UV *Disinfection*

PART II

Designing an effective system that works on various water sources and applications

Part I of this article, featured in the May issue of Water Quality Products*, provided an overview of how UV radiation fluence rates can inactivate various strains of germs, bacteria and pathogens. However, a fluence rate assumed enough to kill certain pathogens in water or wastewater disinfection, can be altered by the turbidity or other contaminants in the water. The protective sleeve can get scaled and block the UV from entering the water stream. In order to properly design an effective system that will work on various water sources, it is important to carefully analyze all the varying parameters. Part II of this article covers theoretical calculations of UV transmission rates based on various fluoropolymers and quartz. The article will evaluate bulb protection material costs and review different applications.*

By Jeff Roseman

Theoretical Calculations

Figure 1 reveals the transmission rates of various fluoropolymers and quartz. These polymers and quartz materials are used to protect the UV bulb from the liquid being treated. There are several styles of fluoropolymers. These vary from straight tubes, such as the quartz sleeve, to coiled protection devices that offer longer contact times. They also have varying degrees of clarity that affect UV transmission. Several of the polymers have a low rate of UV transmission, but when coiled, they offer increased fluence rates and turbulence, which enhances their ability to inactivate microorganisms. Quartz offers a 90% transmission rate, but by studying Figure 2, one can see how the increased contact times offer very effective calculated fluence rates of the coiled tubes, as compared to the quartz. Coil performance has been calculated for three contact times in each of the coil groups having effective transmission rates of 60, 70 and 80%. The different percentages represent the variation in fluoropolymer materials and wall thickness. There is only one contact time for the 90% rate, which represents the quartz sleeve. The coils offer a longer contact time, because the length of the coil is approximately 80 in. as compared to around 10 in. when the same bulb is used in a reactor. Keep in mind these are calculated and theoretical fluence rates, and once a UV system is designed and built, it should be tested for actual performance. All rates are mWs/cm². The graph depicts a visual representation of how well the coils can perform as compared to quartz. A 6,000-mWs/cm² value in each of the transmission rates was used for simplicity.

FIGURE 1: UV Transparency of Fluoropolymers

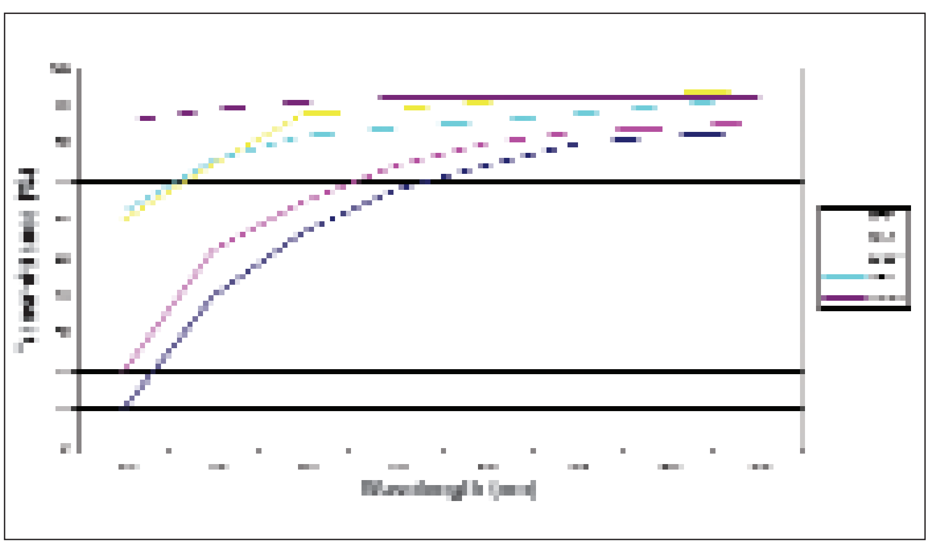
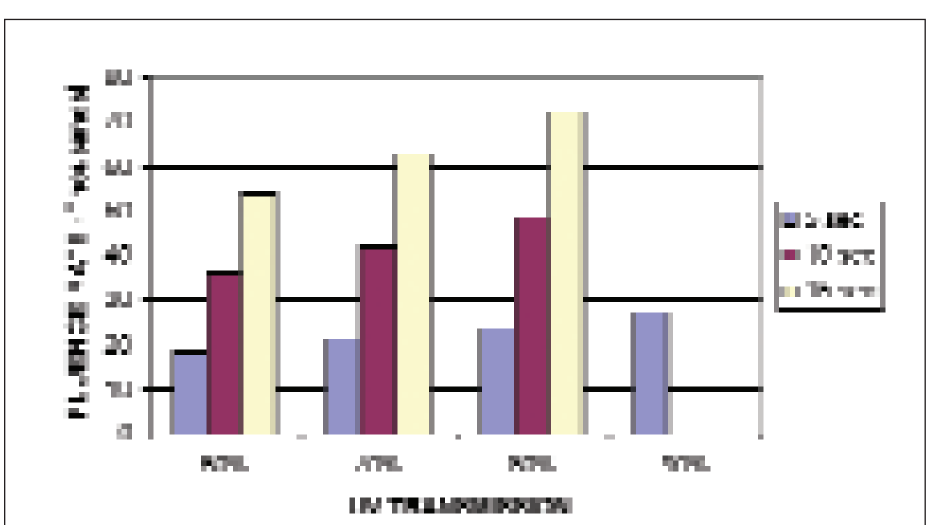


