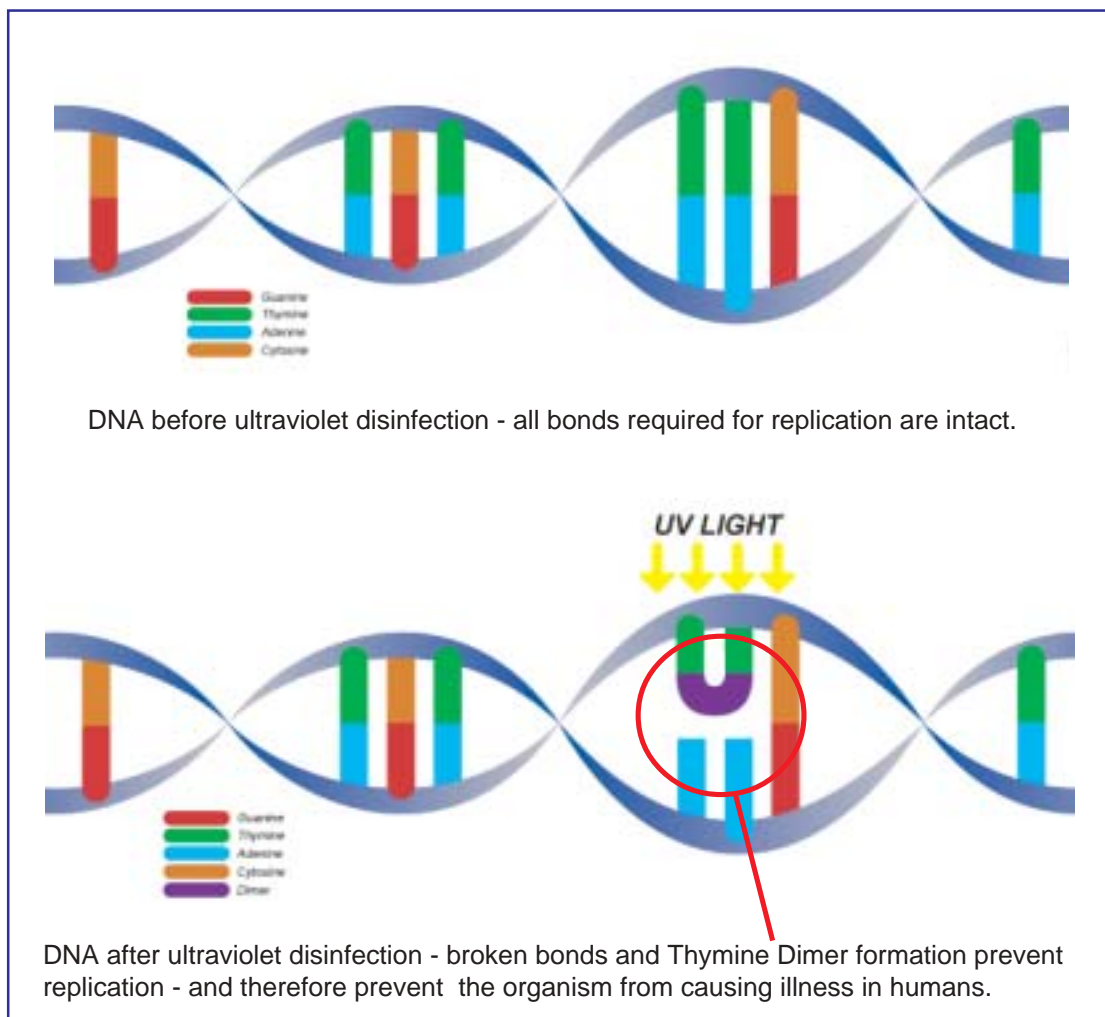


Ultraviolet rays are invisible to the human eye and, at the right intensity, are fatal to bacteria and viruses in water. The most effective ultraviolet wavelength is around 254 nanometers.



