Ultra Violet Filtration

*By: Amy Stone**

When it comes to disinfection in fish culture systems there are a couple of approaches that designers and engineers use.

One of the most common methods is ultraviolet filtration, (UV filtration). Another is ozonation, but we'll save that for another day. This article focuses on the main points to UV filtration which means that there are more finer details that should be considered when determining if UV is the correct answer to your application.

UV Filtration has been used throughout the world for many reasons including sterilizing drinking water, food processing and of course, aquaculture. UV filtration works by harnessing light within the specific light bandwidth range, (200-300 nm), to alter the DNA of the organisms that travel past the lamp. DNA is denatured by UV radiation in this 200-300 nm range, also known as the UV-C bandwidth on the spectrum of light chart, with the most effective wavelength occurring at 264 nm. Once the DNA is altered, the organism either dies or can't reproduce.

The effectiveness of UV is highly dependent on several factors

One of the most important factors with UV Filtration is water quality. For the UV light to penetrate the target organism, the culture water must be pre-filtered. Any organic matter in the water stream can effectively absorb the available UV light being produced inside the UV reactor. It is important to note that once this light is absorbed, there is no residual left over and the microorganisms we are trying to irradiate could potentially flow through the filter without being altered due in part to insufficient amounts of UV-C being leftover to carry out the process. While organic filtration is important to increase a UV filters ability to operate effectively, we must also understand that UV is also affected by dissolved organics which can reduce the transmittance of the UV wavelengths.

Ultraviolet transmittance is an often-forgotten factor in sizing UV systems and until recently, with a few exceptions, was completely ignored in aquaculture. UV Transmittance is the measure of how well UV-C can be transmitted through the water. The lower the UVT percentage of your culture water, the more your system will absorb the UV-C being produced by the UV filter. It is important to note that even if the water is relatively clear, if the UV light can't be transmitted through the water column, the filter is still ineffective. Most of the sizing guides that are published by manufacturer's of UV in our industry are based on a 90% UVT. A 90% UVT is rare in our industry. Due to the high levels of biological activity, we are more likely to see UVT numbers in the 70-85%. Since the curve on UVT is not a linear reduction, it is even more

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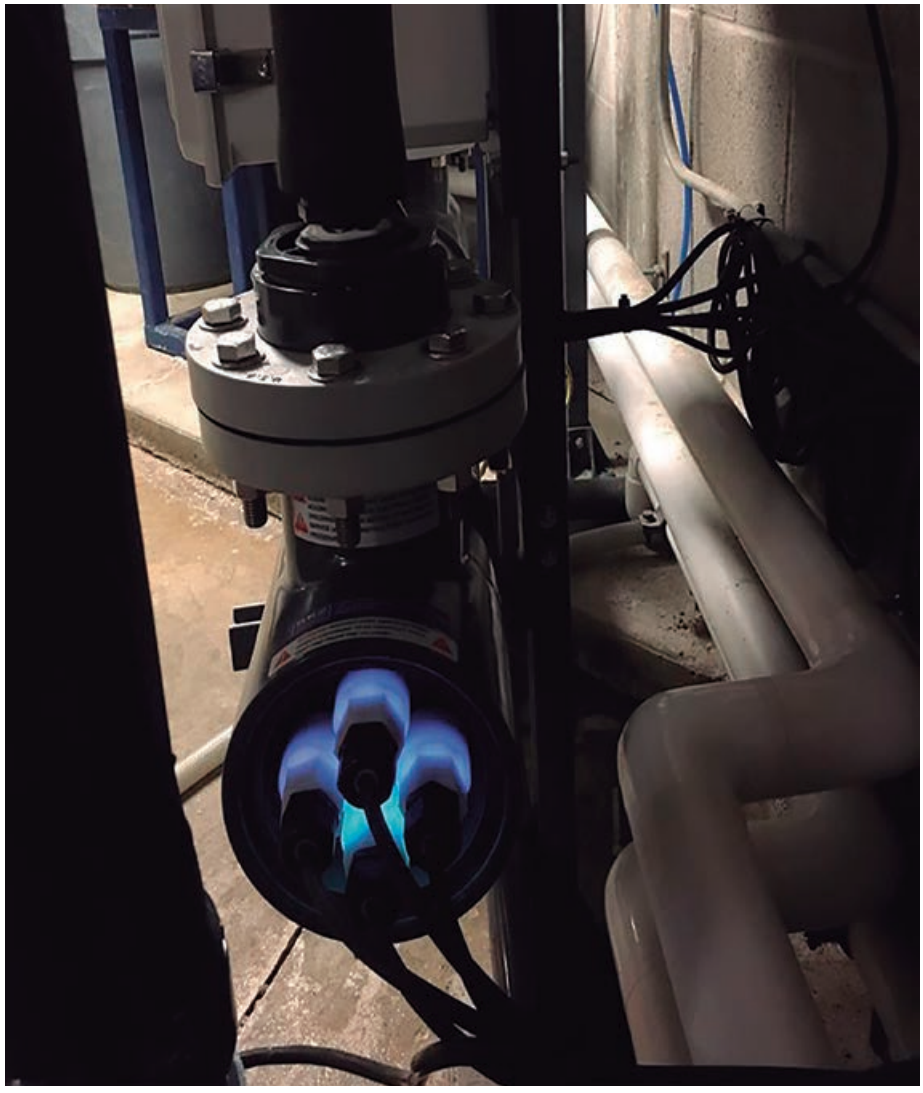

