

## UV LAMP TECHNOLOGIES

What are they and which one is for you?

### UV Spectrum for Organism Inactivation

Organisms typically respond to energy inputs, such as heat. While heat can help an organism by facilitating growth, excessive heat loads or high temperatures can be fatal. Energy in the form of UV can have the same effect.

The UV-C range in the UV spectrum can permanently alter the DNA structure of bacteria and viruses when exposed at appropriate levels - becoming "inactivated" and rendered unable to reproduce or infect.

The ultraviolet spectrum consists of 4 UV bands: Vacuum UV 100-200nm, UV-C 200-280nm, UV-B 280-315nm and UV-A 315-400nm. Despite claims that UV in general can efficiently disinfect in any UV band, the only band being used commercially for disinfection is UV-C.

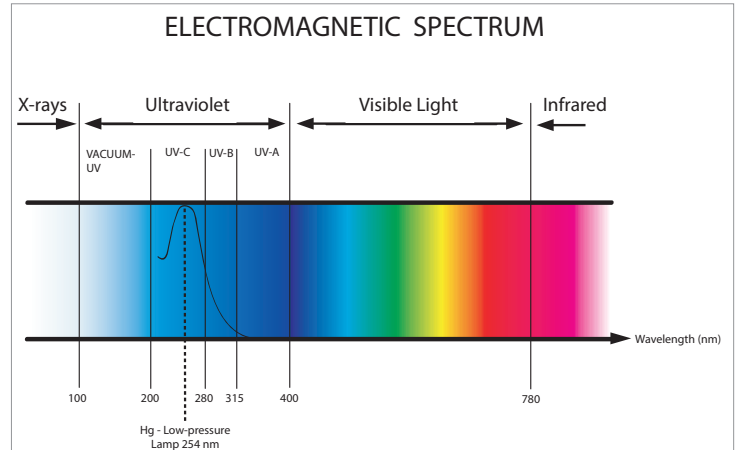


Figure 1. UV Light Spectrum

Organisms such as bacteria and viruses have what is called an inactivation curve. This curve is related to the damage sensitivity of an organism to various wavelength of light. Below is a typical inactivation or sensitivity curve as related to the UV spectrum. The peak of the inactivation curve, or where the organism is most sensitive to UV energy, is at a wavelength of approximately 262nm.

### Low Pressure, Amalgam Lamp, Or Medium Pressure | What's the Difference?

LP, Amalgam LP and MP lamps are mercury based arc lamps, differing primarily by electrical excitation and ionization levels of the mercury within the lamp and corresponding internal pressures.

#### Aquafine Low Pressure (LP) Lamps

Aquafine LP Lamps are considered to be monochromatic or 'single peak output' lamps, operates at about 40°C and has one useful disinfection output peak at 254nm. Roughly 40% of the electrical energy imparted into the lamp becomes UV-C energy of the 254nm wavelength.

This lamp type has the lowest internal pressure and has the lowest power density per unit length of lamp arc. Due to the very low temperatures that LP lamps operate at, fouling of the quartz sleeves is typically not a large issue, even in relatively low UVT fluids. Cleaning requirements are the least severe of the 3 lamp types.

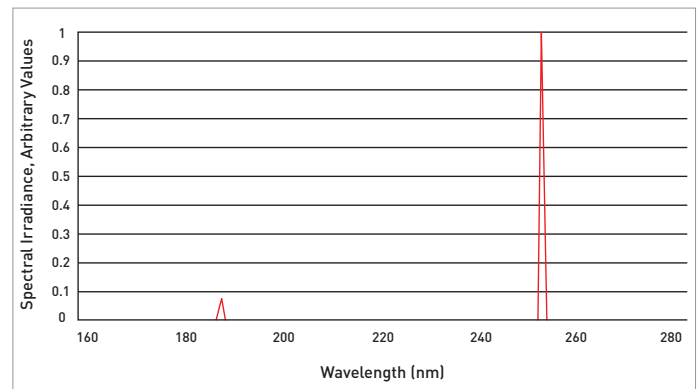


Figure 2. Aquafine Standard & LP Amalgam Lamp Spectrum

#### Aquafine Low Pressure (LP) Amalgam Lamps

Aquafine LP amalgam lamps combine mercury with another element, allowing them to operate at higher temperatures, roughly 100°C. Like Aquafine LP lamps, Aquafine LP amalgam lamps are also considered to be monochromatic with a significant 254nm output peak. Roughly 35% of the electrical energy imparted into the lamp becomes UV-C energy of the 254nm wavelength. Operating at higher temperatures and pressures allow for an increased power density of roughly 1.5 to 4 times of a low pressure lamp per unit of arc length. Because of slightly higher 100°C temperatures that these lamps operate at, fouling may be slightly more than that of a low pressure system but it is typically not a major issue.

