

TOO COOL FOR CORROSION

Alex Mantis and Melissa Callejo, Nalco Water, USA, examine efforts to rethink cooling water management best practices in ammonia plants.

There are many challenges to providing an effective, cost-efficient water treatment programme. For ammonia producers, one significant obstacle is the absorption of ammonia and other contaminants into the cooling water system. Because nitrogen is a major nutrient for bacteria, increased concentrations of ammonia can lead to increased microbial growth – growth that can cause biofouling, increased scaling, and microbially-induced corrosion. Nitrogen producers are further challenged by various incoming water conditions and industry



regulatory requirements. These factors can reduce heat exchanger efficiency, lower ammonia production, and raise plant operational costs.

One industry best practice to reduce the amount of ammonia in the cooling water system is to raise the pH to allow for better stripping of the ammonia. However, this can cause other system problems.

With the banning of chromate, many cooling water treatment measures have relied on phosphate-based programmes for corrosion control. To reduce water corrosivity, higher pH has been

Table 1. Water chemistry

| | Makeup water | Cooling water |
|---------------------------------|--------------|---------------|
| Ca (ppm as CaCO ₃) | 60 | 245 |
| Mg (ppm as CaCO ₃) | 39 | 150 |
| M-A (ppm as CaCO ₃) | 110 | 410 |
| Cl ⁻ (ppm as ion) | 140 | 610 |
| SO ₄ (ppm as ion) | 160 | 690 |
| Fe (ppm as ion) | <0.5 | 0.24 |
| Cond. µs/cm | 1100 | 4000 |
| pH | 8.2 | 8.8 |

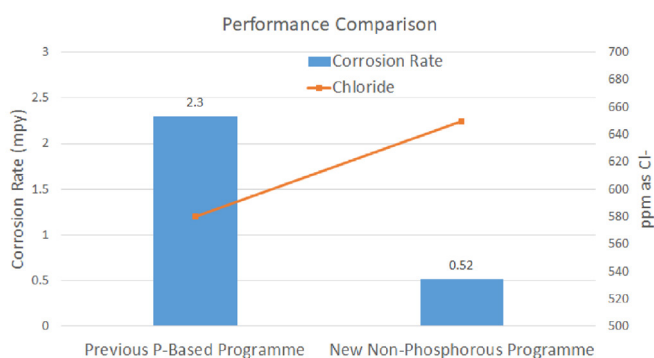


Figure 1. Corrosion rate and chloride concentration comparison between previous phosphorus programme and new non-phosphorus programme.

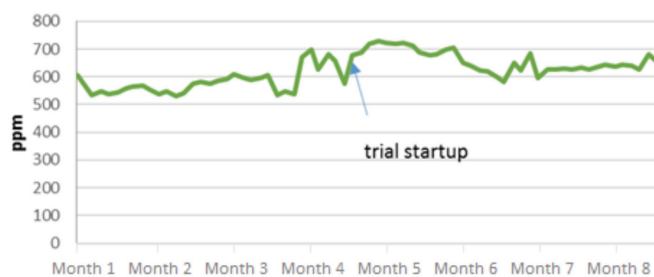


Figure 2. Chloride concentration in cooling water.

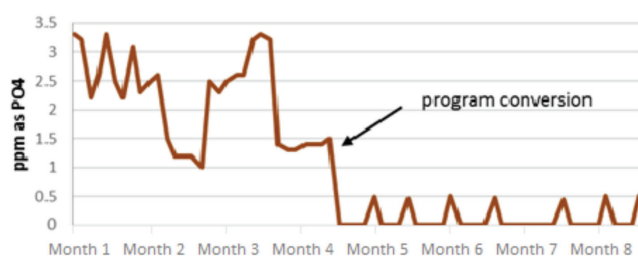


Figure 3. Phosphate concentration in cooling water.

desired for cooling water treatment. Additionally, running systems at greater cycles of concentration helps decrease operational costs by reducing the amount of acid and makeup water needed. However, increasing cycles and pH can result in increased scaling and localised corrosion. The capability of operating at these higher cycles can be limited by the calcium phosphate saturation index.¹

