Let the Light Shine In

Proper maintenance helps keep UV disinfection operations smooth

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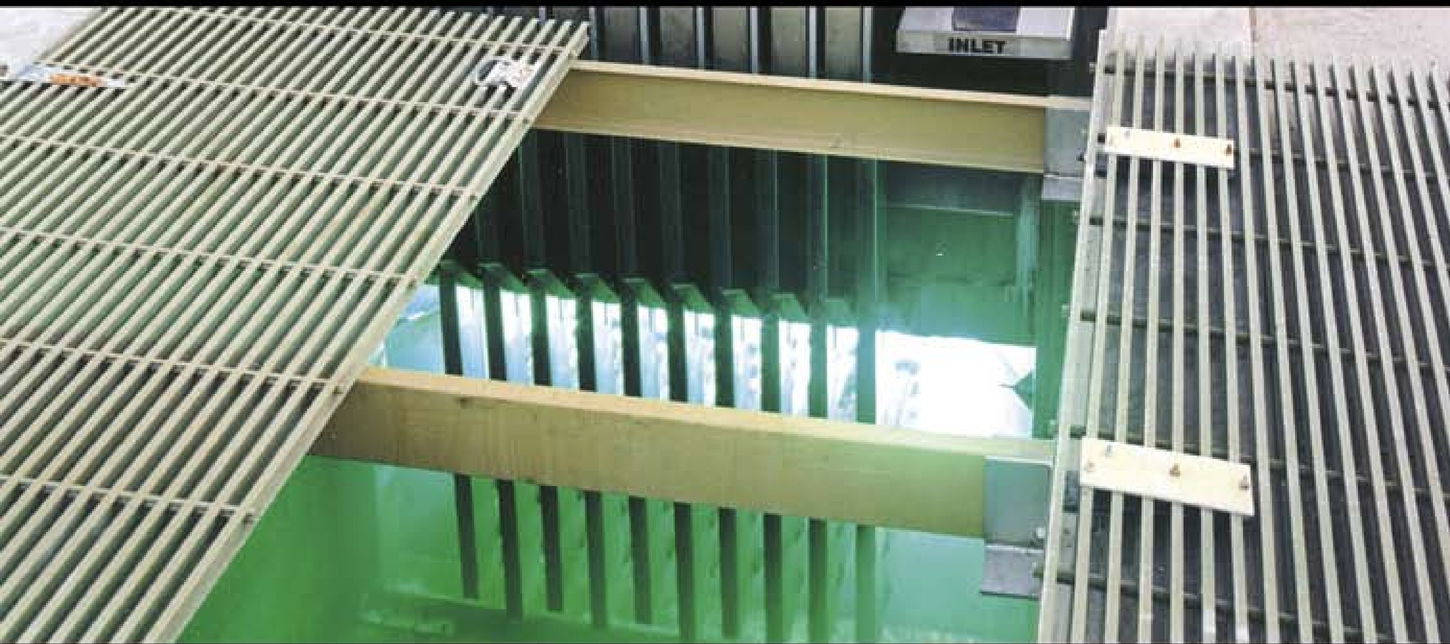

Many wastewater treatment facilities now use ultraviolet (UV) light to disinfect their treated wastewater before discharging it to a receiving waterbody. Although the UV process is fairly simple, it requires regular maintenance to keep it operating at peak performance levels.

UV System Basics

For a UV disinfection system to function properly, UV light must come in contact with the microorganisms in the water. This can happen in various ways. In one common method, UV irradiation involves passing water through a chamber containing rows of lamps (encased in quartz sleeves) that emit UV energy. The UV light inactivates waterborne pathogens. When the UV system functions as intended, operators can easily maintain compliance with the treatment facilities' discharge requirements.

UV disinfection processes have three basic components: the process itself and its electrical and mechanical systems. The process depends on influent quality and the disinfection goals. The electrical system consists of the lamps, wiring, and control system. The mechanical system includes the quartz sleeves, frames, cleaning mechanism, and reactor configuration. All need proper attention, operation, and maintenance to function effectively.

Start Off on the Right Foot

When a new UV disinfection system is installed onsite, the system's manufacturer should train operators to run the equipment properly (see Table 1, below). Operators should review the equipment's operation and maintenance manuals both before and after the training to determine whether any

Table 1. Ultraviolet Light Process Training Highlights
1. Design flows and characteristics.
2. Alarm system.
3. Mechanical checks.
4. Electrical checks.
5. Control logic for programmable logic controller.
6. Replacement of basic components.

materials are missing or need clarification before the manuals are finalized.

To keep the UV disinfection process operating smoothly, operators must supervise the power use, temperature, lamp use, and flow rate. They also must monitor water quality.

Power use. Power is critical to UV disinfection operations. Monitoring power will help utility staff implement strategies to minimize power costs and optimize the performance of the upstream processes that influence water quality (especially transmittance). A power meter can be used to monitor the UV lamps' demand for electricity.