### Medium Pressure (MP) Lamps

Aquafine MP lamps are considered to be polychromatic lamps, due to the wide output spectrum and operate at roughly 800°C to 900°C. With an average of 10 times the power density per unit arc length, Aquafine MP lamps have significantly higher power when compared to Aquafine LP amalgam lamps. Only 11-12% of the electrical energy imparted into the MP lamp becomes UV-C energy, with a range of 220nm to 280nm. Low output efficiency is a result of high power density, causing the lamp to emit many wavelengths outside the 220nm to 280nm output range required for disinfection.

MP lamp systems invariably require an automated cleaned system. Manual cleaning of these systems is very labor intensive and would be very frequent.

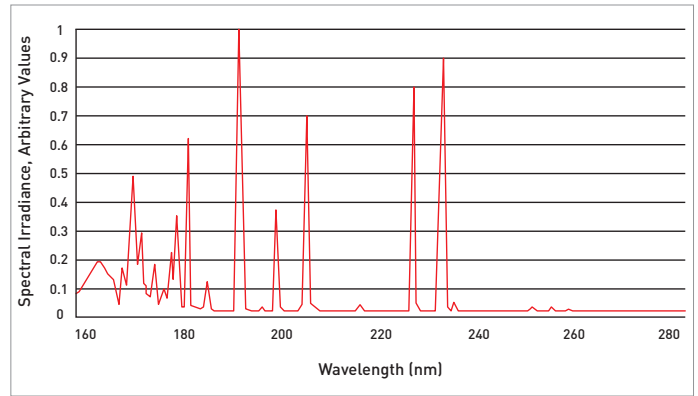


Figure 3. Aquafine MP Lamp Spectrum

### Both Technologies Work | What are your Application Needs?

Both low and medium pressure systems are viable UV disinfection solutions. Your application requirements will dictate the selection of lamp technology you choose and will depend on the requirements of each specific site.

For example; light in the UV-C region of 200nm to 280nm have very high energy levels in MP lamps, and that is why they can be used for disinfection purposes. As 262nm is the peak for the disinfection performance, other wavelengths can be useful, or harmful at their specific energy levels. Nitrite formation requires wavelengths of 230nm for instance. So if nitrite formation is an area of concern for you, a monochromatic light source may be your choice.

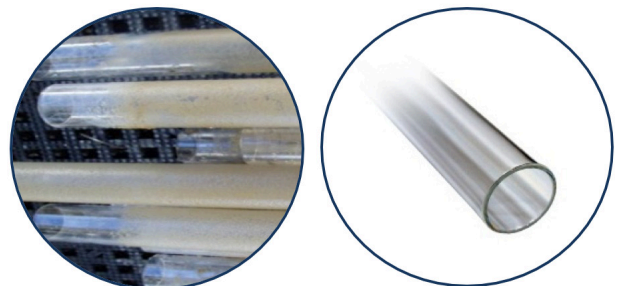
DISINFECTION	LP	LP AMALGAM	MP
UV Spectrum	Monochromatic	Monochromatic	Polychromatic
Relative Output Power per cm/arc 254nm	N	4N	40N
Lamp Efficiency 254nm	35%-40%	30%-35%	15-18%
Annual Operating Cost (Electrical)	\$5,957	\$2,628	\$7,358
Built-in Cleaning System Required <i>Clean Water/WasteWater</i>	No/No	No/Yes	Yes/Yes
Reactor Cooling	NO	NO	YES
Relative Maintenance <i>Clean Water/WasteWater</i>	LOW/MED	LOW/MED	MED/HIGH
Relative Closed Vessel Footprint: Reactor/Panel	LARGE/MEDIUM	MEDIUM/SMALL	SMALL/LARGE
Cost of lamp per UV-C Watt	2.1	3.1	2.7

Figure 4. LP vs. MP Lamp Technology Comparison

### Maximum Performance | Quartz Sleeve Fouling

UV system performance is highly dependent on the cleanliness of quartz sleeves. Fouling quartz sleeves and improper maintenance of your system will directly impair your UV performance.

Appropriate and complete cleaning is functionally dependent on the water quality encountered in the system and the type of UV lamp technology used in the installed UV system. Aquafine’s approach is to match cleaning technologies (and monitoring of the cleaning process) to the application and lamp type being used.

