Ozone for Industrial Water Treatment:

Piloting Practicalities

By Alex Bettinardi

Ozone is the most powerful oxidizing agent permitted for use in water treatment. In industrial water treatment, it can significantly reduce, or even completely remove, contaminants, toxins and many other pollutants from water. Ozone's applications are vast, from mining to textiles, and each one presents a unique set of parameters to treat. This makes pilot testing an essential step in the process to ensure the most successful, efficient outcome.

Ozone applications

Ozone is used across various industrial applications, including, but not limited to mining, oil and gas, food and beverage, textiles and pharmaceuticals. It is not only used to treat wastewater, but also intake and process water.

Ozone is used for a wide variety of reasons, most commonly to remove colour and surfactants, iron and manganese, phenols and hydrocarbons, organics, micropollutants or reduce overall toxicity. Using ozone to decrease biological sludge in wastewater treatment plants is one of the most common applications.

Because of the many advantages of using ozone, the range of applications has continued to grow. Ozone can be generated on-site, making it a simple and cost-effective option for companies to use. It is one of the most active, readily available oxidizing agents. Ozone rapidly decomposes to oxygen, leaving no traces or toxic halogenated compounds. It also reacts faster and more effectively than other common disinfecting agents.

How ozone works

Ozone (O3) is a powerful oxidant with a fast reaction time. It's an unstable compound, a reactive oxygen species, that works to degrade unwanted chemicals and toxins. There are a few mechanisms by which ozone disinfects water. Ozone can oxidise organic material in bacterial membranes, which weakens the cell wall and leads to cell rupture (cell lysis), causing the immediate death of the cell. It can also react with radical by-products of ozone decomposition or cause damage to the constituents of nucleic acids. Finally, it can break down carbon-nitrogen bonds and cause depolymerisation.

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The effectiveness of ozone treatment relies on the susceptibility of the target organism, the concentration of ozone used and the length of exposure. All of the various applications of ozone require a different dose, chemistry and reaction time for the best outcome. But the one thing they all have in common is the basic set-up of the ozone system.

Pilot testing

A pilot test is a small-scale preliminary test to evaluate the feasibility, performance, cost and risk of a project. It provides essential feedback before the final deployment of a system. Piloting is important for effective ozone treatment because industrial water is so varied and complex. It can involve a whole mixture of organics, toxins and micropollutants. Piloting works to fine tune the specifics of dosing and reaction time and create procedures that are correct for each individual application of ozone. The matrix of the water is always very different, so prior testing enables all of the unique parameters to be addressed each time.

Some applications of ozone are fairly straightforward, such as bottled water, which does not require testing and can simply be designed based on experience. However, most industrial applications of ozone are more variable and complex and cannot proceed without some level of testing. A lab test or a pilot test is required.

The first step of testing involves considering the purpose of the test and whether a lab or pilot test would be more suitable. A feasibility study can be conducted to determine if an advanced oxidation process (AOP) can meet the specific treatment objective. Similarly, engineering data can be used for a cost estimate, looking at capital expenditure (CapEx) and operating expenditure (OpEx). The former purpose is a good use of bench top lab testing while the latter would favour a pilot test.

Bench top lab testing

A challenge in bench top testing is to know the transfer dose of ozone. This is the portion of ozone generated that actually dissolves in the aqueous phase. While it's relatively easy to know the amount of ozone applied, the transfer dose requires knowing the transfer efficiency. This is not easy to measure. One way to eliminate this issue is to conduct a stock solution test. To create a stock solution, ozone is dissolved in cold water to form a high concentration in a relatively stable source of dissolved ozone. A known amount of the dissolved ozone can then be transferred to the sample to be tested. This method works well when low doses of ozone are used. Alternatively, a simple diffuser test in a mixed reactor can be conducted. Ozone is sparged (gas bubbled through a liquid) into a reactor vessel containing the sample to be treated. The ozone concentration and flow entering and leaving the reactor can be measured which allows the transfer dose to be calculated.

Small scale pilot systems

Pilot systems are scaled-down ozone systems, and they can be used to generate engineering data to design a commercial ozone system. They can either be conducted onsite or at an offsite facility.

Onsite studies are advantageous as you have an unlimited amount of water available so more tests can be conducted. Larger quantities of water can be studied and both batch and continuous testing is possible. The client can directly observe the results and get a feel for the process. In some cases, the target compounds to be removed require special analytical tests that the client already conducts.

Testing offsite might allow for quicker results since the equipment does not need to be transported and set up at the customer's site. In this case, tests are normally carried out as batch studies. Oxidant is fed to the batch and samples are taken over time. This allows for measurements of interest, such as chemical oxygen demand (COD), to be related to the ozone dose. The test can indicate if the treatment endpoint can be achieved and what the necessary transfer dose is to achieve this objective.

A typical pilot system includes a gas preparation system which is an oxygen concentrator that relies on pressure swing absorption to concentrate oxygen. You have an ozone generator which is air-cooled and produces the ozone and then you have a pump venturi setup which is used to mix and dissolve the ozone into the water to be treated. The system comes with a control panel with an HMI and PLC which manages the process and usually the system is equipped with the applicable instrumentation such as dissolved ozone monitors or ORP. Optional equipment can include proxy dosing pumps, UV, and other components. Larger pilot systems are available that can be packaged in a container with other processes.

Conclusion

The use of ozone for water treatment is widespread across many different industries and it is becoming increasingly popular. It offers companies many benefits, but in order to get the best outcomes, they need to incorporate testing into their procedures. Pilot testing is an essential step when using ozone for industrial water treatment. It allows for a successful project deployment that addresses the unique parameters of the water.