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

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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/cm^2 or mJ/cm^2 or J/m^2)

Quantity of UV Light That Does the Work

Dose = I x T

I = Intensity (mW/cm^2 or W/m^2)

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

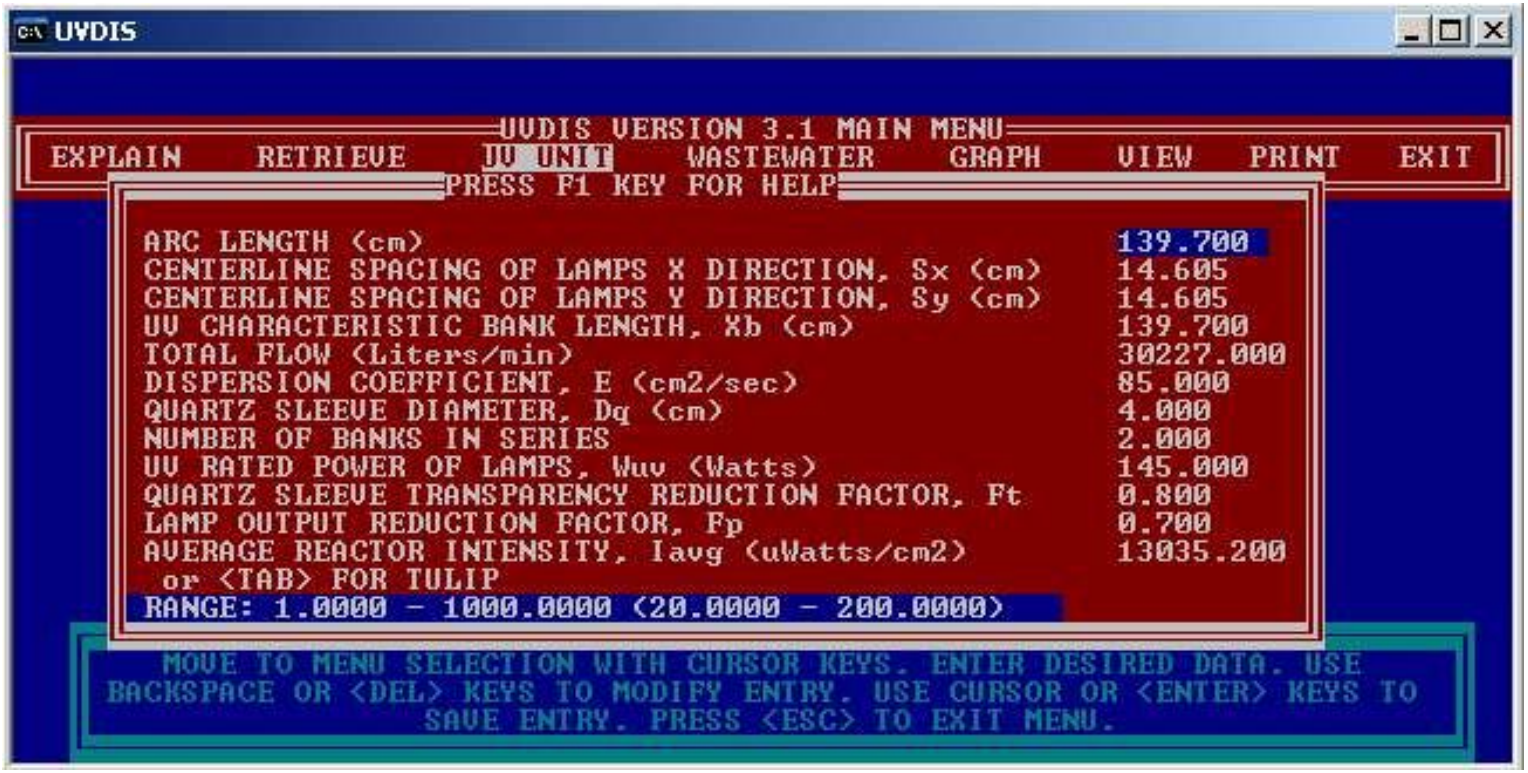
- **UVDIS: Most Commonly Used Sizing Program**