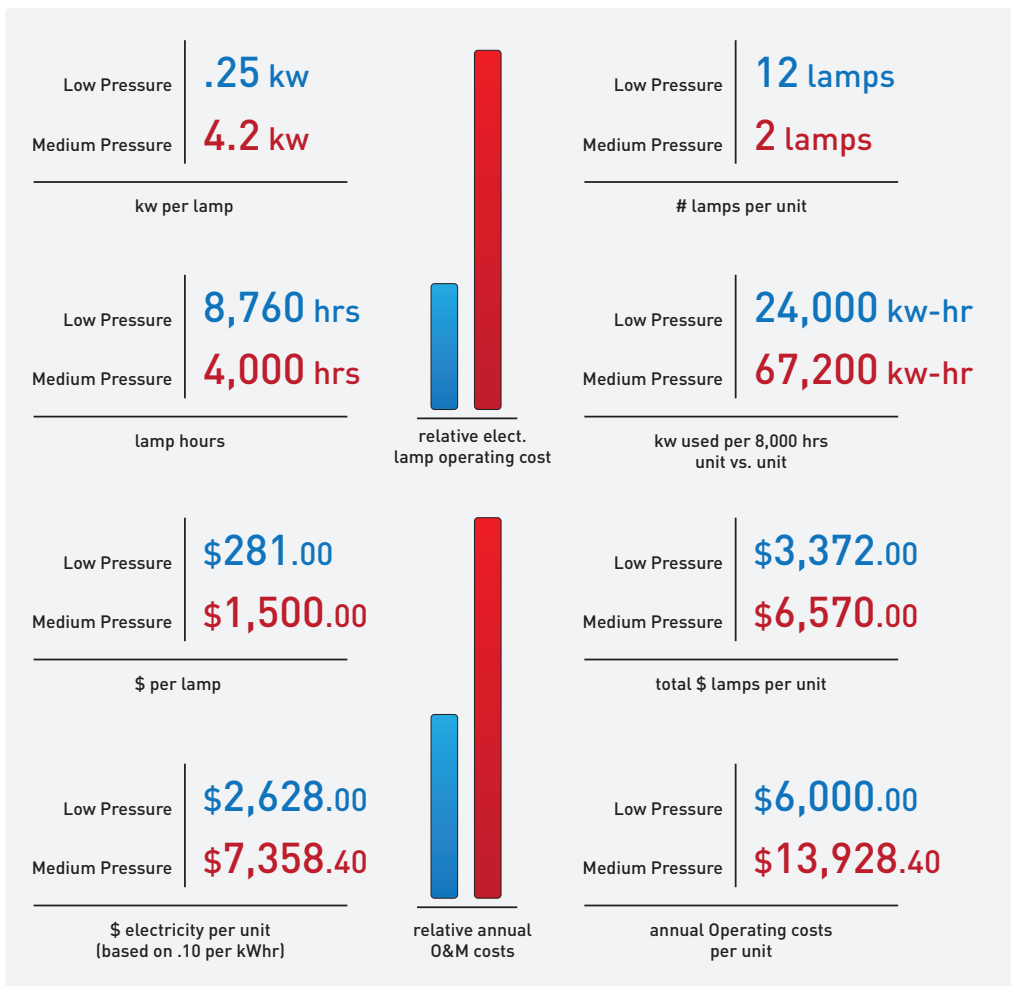


Aquafine LP Amalgam lamps for applications with high UVT water quality may need no quartz sleeve cleaning, or minimally - a mechanical wiping system. Aquafine MP lamps very predominantly require mechanical/chemical cleaning due to the rate and type of fouling induced by high thermal radiant and conduction loads on the wetted quartz surface of the sleeve or window, even in high UVT applications.

## Which one is for you? | Cost, Maintenance and Sustainability Comparisons

When comparing LP vs. MP lamp technology for UV disinfection, cost, maintenance and sustainability are important factors.

For example, in comparing annual operating and maintenance costs, LP is significantly less expensive, up to 50% vs. MP lamp technology. Environmental impact is also dramatically better on an annual basis, with a comparison of 16.5 metric tons of carbon dioxide (CO<sub>2</sub>) for LP technology vs. 46.3 metric tons for MP technology. That's a difference of 29.8 tons of CO<sub>2</sub> per year.



### Beverage Installation

**Lamp Technology:** Low Pressure  
**Drivers:** Low energy consumption, cost effective, low maintenance, sustainability



### Aquaculture Well Boat Installation

**Lamp Technology:** Medium Pressure  
**Drivers:** Space constraints, high-flow requirements

## Your UV Technology Solution | Things to Consider

Aquafine offers both LP and MP UV Solutions.

**Remember:** your application requirements will dictate the selection of lamp technology you choose and will depend on the requirements of each specific site.

- Conventional low-pressure and amalgam lamps are significantly more energy efficient than medium pressure lamps.
- Medium pressure lamps produce the greatest UV output per unit length of lamp, of the three lamp types.
- New high power amalgam lamps are significantly more powerful than low pressure lamps.
- Even though more cleaning may be required for medium and amalgam lamp based systems, due to the reduced number of lamps, these systems can cost effectively incorporate automatic cleaning systems to remove fouling. This automatic cleaning system can thereby significantly reduce labor associated with lamp maintenance.
- Polychromatic light has many different wavelengths, even beyond the disinfection range of 220nm to 280nm that can have positive, and/or negative effects on the fluid being treated.



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