

A little water goes a long way

Kevin Milici and Gary Geiger, GE Power & Water, USA, explain how refineries operating in water scarce areas can reduce cooling water operating costs without sacrificing performance.

Obtaining optimal results from open, evaporative cooling systems requires careful management of the three interrelated dimensions of corrosion, deposition and microbiological activity (Figure 1). For several decades, this concept has been widely understood and practiced by knowledgeable providers of water management services and operators of cooling systems themselves.

Poorly controlled steel corrosion results in the formation and accumulation of corrosion products. As they accumulate on heat exchange surfaces, these products can impede heat transfer, restrict cooling flow, constrain production and increase energy consumption. As a result, production processes can be economically disadvantaged and the life span of capital

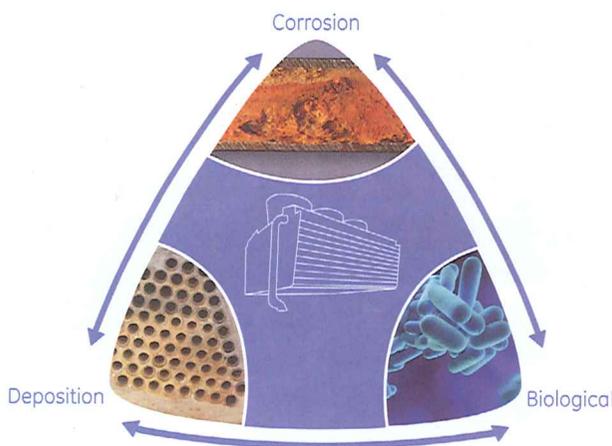


Figure 1. Managing the relationship between corrosion, deposition and biological control in a cooling system is crucial to optimal performance.

assets becomes threatened. The application of inorganic phosphates for steel corrosion control requires the use of polymeric dispersants for the control of calcium phosphate or iron phosphate deposits. While polymers vary in their tolerance characteristics, their efficacy can be compromised by the release of soluble iron from an active corrosion site.

Deposits, regardless of whether they are the result of corrosion and/or mineral scales, facilitate microbiological fouling. Non-biological deposition provides sites that enhance the potential for colonisation and growth of microorganisms. In turn, microbiological growth entraps more suspended solids or particulate matter, thereby accelerating the cycle of deposition. Microorganisms can cause microbiologically influenced corrosion (MIC) associated with biofilms and the proliferation of anaerobic bacteria that prosper in the environments created under deposits. Organisms within biofilm can deplete oxygen, block corrosion inhibitors from reaching fouled surfaces and concentrate corrosive products through metabolism. The result can be severe localised corrosion, as well as the premature loss of capital equipment. Deposits can lead to under deposit or crevice corrosion, resulting in pitting type corrosion.

High iron levels can result in fouling of heat exchange surfaces with iron deposits and subsequent under deposit corrosion. Of particular concern is iron phosphate precipitating. Without treatment, iron will readily precipitate with any inorganic orthophosphate available. Since orthophosphate is a primary corrosion inhibitor for cooling treatment programmes, high iron levels must be treated. Treatment is by either removal of the iron or treating with a combination of lower pH and higher levels of polymeric dispersant. The lower pH will increase corrosion potential, which will require additional corrosion inhibitor.

Phosphate is used in neutral pH cooling treatment programmes as an anodic inhibitor for mild steel. Typical phosphate levels for a cooling treatment programme are in range of 10 – 15 ppm. The phosphate must be in the orthophosphate form to be effective. The difficulty is that the orthophosphate levels necessary for corrosion

protection cannot be achieved without a polymeric dispersant to prevent the precipitation of phosphate compounds, primarily calcium phosphate and iron phosphate. Therefore, it is desirable to control the phosphate residual as low as possible to minimise the need for dispersant. With reclaimed water, the phosphate residual is typically not controlled and dispersant must be fed to meet the cycled conditions of the cooling water. Control of phosphate precipitation at higher levels can be achieved with higher levels of dispersant and lower pH control. Note that this is the same control strategy for the control of the iron precipitants.

Ammonia in a cooling system provides demand for the microbial control programme and can also be a corrosion concern in the case of copper metallurgies. Ammonia creates a demand for the typical oxidiser, chlorine, in a cooling system microbial treatment programme. Although chloramines are somewhat biocidal, they are highly volatile and tend to not provide sufficient control for a cooling system. Typically, the addition of non-oxidising biocides or bromine is necessary to obtain consistent microbial control in a cooling system contaminated with ammonia.