Temperature. If the UV reactor contains medium- or low-pressure high-intensity lamps, they may overheat if flow through the reactor is stopped but the lamps are not shut off. Temperature sensors and alarms should be used to avoid this issue.

Lamp use. All UV systems have meters that measure how long each lamp has been operating (its "elapsed time"). Lamp manufacturers usually note the expected useful life of their lamps. Operators should use these data to determine when lamps should be replaced and then swap them out on a predetermined schedule, rather than risking compliance problems.

Flow rate. UV control is generally based on flow, so the wastewater's flow should be monitored continuously. The flowmeter should be able to produce an electronic signal that can be transmitted to the UV system's programmable logic controller, so the UV dose can be adjusted as necessary. Properly operated and maintained flowmeters will ensure that the UV system remains effective.

Water quality. To ensure that the UV disinfection system's effluent is in compliance, operators must monitor the water quality. Such sampling and analyses may include effluent flow rate, transmittance, bacteria counts, suspended solids levels, turbidity, and particle size.

Proper sampling and analyses are important. Correct sampling procedures (40 *CFR* 136) help prevent the samples from being contaminated by extraneous material. Clean sampling techniques may be required if the UV system's effluent limits are especially stringent. For example, grab samples should be collected in clean, certified containers and immediately refrigerated (at 4°C). They also must be shielded from light (wrapping the bottles in aluminum foil can sometimes be effective). Sometimes, rosolic acid should be added to the sample to ensure that bacteria counts are accurate. Such conditions must be maintained until the samples reach the laboratory and are analyzed. The U.S. requirements for sample collection, proper containers, preservation, and holding times are found in 40 *CFR* 136. Utilities outside the United States should consult their specific sample collection and preservation requirements.

Analysts should follow the appropriate procedures (including quality control and assurance practices) when testing each sample. For example, analysis should begin within 6 hours of sample collection. If the procedures listed in 40 *CFR* 136 are not followed in either the field or laboratory, the results can be misleading and may result in enforcement actions by the U.S. Environmental Protection Agency.

Use the Proper Controls

To be effective, the process-control system must be able to ensure that the delivered UV dose will produce an effluent that meets discharge requirements. The correct dose depends on the influent flow rate, UV intensity, and UV transmittance. Thus, the control system must be operational over the anticipated range of these variables.

Flow-paced control. In flow-paced control methods, the number of lamps in service depends on the facility's effluent flow rate. These methods do not account for changes in lamp output (due to aging) or water quality. This approach is often used alone in low-pressure systems but combined with other control methods when used in low-pressure, high-output, or medium-pressure UV lamp systems.

Dose- or intensity-paced control. In these control methods, the UV dose is calculated based on influent flow rate, UV transmittance, and lamp power (UV intensity and lamp aging). Such methods are used in UV disinfection systems that can modulate both flow rate and lamp power level. Such systems typically use medium- or low-pressure high-intensity lamps.

Sensors. *UV transmittance.* Effective UV transmittance is critical: A drop in transmittance could cause the treatment plant's effluent to be out of regulatory compliance. Transmittance changes may be the result of diurnal variations in influent quality, daily or seasonal variations in residential or industrial discharges, or long-term changes in industrial discharges (as companies grow or relocate). UV transmittance data should be collected regularly (at least once per day) — preferably at the time of day when the transmittance is lowest. These data can be used to adjust the UV dose, as needed.

Both bench-scale and on-line UV-transmittance sensors must be calibrated regularly per the manufacturer's recommendations.

Intensity. Typically used to measure the delivered UV intensity and determine lamp cleaning frequency, UV-intensity sensors respond to changes caused by lamp aging, lamp-sleeve fouling, or UV transmittance.

The sensor data can be used to establish low-intensity alarm setpoints or calculate the UV dose. Intensity sensors must be calibrated regularly per the manufacturer's recommendations and may have to be replaced periodically. If using multiple sensors, operators can compare their readings to each other (to detect anomalies) and to a reference sensor (to identify those needing recalibration).

Temperature. Temperature sensors protect UV systems whose lamps can overheat if the flow is interrupted. If the temperature rises above a preset target, a sensor signal can be used to turn off the UV system, thereby protecting reactor components.

Temperature sensors must be calibrated regularly per the manufacturer's recommendations.

Flow. Operators use flowmeter data to determine the delivered UV dose. In simple systems, they compare the actual flow rate to a chart of dose versus flow rate at various UV transmittances.

Sometimes the flow rate is only one variable that the control system uses to calculate the delivered dose and then adjust the lamp power or number of lamps in service.

Properly installed flowmeters can be used in any of these approaches. However, they must be calibrated regularly per the manufacturer's recommendations.