Mercury arc lamps generate the ultraviolet radiation for water disinfection, with low pressure lamps being the most common and effective type. Since normal glass blocks ultraviolet, the lamp and its protective sleeve are made of fused silica or quartz, which readily transmit the germicidal ultraviolet rays. Low pressure mercury arc lamps are efficient producers of ultraviolet rays in the range lethal to microbes. About 50% of the input energy is converted to ultraviolet rays having a wavelength of 254 nm. This wavelength is very effective in the destruction of all known micro-organisms.

Studies show that DNA molecules in the nucleus of the organism absorb ultraviolet light. The organism is inactivated when sufficient dosage has been absorbed to modify the molecular structure in the DNA. This results when exposure to ultraviolet light causes two thymine molecules to form an inappropriate bond, or dimer. The effect of numerous thymine dimers forming along the DNA chain inhibits replication of the organism. It may not be killed instantly, but the scrambling of the genetic code in the nucleus prevents reproduction, rendering it non-viable and harmless to humans. The amount of energy required to produce this effect is referred to as the lethal dosage.



The term 'dosage' is used to describe the total amount of energy absorbed by the micro-organism. Dosage is the product of intensity and time, and as such, allows the capacity of any ultraviolet treatment unit to be calculated.

ULTRAVIOLET VS. CHLORINATION

Ultraviolet is a more effective viricide than chlorine, but does not add to or alter the composition of water, does not produce toxic by-products or other potentially harmful residual materials, and has no danger of overdose from added chemicals. Nothing is added that would have to be removed by other downstream systems. No dangerous chemicals must be used or stored, and staff need no specialized hazardous materials knowledge or training.

Ultraviolet light at sufficient dosage levels has proven to be an extremely effective means to destroy bacteria, mold, viruses and algae. In fact, all micro-organisms are susceptible to the effects of ultraviolet radiation. With major technological improvements made in the past few decades, ultraviolet irradiation has emerged as a leading water treatment contender with significant advantages over chlorination.

IS THERE A STANDARD FOR ULTRAVIOLET DISINFECTION OF WATER?

The industry benchmark for ultraviolet drinking water disinfection equipment design is the ***NSF Standard 55-1991 Ultraviolet Microbiological Water Treatment Systems***. NSF (National Sanitation Foundation) is a non-profit organization based in the United States and is best known for its role in developing standards and criteria for products and services bearing upon health. Under NSF 55, there are two classes of ultraviolet drinking water treatment systems: Class A and Class B. IWG only installs units on aircraft that exceed the highest (Class A) standards.

- ◆ Class A systems are those designed to disinfect water contaminated by micro-organisms like bacteria and viruses, but not water with an obvious contamination source such as raw sewage, nor are they designed to convert wastewater to safe drinking water. The NSF failsafe set-point dosage for Class A systems is 40 millijoules per square centimeter (mJ/cm^2). The ultraviolet dosages delivered by fully functional NPS-A2, NPS-A3/NPS-A4, and NPS-A6 units are $65.2 \text{ mJ}/\text{cm}^2$, $58.3 \text{ mJ}/\text{cm}^2$ and $62.5 \text{ mJ}/\text{cm}^2$ respectively. See dosage calculations, p.8 -14.

Ultraviolet Dosage Calculations: NPS-A2 Potable Water Disinfection Unit



NPS-A2 Ultraviolet Dosage Calculations

General

The *Dosage* received by the water in an Ultraviolet, (UV), disinfection system is a function of two factors. The first is the *Average Intensity* of the 254nm UV light present in the chamber. The second is the *Retention Time* or the length of time the volume of water is irradiated by the UV light. The 254nm intensity is measured at the chamber wall and represents the worst case dosage scenario, since the UV intensity is higher closer to the UV lamp. In other words, a very conservative approach has been taken to calculate UV dosage (see p.15 for UV dosages required to inactivate micro-organisms).

