The two main reasons to consider CL-40 at Dell are:

1) Rerouting the oil/water separator effluent to the cooling tower will add ammonia to the cooling water. Ammonia will combine with hypochlorous acid (bleach alone), and hypobromous acid (CL-40), to form chloramines and bromamines. Bromamines are much better biocides then chloramines.

2) With the ammonia present in the cooling water, we would increase the pH control range to allow for better removal of the ammonia. Hypobromous acid is much more effective at elevated pH levels than hypochlorous acid alone.

CHEMTREAT CL-40 is a liquid product containing 40% sodium bromide by weight. Used in conjunction with an oxidizer, such as sodium hypochlorite (NaOCL) bleach or gaseous chlorine, **CHEMTREAT CL-40** forms hypobromus acid which is an effective microbiocide for cooling water systems. **CHEMTREAT CL-40** is particularly beneficial in systems with organic contamination, or in systems operating at alkaline pH ranges.

The use of CL-40 is very safe. Safer, in fact, than feeding bleach. CL-40 is sodium bromide – just as safe as feeding sodium chloride. CL-40 would be fed into a motive water line where it would mix with the bleach to form hypobromous acid.

CL-40 would add only a small (a few ppm) amount of TDS to the cooling water. This small increase would be more than offset by the reduction in TDS by reducing acid feed to allow the pH to increase. Our overall recommended program drastically reduces TDS and allows for reduced blowdown rates and lower TDS in the outfall.

If the oil/water separator effluent is not re-routed to the cooling water, we can keep pH at current levels and would not need bromine chemistry.

Halogen Sources

The following halogen sources are commonly used for treatment. All of these biocides function by forming hypochlorous or hypobromous acid as the effective toxicant. Following are the mechanisms by which active halogen is formed.

Bleach

In water, gaseous chlorine hydrolyzes according to the following equation:

$NaOCl + H_2O \rightarrow NaOH + HOCl$

Hypobromous Acid

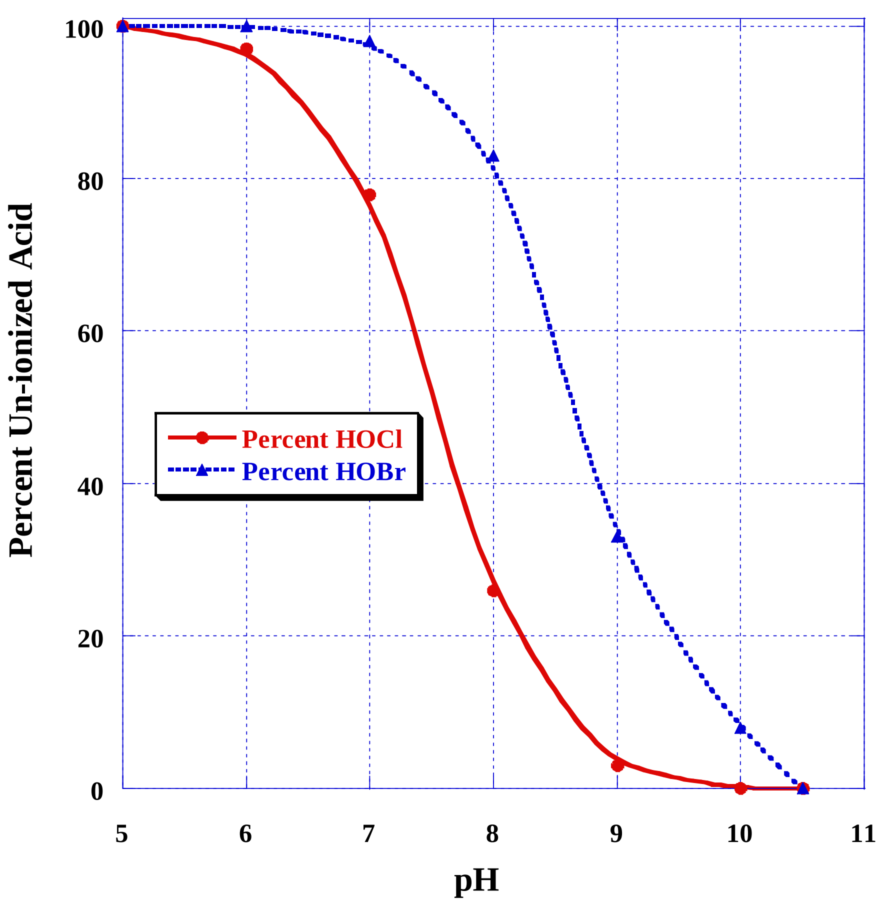
Hypobromous acid also dissociates to hypobromous acid and hypobromide ion. The volatility and pH sensitivity of these components make it much more suitable for use.

