# Chlorination In Industrial Cooling Water Systems

**SEVERN TREND SERVICES**

## CAPITAL CONTROLS

## Background

Chlorine is one of the most widely used chemicals for biofouling control in industrial cooling water systems. When properly applied at water intake screens, chlorine helps to control zebra mussels, asiatic clams, and other marine organisms that grow in cooling water environments.

In fresh water recirculating cooling water systems, the addition of chlorine helps control the formation of algae, slime growth, zebra mussels and asiatic clams.

Increased fuel, operating and construction costs have forced large users of cooling water to strive for maximum thermal and mechanical efficiency. This requires, above all, clean heat exchanger and condenser surfaces to produce the best possible heat transfer and cooling efficiency. Maintaining clean condenser tubes and unrestricted cooling water flow requires careful control of mineral scaling, corrosion, deposition of suspended matter, and biofouling.

## Problem

Biofouling, in addition to restricting heat transfer, often serves as the "glue" that binds other deposits to the heat transfer surfaces.

Conditions in a typical industrial or electric utility cooling water system are close to ideal for biological and marine growth. The water source is often a river, lake, or coastal water. Each contain all the naturally-occurring organisms and nutrients that are required for biological growth.

Inorganic and organic phosphates are often used for corrosion control, thus adding additional nutrients. This, in addition to water temperatures of 90° to 100°F (32° to 38°C), and a pH range of 8 to 9, provide an ideal environment for biological growth.
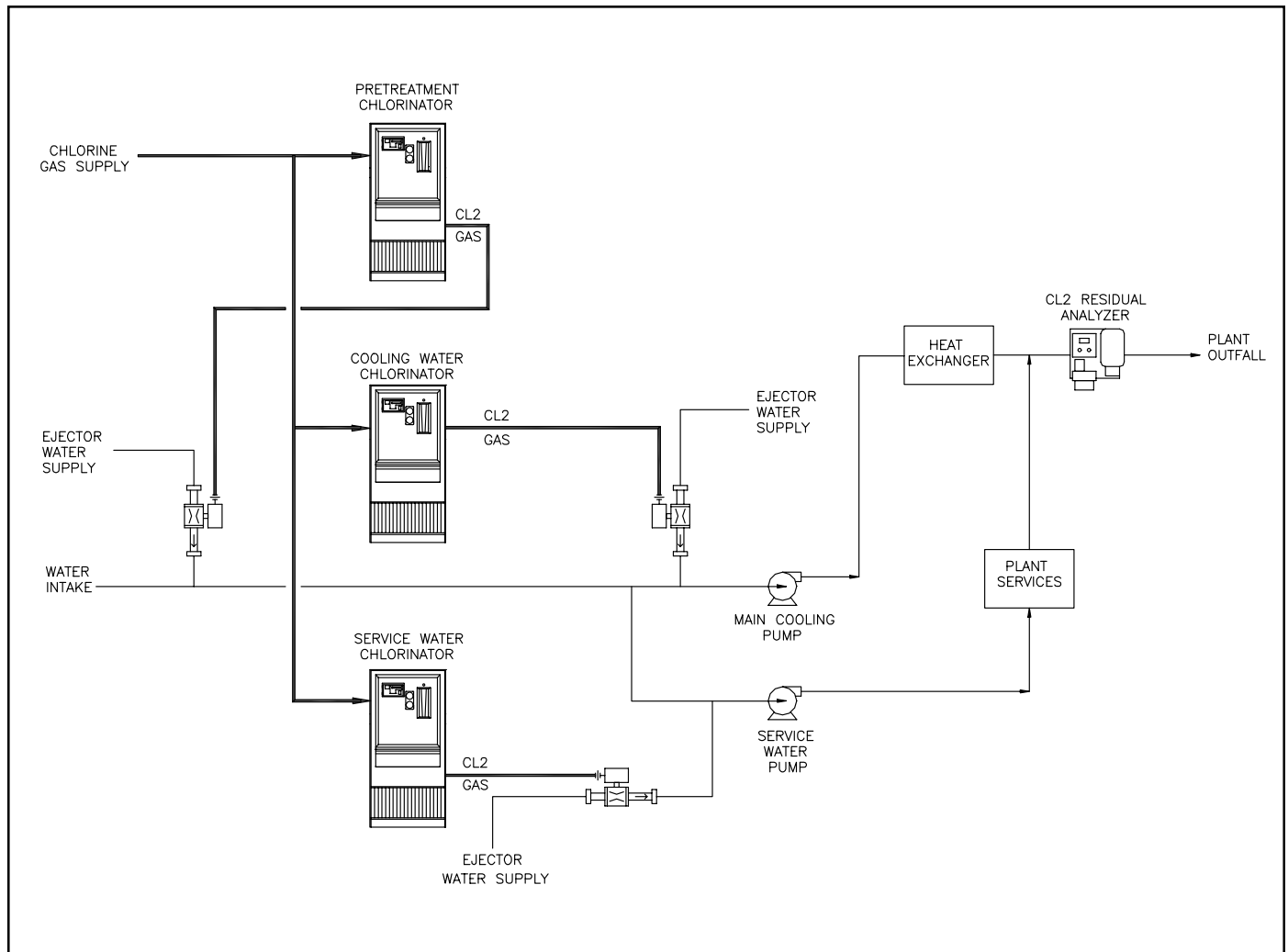


