Recent Advances in UV Technology

By

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PRESENTATION OUTLINE

LATEST ADVANCES

1. UV Lamps
2. Cleaning Systems
3. Need for the Bioassay
DIFFERENT LAMP TYPES

1. Low-Pressure Low Output
2. Low-Pressure High Output
3. Medium Pressure
4. Pulsed Power
HIGHER OUTPUT LOW PRESSURE LAMPS
Germicidal lamps operate electrically on the same principle as fluorescent lamps.
EFFECT OF TEMPERATURE ON LAMP OUTPUT

Optimum
EFFECT OF INCREASING LAMP CURRENT G64T5L

37.5 % Increase in UV Light
The Effect of Water Temperature on the Output of the Suntec *environmental* GXO74T5LS High Output and the G64T5L Low Output Lamp

![Graph showing the effect of water temperature on UV output for GXO74T5LS and G64T5L lamps.](image-url)
SUNTEC 500 WATT AMALGAM LAMP
EFFECT OF THE AMALGAM IN AIR

Fig. 8  Relative luminous flux, operating in free air, of standard lamps and amalgam lamps as a function of ambient air temperature

The regions where the luminous flux > 90% of maximum are indicated

Pt. A. No. 3, April 1980
EFFECT OF WATER TEMPERATURE ON THE 500 WATT AMALGAM LAMP

\[ R^2 = 0.0158 \]

UV Fluence Rate mW/cm² vs. Water Temperature °C

Water Temperature °C
0 5 10 15 20 25 30 35

UV Fluence Rate mW/cm²
7 7.5 8 8.5 9 9.5

R² = 0.0158
COMPARISON OF G64T5L, LPX200 AND LPX500

Graph showing the comparison of Log N/N₀ with Flow in USGPM per Lamp for G64T5L, LPX200, and LPX500. The graph indicates that as the flow increases, the log ratio decreases, with G64T5L having the highest ratio, followed by LPX200, and then LPX500.
LONGER LAMP LIFE
EFFECT OF LAMP AGE ON THE UV OUTPUT OF THE G64T5L

Figure 4. Marine Park UV Light Output Results

- WERF Report 1995
- Lamp Manufacturers
  - Marine Park Results (53.6%)
  - One Year

Noesen et al., WEFTEC 1999
Figure 2: UV output during lamp life

Soft-glass TUV64T5 vs. quartz G64T5

Giller, Disinfection 2000
MEDIUM PRESSURE LAMPS
HIGHER UV OUTPUT
LONGER LAMP LIFE
CONSTRUCTION OF THE MEDIUM PRESSURE MERCURY LAMP
EFFECT OF LAMP DIAMETER

Fig. 2 Relative germicidal efficiency at various power settings vs. mercury pressure and lamp diameter

Giller, IUVA Singapore Oct Nov 2002
EFFECT OF PINCH COATING

Fig. 6 Influence of “Blue Pinch” technology on lamp life

Fig. 4 Typical example of pinch corrosion

Fig. 5 Chromium protected “Blue Pinch” technology

Giller, IUVA Singapore Oct Nov 2002
Fig. 7 Effect of halogenide additives on useful lamp life
COMPARISON OF A LOW AND MEDIUM PRESSURE MERCURY LAMPS
TABLE 2: SUMMARY OF POWER MONITORING AND POWER COSTS ANALYSIS

<table>
<thead>
<tr>
<th>WWTP Plant Type w/UV System</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td># of lamps in use</td>
<td>152</td>
<td>160</td>
<td>60</td>
<td>72</td>
<td>4</td>
</tr>
<tr>
<td>% of max. power</td>
<td>100%</td>
<td>100%</td>
<td>52%</td>
<td>53%</td>
<td>- -</td>
</tr>
<tr>
<td>Ave. Power Consumption (kW)</td>
<td>13.66</td>
<td>9.973</td>
<td>88</td>
<td>116</td>
<td>6.95</td>
</tr>
<tr>
<td>Input kw per lamp @ 100% power</td>
<td>0.090</td>
<td>0.062</td>
<td>2.82</td>
<td>3.04</td>
<td>Not measured</td>
</tr>
<tr>
<td>Rated Lamp Power (kW)</td>
<td>0.0875</td>
<td>0.075</td>
<td>2.8</td>
<td>2.8</td>
<td>2</td>
</tr>
</tbody>
</table>

Water Quality and Power Consumption (Ave. Values) during Power Monitoring Period

| Effluent TSS (mg/L) | 4.6 | 7.3 | 8.9 | 3.1 | - - |
| Fecal Coliform per 100ml after UV | 4.3 | 100 | 15 | 1.4 | - - |
| % Transmittance | 81% | 69% | 59% | 73% | - - |
| Ave. Power Consumption (kW) | 13.66 | 9.973 | 65.8 | 84.9 | 6.95 |
| Ave. Flow during Power Monitoring (MGD) | 2.78 | 1.41 | 3.4 | 3.81 | 0.28 |
| kWh/MG | 118 | 170 | 464 | 534 | 596 |
| Power Cost per MG at $0.06 per kWh | $7.08 | $10.19 | $27.87 | $32.09 | $35.74 |
IMPROVED CLEANING SYSTEMS
CLEANING SYSTEMS BRIEF HISTORY
LPX200/500 ULTRAVIOLET DISINFECTION SYSTEM