Effective Disinfection Chamber Volume

The effective chamber volume is defined as the three dimensional area that contains actively flowing water which is continuously exposed to the 254nm UV light radiating from the germicidal lamp and reflecting off the UV chamber walls. The effective chamber volume is the volume of the chamber exposed to UV light less the volume of the quartz sleeve, less the volume of the flow diffuser. This has been determined by measurement and calculated to be 0.313 liters, or 0.0827 US Gallons.

Retention Time

The Retention Time is the length of time the *actively flowing* water is exposed to the perpendicular 254nm ultraviolet radiation from the germicidal lamp. The flow rate of the NPS-A2 is specified at 1.5 US gallons per minute. The Retention Time is calculated as:

$$t_{(ret)} = \text{Effective Volume} \div \text{Flow Rate}$$

$$t_{(ret)} = 0.0827 \text{ gallons (US)} \div 1.50 \text{ gallons/minute} = 0.0551 \text{ minutes}$$

$$t_{(ret)} = 0.0551 \text{ minutes} \times 60 = \underline{3.306 \text{ seconds}}$$

Dosage

The *Dosage* of the NPS-A2 disinfection system is the product of the 254nm UV intensity (measured at the chamber wall, opposite the midpoint of the lamp), the lamp intensity factor that allows for variations in intensity, and the Retention Time. The 254nm intensity readings were taken with unfiltered Vancouver "Municipal Water" flowing through the disinfection chamber.

The dosage, with new lamps, is calculated as follows:

$$\text{Dosage} = \text{Measured Midpoint Wall Intensity} \times \text{Average Factor} \times \text{Retention Time} \times 2(\text{chambers})$$

$$\text{Dosage} = 10.5 \text{ mW/cm}^2 \times 0.94 \times 3.306 \text{ seconds} \times 2$$

$$\text{NPS-A2 Ultraviolet Dosage (both chambers)} = \mathbf{65.26 \text{ mJ/cm}^2}$$

$$\text{NPS-A2 Ultraviolet Dosage (one chamber)} = \mathbf{32.63 \text{ mJ/cm}^2}$$

Note: International Water-Guard strongly recommends that ultraviolet lamps be replaced at a maximum interval of 3000 hours of operation. It is estimated that an ultraviolet lamp will lose 20% of its ultraviolet intensity by the 3000 hour point. This means that even at the end of its lamps' service life, the NPS-A2 will produce 52.21 mJ/cm² in its normal operating condition with two chambers active, and 26.1 mJ/cm² in its fail-safe mode with one chamber active.

NPS-A3 Ultraviolet Dosage Calculations

General

The *Dosage* received by the water in an Ultraviolet, (UV), disinfection system is a function of two factors. The first is the *Average Intensity* of the 254nm UV light present in the chamber. The second is the *Retention Time* or the length of time the volume of water is irradiated by the UV light. The 254nm intensity is measured at the chamber wall and represents the worst case dosage scenario, since the UV intensity is higher closer to the UV lamp. In other words, a very conservative approach has been taken to calculate UV dosage (see p.15 for UV dosages required to inactivate micro-organisms).

Effective Disinfection Chamber Volume

The effective chamber volume is defined as the three dimensional area that contains actively flowing water which is continuously exposed to the 254nm UV light radiating from the germicidal lamp and reflecting off the UV chamber walls. The effective chamber volume is the volume of the chamber exposed to UV light less the volume of the quartz sleeve, less the volume of the flow diffuser. This has been determined by measurement and calculated to be 0.454 liters, or 0.12 US Gallons.