Figure 1 - Typical Once-Through Cooling System

Under these conditions, control of biofouling is essential in maintaining operating efficiency. At the same time, it is important, for both cost and environmental reasons, to use chlorine as efficiently as possible. For example, in the United States, the electric utility industry has environmental limits on the discharge of residual chlorine to the receiving water supply. To meet these limits, dechlorination is often required before water is discharged from the plant.

## Chlorine Application Points

An integrated industrial plant uses cooling water for many different purposes:

- Main cooling systems once-through
- Main cooling systems recirculating
- Service water systems
- Auxiliary cooling systems

## Main Cooling System Once-Through

In a once-through system, water passes through intake screens directly to the main cooling water and service water pumps. Holding time in the system is short, and all contamination coming in with the water goes directly to the exchangers and service equipment. Typical points of chlorine application are shown in Figure 1. Chlorine is usually applied at the intake screens, and may also be used at the service water and main cooling pumps if needed.

## Main Cooling System Recirculating

In a recirculating system (Figure 2), the water in the tower is cooled by evaporation and thereby, becomes more concentrated with dissolved solids. If the main purpose of a cooling tower is to cool the discharge water, concentration cycles will be low. If the purpose is to conserve water and reduce the discharge volume, the water will be held in the system much longer and become more concentrated with dissolved solids, thus increasing the fouling potential. In recirculating systems, chlorine is generally added at the circulating pump's suction.

