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Hydro-Optic UV technology installed during full-scale trial at Plant Bowen Water Research Center. Photo courtesy: Southern Research Institute

HYDRO-OPTIC UV Technology for Boiler Feed Water Dechlorination

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Coal-fired steam generation power applications typically use reverse osmosis (RO) technology to provide high purity feed water for the boiler and steam cycle. As an oxidizer in aqueous solutions, free chlorine generating solutions are commonly injected into the feed lines of the water treatment process at power plants to reduce the microbial load. However, RO membrane elements are easily damaged by strong oxidants and membrane performance warranty terms usually include specification for the allowable level of free chlorine not to exceed a concentration of 0.1 ppm in feed water to the membrane unit. In a typical power plant dechlorination application, the water treatment facility aims to produce water with undetectable levels of free chlorine.

RO membrane elements must be protected from biological fouling and oxidation in order to minimize frequent membrane and micron-filter maintenance and replacement. Therefore, a dechlorination process is undertaken to remove free chlorine compounds from the feed water in order for the RO technology and other chlorine-sensitive equipment to operate properly. Without dechlorination, the operational impacts of biofouling on RO technology would include more frequent membrane element replacement and associated costs, increased cleaning in place, production loss, increased energy costs and product quality being compromised.

Dechlorination can be achieved through chemical and non-chemical treatment approaches. Passing feed water through activated carbon filters (GAC) is a typical non-chemical dechlorination approach; however, it is not a common practice used in power plant applications. Chemical neutralization, through the injection of a sodium bisulfite (SBS) or sodium metabisulfite (SMBS) solution into the feed water, is common practice in power applications. The difficulty of SBS/SMBS neutralization is that it is a chemically based approach attempting to balance the chemical feed with the ever-changing chlorine demand. Thus, this approach requires additional handling, storage and operational

requirements. As an alternative to conventional methods, ultraviolet (UV) treatment can be used as a chemical-free dechlorination approach in boiler feed water applications.

Plant Bowen, a 3,160-megawatt coal-fired power station, in Cartersville, Georgia faced frequent membrane and micron-filter maintenance and replacement as a result of bio and solids-fouling despite their use of a SMBS dechlorination process. In an effort to address their concerns, the Plant Bowen Water Research Center (Plant Bowen WRC) decided to evaluate a dechlorination treatment alternative that would enable them to replace the use of sodium metabisulfite, reduce the usage of chlorination, and achieve a chemical-free dechlorination process.

During a three-month period, 4 March through 30 May 2014, the Plant Bowen WRC evaluated the performance of a Hydro-Optic™ (HOD) UV water treatment technology, manufactured by Atlantium Technologies, Inc., for use as a chemical-free dechlorination approach to improve the overall quality of RO feed water at the Plant.

UV TECHNOLOGY

UV is a physical process for disinfection that exposes bacteria, viruses and protozoa to germicidal wavelengths of UV light, measured as nanometers (nm), to render them incapable of reproducing or further infecting a water system. Through UV oxidation, UV light can also destroy chemical contaminants.

Medium pressure (MP) UV lamps provide polychromatic UV light (200 - 415nm), while low pressure (LP) lamps provide monochromatic light (254nm). The polychromatic nature of MP lamp technology enables the production of a high-density broad-spectrum UV light that inactivates a greater number of microorganisms as compared to LP lamp based UV systems. Additionally, MP lamps can more easily pick up free chlorine; making it the ideal UV treatment for dechlorination applications.

Georgia Power's Plant Bowen location near Cartersville, Ga., is home to a state-of-the-art water research center dedicated to improving water quality and increasing water efficiency during the power generation process. As a partnership between Georgia Power, the Electric Power Research Institute (EPRI) and Southern Research Institute and other companies aligned with the power generation industry, the water research center tests and explores water-dependent technologies associated with power generation. Photo courtesy: Plant Bowen Water Research Center

The Hydro-Optic UV technology uses a proprietary MP lamp and effectively "recycles" a required UV dose throughout the reaction chamber using a patented internal reflection technology similar to fiber optic science. The core of the HOD 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.

Maintaining a correct UV dose with any UV system is dependent on three parameters: UV intensity, water UV transmittance and water flowrate. Since these parameters are dynamic and fluctuate, continuous measurement is required. The HOD UV system measures these critical data points in real time to determine the actual UV power produced by each of the UV lamps and the amount of UV light available for dechlorination.