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**

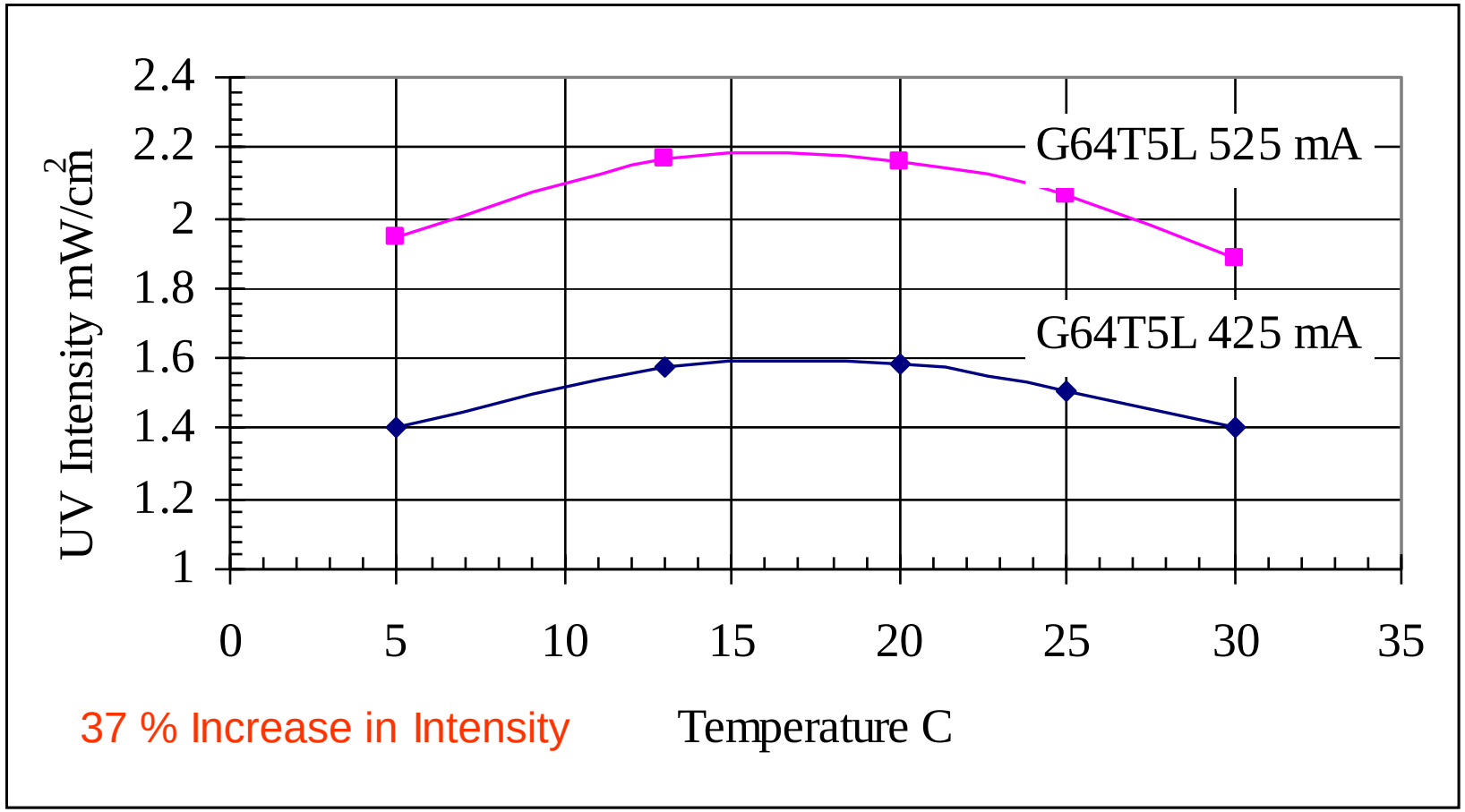
UVDIS: Output of Intensity Calculation



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



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

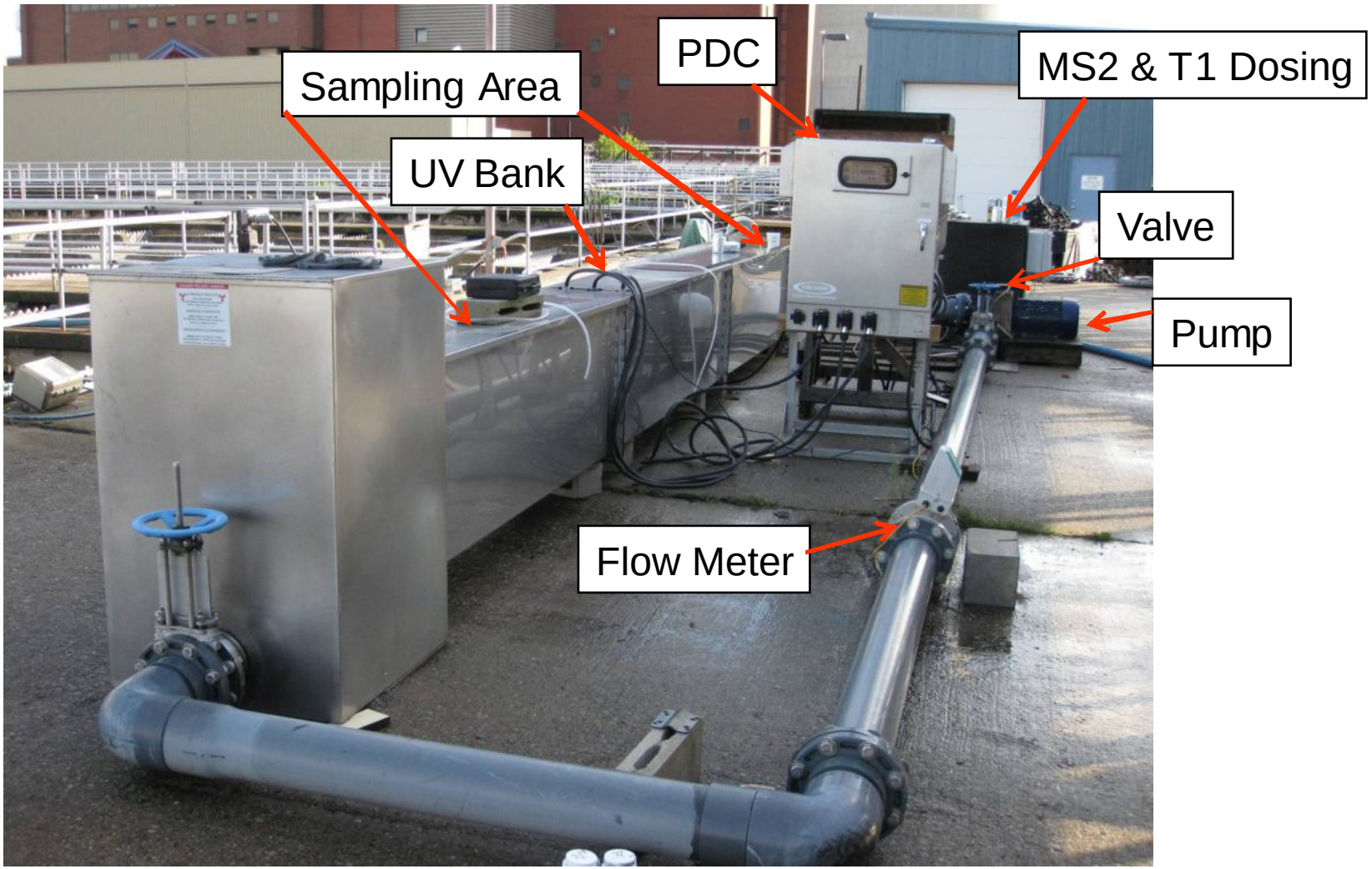
Other Benefits of a Bioassay

