# Chlorine Dioxide Chemistry Review

**Chlorine Dioxide - A Potential Chemical for Ballast Water Control:** Chlorine dioxide is an oxidant that fits a range of applications. It is relatively non-reactive with the vast majority of organics likely to be encountered, and thus most of the applied oxidant goes toward bacterial disinfection. A brief overview of chlorine dioxide is given in the following sections.

**What is $ClO_2$?** $ClO_2$ is a stable free radical. It is a gas at ambient temperatures. $ClO_2$ has an odor similar to that of chlorine, and the aqueous solubility of $ClO_2$ is significantly greater than that of chlorine. For stability reasons, the gas is rarely used directly as a disinfectant. Instead, it is produced and used as a dilute aqueous solution at the point of application.

**Where is $ClO_2$ Used?** $ClO_2$ has achieved fairly widespread usage in a number of applications including the following:

- ❑ in potable water for taste and odor control.
- ❑ in potable water for minimization of trihalomethanes (THMs).
- ❑ in potable water for control of Cryptosporidium cysts and Giardia cysts.
- ❑ in once-through cooling for control of zebra mussels , Asian clams and other mollusks. (All fresh water applications).
- ❑ in evaporative cooling water systems for microbiological control
- ❑ in oil drilling operations to control slime buildup
- ❑ in the pulp and paper industry for pulp bleaching because it imparts a higher degree of brightness to the paper without degrading the fibers.
- ❑ in alkaline whitewater for control of biofilm.
- ❑ in recycled paper mills for odor control.
- ❑ in poultry processing plants to control the transfer of pathogens, direct food contact.
- ❑ in vegetable processing plants to control transfer of pathogens, direct food contact
- ❑ in toothpaste to control anaerobic / sulfate reducing bacteria and their byproducts that contribute to bad breath
- ❑ Cl02 gas was used to irradiate anthrax laden Hart Building in Washington DC

**Why is $ClO_2$ Used?** $ClO_2$ is used in many applications because of its unique reaction characteristics. It is very selective in its reactions, in that it will not react with many of

the compounds with which other oxidants react. The net result is that much lower dosages of $ClO_2$ are normally required than for other oxidants. In general, the 'dirtier' the system, i.e., the greater the level of contamination and hence the demand for oxidants, the greater the spread between dosage requirements for $ClO_2$ and for other oxidants.

The characteristics that differentiate $ClO_2$ from non-oxidizing biocides, which are considered bacterial poisons, are the very rapid disinfection kinetics and the very low dosages required (sub-ppm in many cases).

In summary, $ClO_2$ is used for several reasons:

- $ClO_2$ kinetics of bacterial disinfection is very rapid
- $ClO_2$ inactivates organisms at concentrations well below demand
- $ClO_2$ does not directly chlorinate organics
- $ClO_2$ is relatively non-corrosive towards metals at concentrations of a few ppm in fresh water
- Cl02 has no noticeable effect on corrosion rates in sea water (sea water is already very corrosive and masks any effect from the Cl02 at target dosages).

**Conclusions:** Numerous methods of controlling the spread of pathogenic organisms or non-indigenous aquatic species have been proposed. All have their advantages and disadvantages.

From a strictly performance perspective, $ClO_2$ appears to be a superior alternative for this application. These advantages are listed below:

- The dosage of $ClO_2$ required to achieve a given reduction in viable bacterial counts is lower than any other disinfectant in a contaminated system
- The approach proposed here is more environmental friendly than other chemical approaches
- $ClO_2$ is effective on a wide range of organisms, including vegetative bacteria, viruses, amoebic cysts, spores, algae, protozoa, mollusks and other higher life forms
- Any desired bacteriological reduction can be 'dialed in' by adjusting $ClO_2$ dosages
- The reaction chemistry is safe
- The generation equipment is safe
- Chlorite ion continues to work, retarding bacterial regrowth after $ClO_2$ is consumed.
- A wide range of $ClO_2$ generation options allows for treatment at maximum ballast water pumping or recycling rates. That is, ballast water pumping or recycling is not limited by $ClO_2$ production rates.