If slime and algae build-up in the basin of a cooling tower is a problem, the chlorine should be diffused at the opposite end of the pump or fed directly into the recirculated cooling water flow. This creates a residual chlorine level in the basin.
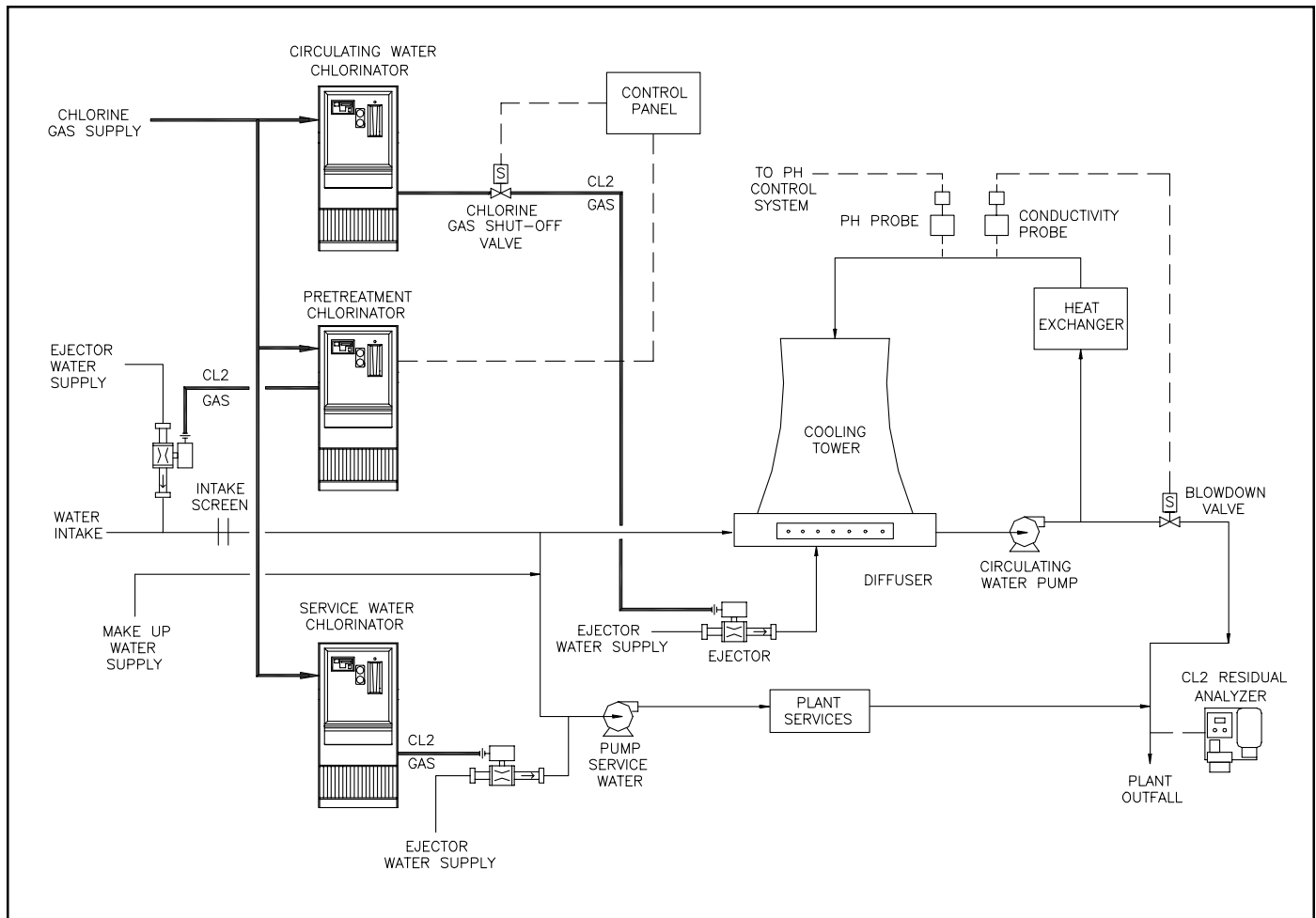


Figure 2 - Typical Recirculating Cooling Water System

f the make-up water source for the recirculating system is an estuary or contaminated water source, some chlorine may be added at the intake screens. This helps control the larvae of shellfish and other marine organisms that can foul the system and reduce water flow. Chlorine is often added into wells to control Gallionella and other iron bacteria. Automatic control systems, using residual chlorine analysis, can improve chlorination efficiency by relating chlorine feed directly to the chlorine demand of the water.

### Service Water and Auxiliary Towers

The service water system is used to cool pumps, motors, and other auxiliary equipment in the plant, and the auxiliary cooling towers provide comfort cooling as needed. The service water system may be a separate once-through system, or may consist of several cooling loops piped from one or more main cooling tower systems. Biofouling in these systems can severely disrupt plant operations, and it is important to monitor chlorine levels in the service water to ensure the treatment program is satisfactory.

