Atlantium
Illuminating Water Technologies

CASE STUDY

UV Water Treatment
Hydro-Optic™ Technology

Coal-Fired Electric Generation Facility Achieves Non-chemical Disinfection of Boiler Feed Water Using Hydro-Optic™ UV

At a coal-fired electric generation facility with a nameplate capacity of 604 megawatts, high purity feed water for the boiler and steam cycle is provided through a treatment scheme composed of multi-media filtration, micron filters, reverse osmosis (RO) filtration and mixed-bed resin treatment. The facility historically used chemical biofouling control methods to protect their RO membrane elements from anaerobic and aerobic bacterial growth; however, in 2015 they decided to eliminate the use of biocides and achieve non-chemical disinfection through the use of a proprietary Hydro-Optic™ ultraviolet (HOD UV) technology.

Background

The purity of make-up water is critical in maintaining steam quality and in limiting boiler blowdown. Since the facility experienced a fluctuating quality of source water, 74-91 percent ultraviolet transmittance (%UVT), RO technology is used to provide high purity feed water and optimize production at the facility. However, the RO membrane elements are susceptible to biological fouling from the growth of microorganisms, algae, and macroorganisms.

Protecting the RO membrane elements from anaerobic and aerobic growth is essential to minimizing the operational impacts of microbial contamination; which include increased membrane element replacement costs, decreased production and increased energy costs. Biocides have historically been used at the facility to control biofouling and protect the membrane elements; however, this chemical-based approach uses toxic substances and the facility desired to reduce the use of chemicals and associated handling.

In 2015 the facility looked to eliminate the use of biocides and achieve a non-chemical disinfection treatment approach that was also easy-to-use and maintain.

UV disinfection, specifically a proprietary Hydro-Optic UV (HOD) technology, was selected due to its proven efficacy of disinfecting and safeguarding water in power generation facilities against harmful microorganisms. A HOD UV system was installed in December 2015 and a performance evaluation was undertaken in two phases through May 2016 to assess disinfection and membrane operation. Membrane normalization data from 2011 was compared to data from 2016.

HOD UV Technology

The HOD UV technology is a physical process for disinfection that exposes bacteria, viruses and protozoa to germicidal wavelengths of UV light, measured in nanometers (nm), to render them incapable of reproducing or further infecting a water system. The HOD UV technology measures four critical parameters including UVT%, flow rate, UV lamp intensity (kW) and apparatus (consisting of Total Internal Reflection and Dose Pacing) in real time to maintain a specified UV dose. The system uses a proprietary Total Internal Reflection (TIR) based apparatus that when coupled with the comprehensive monitoring of critical parameters allows the system to achieve and maintain the specified UV dose.

The system's patented TIR technology, which is similar to fiber optic science, recycles UV light energy within the HOD UV chamber. Simply put, the UV wavelength is effectively lengthened (i.e., magnified) and provides a greater opportunity to inactive microorganisms.

The core of the technology is its water disinfection chamber made of high-quality quartz surrounded by an air block instead of traditional stainless steel. This configuration uses fiber optic principles to trap the UV light photons and recycle their light energy. The photons repeatedly bounce through the quartz surface back into the chamber, effectively lengthening their paths and their opportunities to inactivate microbes.

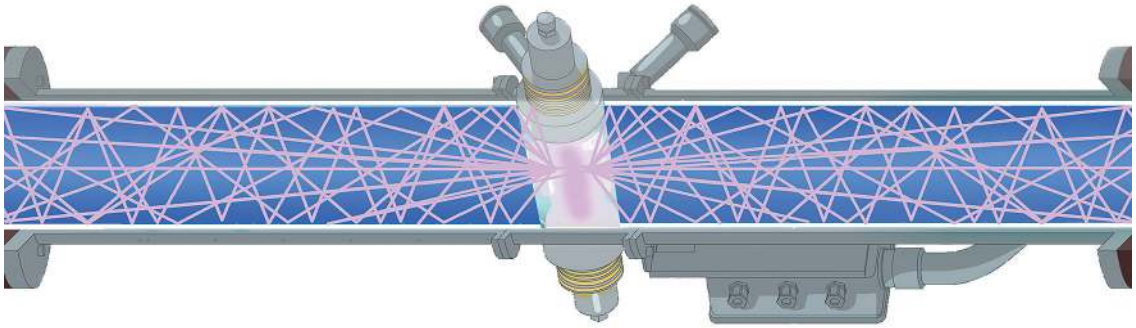

Figure 1: HOD™ UV lamp and chamber depicting the photons bouncing off the quartz surface

Evaluation Study

Atlantium Technologies, Inc. provided one RZ163-13 HOD UV system to the facility for the full-scale evaluation. The HOD UV was installed after the media filters and before the micron filters and RO train to accommodate a flow rate of 300 gpm (68 m^3/hr) with 74-91 %UVT.