critical that we address this issue. For example, a 5% reduction in UVT% does not equate to a 5% reduction in your applied UV dosage but rather a much more significant reduction. Most reputable UV manufacturers will provide free testing of your water provided you send them representative samples. Note that even though your culture water may have a low UVT value, a UV filter can be properly sized for your application.

As many of our readers might already know, UV is sized on flow rate and target organisms (plus now UVT). The most common disinfection rate in aquaculture is 30,000 mws/cm^2 or 30mJ/cm^2. In more critical applications, we see rates upwards of 90,000 mws/cm^2. It is important to note that every microorganism we encounter within aquaculture has its own specific UV dosage requirement. When looking at sizing, one should consider the microorganism with the highest UV dosage requirement and purchase a UV filter that will provide this necessary dosage noting that all other microorganisms with a lower required UV dosage requirement will be effectively irradiated since they require a lesser amount of UV-C. When determining flow rate and disinfection rate, it is a linear correlation which makes it a simple math equation to work out the needs. UVT is more complicated and should be referred to the manufacturer.

Keep in mind, like all products in our industry, there are marketing pieces that get involved. Some manufacturers use reflective material inside the vessel to increase intensity. Others manipulate the inlet and outlet geometry and still more use different lamp technologies to increase the intensity to shorten the length of time that the water has to be in contact with the lamp. There are several methods that are used to introduce UV to water, but in all cases, the actual lamp is not in direct contact with the water. There is typically a quartz sleeve which protects the lamp from the water. The different styles include open channel or enclosed vessel. In most cases, these units utilize one of four UV lamp types outlined below. There are pros and cons for all styles as well as different selling points that you will see manufacturers use. First let's discuss the various lamp types available.

Low pressure lamps

Low pressure lights are available in three styles. Standard output lamps will generally be offered in 9watt-65watt ranges and operate around 102 degrees Fahrenheit. They are found on inexpensive models used in pond applications. They have their place in very low flow applications with culture water temperatures ranging from 65-85 degrees.

High Output low pressure lamps are similar to standard output lamps but have different internal designs inside the lamps which allow for higher UV-C watts to be produced. These lamps typically range between 50 watts and 155 watts and operate around 108 degrees Fahrenheit. They are also most effective when used in 65-85 degree culture water temperatures.