## Feeding Chlorine for Optimum Results

Chlorine can be fed either continuously (typically 1-3 ppm), or as a shock dosage (typically 3-5 ppm) at regular intervals. On a shock basis, sufficient chlorine may be fed to provide a total residual chlorine (TRC) level up to 1 mg/l, measured downstream of water cooling systems, for one hour, two or three times daily. If the cooling system is operating at an alkaline pH (8-9 pH), continuous low dosage chlorination may be preferred. In this case, chlorine is fed to maintain a TRC of approximately 0.2 to 0.5 mg/l throughout the system.

The amount of chlorine needed to destroy the biofouling organisms in the water and oxidize organic and inorganic matter is called the "chlorine demand" of the system. The chlorine feed rate depends upon the degree of biofouling expected under worst conditions, the non-biological chlorine demand in the water, the holding time in the system, and the discharge limitations. Chlorination equipment should be sized to provide a chlorine dosage several times the final TRC level allowed. This provides chlorinator capacity to meet the demand in the system, and losses of chlorine through aeration in the

cooling towers. Feed equipment should be sized for the minimum anticipated feed rate, using the following equation:

U.S. gpm

(Recirculating rate) x (ppm dosage) x 0.012 = PPD chlorine

$mg^3/h$

(Recirculating rate) x (mg/l dosage) x 0.001 = kg/h of chlorine

Thus, to feed 1 ppm to a 100,000 gpm system would require a daily feed rate of:

English Units:

100,000 x 1 x 0.012 = 1,200 PPD

or

Metric Units:

22,727 x 1 x 0.001 = 22.7 kg/h

However, for a two hour feeding cycle per day, the daily chlorine consumption is:

1200 x 2/24 = 100 PPD (45.5 kg/h)

Chlorinators from Capital Controls offer a variety of vacuum gas feeding systems, uniquely designed for introducing chlorine gas safely and efficiently to both once-through and recirculating cooling water systems. Ton mounted and cabinet models are available, with a wide range of flow capacities and control modes. A typical chlorine gas system for shock or continuous treatment is shown in Figure 3.
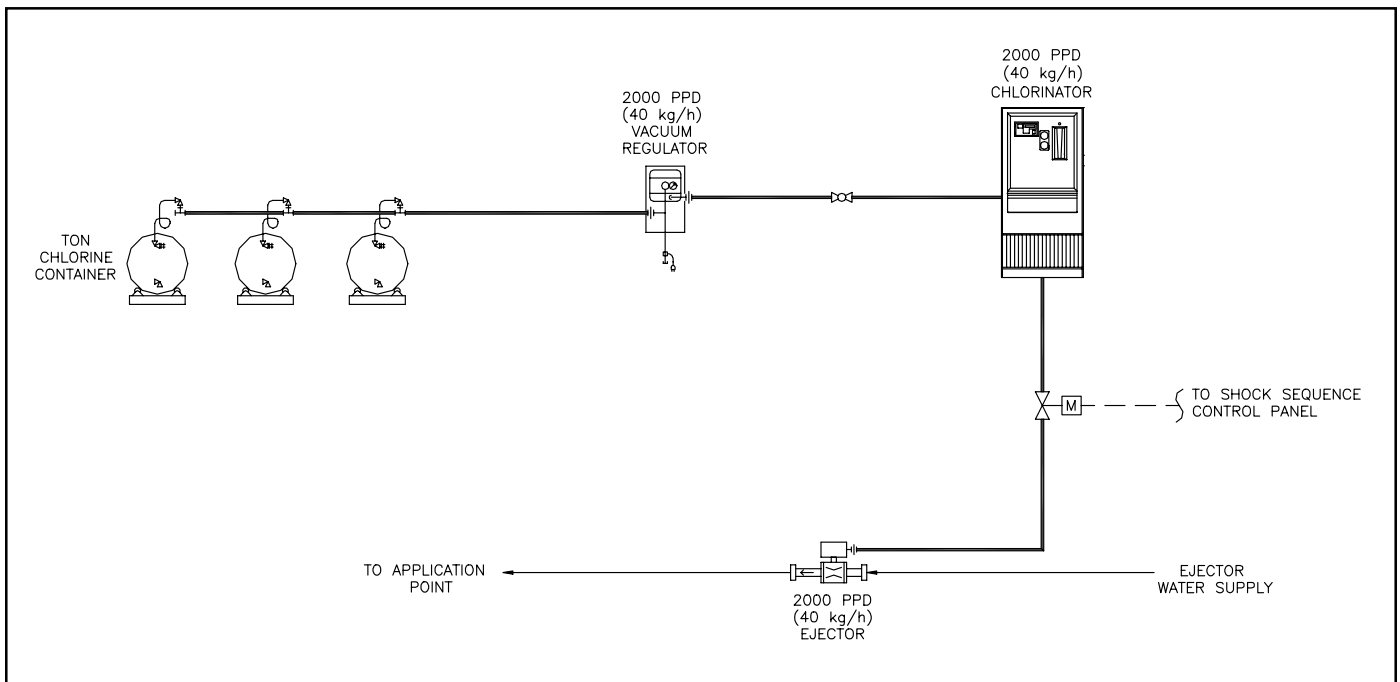