The disinfection efficacy of the HOD UV system was assessed during Phase 1 of the study. Operational parameters, as well as bacteria removal efficiencies, were evaluated from January through April 2016. The use of biocides was discontinued and the existing membrane elements (DOW FILMTEC™ BW30-365 installed 2011) remained in place to accurately gauge the disinfection performance of the UV technology compared to chemical treatment. Microbial sampling and analysis were undertaken by collecting three raw water samples before and after the HOD UV installation.

Membrane performance with the use of the HOD UV system was assessed during Phase 2 of the study. New membrane elements (DOW FILMTEC™ BW30XFR-400/34) were installed May 2016. The main differences of the new membrane elements compared to the prior ones include 1.) additional surface area and 2.) improved locking mechanism to connect the membranes. Additionally, the roughing filter media was replaced to further reduce solids fouling and aid in the production of higher quality filtered water. Operational parameters including membrane normalization analysis and tracking of HPC counts, membrane water-throughputs rates, pressure loss, Clean-in-Place (CIP) frequency and membrane replacement intervals were evaluated from May through August 2016.

Study Results

Initial results of the microbial testing showed an almost complete elimination of bacteria downstream of the HOD UV system (less than 40 CFU per mL). The use of the HOD UV produced results that were good, if not better, than results from using biocides. Results for membrane performance, maintenance and operation showed the HOD UV to have an equally positive affect compared to disinfection with biocides.

Membrane replacement during the use of biocides was undertaken after approximately five years. To date, the HOD UV technology has been shown to provide greater protection of the membranes compared to disinfection with biocides used during the period reflected in the study.

By comparing the operating parameters under the previous membrane type to the present conditions, it appears the facility is using 21% less power, getting 18% more permeate and benefiting from 33% less electricity per volume of permeate (Table 1).

While CIP was required during the equivalent time period of 240 days under biocide treatment, CIP has not yet been required under treatment with the HOD UV technology.

Although it is difficult to precisely distinguish the contribution of the HOD UV technology, it is agreed that biofouling has an exponential growth as compared to solids/mineral fouling. This exponential growth can quickly diminish the value of a membrane with an increased surface area and can only be addressed by chemical or non-chemical disinfection means.

Table 1: Membrane Performance with Biocide or HOD UV Treatment

Parameter	Membranes Treated with Biocides	Membranes Treated with HOD UV	Delta (%)
Required Energy to the pump motor over 106 days of operation (MWh)*	126	99	-21%
Accumulated Permeate Flow (Million Gallon)	51.5	60.8	18%
Calculated kWh/1,000 gallon	2.44	1.63	-33%

Note: *The required energy calculated according to the hydraulic parameters flow and pressure and the operation time. Chemical usage and membrane life not taken into account. UV energy is 13MWh for 106 day period, energy to pump the motor is 86 MWh. Chemical usage and membrane life not taken into account; however annual savings by eliminating chemical treatment is $4K.

Membrane salt passage (Figure 2) and rejection (Figure 3) was not as stable with biocide treatment as with the HOD UV disinfection technology. With the HOD UV technology, the membranes showed a 99.4% salt rejection and did not require CIP.

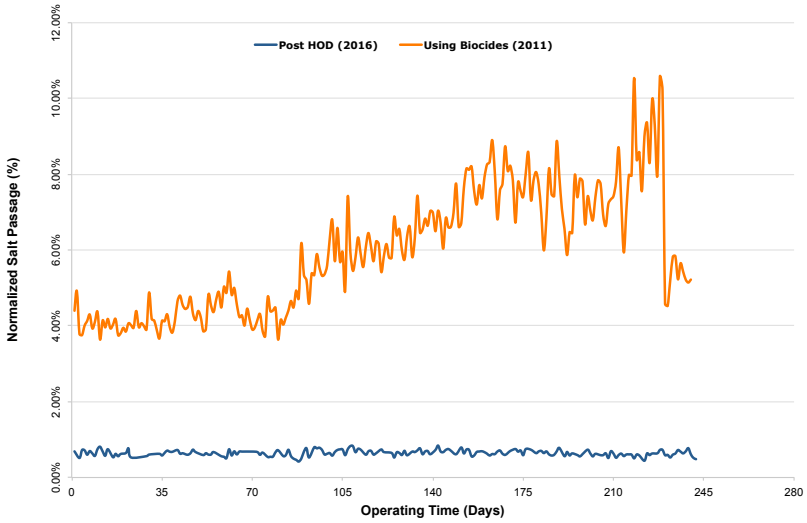

Figure 2: RO 1st stage Normalized Salt Passage during 240 days of operation

(blue – new membrane with HOD UV disinfection only; orange - old membrane using biocides)

