ILLINOIS
AMERICAN WATER

Ultraviolet Disinfection
An Overview

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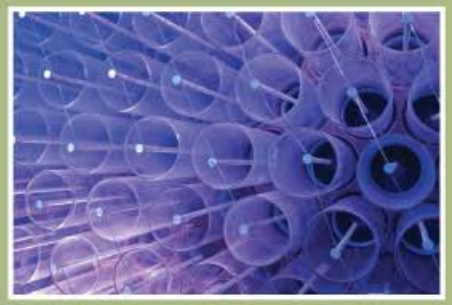

History of UV Disinfection for Drinking Water

Germicidal Properties of Sunlight Discovered (1877)

First Drinking Water Disinfection Application Occurred in Marseilles, France (1910)

Germicidal Tubular Lamps Developed (1930)

Significant Research of UV Disinfection Occurred (1950s)

UV History (Continued)

- Substantial UV research was done in the early 20th century, but the low cost of chlorine and operational problems with equipment limited its use as a drinking water treatment technology.

- In the year 2000, more than 400 UV facilities worldwide were treating drinking water. Most of these facilities treat flows of less than 1 MGD.

- Since 2000, several large US UV installations have been constructed or are under design. The largest facility produces 180 MGD.

A Brief Description of UV

- UV disinfection of drinking water involves generating UV light and transmitting that light to pathogens.

- UV light is in the region of electromagnetic spectrum that lies between X-rays and visible light.

- The UV wavelength is 100-400 nm. The germicidal wavelength is 200-300 nm.

- Very long exposure times are necessary for UV light to be effective as a disinfectant.

How Does UV Disinfection Work?

- Usually UV light is generated by applying a voltage across a gas mixture and this causes a discharge of photons.
- Nearly all UV lamps designed for water treatment use a gas mixture containing mercury vapor.
- The mercury gas emits light in the germicidal wavelength range.
- Other gases, such as Xenon, also emit light in the germicidal range.

Does UV disinfection kill microorganisms?

- No, UV disinfection inactivates microorganisms by damaging their DNA, which prevents them from replicating (reproducing).
- A microorganism that cannot replicate cannot infect a host.
- Viruses are most resistant to UV disinfection followed by bacteria, Cryptosporidium oocysts and Giardia cysts.

UV Disinfection Equipment

- UV equipment typically consists of a UV lamp housed in a quartz sleeve, reactor casing, UV intensity sensor, temperature sensor, quartz sleeve wiper, wiper motor and a UV transmittance analyzer.
- Lamp placement, baffles, and inlet and outlet conditions all affect mixing within a reactor and dose delivery.
- The lamp configuration in a reactor is designed to optimize dose delivery. In a reactor with a square cross-section, lamps are typically placed with lamp arrays perpendicular to flow.
- The flow through UV reactors is turbulent.

UV Disinfection Equipment (continued)

Lamp Sensitivity to Power Quality

- A UV lamp can lose its arc if a voltage fluctuation, power quality anomaly, or power interruption occurs.

- The most common sources of power quality problems are: Faulty wiring, transformer damage, weather related damage, animal related damage, facility and equipment modifications, starting or stopping equipment with large electrical needs on the same circuit at the water plant, or power transfer to an emergency generator.

Lamp Aging

- UV lamps degrade as they age, resulting in a reduction in output that causes a drop in UV dose delivery over time.

- Lamp aging is related to lamp hours of operation, number of on/off cycles, power applied per unit length, water temperature and heat transfer from lamps

Cleaning Systems, UV Sensors, UVT Analyzers, and Temperature Sensors

- UV reactor manufacturers have developed different approaches for cleaning lamp sleeves, depending on the application. Off-line chemical cleaning, on-line mechanical cleaning and on-line mechanical-chemical cleaning methods are used.
- UV sensors measure the UV intensity at a point within the UV reactor and are used with measurements of flow rate and UVT to indicate UV dose.
- UV reactors can be equipped with temperature sensors that monitor the water temperature in the reactor.
- If the temperature is above the recommended operating range, the reactor will shut off.

Byproducts from UV Disinfection

- Studies indicate that UV disinfection at UV doses up to 200 mJ/cm2 do not change the pH, turbidity, DOC, UVT, color, nitrate, nitrite, bromide, iron or manganese of the water being treated.

- UV light doses of less than 400 mJ/cm2 have not been found to affect the formation of THMs and HAAs.

Benefit Of Using UV Disinfection

- The Peoria river treatment plant will be able to remove prechlorination from the treatment train.
- The UV will be used to disinfect the water instead of chlorine in pretreatment.
- UV disinfection does not remove DBPs.
- The removal of chlorine will reduce the amount of disinfection by-products in the finished water.
- Post chlorine and ammonia will be used after the UV to further disinfect the water.

References

- USEPA Ultraviolet Disinfection Guidance Manual For The Final Long Term 2 Enhanced Surface Water Treatment Rule
- Black and Veatch UV Disinfection Seminar Summary 9/1/09