Proprietary software enables the reactor to self-adjust and manage a "safety zone" so the HOD unit continuously provides the minimum dose or registers and reports off-spec status when any of the critical parameters affecting UV dose fluctuate outside of the "safety zone".

EVALUATION STUDY

Atlantium Technologies, Inc. provided three RZ300-13 HOD UV systems to the Plant Bowen WRC for the full-scale demonstration study to achieve dechlorination on feed water with a free chlorine concentration of 0.5 ppm. The units accommodated a flowrate varying from 340 to 680 gpm (77 to 154 m^3/hr) with 95 percent UV transmittance. The UV units were installed in series on existing stainless steel piping after the media filters and before the micro and the RO train.

Operational parameters as well as dechlorination and bacteria removal efficiencies of the HOD UV technology were evaluated. To evaluate the effectiveness of HOD UV technology at removing chlorine, free and total chlorine levels were monitored at four sampling points. Oxidation reduction potential (ORP) values of the RO feed water were continuously monitored during the trial as well. Generally, positive ORP values indicate oxidizing conditions while negative ORP values indicate reducing conditions.

During the study, HOD UV operational parameters continuously monitored included:

- The water flow in the pipe gpm (m^3/h) through a signal received from a flow meter.
- The actual UV output of each lamp as measured by the UV unit's sensor, one per lamp.
- The UV Transmittance (UVT- percent) of the water as measured by the UV unit's embedded UVT sensor (two per unit).
- The UV unit's delivered dose (mJ/cm^2) as calculated by the units controller (colored display touch screen) based water flowrate, the actual output of each lamp and the UVT of the water.
- The water temperature (°F or °C) as measured from the UV dedicated temperature sensor.

During the study several operational modes were also tested and included 100 percent power of all three systems, 90 percent power of all three systems and 90 percent power of two systems with no power to the third.

STUDY RESULTS

The HOD UV systems yielded a Post-UV total chlorine ranging between non-detectable and 0.11 ppm and free chlorine was non-detectable (<0.05 ppm) when processing boiler feed water with an average inlet value of 0.3 ppm total chlorine and 0.2 ppm free chlorine. These values indicate the HOD UV technology effectively removed chlorine. The Post-UV ORP values fluctuated between 277 mV and 368 mV with an average value of 316 mV. The Pre-RO ORP values varied between 197 mV and 444 mV with an average value of 326 mV, which was acceptable for plant operations.

At equipment startup, the SMBS feed was reduced from 5 gpd (19 Liter per day) on 4 March 2014 to 0 gpd (0 Liter per day) on 20 March 2014. After reducing the SMBS feed rate to zero (or near zero) the water was strictly dechlorinated by HOD UV and the results were comparable, or better in certain instances, than chemical dechlorination. The HOD UV technology was also effective at controlling bacteria growth. The Post-UV heterotrophic plate counts were comparable with those in Pre-UV chlorinated waters.

"Results from the full-scale demonstration testing of the Atlantium UV system confirm the efficacy of UV as a treatment technology option suitable for dechlorination. What's unique about the Hydro-Optic treatment approach is its ability to disinfect and dechlorinate in a single, chemical-free process," said Richard Breckenridge, EPRI Water Management Technology Program Manager.

At the conclusion of the evaluation period, results showed the HOD UV system to consistently meet or exceed treatment objectives. The HOD UV technology effectively removed free and total chlorine from boiler feed water to undetectable levels from inlet free and total chlorine levels above 1 ppm. Bacteria levels were also reduced to low acceptable levels.

CONCLUSION

Following the successful full-scale demonstration of the HOD UV technology, the Plant Bowen WRC is finalizing the justification necessary to incorporate the system into full-scale operations at the plant. Based on the savings in chemical elimination, benefits of reduced CIP, extended life of the membranes, and reduced organic loading leading to fewer regeneration cycles of the demineralizers, the HOD UV technology will be a favorable addition to dechlorination treatment efforts at Plant Bowen WRC.

The HOD system decomposes the free chlorine oxidant in process water to protect RO membranes. Additionally, the HOD technology provides disinfection to reduce the membrane biofouling potential by eliminating anaerobic and aerobic bacterial growth.

Power plant applications looking to replace the use of SBS/SMBS and achieve a chemical-free dechlorination process may benefit from a physical process such as the HOD UV technology. UV treatment allows for a dechlorination treatment approach with the potential to eliminate the handling, storage and operational requirements of chemical disinfection solutions. The efficacy of the HOD UV technology, coupled with its specific operating principles and ease of use, allows for a unique chemical-free approach to dechlorinate and disinfect boiler feed water. pe