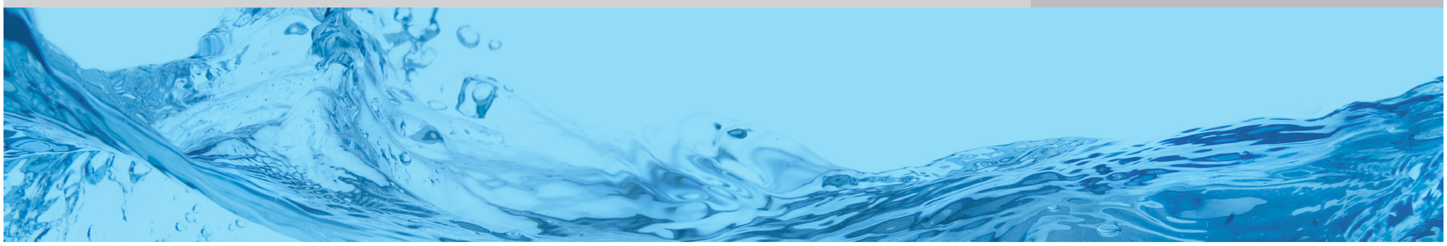

Control Ultraviolet Disinfection Systems with Dose Pacing

Principle

Ultraviolet (UV) radiation has become a common method for final disinfection during the wastewater treatment process in municipal plants with up to 20% of US plants utilizing it[1]. Specific wavelengths of UV light damage the genetic information (e.g., DNA and RNA) of microorganisms leaving them unable to reproduce. When applied to a flow of wastewater, UV light can provide disinfection without the addition of any chemicals. Advantages (and cost savings) related to utilizing UV disinfection compared to typical chemical disinfection processes like chlorination include reduced lifecycle costs, reduced need for technically trained chemical handling professionals, and reduction in storage and handling of potentially hazardous chemicals. A disadvantage of utilizing a UV disinfection system as opposed to chemical counterparts is the increased energy usage due to the UV lamps. Therefore, many control strategies that are employed to decrease the energy use of these lamps are considered best practice.

Suggested Actions

- Install dose pacing sensors on UV lamps.
- Continuously control number of lamps and light intensity to match the appropriate amount of disinfection required as dictated by dose pacing sensors.

Since UV disinfection systems need to be designed for the worst-case scenario (i.e. highest flow, greatest amount of bacteria, most interference from other water constituents, etc.), the number of UV lamps installed and their light intensity tend to be much greater than what is required under typical operating conditions. A control strategy that decreases the light output (and energy consumption) when the wastewater flow and composition does not require it can lead to significant energy and cost savings. One such common control strategy for UV disinfection systems is dose pacing.

The required dosage of UV radiation for a flow of wastewater is a function of the flow rate of water, turbidity (cloudiness), and UV transmittance (light reaching target). Thus, dose pacing is a control strategy for UV disinfection systems that uses sensors on the UV lamps to measure flow and turbidity then adjusts lamp intensity correspondingly in real time. This ensures that the proper dosage of UV radiation is being applied to the wastewater at all times. For example, if the flow rate were low and the water was relatively un-clouded, then the dose pacing system would tell the UV lamps to decrease their intensity (dim) until one of those factors changed, thereby decreasing the energy consumption of the UV lamps considerably.

[1] US EPA. 2016. "Clean Watersheds Needs Survey 2012." United States Environmental Protection Agency 53 (9): 1689–99.

Dose pacing can provide significant cost benefits both in terms of energy savings and component replacement. Dimmed lamps draw less power and lamps that are not operated at full power continuously last longer. However, the magnitude of the benefits will depend on the variability of a particular facility's wastewater flow rate, water quality, fouling, and lamp age[2].

There are two common kinds of UV lamps that can be installed at a wastewater treatment facility – low-pressure or medium-pressure. Low-pressure lamps tend to be utilized at facilities with either lower flow rates or higher quality (less cloudy) wastewater because they use less power and output less UV radiation. Common estimates for UV system energy usage put low-pressure lamp systems at 100-250 kWh per million gallons of wastewater treated and medium-pressure lamp systems at 460-560 kWh per million gallons[3]. Therefore, there are greater cost benefits for applying dose pacing to medium-pressure systems as opposed to low-pressure systems.

Example

Being conservative in our estimates, let's assume a 15 million gallons per day (MGD) wastewater treatment plant utilizes a low-pressure UV lamp system that is designed for a peak disinfection rate 20% greater than its typical disinfection requirements. Therefore, a majority of the time, the energy consumption of the UV system can be reduced by 20%. Utilizing the median estimated energy consumption of a low-pressure UV system and assuming the peak occurs only 5% each year (18 days), the annual energy savings with a proper dose pacing control strategy would be:

Resources

For more information on UV Disinfection view the other AMO Wastewater Energy Tip Sheets at energy.gov/eere/amo/tip-sheets-system

See the Sustainable Wastewater Infrastructure of the Future (SWIFt) website for more information on wastewater energy solutions at betterbuildingssolutioncenter.energy.gov/accelerators/wastewater-infrastructure

To access these and many other industrial efficiency resources and information on training, visit the Advanced Manufacturing Office Website at manufacturing.energy.gov

Annual Energy Savings =

UV System Energy Usage (kWh/MG) × Average Flow (MGD) × Operating Days × % Savings

$$175 \frac{\text{kWh}}{\text{MG}} \times 15 \frac{\text{MG}}{\text{day}} \times 347 \frac{\text{days}}{\text{year}} \times 20\% = \mathbf{182{,}175} \frac{\textbf{kWh}}{\textbf{year}}$$

Which, at an estimated $0.10 per kWh, would provide annual savings of about $18,218. This is in addition to the lifecycle cost savings related to fewer UV lamp replacements.

[2] NYSERDA. 2007. "Optimization of UV Disinfection." New York State Energy Research and Development Authority: 1-376.

[3] "Water Disinfectant: Ultraviolet vs. Chemical or Ozone." Ultraviolet Disinfection of Water and Wastewater. Washington State University - Energy Program. Accessed September 3, 2021. http://e3tnw.org/ItemDetail.aspx?id=13#:~:text=WWTFs%20using%20low%2Dpressure%20UV,on%20the%20chlori.