Foul No More

Strategies for reducing UV disinfection maintenance & energy costs

By Diane Arnott

Driven by the accumulation of fouling at the sleeve-water interface, maintenance time and costs remain significant challenges in the application of ultraviolet (UV) disinfection. New lamp-dimming technology can extend the sleeve cleaning maintenance cycle and contribute to labor and power savings for water treatment operations.

UV systems have long provided safe, effective treatment for small and very small operations.

In the U.S., there are more than 19,000 non-transient, non-community water systems, most of which are small or very small operations relying on private water supplies. For years, UV disinfection has provided them with safe, effective treatment to meet jurisdictional water quality requirements. However, there is an inherent challenge for these types of systems: Facilities like day cares, churches, schools, and smaller healthcare and elder care operations experience extended periods when the building is vacant, like evenings, weekends or overnights, when water demand is minimal or non-existent. While actual water usage can vary significantly in a 24-hour period, no-flow periods can account for 60% or more of the time. This can exacerbate a critical challenge in effective UV disinfection: sleeve fouling.

Sleeve fouling is the accumulation of mineral compounds on the lamp sleeve. These mineral deposits absorb UV light, which decreases the UV transmittance of the sleeve, negatively impacting the intensity of UV light penetrating the water being treated. Thus, fouling can rapidly and significantly decrease the UV dose the water receives, resulting in reduced disinfection performance.

Various chemical and physical water characteristics determine the rate at which fouling occurs. The reduction in UV light transmittance through a quartz sleeve occurring in as little as 24 hours can be dramatic. It is influenced by a combination of hydraulics, heat and water quality effects.

Key site-specific water quality factors are hardness, alkalinity, iron and pH. With hard or iron-bearing waters, carbonate compounds that exhibit decreasing solubility with increasing temperature are affected at the sleeve-water interface and deposit on the sleeve. Because this type of fouling is temperature dependent, it is intensified by periods of no flow. During these times, the UV lamp transfers heat, resulting in water temperatures as high as 131˚F in the chamber, increasing the rate of sleeve fouling. Fouling necessitates cleaning the quartz sleeve to maintain optimal system efficiency and performance, and the rate of fouling determines a site's maintenance schedule and costs.

Sleeve Cleaning Options

The UV industry has responded with approaches that either limit fouling or facilitate sleeve cleaning. Cleaning strategies for the water-side surfaces of the quartz sleeve may be physical or chemical. They include off-line chemical cleaning, on-line mechanical cleaning and on-line mechanical-chemical cleaning.

The performance and cost-effectiveness of these options vary. Although it is labor-intensive, off-line chemical cleaning remains the mainstay of the industry. Shutting down the UV system and manually giving the sleeve a thorough cleaning remains both an effective and necessary approach. Visual inspection of the sleeve also can occur at that time. As noted, the sleeve maintenance cycle is dependent on site-specific fouling.

Mechanical cleaning systems facilitate routine cleaning of the quartz sleeve without service interruption or disassembly of the UV system. These accessories may consist of stainless steel brushes, rubber wipers and/or Teflon rings that physically remove foulants from the sleeve. They can be automated and, once programmed, unattended cleaning of the quartz sleeve can be achieved. Mechanical cleaning systems have shown varying degrees of success in removing scale accumulation. Frequent passes of the wiper over the quartz sleeve may impede the buildup of scale, but ultimately, chemical cleaning will likely still be required. Over time, the cleaning system wipers may damage the quartz, creating scratches in which fouling materials

In a study, sleeves from lamp-dimming systems (left) showed less fouling than standard systems.

may more readily adhere. Consideration also should be given to the maintenance of the wiper system and associated labor costs. Lastly, wiper jams have been known to contribute to lamp breakage. Nevertheless, the sleeve maintenance cycle can be extended with this approach.

An alternative approach is to limit fouling by moderating the water temperature in the UV chamber. Configuring the UV installation with a high-heat dump or purge valve allows hot water to dump when a temperature threshold is exceeded. Cooler water then enters the chamber. These devices typically are incorporated to manage "low-UV" alarms, but also may effectively limit fouling. Some UV systems are available with a built-in purge valve or specially equipped to allow a small amount of water to continue to flow through the UV system in periods of no water demand. The downside of these devices is water waste, which can be considerable in the long term.

Lamp dimming is a novel approach to managing the water temperature in the chamber without water waste. It prevents temperature rise during no-flow conditions by reducing lamp power, or "dimming" the lamp, during periods of no flow. By adjusting lamp power to 50%, the water temperature is maintained below 104˚F and the rate of sleeve fouling is reduced. Note that this can only be achieved in UV systems equipped with a flowmeter.

Lamp Dimming Demonstration

To demonstrate the impact of lamp dimming on fouling and associated sleeve maintenance requirements, two pairs of NSF Class A UV systems equipped with flowmeters were operated side by side in a facility mechanical room. The first pair operated at 100% power at all times. The second pair operated at 50% power throughout, simulating the full dimming condition. Performance was evaluated using UV transmittance (at 254 nm) through the quartz sleeves, compared to a new, clean reference quartz sleeve. At timed intervals, the sleeves were removed from the system and visually inspected, and UV transmittance was measured by spectrophotometry. The rate of quartz transmissibility (UVT) degradation was significantly reduced in the lamp-dimming systems and a distinct visual difference was observed.

A typical low-UV alarm set point that would trigger sleeve maintenance is 65% UVT. On this basis, the systems operating at 100% power would have required sleeve cleaning by week 32. However, another 40 weeks would have elapsed before the systems enabled with lamp dimming would have required sleeve cleaning (week 72). Thus, the sleeve maintenance cycle was extended more than twice. Again, the fouling rate is site-specific and actual results vary with water quality. Nevertheless, a similar relationship should hold true. Water treatment facilities incorporating UV lamp-dimming technology can expect up to 60% less sleeve maintenance. If, for example, a facility currently is performing sleeve cleaning maintenance every quarter, it is expected that its schedule could be revised to once every six months.

Lamp dimming is automatically triggered when no flow has been detected for a period of one minute, and the power reduces to the 50% level after another minute. However, when the flowmeter once again detects water demand, the lamp immediately returns to full power. This happens with no interruption in disinfection and without the "hot shot" of water that typically occurs after an extended period of no flow. For many facilities experiencing extended periods of no flow, this can correspond to approximately 30% less power consumption or more. (Facilities should use system diagnostics to establish a sleeve cleaning cycle that optimizes energy savings.)

Lamp-dimming technology reduces sleeve fouling without the addition of mechanical wiper systems or water wastage. Reducing fouling by powering down the lamp during periods of no flow means a water treatment facility can experience up to twice the operating time between sleeve cleaning maintenance and significant power and labor savings. **WQP**

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