BROMINATION OF THE COOLING TOWER WATER

By L. GOVENDER
CG Smith Sugar Ltd, Gledhow

Abstract

Bacterial corrosion of cooling or injection systems is directly proportional to the quantity of slime present in the system. Normal control has been through the use of biocides or chlorination together with a dispersant. A cost effective control and almost complete elimination of slime has been achieved by bromination of the injection water at Gledhow. Results of trials conducted in the 1991 season are discussed.

Introduction

In cooling tower water systems it is futile to expect very low corrosion rates, even with the best corrosion inhibitor available, if the bacterial growth is not properly contained. In recent years the trend in corrosion inhibitors has been the application of polyphosphates due to their superior passivation properties. However these same phosphates provide a suitable nutrient source for bacterial growth and it becomes imperative to follow a precise biological control programme so that the phosphates can work as inhibitors.

The use of chlorine for biological control together with a corrosion inhibition programme has been practised at Gledhow since 1979. Although effective, the efficiency of chlorine is very dependent on precise pH control (7,0-7,5).

An alternative biological control system, involving the use of hypobromous acid, also referred to as "Target Bromination", was introduced during the 1991/92 season. Apart from its greater efficiency over a broader pH range, it has the added advantage that the bromamines formed decay very quickly in comparison to the chloramines from the hypochlorous acid generated in the previous treatment and hence has a negligible impact on the environment.

Previous treatment programme

The high cost of the zinc phosphate corrosion inhibition programme resulted in a shift towards an effective alternative, viz. a polyphosphate. The dosing rate of this chemical was adjusted so that a residual of some 2-5 ppm phosphate remained in the system. In terms of costs, a reduction of up to 30% was achieved.

Biological growth in the tower was controlled by chlorination together with a dispersant. Gaseous chlorine was dosed at a rate of six ppm for a duration of one hour during the evening and morning shifts.

The cooling tower system was kept quite clean using the above treatment programme, but if for some reason there was an increase in the biological growth it was extremely difficult to reduce and bring back to the same level again.

The tower would foul up rapidly, even with prolonged chlorination of up to three hours per shift. During this period the corrosion inhibition programme would cease to have any effect as the bacteria would feed on the phosphate, resulting in negligible amounts of ortho-phosphate being available for the inhibition. Added to this problem was the control of the pH of the circulating water. Lime was added to adjust the pH and this fluctuated between 7 and 8,5. The higher range negated the peak performance of the gaseous chlorine which functions effectively in the pH range of 7-7,5. Unless a sophisticated pH control system is used, in conjunction with caustic soda, it will be almost impossible to maintain this optimal range.

An alternative biological control programme more suited to the needs of general water conditions was investigated. The practice of using hypobromous acid in cooling systems has featured in local water treatment publications and has been actively used in other countries (Fellers *et al.*, 1987).

Current programme followed

Target bromination

The optimum level of hypobromous acid required for each plant is dependent on the amount of biological growth, the size of the plant and other factors. The bromination time is also a function of the same factors. Therefore each plant will have to achieve its own target level which will be indicated by a plot of bacterial level versus the chemicals dosed.

Mechanism and generation of hypobromous acid

$$Cl_2 + H_2O \rightarrow HOCl + HCl$$
(Hypochlorous acid)

$$HOCl + NaBr \rightarrow HOBr + NaCl$$
(Hypobromous acid)

An Aqueous solution of sodium bromide (in this case a Buckman Laboratories product Bulab 6041) is designed to be used as a forerunner for the generation of the hypobromous acid (HOBr). The bromide (Br^-) when mixed with chlorine or a hypochlorite species is converted to hypobromous acid. To achieve an optimum, the molar ratio should be 1:1, which equates to 2,9 kg of sodium bromide per kg of chlorine. Gaseous chlorine is educted at a rate of 2 ppm per hour into the carrier water. Immediately after the eduction, the aqueous solution of sodium bromide is dosed into a side stream at a rate of approximately 6 ppm via a plastic in-line mixer. This bromination sequence is carried out for a one-hour period on the evening and early morning shifts.

Properties of hypobromous aAcid

Cooling tower systems operate within a pH range of 7,0-8,5 (with efficient pH control) with an average around 8,3. The dissociation curves (presented in Figure 1) show that the activity of the hypobromous acid over this pH range is far greater than that for hypochlorous acid. At the pH norm of 8,3 only 15% of the hypochlorous acid is active as opposed to 75% for hypobromous acid.

Dispersant addition

To help in the prevention of deposits of organic contaminants and inorganic products a dispersant is added (in this case Bulab 8008). This dispersant is multi-functional (i.e. catering for both organic as well as inorganic contamination) and is effective over a broad pH range. The product was dosed at a rate of 3-4 ppm and this application was started 15 minutes before bromination.

