

Forms of Chlorine in Water

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Chlorine is a common disinfectant used in automated watering systems. At lower concentrations, it is used to disinfect animal drinking water or to pre-treat the feedwater for a reverse osmosis purification system. At higher concentrations, chlorine is used to sanitize rack manifolds, recoil hoses, and room distribution piping. A chlorine test kit must be used to measure the concentration of chlorine in water.

At Edstrom Industries, we are often asked questions about chlorine, such as:

- "What does my chlorine test kit measure?"
- "What is the difference between free and total chlorine?"
- "Which form of chlorine is the best disinfectant?"

This document was written to help answer these questions. If you have any further questions or concerns about chlorination or water quality, contact Edstrom Industries at 800-558-5913.

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Chlorine test kits can measure either free chlorine or total chlorine in water.

Free chlorine

Free chlorine is defined as the concentration of residual chlorine in water present as dissolved gas (Cl_2), hypochlorous acid (HOCl), and/or hypochlorite ion (OCl^-). The three forms of free chlorine exist together in equilibrium.



Their relative proportions are determined by the pH value and temperature. Figure 1 shows the effect of the pH value on the form of free chlorine in water at 25°C.

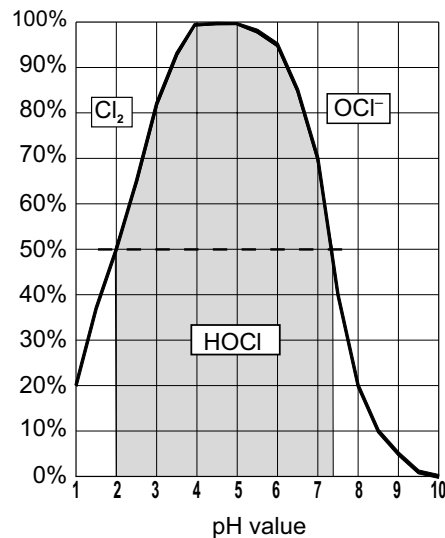


Figure 1. The Effect of pH Value on the composition of Free Chlorine. Between a pH of 2 to 7.4, the predominant form of chlorine is HOCl.

When the pH is between 2 and 7, the equilibrium is in favor of HOCl. As the pH falls below 2, the predominant form of the chlorine is Cl₂. At a pH of 7.4, HOCl and OCl⁻ are about equal, and as the pH goes above 7.4, increasing proportions of OCl⁻ are present.

A test kit that measures free chlorine will indicate the combined concentrations of HOCl, OCl⁻, and Cl₂.

Combined chlorine

Combined chlorine is defined as the residual chlorine existing in water in chemical combination with ammonia or organic amines. Organic amines can be found in natural or polluted waters. Ammonia is sometimes deliberately added to chlorinated public water supplies to provide inorganic chloramines.

Total chlorine

Total chlorine is the sum of free and combined chlorine. When chlorinating most potable water supplies, total chlorine is essentially equal to free chlorine, since the concentration of ammonia or organic nitrogen compounds needed to form combined chlorine will be very low. When chloramines are present in the municipal water supply, then total chlorine will be higher than free chlorine.

Disinfectant Strength Comparison

The germicidal strength of different forms of chlorine in water are ranked as follows:

HOCl > OCl⁻ > inorganic chloramines > organic chloramines

HOCl is 100 times more powerful an oxidant and disinfectant than is the hypochlorite ion. Consequently, free chlorine is most effective at a pH of 5 to 7 where HOCl is the predominant form. The effectiveness declines with increased pH.

Caution

In an automated watering system, do not acidify chlorinated water below a pH of 5.0. At a lower pH, chlorine will be present as dissolved chlorine gas (Cl₂), which may cause swelling of the silicon O-ring in animal drinking valves.

Although inorganic chloramines are weaker disinfecting agents, they are more stable than free chlorine and can provide disinfection over long exposure periods. Some municipalities use chloramines for disinfection because they do not form trihalomethanes. Since free chlorine is a stronger disinfectant than combined chlorine, the free chlorine test gives the best measure of disinfection at low concentrations (below 2 ppm). At higher concentrations, the difference between free and total chlorine will be insignificant, so the total chlorine test can be used.

References

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