

Potable Water Disinfection with Chlorine Dioxide

Chlorine dioxide (ClO_2) is used as both a disinfectant and an oxidant in drinking water treatment. It has several distinct chemical advantages, which complement the traditional use of chlorine in potable water treatment.

Chlorine dioxide is highly effective in controlling waterborne pathogens while minimizing halogenated disinfection by-products. Chlorine dioxide is a broad-spectrum microbiocide as effective as chlorine against viruses, bacteria, and fungi, and more effective than chlorine for the inactivation of the encysted parasites *Giardia* and *Cryptosporidium*. Chlorine dioxide is also an effective control strategy for taste, odor, color, iron, and manganese removal.

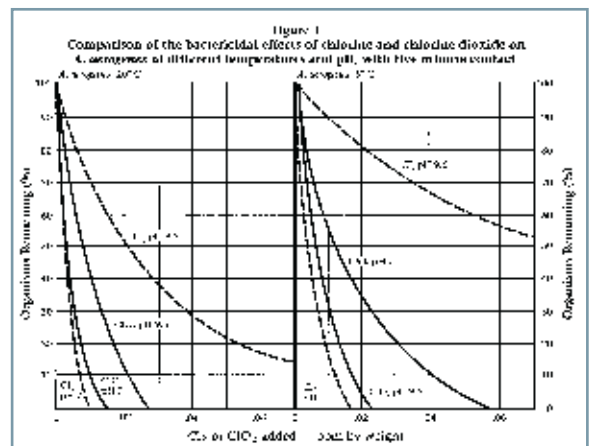
Application Description

Chlorine dioxide is an extremely effective disinfectant and bactericide, equal or superior to chlorine on a mass dosage basis. Its efficacy has been well documented¹ in the laboratory, in pilot studies and in full-scale studies using potable water and wastewater. Unlike chlorine, chlorine dioxide does not hydrolyze in water. Therefore, its germicidal activity is relatively constant over a broad pH range (See Figures 1, 2, and 3).

At pH 6.5, doses of 0.25 mg/L of chlorine dioxide and chlorine produce comparable one-minute kill rates for the bacterium *Escherichia coli*. At pH 8.5, chlorine dioxide maintains that same kill rate, but chlorine requires five times as long. Thus, chlorine dioxide should be considered as a primary disinfectant for high pH, lime-softened waters. Chlorine dioxide has also been shown to be effective in killing other infectious bacteria such as *Staphylococcus aureus* and *Salmonella*.

When applied for disinfection (as opposed to oxidation), a disinfectant must provide specified levels of microorganism kills or inactivations as measured by reductions of coliforms, heterotrophic plate count organisms and *Legionella* bacteria. Under current regulations², the disinfection treatment must be sufficient to ensure at least a 99.9 percent (3-log) removal and/or inactivation of *Giardia lamblia* cysts and 99.99 percent (4-log) removal and/or inactivation of enteric viruses. At the contact time (CT) values necessary for chlorine dioxide to inactivate 99.9 percent of *Giardia lamblia* cysts, the simultaneous inactivation of 99.99 percent of enteric viruses is also assured.

These regulations also establish treatment technique requirements in lieu of MCLs for *Giardia lamblia*, viruses and *Legionella*. The published CT values (40 CFR 141.74) required for various disinfectants to achieve these goals show that chlorine dioxide is more effective than chlorine or monochloramine. Over the pH 6-9 range, chlorine dioxide is at least twice as effective as free chlorine is at pH 6. At pH 7-9, free chlorine becomes progressively less effective than chlorine dioxide. Chlorine dioxide is also substantially more effective than monochloramine.



Application Note

Feed Requirements

For most municipal and other potable water systems, a chlorine dioxide residual concentration of up to 2 mg/L is sufficient to provide adequate disinfection. Chlorine dioxide must be applied at a sufficient residual concentration for a sufficient CT value to achieve the required disinfection. Residual disinfectant and disinfectant by-products must be monitored as required by the National Primary Drinking Water Regulations (40 CFR Part 141) and state drinking water standards.

For more information on dosage requirements specific to your application contact your Siemens Representative.