Ammonia is also a corrosion concern for copper metallurgies. The increased halogen levels for microbial control can affect the copper corrosion inhibitor leading to pitting. In the case of a refinery cooling system with mixed metallurgies and non-ideal exchanger characteristics, it is recommended that ammonia be removed from the water to reduce the possibility of stress corrosion cracking. Reclaimed water may be treated with biological nitrification of the ammonia to nitrates; a process that converts the ammonia to nitrates eliminating the corrosion issues and chlorine demand issues. The nitrates are still a nutrient source for microbiological activity that necessitates an aggressive and consistent bio control programme.

Refinery cooling systems

Refinery cooling systems provide a cooling water treater with the greatest opportunity to experience all aspects of unfavourable cooling system conditions. Refinery cooling systems tend to be complicated and they have often been added to and subtracted from several times over years of operation. System half life times (residence times) can be short or very long. The systems are mixed metallurgy from carbon steel to admiralty to stainless and even titanium. Generally, refinery exchangers are lower in velocity and higher in temperature than a power plant condenser. The exchanger designs can include shell side cooling water that has very low velocities and no flow areas and tube side exchangers with extreme process inlet temperatures. Add to these design issues the possibility of process leakage into the system if an exchanger leaks (hopefully due to process side corrosion), and it is clear that the treatment of a refinery cooling system is challenging at best.

Challenge: water scarcity

Many regions are suffering from an increasing trend of fresh water scarcity. While demand continues to grow, the supply of fresh water of adequate quality for human

consumption, agricultural and industrial use is dwindling. That led the US Bureau of Reclamation, along with eight state and local agencies, to implement a regional recycling programme for the water scarce region of Southern California. One of the most underutilised supplies of water in Southern California is reclaimed water, which is wastewater originating from municipal, industrial or agricultural activities that has been treated to a quality suitable for beneficial reuse.

The reuse of reclaimed water from municipal wastewater treatment facilities has been considered for a number of applications such as irrigation, industrial processes and groundwater recharge. The plan established treatment facilities and distribution systems for the use of recycled water in four geographical sub regions in the greater Southern California area. The majority of the refineries in Southern California are located in the Los Angeles Basin region. As a solution to the supply and demand problem, refineries in this region often look to use reclaimed municipal wastewater as the sole source of cooling tower makeup water. Makeup water originates from municipal wastewater that has received tertiary treatment. That effluent is then further treated with clarification, filtration, and finally, biological nitrification that converts the high levels of ammonia to nitrates.

Iron levels in the makeup water may be high and highly variable, ranging 0.5 – 2.0 ppm, sometimes more. Further cycled in the cooling system, high iron levels pose the threat of fouling heat exchange surfaces with iron deposits and increasing the propensity for under deposit corrosion. Of particular concern is the formation of iron phosphate deposits due to the use of orthophosphate for steel corrosion control.

Orthophosphate may be present in the treated makeup water, but after cycling, and given the low pH target of recirculating cooling water, it may not be sufficient to produce the 15 – 20 ppm as PO_4 necessary for effective anodic inhibition of steel corrosion. As such, a

supplemental source of orthophosphate will likely need to be added to the cooling water.

A neutral pH, high orthophosphate treatment programme utilises a polymeric dispersant to prevent the precipitation of phosphate compounds, primarily calcium phosphate and iron phosphate. This treatment programme is designed to balance the control targets for pH, along with the concentrations of orthophosphate and polymeric dispersant to achieve the desired results for corrosion and deposit control, at reasonable economics. However, it leaves room for a better, less costly way to achieve deposit control balance and inhibit corrosion, without hampering production operations.

Treatment solutions

This type of challenge presents a clear opportunity to merge automation and process control with cooling chemicals technology for total cost reduction and to improve the accuracy of dosing optimised chemicals. This will result in lower costs for cooling tower makeup water acquisition as well as blowdown water disposal. This optimisation plan brings together the technologies of TrueSense™ Online for Cooling for automation and process control with GenGard™ chemical treatment technology.

