How to Properly Specify a UV System for Disinfecting Water or Wastewater

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G. Elliott Whitby, PhD
Principal Scientist
Calgon Carbon Corporation
7100 Woodbine Ave., Suite 310
Markham, Ontario, Canada
L3R 5J2
Telephone: 416-399-3118
Fax: 905-477-7355
E-mail: ewhitby@calgoncarbon-us.com
Advantages of Using UV Light to Disinfect Water or Wastewater

- Physical process not a chemical process: Water chemistry & characteristics, such as pH, taste, odor, color etc. are unchanged
- Fast kinetics - reaction time in seconds: Minimizes building requirements
- Does not create toxic compounds which may affect humans when they consume drinking water
- Does not create toxic compounds in wastewater that may affect the aquatic biota or a source of drinking water
- Inactivates viruses and vegetative and spore forming bacteria in wastewater where chlorine is affected by ammonia
- Inactivates Cryptosporidium and Giardia whereas chlorine does not
- Is cost competitive with chlorination, ozonation and chlorination/dechlorination
- Eliminates handling and storing of dangerous toxic chemicals
- Very few moving parts
- Environmentally responsible and increasingly accepted technology
Open Channel UV Disinfection of Wastewater for Discharge or Reuse
Pressurized UV Disinfection of Drinking Water or Wastewater for Reuse
UV Dose or Fluence
(mW·sec/cm² or mJ/cm² or J/m²)

Quantity of UV Light That Does the Work

**Dose = I x T**

- **I** = Intensity (mW/cm² or W/m²)
- **T** = Time (seconds)

It is how this Dose is specified that will affect the operation of the UV system and its success.
Calculated Dose vs Bioassay Dose ???

- A bioassay dose is the only acceptable method for sizing a UV system for drinking water anywhere in the world.

- Calculated doses are used for wastewater: This is not acceptable.

- A bioassay dose is the only acceptable method for sizing a UV system for water reuse in North America.
Why a Calculated Dose is not Acceptable

- UVDIS: Most Commonly Used Sizing Program
  Developed by HydroQual Inc. for the U.S. EPA in the 1980’s

Four Sections:

1. Tulip: Determines the average intensity within the lamp array
2. UV Unit: Describes all the characteristics of the UV system and the number of banks in series
3. Wastewater and disinfection limit
4. Output
   - It is highly dependent on the lamp output
   - It does not account for system hydraulics
UVDIS: Output of Intensity Calculation

Very dependent on UV lamp output

30 % Lamp Efficiency 170 Lamps
45 % Lamp Efficiency 94 Lamps
Effect of Lamp Current on UV Output Inside a Quartz Sleeve Underwater

37% Increase in Intensity
What is a Bioassay?

It is a microbiological method of determining the delivery of UV light by a UV system under specific conditions of the UV unit and the water.

- It detects the actual affect of:
  - UV Transmission on UV Intensity
  - Flow Rate on UV System Hydraulics
  - Lamp Output: Real Lamp Output
Other Benefits of a Bioassay

- With the introduction of electronic ballasts, proprietary lamps and lamp configurations all the UV systems are different so they are very difficult to compare.
- Allows the comparison of low and medium pressure UV lamps
- Under similar conditions a bioassay insures that the UV dose claimed by the manufacturer is actually delivered by the UV equipment.
- A bioassay confirms the UV output of the UV lamps under actual operating conditions as versus measurements in air.
- A bioassay eliminates any disagreements that may take place over how to calculate the UV dose within a reactor.
- Ensures the UV system will operate under worse case conditions
- The lamps will last longer since fewer will be on all the time
- Lower power consumption
- Longer periods between cleaning
How is a Bioassay Performed?

- Basic Steps in a Bioassay
  - Hire a third party to independently test the UV system
  - Select a microorganism that is UV resistant, not pathogenic and easy to grow
  - Irradiate the microorganisms with exact UV doses to create a calibration curve of UV dose versus log inactivation
  - Set-up a UV system to simulate worst case conditions of the lamps and water
  - Put the calibrated microorganisms through the UV unit at different flow rates and measure the test organism in the influent and effluent to get the log inactivation
  - Using the calibration curve create a curve of flow per lamp versus UV dose at different UV transmissions
  - Create a third party report describing the exact test conditions and results
Schematic of a Bioassay

- Sampling Area
- PDC
- UV Bank
- MS2 & T1 Dosing
- Valve
- Pump
- Flow Meter
Effect of Lamp Output on the UV Dose of an Open Channel UV System

G64T5L UV Lamp
3 Inch Spacing
20 mm by 23 mm Quartz Sleeve

Fluence microW.sec/cm²

Flow in Litres per Minute per Lamp

MS2 Coliphage Bioassay 65 %T Drinking Water
Standard Bioassay Test Protocols

NWRI/AWWARF UV Guidelines
  Water Reuse
ETV/EPA/NSF Program
  Stormwater
  Secondary Effluent
  Water Reuse
German DVGW W294 Drinking Water
Austrian ONORM 5873-1 Drinking Water
US EPA UVDGDM
  Only Acceptable Method for Drinking Water in USA
Example of a Bioassay Based Standard  NWRI/AWWARF UV Guidelines

The effluent must meet the following standard:

- Secondary Treatment
- Coagulation
- Filtration
- Less than 5 mg/L TSS
- 5 Log Poliovirus Inactivation
- 7 Day Median of 2.2 Total Coliforms per 100 mL by the MPN Method
Dose Requirements by a Bioassay with MS2 Coliphage by a Third Party

- **Media Filtration 100 mJ/cm²**
  - > 55 % UVT
  - Less than 5 mg/L TSS

- **Membrane Filtration 80 mJ/cm²**
  - > 65 % UVT
  - 0.2 NTU

- **Reverse Osmosis 50 mJ/cm²**
  - > 90 % UVT
  - 0.2 NTU
Specifying the Dose Delivered by a UV System with a Bioassay is the Only Acceptable Method
Thank you