

Optimize Ozone for Wastewater Reuse

“Simple steps to assure ozone process success”

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Over the past several years, we’ve had overwhelming response and feedback to several articles we’ve written about using ozone for water & wastewater disinfection. The profound drought across many areas of the country has piqued interest in this wastewater reuse, and more specifically how ozone can play a role.

Expanding on our past articles, below are some of the most common questions about ozone systems for wastewater applications. While no such discussion can possibly cover every case, this discussion should provide insight to better understanding of how ozone might be applied to your project.

Ozone Demand and Reaction Kinetics?

By far the most common question asked about ozone applications relates to determining ozone demand for a particular project’s water chemistry.

Indiscriminant Oxidants and Reaction Kinetics

Ozone is an indiscriminant oxidant, meaning it will potentially react with anything and everything in the water. However, the rate and order with which reactions occur is entirely dependent on the composition of your water. Some ozone reactions occur almost instantaneously, while others may require some time to complete or will not react at all. This means that a large portion of the ozone could be consumed



by reactions with relatively fast reactions such as H_2S , dissolved iron, nitrite (NO_2) and other inorganics before reacting with organics. Similarly, medium rate ozone reactions with dissolved organics will also consume ozone on the pathway to disinfection. The key to a successful wastewater application is providing sufficient ozone for all of these competing reactions to occur while still achieving a small dissolved ozone residual or positive ORP (>700 mV) with a contact time in the 5 to 10 minute range. The ozone demand-decay test will reveal the most important reaction kinetics, including the instantaneous ozone demand and half-life, which are critical to assure that the correct process conditions are achieved.

What are my ozone injection options?

The two most common methods of injecting ozone into water remain submerged diffusers and side-stream injection.

Submerged Diffusers

Traditionally, submerged diffusers have been the most com-



Figure 1 - Diffusion Gas Sparging array.

mon method for injecting ozone into water. This process should be very familiar to most wastewater plants and operators. An array of submerged diffusers is placed along one or more manifolds at the bottom of a contact chamber. Ozone gas is then introduced at sufficient pressure to allow bubbles to rise through the water column affecting transfer.

All of the same design factors that are important for air diffusion systems are also important for systems using ozone. Deeper basins with fine bubble diffusers generally produce the best results. The main difference in ozone diffusion systems is the need for ceramic or stainless materials throughout the diffusion equipment to withstand long-term contact with ozone gas. Modern ceramic diffusers are available from a number of different suppliers and generally show good service life compared to older products.

The biggest challenges to diffuser based systems are limited turn-down mass transfer efficiency (MTE). Depending on the system geometry and operating points, MTE is typically limited to 70-85%. Turn-down is usually limited by the gas flow to operate efficiently. Under the correct operating conditions some systems can approach 85-90% MTE, but this requires very careful design, operation, and maintenance. These can be important factors at plants that experience wide fluctuations in flow or ozone dose and must be considered in your design.

Side-Stream Injection

The majority of new ozone projects involving large process water flows, typically greater than 250 gpm, utilize a specific version of a side-stream injection system. These systems employ a venturi that is capable of injecting the ozone gas at the maximum design dose rate. The dissolved ozone and

entrained gas mixture are then immediately introduced into the main process pipeline through a set of injection nozzles. These nozzles effectively shear and mix the gas bubbles within the main pipeline completing the mass transfer process.

The main benefit of side-stream injection systems is very good MTE at relatively high transferred ozone doses (TOD). Properly designed side-stream systems can consistently achieve 90-95% MTE (or higher) under most any operating conditions. Side stream systems also offer relatively simple and lower cost maintenance as compared to diffuser systems. Although not appropriate for all projects, side-stream injection is definitely an option to be considered in your next ozone project.

What are the important design considerations in a side-stream injection system?

While an exhaustive discussion of side-stream injection design is beyond the scope of this article, we can certainly cover some of the basic points as they apply to most wastewater ozone projects.

Gas to Liquid (G:L) Ratio:

One of the most critical aspects of every side-stream injection design is the ozone gas to liquid ratio. For ozone doses up to 5 mg/L, a G:L ratio of up to approximately 0.1:1 is considered optimal. Such ozone doses and G:L ratios are possible on high quality treated wastewater effluent such as results from MBR or tertiary filtration processes. Ozone doses of 5-15 mg/L will result in a high G:L in the sidestream, and so requiring entrained ozone gas injection into the main pipeline. The G:L typically drops to less than 0.1:1 in the main line which facilitates excellent MTE. These higher dose applications require aggressive blending of the ozone enriched process stream into the main stream via pipeline flash reactors, or other mixing devices. Overall, side-stream systems designed using these rough guidelines should easily achieve >90% MTE in most applications.