FIGURE 2: Fluence Rate



A collimated beam apparatus is the best method to define the fluence rate of a UV reactor. Several variances must be considered when collimating the beam of UV light to be sure the readings are accurate and definitive. Corrections must be made because water will absorb UV in low-pressure mercury bulbs and if medium pressure bulbs are used, a sensor correction must be accounted for in the calibration. These fluence rate calculations can become very complex because of inefficiencies in fluence distribution to the microorganisms depending on trajectories. Computerized Fluid Dynamics can be used to model the behavior of a real UV reactor.

Biodosimetry is the most reliable method available to measure fluence rates in a UV reactor. A harmless microorganism can be introduced in the water upstream of the reactor. Samples of the influent and effluent are taken and the log reduction of the inactivated microorganisms can be calculated. A dose response curve can be determined using a collimated beam apparatus and a dose rate can be obtained by using the corresponding log inactivation found in the UV reactor.

The coils have proven to be very effective and several products have been designed using these components. Further developments in fluoropolymers that have better clarity and UV resistance are being introduced. Thinner wall tubing, in applications with low pressure, are proving to be very satisfactory in system designs and microorganism control. Overall, the fluoropolymers have a place in water and wastewater treatment when applied properly.

Costs

Cost effectiveness in comparing the two bulb protection materials must be considered when designing UV reactors. Replacement and maintenance costs, whether a straight tube is utilized or a coil, help the systems designer choose components. Reactors must be made to provide economical run times and proper UV protection for the consumer. The average wholesale cost of a 10-in. quartz sleeve is around $20, depending on quality and market area. The cost of a coiled fluoropolymer tube is less than the quartz and the length of the bulb can be reduced, thus lowering the cost of the overall system. Coil costs vary with wall thickness and number of loops. Low-pressure systems benefit from the use of very thin wall tubing, which cost less, and higher UV transmission rates can be obtained because of the thinner wall. The fluoropolymers offer more flexibility in design, smaller system size, easier maintenance, and are safer to handle. They are very useful and suitable in many applications, but do have limitations because they are restricted to lower flow rates and lower pressures; however, they provide the industry an exceptional twist for UV applications.

Applications

There are several applications that can use UV to help reduce and control microorganisms. The fluoropolymers offer flexibility. Various venues have been explored with successful products being introduced in wastewater and fresh water. The limitations of using these coiled or straight tubes are only confined by the imagination. Using these components to protect the UV bulb in the reactor can help reduce the footprint of building a tabletop model water treatment system. Space requirements for a wastewater system utilized these coils in order to meet their specification and sizing parameters.

Some ideas for use would be water coolers or as post treatment on RO (reverse osmosis) systems as a precautionary measure. The water quality would be superior and not be compromised with hardness, iron, or other contaminants that would scale the protective coil or sleeve. This water would not need high fluence rates to remove bacteria, but ensure bacterial control. Pretreatment of water prior to UV is always recommended and this would be an example of a good application.

Fish tanks and aquaculture would also be very good applications, especially for the straight tubing since it can be cleaned and reused. Scale from nitrates and other debris found in this type of water needs to be wiped off to keep the UV dose high enough to control bacteria. Wastewater systems that require regular maintenance because of contaminants could benefit from these components.

Apple cider disinfection is another new possible use. The FDA has recently accepted UV as a method of disinfection for apple cider. A five-log reduction must be achieved, but if these systems can be proven and used, the FDA accepts the use of the food grade fluoropolymers. Pasteurization alters the taste of cider, and since UV does not add anything to the cider, this method will become acceptable within the industry because consumers want the natural taste of apple cider.

Ozone destruct systems could be another possible use. The 254 nm range is very good at destructing ozone and in low flow environments the tubing could be very instrumental in product design, by keeping the systems small, portable and within sizing parameters.

Conclusion

Fluoropolymer tubing, whether it is coiled or straight, offers good bulb protection in UV system design. Even though the transmission levels are lower, the increased contact time and turbulence offer effective fluence rate ability, smaller footprint sizing parameters and cost-effective design considerations. Although not traditional and widely used as the quartz comparison, the fluoropolymers are emerging as an alternative and will continue to win acceptance in many applications. These plastics, by far, are not the answer or cure all for every application, but they should be considered and trusted as a good alternative to using quartz. Their cost and safety issues are very appealing and the effectiveness have been proven in several applications and new innovative methods are being considered for future use. Some of the above uses are only a small sampling of where these plastic tubes can be used. The limitations, again stated, are only confined by the imagination. *wqp*

Note: For references to this article please visit our website at www.wqpmag.com/lm.cfm/wq060502.

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