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Water Disinfection with UV Equipment

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Abstract: This paper presents a study of treatment with UV for disinfection of swimming pool water. All public and private pools, water disinfection require treatment to reduce microorganisms present in water. Currently, chlorine is used. But using chlorine chloramine formation is negative. Using UV treatment reduced by 90% chlorine from the pool.

Keywords: chlorine, chloramine, enzymes and UV.

1. INTRODUCTION

It is the safest method of water disinfection worldwide.

Bacteria, viruses and other microorganisms are destroyed at the rate of 99.97%, when passing in front of the UV lamp.

Ultraviolet light disinfection is an efficient and well suited in terms of interaction with the environment, do not leave water residue or harmful products and do not affect the sense of taste or smell.

If microorganisms are exposed to ultraviolet (UV) type C, is affected cell nucleus and DNA (desoxiribonucleic acid) multiplication is stopped. UV rays affect DNA on the nucleic acid and enzymes.

The result is that pathogenic microorganisms are inactivated or destroyed.

Production of UV-C radiation is performed using neon tubes type of files that are protected transparent quartz with a diameter between 15 and 25 mm and a length of 100 to 1200 mm.

These tubes are filled with a gas containing mercury. Wavelength effect on microorganisms which are situated between 240 and 280 nm with a peak at 253.7 nm. These wavelengths are located in the UV-C [5].

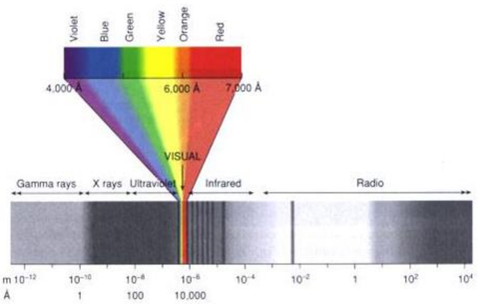

Fig.1 Distribution of wave lengths emitted by low pressure lamps

The chart below is the distribution of wavelengths emitted by low pressure lamps (black) and medium pressure (blue).

Red curve represents the spectrum of radiation absorption by DNA. [6]

2. STRENGTH OF EXPOSURE

Dose radiation exposure is the product of intensity and time of exposure: Dose = I x T

Unit of measure used is mJ/cm^2 which is equivalent to 1000 micro watts $second/cm^2$.

The table below, Table 1, shows the dose required for 90% destruction of microorganisms.

Table 1 . Dosing required for the destruction of 90% of bacteria

Bacteria	Dose (mJ/cm^2)
Bacillus subtilis (spore)	12,0
Clostridium tetani	4,9
Legionella pneumophilla	2,0
Pseudonomas aeruginosa	5,5
Streptococcus faecalis	4,5
Hepatitis A virus	11,0
Hepatitis Poliovirus	12,0
Saccharomyces cervisiae	6,0
Infectious pancreatic necrosis	60,0

The following table is shown the dose / damage to E. coli, see Table 2.

Table 2. The dosage required to destroy bacteria E.Coli

Dose (mJ/cm^2)	No reduction of micro's. E.Coli
5,4	90,0%
10,8	99,0%
16,2	99,9%
21,6	100,0%
27,0	100,0%

Ultraviolet radiation is used to disinfect liquids, surfaces, air or gas and certain oxidation such as removing chlorine, pesticides destruction or eliminate odors from industrial emissions.

Equipment UV water treatment consist of one or more lamps protected by transparent quartz sheaths placed in the irradiation room. [7]

Water circulates through the rooms to be treated. UV lamps emit a certain energy and may be low,

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medium or high pressure. Lamps have medium or high pressure power between 0.4 and 7.0 kW for a single lamp.

If debit exceeding 13 m^3 / h is more effective use of medium pressure lamps have wider range of wavelengths than using low pressure lamps. [4]

Life of high pressure lamps is about. 3000 hours, and a decrease in pressure is about average. 8000 hours.

Low pressure lamps are used for treatment of low flows, the available power of 15-200 W. The wavelength is unique and has a value of 254 nm.

Photochemical reactions in applications using lamps with a spectrum of wavelengths between 185 and 480 nm. Efficacy of UV is independent of temperature.[2] Water with UV radiation is radiation inside a room. [8]

Design and size of this room plays an important role for the efficiency of the process. The room must be such as to ensure turbulent flow leading to full exposure to UV rays regardless fluid flow.

Room shape should avoid areas where they are irradiated bacteria can make are not destroyed. UV systems are designed optimal dose exposure chamber wall throughout the life of the lamp. UV treatment systems can be achieved with a single lamp or multiple lamps. Using a single lamp provides performance necessary for the treatment.

Using a single bright light is able to provide treatment up to 600 m^3 / h Lamp intensity control is simple and effective.

Systems which use multiple low-pressure lamps in a single irradiation chambers can put mechanical and hydraulic problems.