Method of Feed

Chlorine dioxide is a gas produced by activating sodium chlorite with an oxidizing agent or an acid source. Sodium chlorite is converted to chlorine dioxide through a chlorine dioxide generator and applied as a dilute solution. Chlorine dioxide solutions should be applied to the processing system at a point, and in a manner, which permits adequate mixing and uniform distribution. The feed point should be well below the water level to prevent volatilization of the chlorine dioxide. Do not apply sodium chlorite directly to potable water. Avoid co-incident feeding of chlorine dioxide with lime or powdered activated carbon.

Chlorine Dioxide Analysis

In addition to other monitoring requirements, the DBPR also requires that water systems using chlorine dioxide for disinfection or oxidation must monitor their system for chlorine dioxide and chlorite.

Chlorine Dioxide: For compliance monitoring for residuals of chlorine dioxide, one of the two approved methods specified in 40 CFR §141.131(c) must be used:

DPD Method, 4500-ClO₂ D, and
Amperometric Method II, 4500-ClO₂ E.³

Where approved by the state, systems may also measure residual disinfectant concentrations of chlorine dioxide by using DPD colorimetric test kits.

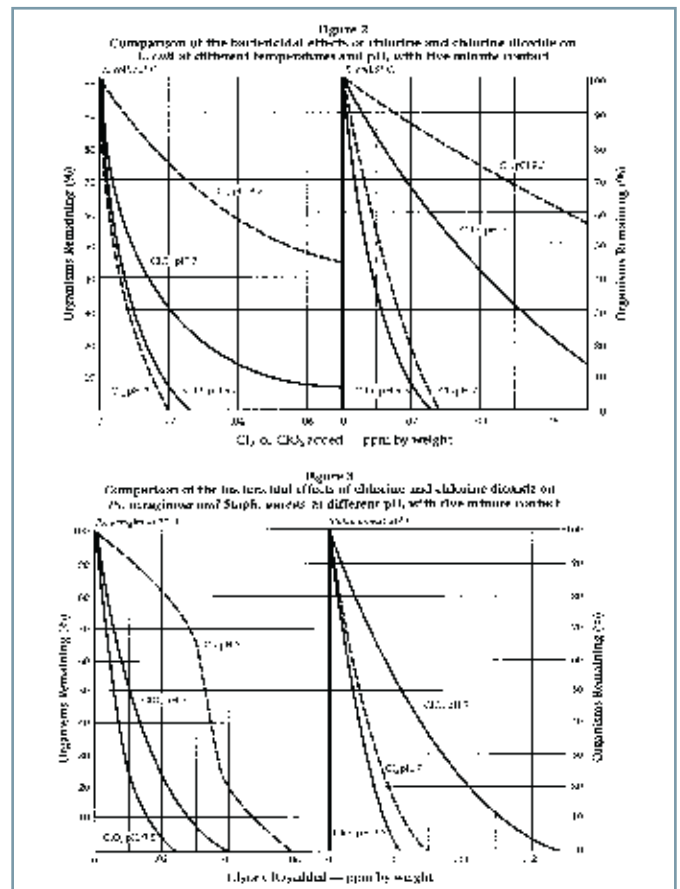
Sodium Chlorite: For compliance monitoring for chlorite, water systems must use one of three approved methods specified in 40 CFR §141.131(b):

Amperometric Method II, 4500-ClO₂ E
Ion Chromatography, EPA Method 300.0⁴, or
Ion Chromatography, EPA Method 300.1⁵.

The regulations further specify that Amperometric Titration may be used for routine daily monitoring of chlorite at the entrance to the distribution system but that Ion Chromatography must be used for routine monthly monitoring of chlorite and for additional monitoring of chlorite in the distribution system.

References

1. Aieta, E.M. and Berg, J.G., "A Review of Chlorine Dioxide in Drinking Water Treatment," *JAWWA*, 78:6:62 (June, 1986).
2. *Code of Federal Regulations*, National Primary Drinking Water Regulations, Subpart H - Filtration and Disinfection. 40 CFR § 141.70-75.
3. *Standard Methods for the Examination of Water and Wastewater*, APHA, AWWA and WEF, Washington, D.C. (20th Ed., 1998).
4. *Methods for the Determination of Inorganic Substances in Environmental Samples*. USEPA. 1993. EPA/600/R-93/100
5. USEPA Method 300.1, *Determination of Inorganic Anions in Drinking Water by Ion Chromatography*, Revision 1.0. USEPA. 1997. EPA/600/R-98/118.



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