Retention Time

The Retention Time is the length of time the *actively flowing* water is exposed to the perpendicular 254nm ultraviolet radiation from the germicidal lamp. The flow rate of the NPS-A3 is specified at 1.0 US gallons per minute. The Retention Time is calculated as:

$$\begin{aligned}
 t_{(ret)} &= \text{Effective Volume} \div \text{Flow Rate} \\
 t_{(ret)} &= 0.12 \text{ gallons (US)} \div 1.00 \text{ gallons/minute} = 0.12 \text{ minutes} \\
 t_{(ret)} &= 0.12 \text{ minutes} \times 60 = \mathbf{7.20 \text{ seconds}}
 \end{aligned}$$

Dosage

The *Dosage* of the NPS-A3 disinfection system is the product of the 254nm UV intensity (measured across from the midpoint of the lamp at the chamber wall), the lamp intensity factor that allows for variations in intensity, and the Retention Time. The 254nm intensity readings were taken with unfiltered Vancouver "Municipal Water" flowing through the disinfection chamber.

The dosage, with new lamps, is calculated as follows:

$$\begin{aligned}
 \text{Dosage} &= \text{Measured Midpoint Wall Intensity} \times \text{Average Factor} \times \text{Retention Time} \\
 \text{Dosage} &= 9.0 \text{ mW/cm}^2 \times 0.90 \times 7.20 \text{ seconds}
 \end{aligned}$$

$$\mathbf{\text{NPS-A3 Ultraviolet Dosage} = 58.32 \text{ mJ/cm}^2}$$

Note: International Water-Guard strongly recommends that ultraviolet lamps be replaced at a maximum interval of 3000 hours of operation. It is estimated that an ultraviolet lamp will lose 20% of its ultraviolet intensity by the 3000 hour point. This means that even at the end of its lamp's service life, the NPS-A3 will produce 46.66 mJ/cm² in its normal operating condition.

Ultraviolet Dosage Calculations: NPS-A4 Potable Water Treatment Unit



NPS-A4 Ultraviolet Dosage Calculations

General

The *Dosage* received by the water in an Ultraviolet, (UV), disinfection system is a function of two factors. The first is the *Average Intensity* of the 254nm UV light present in the chamber. The second is the *Retention Time* or the length of time the volume of water is irradiated by the UV light. The 254nm intensity is measured at the chamber wall and represents the worst case dosage scenario, since the UV intensity is higher closer to the UV lamp. In other words, a very conservative approach has been taken to calculate UV dosage (see p.15 for UV dosages required to inactivate micro-organisms).

Effective Disinfection Chamber Volume

The effective chamber volume is defined as the three dimensional area that contains actively flowing water which is continuously exposed to the 254nm UV light radiating from the germicidal lamp and reflecting off the UV chamber walls. The effective chamber volume is the volume of the chamber exposed to UV light less the volume of the quartz sleeve, less the volume of the flow diffuser. This has been determined by measurement and calculated to be 0.454 liters, or 0.12 US Gallons.

Retention Time

The Retention Time is the length of time the *actively flowing* water is exposed to the perpendicular 254nm ultraviolet radiation from the germicidal lamp. The flow rate of the NPS-A4 is specified at 1.0 US gallons per minute. The Retention Time is calculated as:

$$\begin{aligned}
 t_{(ret)} &= \text{Effective Volume} \div \text{Flow Rate} \\
 t_{(ret)} &= 0.12 \text{ gallons (US)} \div 1.00 \text{ gallons/minute} = 0.12 \text{ minutes} \\
 t_{(ret)} &= 0.12 \text{ minutes} \times 60 = \mathbf{7.20 \text{ seconds}}
 \end{aligned}$$

Dosage

The *Dosage* of the NPS-A4 disinfection system is the product of the 254nm UV intensity (measured across from the midpoint of the lamp at the chamber wall), the lamp intensity factor that allows for variations in intensity, and the Retention Time. The 254nm intensity readings were taken with unfiltered Vancouver "Municipal Water" flowing through the disinfection chamber.