Table 2. Recommended Typical Maintenance Activities for UV Processes

Frequency	Task/general guideline	Action
Weekly	Check on-line UV transmittance analyzer calibration (if applicable).	Calibrate UV transmittance analyzer, based on manufacturer's recommendations.
Monthly	Check sleeves and wipers for leaks.	Replace sleeves, seals, O-rings, or wiper seals if damaged or leaking.
Monthly	UV intensity calibration check.	Check sensor calibration at the lamp power output utilized during routine operating conditions.
Monthly	Check cleaning efficiency.	• Record UV intensity sensor reading. • Examine sleeves for streaks or remaining deposits. • Record UV intensity sensor reading after cleaning and compare with precleaned value. • Reclean or replace sleeves if intensity is not restored to precleaned value.
Semiannually	Check cleaning fluid reservoir (if applicable).	• Replenish solution if the reservoir is low. • Drain and replace solution if the solution is discolored.
Annually	Test-trip ground fault interrupt breakers.	Maintain ground fault interrupt breakers in accordance with manufacturer's recommendations.
Lamp/ manufacturer-specific	Replace lamps.	Replace lamps when any of the following conditions occur: • Initiation of low UV intensity after verifying that condition is caused by low lamp output. • Initiation of lamp failure alarm. • System not achieving permit requirements.
Manufacturer's recommended frequency	Check flowmeter calibration.	If effluent weir or flume is available, manually check depth and compare to primary device measurement. Primary device should be calibrated at recommended frequency or when measurement uncertainty is exceeded.
When lamps are replaced	Properly dispose of lamps.	Send spent lamps to a mercury-recycling facility or back to the manufacturer.
When quartz sleeves are replaced	Properly dispose of quartz sleeves.	Replace sleeves as recommended by manufacturer or when damage, cracks, or excessive fouling occurs that would impede UV intensity.
Manufacturer's recommended frequency	Clean and calibrate transmittance monitor (if installed).	Clean and calibrate according to manufacturer's recommended frequency.

(Adapted from the U.S. Environmental Protection Agency's 2003 UV Disinfection Guidance Manual)

UV = ultraviolet.

Table 3. Process Checks
1. Effluent transmittance.
2. Effluent total suspended solids concentration.
3. Ultraviolet spectra.
4. Effluent color.
5. Industrial dischargers.
6. Algae.
7. Iron/manganese/hardness.
8. Microbial testing procedures.

Table 4. Electrical Checks
1. Lamps are energized.
2. Lamps are connected.
3. Useful lamp life.
4. Ballast output.

Table 5. Mechanical Checks
1. Cleaning system to ensure acceptable performance.
2. Proper delivery of chemical.
3. On-line transmittance measurements.
4. On-line intensity measurements.
5. Flowmeter calibration.
6. Ballasts closed loop-cooling system.

Maintain Top Performance

To ensure that the UV disinfection system will continue to function effectively for many years, operators should follow the U.S. Environmental Protection Agency's maintenance recommendations for the use of UV in potable drinking water applications (see Table 2, p. 75). For example, periodic cleaning and calibration of related instrumentation is critical. Also, during system startup, operators should review all the equipment manufacturers' recommendations and compile a master maintenance checklist.

Keep Trouble Out

Operators also should learn the troubleshooting techniques that will help keep the UV process on-line as much as possible.

Process control. The effectiveness of a UV disinfection process depends on the upstream treatment processes and the quality of the water they produce. For example, industrial dischargers may contribute UV-absorbing organics or inorganics, or other substances that inhibit UV process performance. Likewise, upstream processes may contribute solids or organics that interfere with disinfection. For a checklist of factors that could influence UV process performance, see Table 3 (left).

Electrical system. If the UV process problems seem to be related to the electrical system, operators should check the items listed in Table 4 (left).

Mechanical system. Mechanical systems — especially the quartz sleeves for the UV lights — are critical to the operation of UV disinfection processes. The primary maintenance task is cleaning these sleeves, because wastewater constituents tend to foul them. The cleaning system may be mechanical or chemical; its frequency depends on how rapidly the fouling impedes the transfer of UV light into the wastewater.

For more information on the mechanical systems and their maintenance requirements, see Table 5 (left).

Let There Be Light

The UV disinfection process has several advantages, compared to other alternatives. Unlike chlorination and ozonation, UV disinfection involves no chemicals, so it produces no toxic residuals or byproducts. In contrast, many municipalities are required to remove residual chlorine from their effluent before discharge because of concerns over chlorine's toxicity to aquatic life. This involves the addition of sulfur dioxide or other reducing agents, thereby increasing costs.

Another benefit of UV disinfection is that it eliminates the need to transport, store, and handle potentially dangerous chemicals. This is both a safety and a cost benefit. The 1988 Uniform Fire Code (and subsequent revisions) lists requirements for controlling accidental discharges of gaseous chlorine, as well as the sulfur dioxide often used in dechlorination. The scrubbers required to meet these codes increase chlorine disinfection's capital costs. Because UV disinfection facilities do not require scrubbers and occupy minimal building space and basin volume, UV disinfection is often a viable, cost-effective alternative to chlorination and ozonation.

When maintained properly, UV disinfection systems will operate for many years to keep the utility's effluent pathogen-free.

For more information on UV systems, see the *Wastewater Disinfection Operations Manual*, which was published by the Water Environment Federation (Alexandria, Va.) in 2006.

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