Ozone in Drinking Water Treatment

Introduction

New regulations governing treatment objectives for disinfection byproducts and for inactivation of micro organisms will increase the need to consider new disinfection technologies for drinking water. Ozone is one such alternative that has been successfully used in Europe for over a century. In the US over 250 drinking water plants use ozone including Los Angeles, Dallas, Detroit and Tampa.

Advantages of Ozone for Drinking Water

Ozone is a powerful oxidant and disinfectant. The time concentration factor for ozone to achieve a 3 log inactivation of Giardia Lamblia is 100 times lower than for chlorine. It is also effective against viruses, bacteria, algae and other protozoan. It does not produce taste and odor in water, in fact, it is an effective agent for removing taste, odor and color from drinking water. It reacts with and removes organic matter from water while aiding in coagulation and flocculation. Many plants using ozone have found that they have been able to reduce coagulants/flocculants by 20-50%. Ozone can also oxidize Fe and Mn facilitating their removing from drinking water.

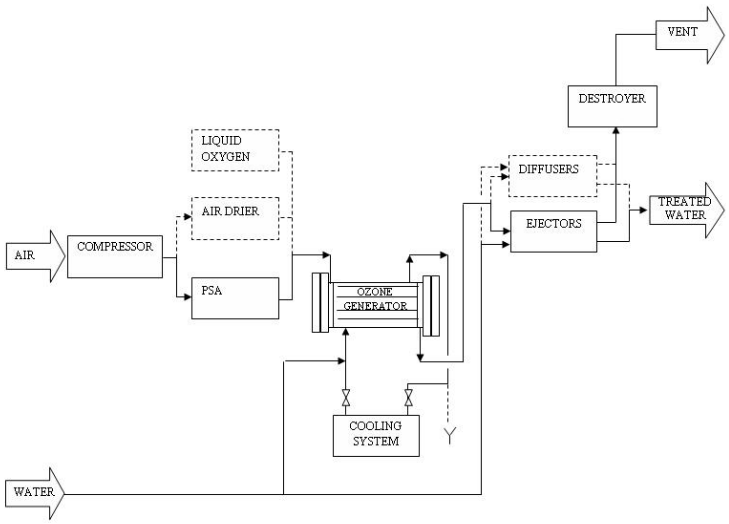
Ozone Drinking Water Treatment Systems

Large scale ozone generation must be done on site from either oxygen or air. The figure below shows a general schematic of an ozone system for drinking water treatment applications. The basic steps are feed gas preparation, ozone generation, cooling, ozone contacting and decomposition.

If air is used as a feed gas, it must be dried to a dew point of -70^{o} C. This is most often done with pressure swing adsorption operating at around 100 psi. Alternatively, oxygen can be concentrated from air using similar technology, but at higher pressures. The final approach, and one used in larger applications, is to use liquid oxygen (LOX). Ozone generation from LOX is more efficient than from air. The choice of feed gas is based on the LOX price, energy and capital costs for each approach.

Today, ozone generation in drinking water treatment is almost always done with the corona discharge method. In this process the feed gas is passed through an electric arc or plasma where a portion of the oxygen (O_2) is converted to ozone (O_3). The typical configuration is similar to a shell and tube heat exchanger.

The ozone generation process generates heat and the system must be cooled to prevent damage to the equipment and minimize decomposition of the ozone. If a source of cooling water (15-20^{o} C) is available, a once through cooling system can be used or alternatively the water can be used indirectly with a heat exchanger. If a source of good quality cooling water is not available chillers are often employed.



While ozone is more soluble in water than oxygen, it is not as soluble as chlorine. Two methods are usually used for introducing the ozone into water. The first is to employ fine bubble diffusers in deep (5-6 m) multi chamber contact vessels. Ozone generators normally have a high enough pressure to operate the diffusers without further pumping. The alternative is to inject the ozone via a venturi in a side stream. This side stream injection method normally requires a booster pump and a degassing vessel. Whether the ozone is introduced via fine bubble diffusers or side stream injection, sufficient contact time must be provided to insure inactivation of micro organisms if CT credits are sought.

After contacting the ozone with the drinking water, the vented gas will still contain some ozone which needs to be decomposed (destroyed) prior to release into the environment. This can be done thermally or thermo catalytically. Either approach can lower ozone concentration in the exhaust gas to less than 0.1 ppm.

Application of Ozone in Drinking Water

The principal applications of ozone in drinking water include: primary disinfection, iron and manganese removal, taste and odor control, color abatement, reduction of disinfection byproducts (e.g. TTHM), elimination of synthetic organic chemicals and enhanced coagulation. Dosage rates vary widely depending on application and water quality, but 2-3 ppm would not be unusual. Ozone does not maintain a residual in the distribution system, so it must be used with another disinfectant that can maintain such a residual such as chlorine or chloramines.

The US EPA has established rules for determining the amount of ozone that is required to achieve a specific level of inactivation for specific micro organisms. The methods of calculating these levels of treatment are found in the EPA's surface water treatment rules (SWTR). The inactivation rate is based on the concentration multiplied by contact time (CT) and the water temperature. These calculations will determine the size and design of the contact vessel for the system.

Ozone generally works by oxidizing inorganic or organic materials, including micro organisms. When ozone is substituted for chlorine in pre oxidation of drinking water, the formation of chlorinated organic compounds, such as TTHM or HAAC, is prevented. Since ozone also acts as a primary disinfectant, less chlorine is needed for secondary disinfection. The use of ozone can significantly reduce the disinfection by products formation potential of drinking water.

Ozone normally does not oxidize organic compounds to CO2 but breaks down the organics to smaller molecules assimable organic carbon (AOC) which is more biodegradable. Typically, to prevent nutrient from entering the distribution system, bio filters are used to remove the AOC. The combination of ozone and bio filters is a method to reduce TOC levels in drinking water.

Ozone can oxidize bromide ion into bromate, a regulated compound in drinking water. If bromide levels are above 200 ppb, techniques must be employed to prevent the formation of bromate. These techniques include pH adjustments and the use of ammonia or chloramines.

Spartan Environmental Technologies

Spartan supplies complete ozone generation systems for drinking water treatment. You can learn more about these products at www.spartanwatertreatment.com/ozone-generator-products.html. In addition, the Spartan website also has links to EPA documents including the SWTR.

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