The dosage, with new lamps, is calculated as follows:

$$\begin{aligned}
 \text{Dosage} &= \text{Measured Midpoint Wall Intensity} \times \text{Average Factor} \times \text{Retention Time} \\
 \text{Dosage} &= 9.0 \text{ mW/cm}^2 \times 0.90 \times 7.20 \text{ seconds}
 \end{aligned}$$

$$\text{NPS-A4 Ultraviolet Dosage} = \mathbf{58.32 \text{ mJ/cm}^2}$$

Note: International Water-Guard strongly recommends that ultraviolet lamps be replaced at a maximum interval of 3000 hours of operation. It is estimated that an ultraviolet lamp will lose 20% of its ultraviolet intensity by the 3000 hour point. This means that even at the end of its lamp's service life, the NPS-A4 will produce 46.66 mJ/cm² in its normal operating condition.

NPS-A6 Ultraviolet Dosage Calculations

General

The *Dosage* received by the water in an Ultraviolet, (UV), disinfection system is a function of two factors. The first is the *Average Intensity* of the 254nm UV light present in the chamber. The second is the *Retention Time* or the length of time the volume of water is irradiated by the UV light. The 254nm intensity is measured at the chamber wall and represents the worst case dosage scenario, since the UV intensity is higher closer to the UV lamp. In other words, a very conservative approach has been taken to calculate UV dosage (see p.15 for UV dosages required to inactivate micro-organisms).

Effective Disinfection Chamber Volume

The effective chamber volume is defined as the three dimensional area that contains actively flowing water which is continuously exposed to the 254nm UV light radiating from the germicidal lamp and reflecting off the UV chamber walls. The effective chamber volume is the volume of the chamber exposed to UV light less the volume of the quartz sleeve, less the volume of the flow diffuser. This has been determined by measurement and calculated to be 0.833 liters, or 0.22 US Gallons.

Retention Time

The Retention Time is the length of time the *actively flowing* water is exposed to the perpendicular 254nm ultraviolet radiation from the germicidal lamp. The flow rate of the NPS-A6 is specified at 2.0 US gallons per minute. The Retention Time is calculated as:

$$t_{(ret)} = \text{Effective Volume} \div \text{Flow Rate}$$

$$t_{(ret)} = 0.22 \text{ gallons (US)} \div 2.00 \text{ gallons/minute} = 0.11 \text{ minutes}$$

$$t_{(ret)} = 0.11 \text{ minutes} \times 60 = \mathbf{6.60 \text{ seconds}}$$

Dosage

The *Dosage* of the NPS-A6 disinfection system is the product of the 254nm UV intensity (measured across from the midpoint of the lamp at the chamber wall), the lamp intensity factor that allows for variations in intensity, and the Retention Time. The 254nm intensity readings were taken with unfiltered Vancouver "Municipal Water" flowing through the disinfection chamber.

The dosage, with new lamps, is calculated as follows:

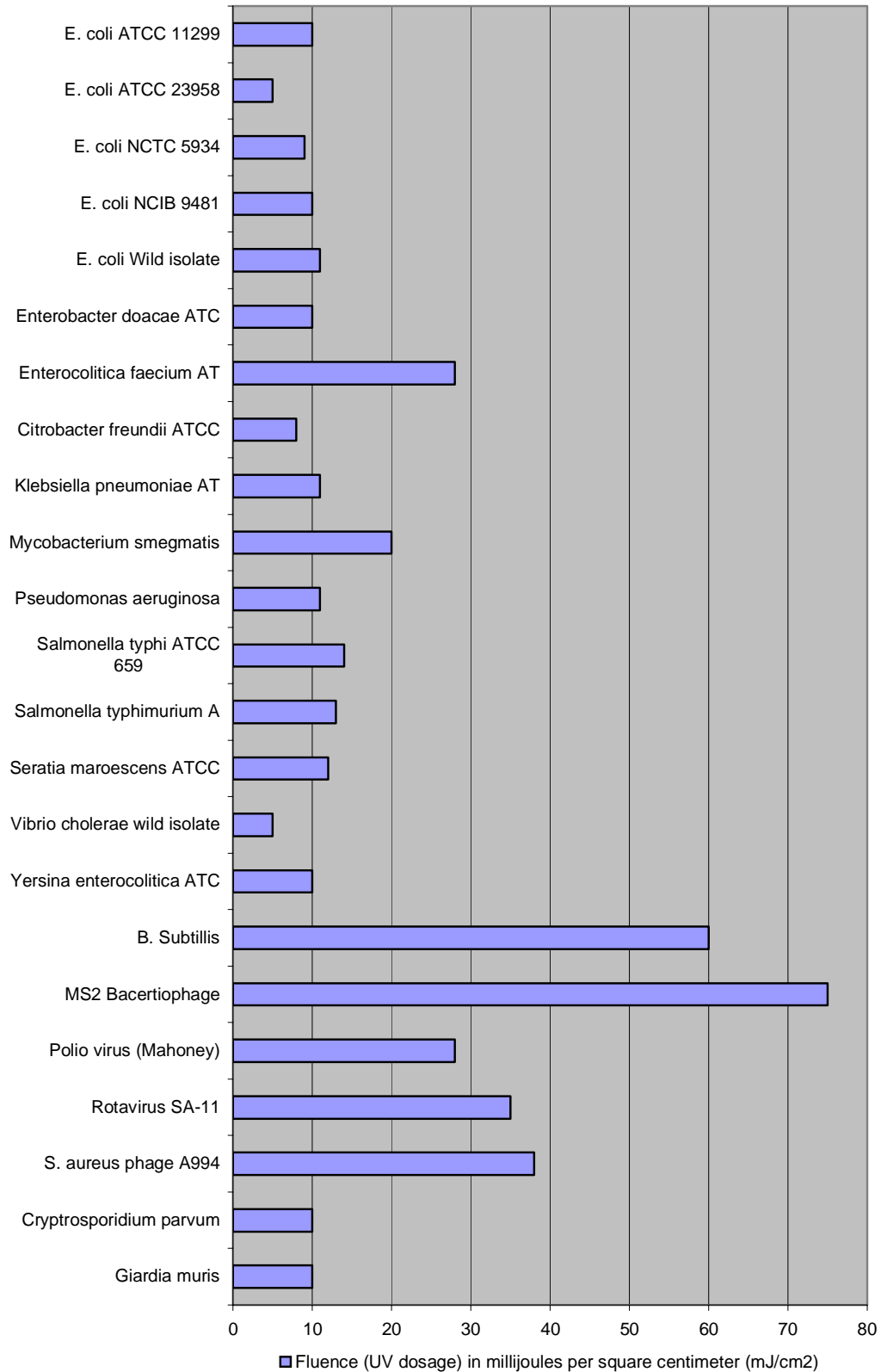
$$\text{Dosage} = \text{Measured Midpoint Wall Intensity} \times \text{Average Factor} \times \text{Retention Time}$$

$$\text{Dosage} = 10.52.0 \text{ mW/cm}^2 \times 0.90 \times 6.60 \text{ seconds}$$

$$\mathbf{\text{NPS-A6 Ultraviolet Dosage} = 62.50 \text{ mJ/cm}^2}$$

Note: International Water-Guard strongly recommends that ultraviolet lamps be replaced at a maximum interval of 3000 hours of operation. It is estimated that an ultraviolet lamp will lose 20% of its ultraviolet intensity by the 3000 hour point. This means that even at the end of its lamp's service life, the NPS-A6 will produce 50.0 mJ/cm² in its normal operating condition.

UV Dosage required for 4 logs (99.99%) inactivation of bacteria, spores, viruses & protozoa "in the absense of photoreactivating light".



Source: Ultraviolet Applications Handbook, Bolton Photosciences Inc., 2001.

Ultraviolet Light vs. *Cryptosporidium parvum* and *Giardia lamblia*

Cryptosporidium is the waterborne pathogen responsible for 403,000 cases of diarrheal illness in Milwaukee WI in 1993, and possibly as many as 50 deaths. *Giardia* is a similar organism.