- A non-chemical method of cleaning the quartz sleeves
- Fully programmable cleaning cycle
- Scrapers are easily replaced
- Electrically driven, no air or hydraulic fluids
- Free floating scrapers follow the contours and alignment of the quartz sleeves
LPX200/500 Ultraviolet Disinfection System

Control UV System
LPX200/500 Ultraviolet Disinfection Systems

UV System with Added Iron
Wastewater Characteristics
Fecal Coliforms per 100 mL 73,000
Total Suspended Solids < 5.0 mg/L
Percent Transmission at 254 nm 68 %
EFFECT OF IRON ON THE FECAL COLIFORMS AFTER UV DISINFECTION

![Graph showing the effect of iron on the fecal coliforms after UV disinfection. The graph plots the log number of fecal coliforms against the number of hours. Two lines are shown: one for added iron and one for no iron. The graph indicates that the addition of iron decreases the log number of fecal coliforms over time.]
THE NEED TO HAVE A METHOD FOR COMPARING DIFFERENT UV SYSTEMS

A STANDARD BIOASSAY
WHY PERFORM A BIOASSAY

• With the introduction of electronic ballasts and proprietary lamps all the UV systems are different.

• Allows the comparison of low and medium pressure UV lamps.

• A standardized bioassay allows the direct comparison of different UV systems and this allows the consultant to tell each manufacturer how many lamps they must use to deliver a specific UV fluence.

• Under the proper conditions a bioassay insures that the UV fluence or 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 fluence within a reactor.
## Lamp and Ballast Comparison

<table>
<thead>
<tr>
<th>Parameters</th>
<th>G64T5L</th>
<th>Company A Test Report</th>
<th>Company B Literature etc</th>
<th>Company C Publications etc</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power to the lamp and Ballast</strong></td>
<td>85 W</td>
<td>225 W</td>
<td>271.5 W</td>
<td>330 W</td>
</tr>
<tr>
<td><strong>Ballast</strong></td>
<td>Electronic</td>
<td>Electronic</td>
<td>Electronic</td>
<td>Electronic</td>
</tr>
<tr>
<td><strong>Power to the Lamp</strong></td>
<td>78 W</td>
<td>210 W</td>
<td>247.2 W</td>
<td>310 W</td>
</tr>
<tr>
<td><strong>Lamp Current (A)</strong></td>
<td>0.525 A</td>
<td>1.1 A</td>
<td>3.3 A</td>
<td>3.3 A</td>
</tr>
<tr>
<td><strong>UVC Watts</strong></td>
<td>32 W</td>
<td>65 to 70 W</td>
<td>139.9 W</td>
<td>125 W</td>
</tr>
<tr>
<td><strong>Efficiency including the Ballast</strong></td>
<td>37.7 %</td>
<td>30 %</td>
<td>52 %</td>
<td>38 %</td>
</tr>
<tr>
<td><strong>Efficiency excluding the ballast</strong></td>
<td>41 %</td>
<td>32 %</td>
<td>57 %</td>
<td>40 %</td>
</tr>
</tbody>
</table>
Factors Affecting UV Performance

- UV Transmission*
- Suspended Solids
- Hydraulics* (Retention Time, Turbulence)
- Iron, Hardness, Dissolved Solids*
- Wastewater Source*
- Disinfection Requirement* (UV Fluence)
- Lamp Output* (New, End of Life, % Germicidal Light)

*Tested by a Bioassay
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.
How is a Bioassay Performed?

Basic Steps in a Bioassay

1. Select a microorganism that is UV resistant, not pathogenic and easy to grow or is already present in the effluent.

2. Irradiate the microorganisms with exact UV fluences to create a calibration curve of UV fluence versus log kill.

3. Set up an UV system to simulate worst case conditions of the lamps and water.

4. Put the calibrated microorganisms through the UV unit at different flow rates and measure the numbers in the influent and effluent to get the log kill.

5. Using the calibration curve create a curve of flow per lamp versus UV fluence.

6. Create a report describing the exact test conditions.
BIOASSAY ON A UV SYSTEM WITH TWO LAMP CURRENTS

- 425 ma QS 23 by 20 mm
- 525 ma QS 23 by 20 mm

Log Kill of MS2 Coliphage vs. Flow in Litre per Minute per Lamp
Standard Test Protocols

NWRI/AWWARF UV Guidelines
- Drinking water
- Water reuse

ETV/EPA/NSF Program
- Stormwater
- Secondary Effluent

German and Austrian Standards
- Drinking water
SUNTEC environmental

WORLD LEADERS AND INNOVATORS OF UV TECHNOLOGY