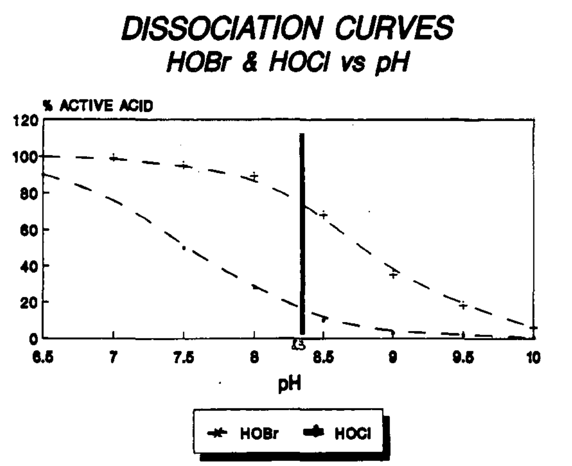

FIGURE 1

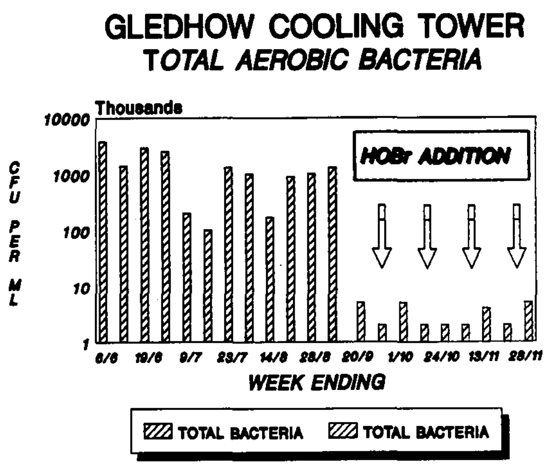

FIGURE 2

Treatment costs

The costs of the old and the new treatments are presented in Table 1 and represent the expected costs over a season. The saving represents a drop in the original treatment costs of some 30%. In addition there will be savings experienced within the plant in terms of reduced corrosion rates of both piping and pump components.

Table 1

Comparative treatment costs

Chemical	Previous treatment (R)	New treatment (R)	Savings (R)
Chlorine	17 280	3 600	+ 13 680
Aqueous sodium bromide	0	7 776	− 7 776
Dispersant	7 200	7 200	0
Total costs	24 480	18 576	+ 5 904

Results

Total aerobic bacterial levels

The total aerobic bacterial levels, measured in terms of colony forming units per ml., are presented in Figure 2. A marked drop in the bacterial levels was noticed with the commencement of bromination. Levels decreased from 10^7 to 10^3 cfu/ml and the lower levels were consistently maintained with the new treatment programme.

Corrosion levels

A significant decrease in the mild steel corrosion rates (standard coupon type C1010) were noticed from the month of September onwards, which coincides with the period of the bromination treatment (Figure 3). Corrosion rates dropped from 44 m.p.y. to 6 m.p.y., levels that were very difficult to achieve in the previous season.

Visual observations

Visual inspection of the pack within the tower, and the drift eliminators, indicated that there was a marked decline in the amount of slime present after the bromination programme was started. It had previously been difficult to see the concrete walls as they had been covered with slime and sulphite reducing bacteria.

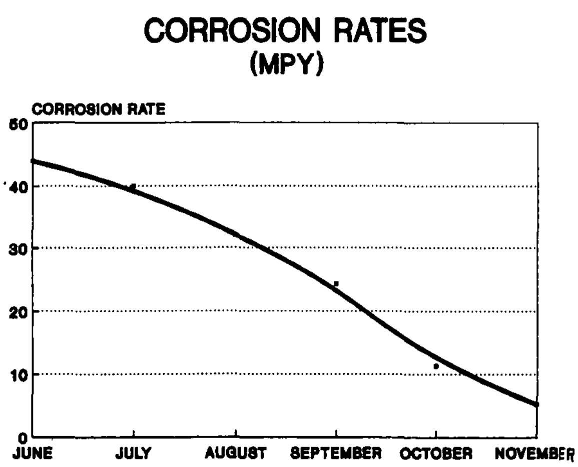

FIGURE 3

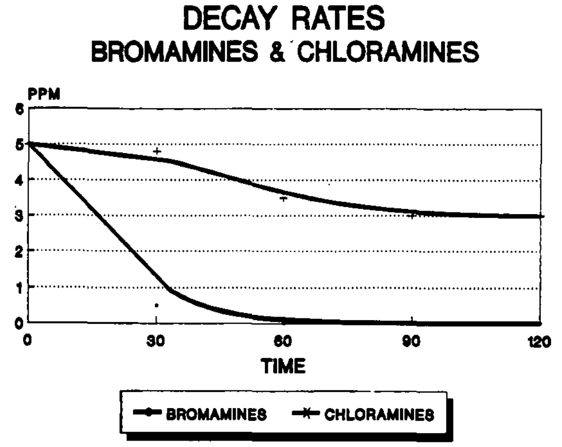

FIGURE 4

Environmental impact

The products formed during the bromination programme have less of an impact on the environment due to their accelerated rate of decay when compared to those produced during a straight chlorination treatment. Figure 4 indicates the rates of decay that may be expected from each of the two treatment programmes.

Conclusions

The use of "Target Bromination" has been very effective in the control of biological growth in a cooling tower water system. Due to its rapid kill efficiency, superior results were achievable in both bacterial and corrosion control.

Further work should perhaps be concentrated on the generation of the hypobromous acid. The objective should perhaps be the complete elimination of gaseous chlorine which would make a safer working environment.

Acknowledgements

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REFERENCES

Fellers, BD, Flock, EL and Conley, JC (1987). The efficiency of bromine versus chlorine. *Proc Annual Int Water Conf* 48: 55-58.