Figure 3 - Typical Chlorination System

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## Monitoring Residuals

In a once-through system, residual chlorine can be detected in the plant discharge within a few minutes after chlorination begins, unless demand in the system is very high. In a recirculating system, chlorine residual should be monitored in the cooling water return line or the tower basin, as well as in the plant effluent. The time required to detect the residual in the return line of the recirculating system will depend upon many factors including: water volume; number of cycles of circulation; chemical contamination present, and degree of biofouling

The residual chlorine consists of the free residual chlorine (FRC), and the combined residual chlorine (CRC). The sum of these make up the total residual chlorine (TRC).

Free residual consists of available unreacted chlorine that can react immediately with any new biological or chemical demand. The combined residual is chlorine combined with ammonia and organic nitrogen compounds. Combined residual exhibits biological kill, but sometimes less effectively and at a slower rate than free residual.

Alternative chlorine-bearing compounds, such as chlorine dioxide, may be preferred where ammonia concentration is so high that much larger quantities of chlorine will be required to control the biofouling.

The appearance of a residual in the water indicates that all demand has been satisfied and chlorination can be stopped. It is not necessary to have a persistent residual to obtain effective biofouling control. With experience in a given system, it is possible to develop a relationship between the amount and timing of the total residual, and the biofouling control obtained. This relationship then becomes the basis for designing the chlorination program. Many large industrial systems, especially those operating in the alkaline pH range, operate effectively with a continuous low level feed and may never have any measurable residual chlorine.

In electric utility plants, the main contamination source is the make-up water. This is a predictable source unless the water supply quality varies widely. An unusual loss of residual should be an immediate warning of possible biofouling in the system.

In an industrial plant, such as a steel mill or petro-chemical plant, many factors contribute to the chlorine demand. Make-up water contamination, leakage from process streams, ground water runoff, airborne process gases (such as ammonia and hydrogen sulfide) and other elements, all provide either nutrients that encourage biological growth, or compounds that react directly with chlorine.

Techniques for measuring the free and combined residual chlorine in cooling water vary from simple chemical tests to sophisticated on-line electro-chemical methods. All methods require careful maintenance and frequent calibration to ensure accurate readings. Capital Controls' chlorine residual analyzers provide state-of-the-art continuous, on-line, amperometric measurements of free or total residual chlorine in water. They offer a unique, positive drive, internal cleaning mechanism that keeps the electrodes clean and avoids the signal drift problem that plagues most on-line chlorine residual monitors. Capital Controls also offers a complete line of pH, conductivity, ORP, and temperature monitors.

Design improvements may be made without notice.
Represented by:

## CAPITAL CONTROLS

**Severn Trent Water Purification, Inc.**
3000 Advance Lane Colmar, PA 18915
Tel: 215-997-4000 • Fax: 215-997-4062
Web: www.severntrentservices.com
E-mail: marketing@severntrentservices.com

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