What the research says:

“This study measured the effect of germicidal ultraviolet (UV) light on *Giardia lamblia* (the etiologic agent for giardiasis outbreaks associated with drinking water) and *Giardia muris* cysts (a more easily handled rodent parasite)... At >3 millijoules per square centimeter (mJ cm⁻²), a dose significantly lower than what large-scale UV reactors would be designed to provide, more than 2 log₁₀ (99 percent) inactivation was observed. These results show that both organisms are significantly more susceptible to UV light than many bacteria and most viruses... Recently, analysis by animal and cell-culture infectivity assays demonstrated that *Cryptosporidium parvum* oocysts (another waterborne protozoan pathogen) are highly susceptible to low dosages of UV light.”

Extracted from:

Disinfection of *Giardia Lamblia* and *Giardia Muris* Cysts by UV Light*

Alexander A. Mofidi, Associate Engineer, Connie I. Chow, Laboratory Technician, Bradley M. Coffey, Senior Engineer, Metropolitan Water District of Southern California, La Verne California USA 91750-3399.

Ernest A. Meyer, Professor, Oregon Health Sciences University, Portland, Oregon, USA 97201-3098.

Peter M. Wallis, President, Hyperion Research, Ltd., Medicine Hat, Alberta Canada T1A 3G8.

2001.

“Low doses of ultraviolet (UV) light are highly effective for inactivation of *Cryptosporidium parvum* oocysts in water. While used in the US for ground water disinfection of viruses and bacteria, the United States Environmental Protection Agency (USEPA) has now included UV as a technology for disinfecting surface waters to control *Cryptosporidium*.”

Extracted from:

Susceptibility of Multiple Strains of *Cryptosporidium parvum* Oocysts to UV Light*

J.L. Clancy, T.M. Hargy, J.P. Durda, D.G. Korich, and M.M. Marshall
Clancy Environmental Consultants Inc., POB 314, St. Albans VT 05478
U. of Arizona, Veterinary Science Department, Tucson AZ 85721

2001.

*Full copies of these studies are available on request.



BC Research Inc., BC Research and Innovation Complex, 3650 Westbrook Mall, Vancouver, BC, Canada V6S 2L2
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File No: 2-51-0949

March 8, 2000

Mr. George Thorpe, P. Eng.
Director of Product Development
International Water-Guard Industries Inc.
575 Powell Street,
Vancouver, B.C.
V6A 1G8

Subject: Ultraviolet Disinfection Efficacy Evaluation of Two Microbiological Drinking Water Treatment Units (NPS-A2 and NPS-A3)

International Water-Guard Industries Inc. contracted BC Research Inc. to conduct a disinfection efficacy evaluation of their ultraviolet (UV) microbiological water treatment units (NPS-A2, serial No. 1258 and NPA-A3, serial No. 2-1026). The evaluation consisted of determining the number of viable challenge coliform bacteria in chlorine-free flowing water at a flow rate of 1.5 gpm before and after UV light treatment.

The test protocol for evaluation of UV bactericidal efficacy and the results obtained for this test program are presented below.

Preparation of Challenge Bacterial Inoculum. The challenge bacteria were derived from a local municipal domestic wastewater treatment plant. A sample of mixed liquor suspended solids was taken from the aeration tank of a wastewater treatment plant. The coarse sludge was separated by filtering through a 50-mesh Nytex filter (0.05-inch diameter openings). The filtrate was collected and the number of viable bacteria was determined. The predominant viable bacteria were identified as coliform bacteria consisting primarily of *Escherichia coli*.

Test Procedure. Four concentrations of the challenge coliform bacteria ranging between 2,000 MPN/100 mL and 200,000 MPN/100 mL were spiked in 45 gallons of chlorine-free Vancouver city tap water at room temperature (20°).

An appropriate volume of the challenge bacteria was introduced to the test water to give desired concentration of coliform bacteria per 100 mL. To maintain the bacteria in suspension, the feed test water was mixed thoroughly throughout the experiment.