Phosphate-based treatment programmes require careful monitoring to prevent potential adverse effects. The pH, polymer and phosphate treatments must be monitored closely to control scaling. As programmes increasingly use alternate sources of makeup water or varying makeup water sources, fluctuations in system calcium levels become more likely. These fluctuations will affect the capabilities of the programme: too little calcium and the programme will provide insufficient corrosion protection, too much calcium and the programme will have an increased potential to scale the system. Additionally, the polymer requirements will vary as the scaling potential changes with the system. When combined with increased ammonia concentrations, these cooling water challenges can negatively affect plant operations.¹

Additionally, phosphate alone is an undesirable aquatic nutrient because of the potential microbial challenges it can cause.² Many attempts to develop non-phosphorus treatment programmes for mild-steel corrosion and scale control have been only moderately successful.^{2,3,4} Non-phosphorus programmes have traditionally been hindered by narrow application windows, diminished performance, and high treatment costs.

Due to increased concentration of chloride in the cooling water, robust corrosion control is required in order to reach higher cycles of concentration. Increased chloride can cause localised corrosion. Without proper corrosion protection, the increased system stress can cause pitting. Increased cycles also cause issues with longer holding time index applications. A programme cannot effectively prevent corrosion if it is being consumed faster than the system is blowing down.

A new non-phosphorus programme providing excellent mild-steel corrosion control and calcium carbonate scale control allows cooling water systems to reach higher cycles of concentration and higher pHs without compromising performance. With the ability to withstand high cycles (10) and long holding time index (200 hours) application, such a programme offers constant protection in a range of applications. Additionally, it offers superior performance in varying water conditions without dosage adjustments. Flexible and robust, it allows systems to reach higher pH conditions to help strip ammonia from the water. By removing added phosphate and allowing for better ammonia stripping, this non-phosphorus programme removes two major aquatic nutrients for bacteria. Furthermore, this programme offers wider application windows for performance in high conductivity water with high levels of chlorides. It is tolerant to fluctuation in the makeup water and tower, requiring no treatment programme adjustments.

Case study

A polycrystalline silicon manufacturer in northern China struggled while using underground water as the makeup source for its cooling system. With limited sources of water, the customer needed to reduce their operating cycles to limit the chloride concentration to less than 600 ppm in order to control localised corrosion. The system has a volume of 12 000 m³ with a 2500 m³/hr recirculation rate. A conventional phosphate programme was used before, but the phosphate dosage was

limited to approximately 3 ppm as phosphate to meet discharge limits. The water conditions are listed in Table 1. The makeup water contains a large amount of chlorides and the use of bleach in other parts of the plant contributed to the total chloride levels in the cooling water.

Figure 1 shows the comparison of corrosion rates on mild steel coupons between the previous phosphorus-based programme and the new non-phosphorus programme. After switching to the latter, the corrosion rate decreased from 2.3 mils per year (mpy) to 0.52 mpy. During this period the customer was able to increase their cycles by 0.5 cycles, which resulted in the chloride concentration increasing towards 700 ppm. Figure 2 shows the chloride concentration trend over one year, including during the trial. This improved corrosion control and reduced both water usage and risk due to water scarcity. Additionally, the customer reduced their acid consumption by 100 tpy with the new programme.

Figure 3 shows the reduction of phosphate in the cooling water. The new non-phosphorus programme maintained less than 1 ppm the concentration of phosphate as phosphate during the entire trial. This removed the risk of the customer incurring fines related to phosphate discharge regulations.

The switch from a phosphate-based mild-steel corrosion programme to the new non-phosphorus programme improved the mild-steel corrosion control significantly within a high chloride stressed condition. Furthermore, the new non-phosphorus programme allowed the customer to decrease their water consumption by increasing their system by 0.5 cycles. This new non-phosphorus programme offers reliable performance without

constant monitoring of calcium phosphate scale stress, pH variations, or chloride concentration.

Conclusion

A new non-phosphorus programme providing excellent mild-steel corrosion control and calcium carbonate scale control allows cooling water systems to reach higher cycles of concentration and higher pHs without loss of performance. With the ability to withstand high cycles and long holding time index application, this programme offers constant protection in a range of applications. Additionally, it offers superior performance in a variety of water conditions without dosage changes. With this programme, systems can reach higher pH conditions and more effectively strip ammonia from water. This non-phosphorus programme removes two major nutrients for bacteria by eliminating added phosphate and allowing for better ammonia stripping. With a broad application window, the programme performs in high-conductivity water with high levels of chlorides. It tolerates fluctuations in the makeup water and tower without treatment changes. **WF**

References

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