Maintenance is also more expensive and complex. In addition, such systems must be equipped with wall to ensure turbulent flow which favors the creation of surfaces that are not irradiated.

Equipment manufacturers have UV treatment in their manufacturing range standard devices meet certain requirements of treatment, especially in residential water treatment and small communities.

If specific treatment, industrial water and drinking water for large communities, to ensure fully equipped to meet the needs of that process is necessary to establish the parameters necessary to manufacture equipment.[3]

In these cases, parameters are taken into account, not necessarily all needed are:

1. Maximum flow Treaty;
2. Analysis of fluid to be treated;
3. What is bacterial population that wants to be removed;
4. What is the result which is intended to reach.

Advantages of UV treatment are:

- UV rays does not alter the organoleptic characteristics of water (taste, odor, color) or Ph;
- Using UV rays do not require the use of other chemicals;
- Do not create toxic by-products in water;
- The equipment is compact and easy to install;
- Maintenance is simple and quick;
- Power consumption is very low.

When using this method of treatment should be kept in mind that UV radiation has no residual effect.

Therefore treatment should be applied as close to the water consumption and storage of treated water is not recommended because it can lead to recontamination of water.

UV treatment is widely applied in waste water from industrial processes:

- Water disinfection
- Residual ozone destruction
- Production of ultra-pure water
- Dechlorination: reducing chlorine compounds as
- Reduction of total organic carbon
- Advanced oxidation processes

3. DESIGN A UV EQUIPMENT

Destruction rate depends on the minimum UV radiation (UV dosage), and the time in which an organism is exposed to a certain intensity of UV radiation (W / m^2).

At a UV dose of 400J / m^2 largest human pathogenic virus or bacteria are reduced by 4 logs (decimal exponents), which corresponds to international requirements and ensure safe disinfection.

Proposed prototype design is relatively simple, see figure 2.

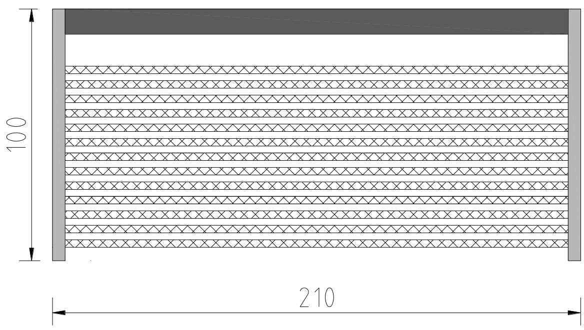

Fig. 2 Front view of prototype UV equipment [1]

The System Control Center (SCC), see figure 3 monitors lamp hours and uses a submerged UV sensor to feed accurate data on UV intensity for at-a-glance system status.

The SCC also allows flow pacing to minimize operating and maintenance costs by turning banks on and off based on flow requirements.

Fig. 3 The System Control Center

Equipment installation can be done both in parallel and in series, see Figures 4, 5, 6 and 7.

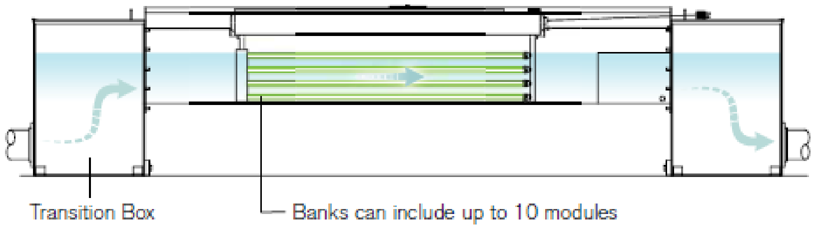

Fig. 4 Banks in Series – Side View

Fig.5 Banks in Series With Turn Box – Overhead View

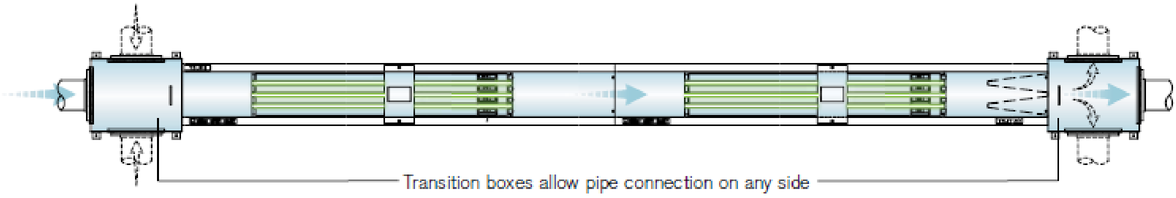

Fig. 6 Banks in Series – Overhead View


Fig. 7 Mounted prototype equipment

The selection of plants for disinfection with ultraviolet light is depending on two factors:

- Disinfect water flow, see figure 8 and 9;
- UV transmission coefficient of water.