GE's TrueSense technology platform can optimise the aforementioned cooling water triangle. It integrates multiple unique functionalities into one platform: direct online monitoring of critical water chemistries; and a powerful data analysis and visualisation capability that provides insight into system status.

A core element of the platform is TrueSense Online for Cooling, a single unified online technology that can directly measure and monitor multiple core chemistries that are applied for effective cooling water treatment. These treatments include orthophosphate for corrosion control; proprietary polymers for deposit control; and the management of halogens, such as chlorine or bromine, for microbiological control. This technology provides a better understanding of cooling system status, enabling users to tighten control parameters to avoid or better respond to system variation and upsets, reduce water use and costs and to lower total cost of operation.

GE's total cooling water solution also includes the halogen stable GenGard series, featuring stress tolerant polymer (STP) and the innovation of direct polymer detection and control without the use of or disadvantages of tracers. Unlike other commercially available polymeric dispersants, the performance of GenGard STP is not adversely affected by the presence of iron. GenGard STP is effective in both neutral and alkaline pH scenarios and is a forgiving chemistry with inhibition and dispersant capabilities.

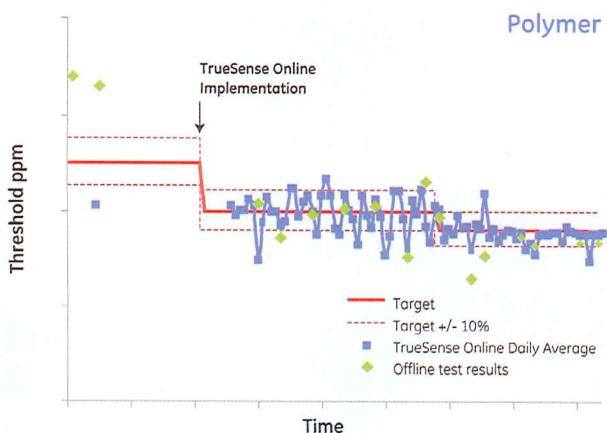


Figure 2. Implementing TrueSense Online technology typically results in systematic improvement of polymer usage.

Sample results

Before TrueSense is introduced, polymer concentrations are generally, periodically measured with manual offline testing, adjusting the control system to maintain a threshold polymer concentration target in the recirculating

water. Limitations in the control system can result in measured polymer concentrations that are often above target level, so as to avoid an under feed situation.

Upon the introduction of TrueSense, the target is often reduced and then fine tuned. As the set points are reduced, the variation systematically tightens as well. While opportunities to reduce chemical dosing can vary widely due to the circumstances and technical variations present in each system, the polymer level generally decreases (Figure 2).

Soluble orthophosphate is measured after passing a sample through a 0.22 μm filter. Delta orthophosphate is the difference between unfiltered and filtered orthophosphate. Despite considerable reduction in polymer consumption, a stable delta orthophosphate reveals that there is still adequate polymer in the system to inhibit calcium and iron phosphate deposits, creating the potential for further polymer dosing optimisation.

While TrueSense Online can optimise the existing polymeric dispersant, there is further opportunity to improve performance by replacing the standard polymeric dispersant with GE's patented GenGard STP. The cost performance of STP to inhibit calcium phosphate and iron phosphate is useful in highly stressed (high iron), low pH and high orthophosphate cooling water design, such as might be present in a refinery utilising a reclaimed municipal water source.

Once system control and chemistry are optimised, it is possible to increase cycles of concentration, resulting in reductions in the volumes of makeup water consumption and blowdown water discharge.

In summary, typical results may include:

- Chemical consumption may be improved, enabling the consistent feed of just the right amount of product for varying systems conditions.
- Variation in measured polymer around the improved concentration may be reduced, yielding the confidence to operate under more demanding conditions that would be encountered with more cost advantageous tower operating water balance parameters.
- Cycles of concentration may be increased, reducing annual makeup water consumption and blowdown discharge, and their associated cost.
- Production efficiency and reliability are not compromised. Heat exchanger bundle life and performance continue to be excellent while experiencing total cost reduction comprising of makeup water acquisition, blowdown water discharge and chemicals.

Refineries in water scarce areas may be able to lower the total cost of cooling operations without sacrificing the technical performance required to maintain clean heat transfer surfaces and low corrosion rates. Therefore, production is not impaired and the integrity of the plant assets is maintained. 