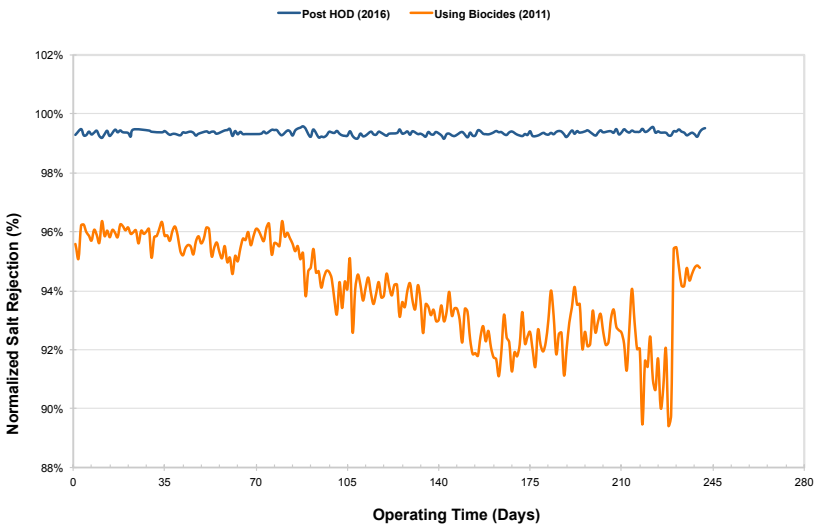

Figure 3: RO 1st stage Normalized Salt Rejection during 240 days of operation

(blue – new membrane with HOD UV disinfection only; orange - old membrane using biocides)

There was a high variance in the normalized permeate flow (Figure 4) and differential pressure (Figure 5) between the membranes treated with biocides or HOD UV. The membranes treated with the HOD UV technology produced more permeate and did not require CIP while the membranes treated with biocides required periodic CIP (3–4 times per year).

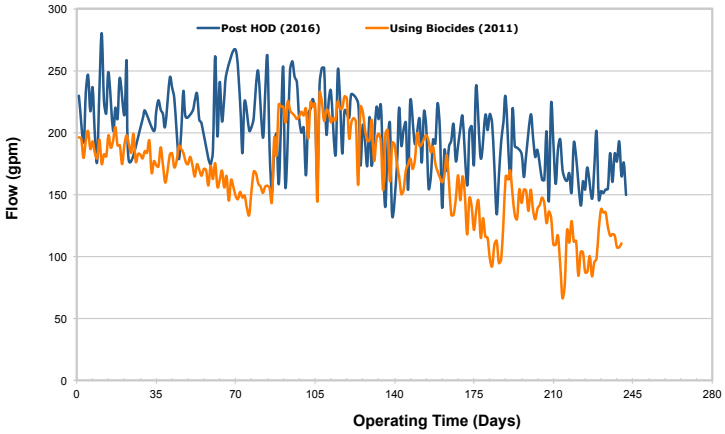

Figure 4: RO 1st stage Normalized Permeate Flow during 240 days of operation

(blue – new membrane with UV disinfection only; orange - old membrane using biocides)

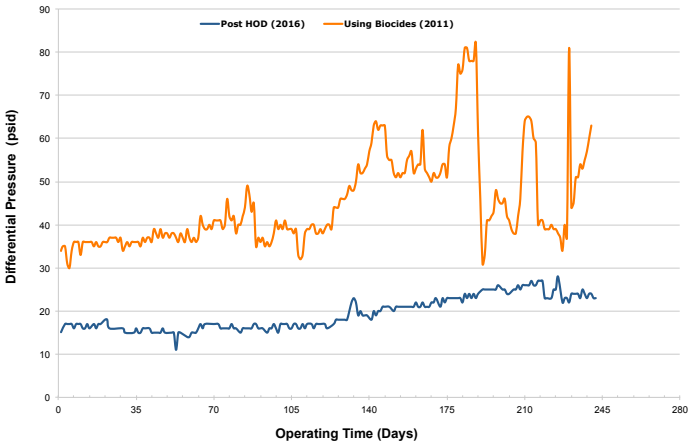

Figure 5: RO 1st stage Differential Pressure during 240 days of operation

(blue – new membrane with UV disinfection only; orange - old membrane using biocides)

Conclusion

Since the installation of the HOD UV technology in December 2015 the membrane performance, maintenance and operation have been positively affected compared to disinfection with biocides. By comparing previous operating parameters to the present conditions, the facility is using 21% less power, getting 18% more permeate and benefiting from 33% less electricity per volume of permeate.

The HOD UV technology is a non-chemical biofouling control method proven as a sustainable and environmentally friendly disinfection alternative in power applications.

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