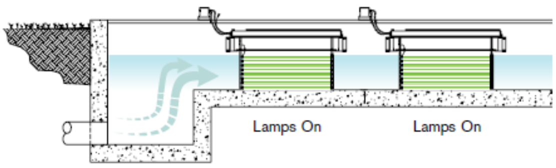

Fig. 8 Operation During Periods of High Flow

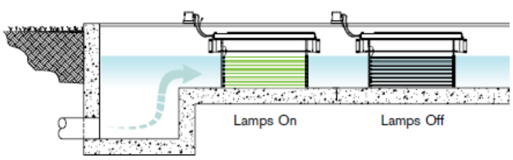

Fig.9 Operation During Periods of Low Flow

Equipment Validation

The validation study was conducted on a pilot plant equipped with LPHO UV lamps at 4-inch lamp spacing.

Figure 10 is a schematic diagram of the pilot plant. The pilot plant consisted of one stainless steel open channel reactor that housed three UV banks in series.

The pilot plant included inlet and outlet hydraulic transition structures and an 8-foot straight section before the first UV bank.

A 10-inch (25.4 mm) diameter pipe carried the unchlorinated filtered secondary effluent to the pilot plant. The flow rate to the pilot plant was measured by a magnetic flow meter.

Two chemical feed pumps were located approximately 50 feet upstream of the influent sampling port. These pumps were used for UVT adjustment and seeding of the surrogate microorganism, male- specific coliphage MS-2, respectively.

Effluent from the pilot plant was discharged to a sewer manhole and conveyed to a downstream facility for further treatment.

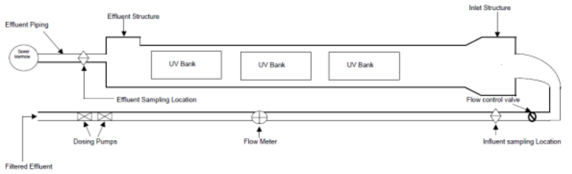

Fig.10 UV Pilot Plant Schematic Diagram (Not to Scale)

4. CONCLUSIONS

In this paper is presented a new prototype which is composed of ultraviolet germicidal irradiation. The concept that it requires a news new prototype involves the following:

- Installation of pipes, immersion, UV water longitude (all products on market of this type exists only in transverse mounting and above water);

-increase surface disinfection by applying microperforations in UV tubes;

- Disinfection tank wall to solve the design including large mirror type crizzal forte;

- Installation of a monitoring system amount of microorganisms (see figure 3);

Using this UV treatment reduces 99,5% of chlorine in swimming pool water treatment and 99,99% microorganisms.

UV radiation from ultraviolet water systems alone is not suitable for water with high levels of suspended solids, turbidity, color, or soluble organic matter.

These materials can react with UV radiation, and reduce disinfection performance. Water turbidity makes it difficult for the ultraviolet radiation to penetrate water.

If your water supply has these characteristics, a sediment prefilter (5 micron or less) should be installed before your UV water purification system to remove particulate matter prior to UV water disinfection.

Ultraviolet radiation can be used as a pretreatment or polishing step to sterilize and disinfect water.

UV systems are typically used to pre-treat a water supply that is considered biologically unsafe (lake or sea water ,pool, well water, etc).

The UV disinfection process is a non-chemical method for destroying microorganisms by altering their genetic material, and rendering them unable to reproduce.

There are several advantages of using UV rather than a chemical disinfection solution (such as chlorination):

- No known toxic or significant nontoxic byproducts;
- No danger of overdosing;
- Does not require storage of hazardous material;
- Adds no smell to the final water product;
- Requires very little contact time

Applications include private wells, camp grounds, hotels, bottlers, aquaculture, hospitals, food, cottages, restaurants, breweries, water systems, laboratories, marine, pharmaceutical, dairies and many other applications.

During the process of designing the UV disinfection system, "Apa Nova"(Districts) had an opportunity to participate in an equipment validation study that was conducted by a third party consultant.

A pilot scale UV system equipped with low-pressure high-output UV lamps was validated according to Ultraviolet Disinfection Guidelines for Drinking Water and Wastewater Reclamation, and the equipment validation report was approved by the Government.

Following the equipment validation testing, the Districts conducted additional UV disinfection studies, using the same pilot system, at two lamps in 2012 and 2013.

The objectives of these studies were to verify the UV dose regression model developed from equipment validation testing, and to determine if the UV dose regression model developed at one lamp could be used for design of a full-scale UV disinfection system at another lamp with similar treatment processes and water quality.

Results showed that the delivered UV doses from the Districts' tests were different from those calculated using the dose regression model.

Factors that may attribute to this apparent discrepancy include differences in collimated beam testing procedures, water quality, data analysis procedures, and assumptions made to calculate doses of multiple-bank systems.

The findings from this study have implications on UV system design and operation which rely on the dose regression model.

It is recommended that the factors discussed in this study be considered in UV equipment validation and full-scale UV system design and operation to ensure that the full-scale UV systems function as designed and provide adequate safety factor for protection of human health.

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