Representative samples of untreated raw feed water and UV treated water were taken from both water treatment units in full operation for viable total coliform bacterial determination. Untreated water samples were collected aseptically in sterile bottles from the outlet after pumping the test water passed through the water purifier (with UV light turned off) at a rate of 1.5 gpm for few minutes. Ultraviolet light treated water samples were collected aseptically in sterile bottles from

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the outlet after the UV light was switched on for at least 5 minutes of operation. All samples were kept in the dark on ice prior to microbiological analysis.

The challenge coliform bacteria in chlorine-free water samples collected before and after UV sterilisation was plated in triplicate Lactose Monensin Glucuronate (LMG) agar plates. All plates were incubated at 35°C for 24 hours. The number of viable coliform bacteria were directly enumerated as described in the ISO-GRID Microbiological Method #990.11 procedure, ISO-GRID Methods Manual (1989), QA Life Sciences, Inc., San Diego, CA 92121, the Association of Official Analytical Chemists (AOAC) (1990) and the Standard Methods for Examination of Water and Wastewater (1995).

Characteristics of the challenge chlorine-free water are: pH 7.4 ± 0.1; UV transmittance at 254 nm, 98 ± 2%; turbidity, <2.0 NTU; temperature, 20°C ± 1.0°C; total dissolved solids, 40 to 60 mg/L.

The samples were processed immediately after collection. A portion of the water samples (usually 100 mL) was filtered through a sterile 0.45 µ Millipore membrane filter, transferred onto the surface of the pre-dried LMG agar, using sterile forceps. Total coliform bacteria were counted on the LMG agar plates after incubation at appropriate temperature for 24 hours. The number of colony formation units (cfu) observed on the membrane filters were counted and expressed as coliform bacteria per 100 mL of water. All cfu/100 mL were converted and reported as Most Probable Number/100 mL (MPN/100 mL).

Reduction of total coliform bacterial population density (MPN/100 mL) in the contaminated water are summarised in Table 1. The results represent an average of three plate counts before and after UV sterilisation against four levels of challenge bacteria at water flow rate of 1.5 GPM.

Table 1. Reduction of Coliform Bacteria in Chlorine-Free Water

UV System	Untreated Water (MPN coliform bacteria/100 mL)*	UV Treated Water (MPN coliform bacteria/100 mL)*
Model NPS-A2	1,900	0**
	54,000	0**
	75,000	<1***
	200,000	130
Model NPS-A3	1,900	0**
	54,000	0**
	75,000	0**
	200,000	150

BC Research Inc.

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* An average of three plate counts.

** zero MPN/100 mL means no coliform bacterium was found in any of the triplicate plates.

*** <1 MPN/100 mL = one colony formation unit (cfu) of coliform bacterium was found in one of the three plates.

The results presented in Table 1 indicate that under specified test conditions, both UV microbiological water treatment units (model NPS-A2 and NPS-A3) were capable to produce sterile or bacteria-free water from artificially contaminated chlorine-free Vancouver city tap water at a flow rate of 1.5 gpm throughout the experiment where the bacterial population was approximately 54,000 MPN/100 mL or less.

When the concentration of coliform bacteria was increased to 75,000 MPN/100 mL, only model NPS-A3 produced sterile water; i.e. no coliform bacteria were found in three portions of 100 mL samples. The other UV water treatment system (model NPS-A2) produced water containing <1 coliform bacterium/100 mL or 99.99% kill, representing one colony was found on one out of the three plates. The UV bactericidal efficiency was slightly decreased, when the coliform bacterial population density was increased to higher level; i.e. 200,000 MPN/100 mL the viable coliform counts for UV treated water samples were 130 MPN/100 mL or 99.94% kill from model NPS-A2 and 150 MPN/100 mL or 99.93% kill from model NPS-A3. The results suggest that the bactericidal capability of both units tested was equivalent to a "Log Kill" value of between 4 and 5.

Please call me at 224-4331, if you have question. Thank you.

Sincerely,
BCRI



Ernie Lee,
Environmental Microbiologist



INTERNATIONAL
Water·Guard

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