- 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

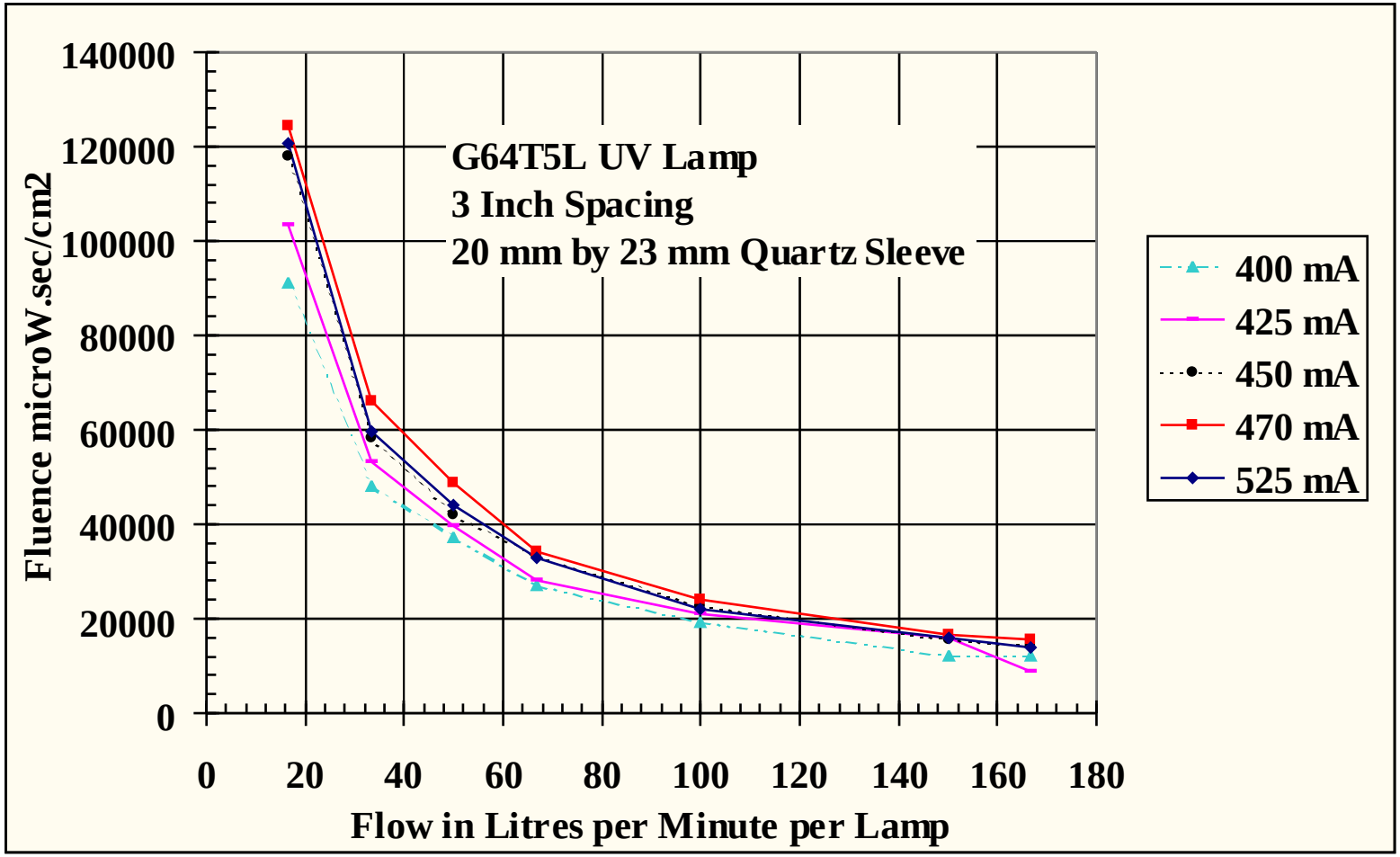
How is a Bioassay Performed?

- **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



Effect of Lamp Output on the UV Dose of an Open Channel UV System



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 UVDGM

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/cm^2
  - > 55 % UVT
  - Less than 5 mg/L TSS
- Membrane Filtration 80 mJ/cm^2
  - > 65 % UVT
  - 0.2 NTU
- Reverse Osmosis 50 mJ/cm^2
  - > 90 % UVT
  - 0.2 NTU

Specifying the Dose Delivered by a UV System with a Bioassay is the Only Acceptable Method

Thank you