As noted in the following chart, at a pH of 8.0, bromine is 83% active. The bromamines formed when bromine combines with organic matter are considerably less volatile and remain as active toxicants in the water phase.

Complete Conversion of CL-40 to HOBr Using Bleach

$$HOCl + NaBr \longrightarrow HOBr + Cl^-$$

To get complete conversion of CL-40 to hypobromous acid when using bleach, equal molar amounts of each chemical are needed. Therefore, 1 pound of hypochlorous acid (or 8.7 moles) is produced from 1.42 pounds of sodium hypochlorite. Since the sodium hypochlorite is a 12.5% solution, the amount of solution needed to produce 1 pound of hypochlorous acid is 11.3 pounds of bleach (1.42 / 0.125 = 11.3). Therefore, 11.3 pounds of bleach will require 8.7 moles of NaBr, or 1.97 pounds of NaBr. Since the CL-40 is a 40% solution, the amount of CL-40 needed is 4.9 pounds (1.97 / 0.4). Overall, the reaction of 11.3 pounds of bleach with 4.9 pounds of CL-40 (or a general ratio of 2.3 pounds of bleach per pound of CL-40, or 3 gallons of bleach per gallon of CL-40) will produce 1.86 pounds of HOBr.



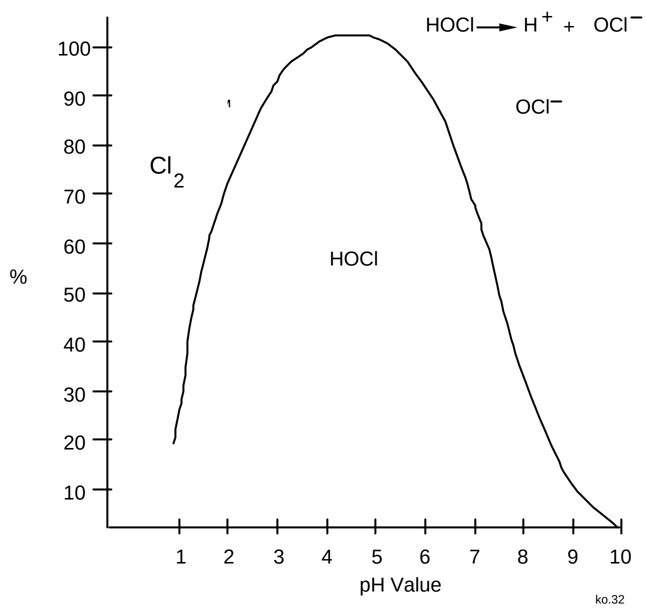
Bromine/Chlorine

Advantages

• Highly effective in neutral-to-alkaline waters
• Bromamines are extremely good biocides; quick kill
• Fast kill rate; seven to eight times faster than chlorine
• Combined bromine can dissociate to re-form hypobromous acid
• Easy to implement and control; operator attention is minimal
• Cost-effective in systems contaminated with ammonia and other nitrogen compounds
• Ease of testing
• Less corrosive than chlorine

Microbial Control Programs

As our experience with antimicrobial programs in industrial cooling waters continues to grow, the following chemical treatment programs have been developed. This information is to serve as a resource in helping to choose which biocide program to use.



This chart shows that hypochlorous acid (HOCL) predominates between a pH of 3.0 and 7.0. Since corrosion increases as water pH is lowered, a pH of 6.5 to 7.0 is an optimum pH range for water contacting the metals found in most cooling water systems. Above a pH of 7.5, the less effective hypochlorite ion is the dominant species. HOCL formation is 50 percent at pH 7.5 and declines rapidly as pH increases.

This well-known effect of pH on chlorine effectiveness had caused many utility engineers to operate cooling water systems at a pH range of 6.0 to 7.0. This pH range accelerates the corrosion of system metal. Also, the form of chlorine being used can depress the pH of the tower water. Gaseous chlorine, for example, will produce both hypochlorous acid ($HOCl$) and hydrochloric acid (HCl).

In addition to the potential for corrosion because of low cooling water pH during chlorination, the concentration of chlorine in the water affects corrosion considerably. As with any strong oxidizing agent, the corrosiveness of the cooling water increases as the oxidant (chlorine) levels are increased.

To summarize, the benefits of bromine chemistry include:

- Bromine is more efficacious than chlorine at equivalent concentrations
- Bromine exhibits biocidal activity in a broader pH range than chlorine
- Minimal loss of bromine's biocidal activity in the presence of amines and ammonia
- Lower concentrations can be used, leading to lower corrosion rates, less delignification, less attack on the inhibitors
- Traditional field test methods for chlorine can be used to monitor bromine residuals.