Ozone Gas Concentration (%BW):

Another significant factor in side-stream injection design is the ozone gas concentration, most commonly expressed in % by weight (O_3 %BW). Almost all modern ozone systems are designed to operate at ozone concentrations of 8-12%BW,

which allows sufficient concentration gradient to drive ozone gas into the liquid. Designers and operators should pay particular attention to ozone gas concentration and injection when high plant turn-down is required. Some ozone systems operate at reduced %BW at turn-down while maintaining a high gas flow, which can have a significant impact on transfer efficiency. Although higher ozone gas concentrations of greater than 14%BW are possible, the increased operating cost of these high gas concentrations usually offsets any gains in transfer efficiency.

Post-Injection Backpressure:

An often overlooked aspect to side-stream injection design is providing sufficient back-pressure down-stream of the ozone injection point. A slight back pressure raises the partial pressure of the ozone gas which helps to increase the rate of ozone dissolution. Backpressure will also help to keep the

changes in the production rate of the ozone generator versus the dissolved ozone concentration. A poor MTE will lead to inefficient ozone dosing and subsequently higher energy costs in order to compensate for the loss of ozone gas transfer.

Although far from comprehensive, the brief discussion points above should help shed some light on key aspects of using ozone in your next wastewater reuse project. No 'one-size solution' is applicable to every plant, so designers and operators are encouraged to consider how reaction kinetics, injection design, gas-to-liquid ratio, transferred ozone dose, and back-pressure apply to each project. Each site and application will have its own particular set of limitations, which makes design selection of the other parameters that much more important. Naturally, designers and operators should also avoid the 'go-it-alone' approach. Please feel free to contact us if we can ever be of assistance.

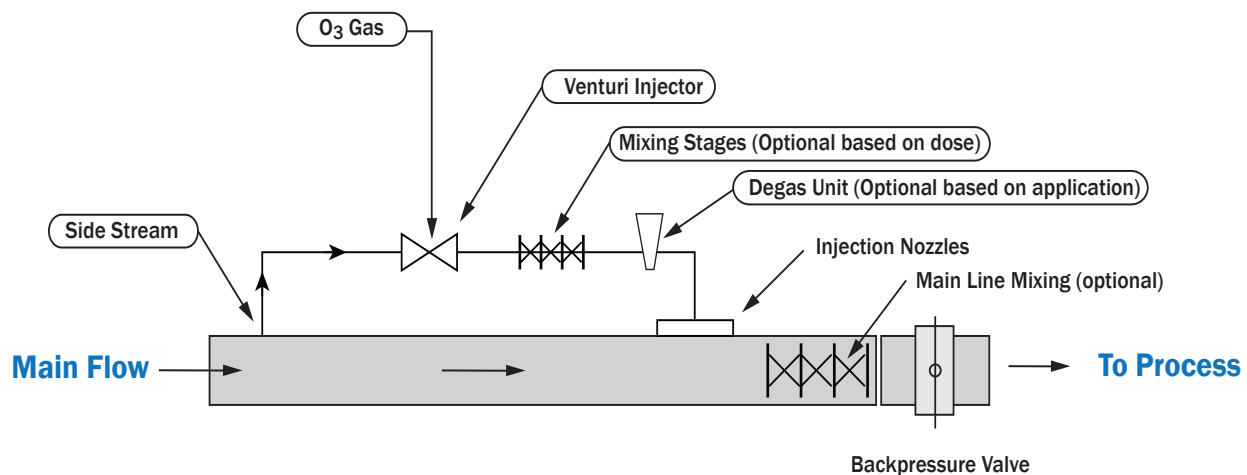


Figure 2 - Typical side-stream injection process

dissolved ozone residual in solution, allowing time for the medium to slow oxidation reactions to take place. Failure to provide sufficient back-pressure can lead to a poor MTE which will cause an increase in the loss of ozone. Herein also lies an opportunity for troubleshooting and improving process efficiency. Operations staff should pay particular attention to

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