The third and final low-pressure lamp option is known as an amalgam lamp. These lamps achieve very high UV-C outputs thus allowing for fewer lamps to be utilized within UV filter designs. These lamps typically range in sizes from 70 watts to 360 watts and operate at 180 degrees Fahrenheit. Amalgam lamps offer facilities the best range of culture temperatures due to their robust design.

These lamps operate best for cold water culture systems and have an overall range of 40-95 degrees Fahrenheit.

It is important to note that as the culture system flow rates increase, the sterilizers will use more than one lamp. The low-pressure lamps run at lower temperatures as and convert more of their input wattage into UV-C wattage, (34%-40%). Also of importance is the overall lamp life of these lamps. Low pressure lamps typically last 12,000-16,000 hours before needing replacement.

Medium Pressure Lamps

Medium pressure lamps require a smaller vessel footprint but run at much higher temperatures, (1600 degrees Fahrenheit), which contributes to a higher energy requirement and can heat the water. All of the manufacturers that I have seen with medium pressure lamps require a flow switch or an over-temp sensor to shut down the unit if for some reason the flow is interrupted. It's really important to have this safety factor as the vessels have been known to melt down if they are energized without adequate water flow.

Medium pressure lamps have an average useful life span of 4500-8000 hours depending on the manufacturer which is about half that of the low-pressure lamps. The high heat from these units has also been known to "bake" minerals and waste materials onto the quartz sleeve which also affects its ability to function. To avoid this "baking effect", most medium pressure UV systems require an automatic wiper system to aid in eliminating any potential bio floc from fouling the quartz sleeves. These are most commonly used in clear water applications such as drinking water. It is important to note that these wiper assemblies are not required on low pressure lamp systems due to their significantly lower operating temperatures. Now we can address our two UV reactor styles.

Open Channel UV

Open channel UV is a method where the lamps are suspended in an open tank or raceway either in a drop in (rack style), for a horizontal installation or a top mounted vertically loading UV filter. The spacing is specific to the flow rate and size of the tank/raceway. The biggest pro for this design is that you can install this in existing sumps if necessary. Some of the cons for this style are that variable flow rates and/or water levels can influence the kill rate and fluctuations in water levels can short circuit the lamps if water levels get too high and flood the lamp connections or if levels get too low and leave exposed lamps above the water level thus reducing UV-C dosage outputs.

Vessel Style UV

This style comes in several formats. The more economical versions utilize polypropylene. More robust systems will utilize PVC or stainless steel. It is important to note that plastic vessels are well suited for aquaculture but it is important to note what material your unit is comprised of so that you can best determine its life expectancy. Polypropylene units have

the shortest life expectancy ranging from 5-8 years on average. Standard schedule 40 PVC offers a slightly better life span 8-12 years. Schedule 80 PVC and stainless-steel reactors offer the longest life expectancy, 15-20 years on average. With plastic vessels, it is important to note that the body degrades over time due to prolonged exposure to the UV-C being produced but they are most commonly utilized due to their non-corrosive material composition. The stainless-steel vessels are more resilient to the UV-C being projected inside the vessel, but they are significantly more expensive and tend to corrode when used in marine applications.

Keys to keeping your UV functioning properly

One of the most neglected things about UV Sterilizers is their lamps and quartz sleeves. I can tell you that when I first started working at the farm, we only changed the lamp when it burnt out. Of course, the lamp continues to burn long after it has lost its capability to produce the needed UV-C to irradiate our targeted microorganisms, so who knows how well that thing worked for us. We also didn't clean the quartz sleeve. Over the years of working with customers with these filters, we have discovered that I wasn't the only one neglecting them. Depending on the water quality, the quartz sleeves can have mineral deposits and even yellow. The wavelength is dependent on the quartz sleeve being clear and clean.

Some of the more advanced models have hour counters, and UV Intensity meters built in which can help determine when this maintenance is required. It is imperative that everyone adhere to the manufacturer's preventative maintenance protocol when using these products. Otherwise, you are likely wasting electricity and your investment in livestock and equipment.

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