Mazzei®

CASE STUDY

Update and Upgrade of Ozone Dissolution System at Southwest Water Treatment Plant

Sidestream Venturi Injection—Pipeline Flash Reactor™

Orlando Utilities Commission (Orlando, Florida, USA)

The Problem: The Orlando Utilities Commission's (OUC) 45.6 MGD Southwest Water Treatment Plant, in operation since 1997, was originally designed to oxidize hydrogen sulfide (H2S) with ozone produced by four 950 ppd air fed ozone generators. Ozone contacting was provided by three fine bubble diffusion (FBD) basins. By 2009, the unavailability of replacement parts for the aging generators and the FBD basins' high maintenance motivated OUC to update and upgrade the plant's ozone system.

The Solution: Design of a new ozone system began in early 2010 and was completed by September 2012. The design replaced the four air fed generators with three 1,260 ppd oxygen fed generators, which would provide an applied ozone dosage of 7.4 to 9.84 mg/l at ozone gas concentrations of 8% – 12% wt. The three contact basins' 1,656 diffusion stones were replaced by five, small Venturi gas injectors. The injectors discharge into a common Pipeline Flash Reactor™ (PFR) located directly upstream of the three ozone contact basins. The design team used multiple, small injectors to provide turn down that would allow the plant to minimize pump energy costs by reducing the number of ozone injectors required at low to average ozone production rates.

A miscommunication during the 2010 initial design of the gas injection system resulted in a Mazzei process design which utilized 15.5 feet of PFR hydrostatic water pressure, in spite of the fact that design criteria called for 6 – 8 feet of water above the PFR. The 15.5 foot process design was maintained, in spite of multiple design discussions and written communications on the gas injection design, until a layout drawing was sent to Mazzei in summer of 2012. Once aware of the shallow water conditions, Mazzei expressed concern that low pipeline hydrostatic pressure would result in poor ozone transfer. An additional concern was the possiblility of gas stripping of dissolved ozone residual from gas sparging, when bubbles discharged into the contact basins just below the water surface. To mollify Mazzei's concerns, the project's ozone transfer efficiency (TE) specifications were modified so that ozone TE would only be measured at minimal dissolved ozone residual targets. At higher dissolved ozone residuals or lower ozone gas concentrations, meeting the TE target of 96% would not be required. Mazzei accepted the modified process specifications, assuming that the very rapid reaction of ozone with hydrogen sulfide (sulfide ion) would ensure a high ozone TE. The final ozone TE projection that was submitted by Mazzei showed that a 12% wt ozone applied at the peak design dosage would achieve a 96% TE or better, provided IOD > 0.70 mg/l per mg/l of applied ozone.

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The Results: In the summer of 2014, Mazzei's concerns about ozone transfer efficiency were a distant memory. Functional testing of the injection system verified each Venturi would accept peak design gas volume. Staging the operation of multiple injectors with increasing gas flow worked flawlessly and injector noise and vibration was minimal.

Process performance testing began after the first new generator was installed. Although initial TE data suggested the gas injection system was not meeting the specified 96% TE, it was thought that it may be due to the limited testing of the system as they waited until additional ozone generators were installed and commissioned, and/or the instrumentation readings may be suspect. However, after instrumentation calibration was completed and the additional ozone generators were brought on line, it became evident that the TE performance target could not be met with the installed gas injection system. By the end of August 2014, system testing had confirmed that ozone TE was 11% – 12% below the specified 96%. Attempts to improve performance by bringing more gas injectors on line failed to increase TE and OUC began to have grave concerns that the new ozone system would not provide sufficient transferred ozone to treat the plant's peak water flow.

Injection System Modification

Over the course of multiple conference calls, OUC, the process engineer, site contractors and Mazzei discussed possible design modifications that would allow the gas injection system to meet the TE performance target. The fail safe option, placing the PFR in the contact basins existing influent pipeline that entered at a 22 foot water column depth, was dismissed due to the considerable construction cost and time requirement. Instead, alternative options were examined. Alternative design modifications included: 1) Installation of four additional pump injection systems, and 2) Placement of basin nozzle manifolds at the bottom of each contactor and re-piping the injectors to the manifolds. Both of these options were respectively rejected due to the excessive pump energy costs or due to design and construction complications.

A third design modification, replacing the specified ozone injectors with custom injectors, was accepted. It provided an increased ozone TE without increasing capital or pump energy costs and without requiring new construction. Multi-phase computational fluid dynamic (CFD) analysis conducted by Mazzei showed the PFR nozzle jets were only contacting 60% –70% of the bulk water flow. Mazzei offered to provide custom injectors which had the same external dimensions of the existing Venturis, but which would operate at a higher water flow to lower the injectors' gas/liquid (G/L) ratio while simultaneously increasing PFR nozzle velocity to contact more of the pipeline's bulk water flow. The combination of lower injector G/L ratio and improved pipeline contacting increased ozone TE.

Ozone System Follow Up

In January 2015, Mazzei visited OUC and was informed that the Southwest WTP ozone system continues to operate at an ozone TE of > 98% utilizing two injectors for low and average plant flows and a maximum of three injectors for peak flow, making cost of gas injection < 0.65 kW·h/lb. The high ozone TE performance provided by a minimal number of gas injectors has significantly contributed to the plant's overall reduction in operating costs. An additional benefit of the gas injection retrofit has been improved ozone dosage control. In the past, a change in plant flow or ozone dosage would result in a fluctuating dissolved ozone residual that took several hours to stabilize. Following the switch to gas injection, the dissolved ozone residual stabilizes in < 15 minutes, providing better water quality at a lower ozone production rate. OUC continues to show a significant energy savings at the Southwest WTP and plans to convert their 6 remaining ozone plants to gas injection in the years ahead.