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Monitor cooling water quality—Part 1

Refineries and petrochemical plants use large volumes of water for indirect cooling. The cooling tower (Fig. 1) removes heat from water via evaporation and returns the water to the heat exchanger networks to cool processing streams. Recirculating cooling water requires additive systems to minimize corrosion, deposition and microbiological fouling on heat transfer equipment and to maintain reliability of the system to industry standards.

System-health monitoring of cooling water provides the most definitive information about the reliability of the equipment. The most fundamental measure of system health is the appearance of the cooling water in the basin and the cleanliness of the tower deck. Accumulations of silt and algae on the deck and in the basin indicate high risk for compromised heat transfer capabilities and corrosion under deposits that might have accumulated on heat-transfer surfaces.

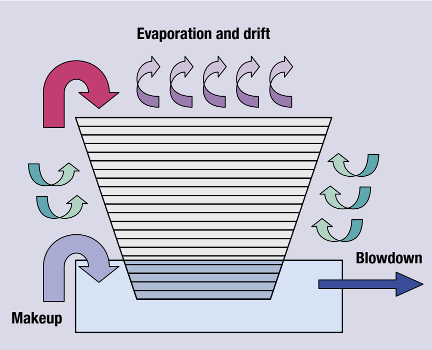

FIG. 1 Heat exchange processes occurring within the cooling water tower.

Microbes within the system. Operators measure aerobic and anaerobic *microbiological populations* by immersing a small plastic paddle with the appropriate fixed media and stain (e.g., "dip" slide) into a sample of cooling water for a few seconds and then storing the wetted media at ambient or a controlled temperature for a pre-determined period (incubation). The number of colonies correlates to a measure of the microbiological population. The appropriate frequency of these tests is very dependent on system-specific parameters such as historical incidence of leaks and ability of plant personnel to implement corrective actions.

Corrosion indicators. The most common technique to measure *corrosion rates* uses unpassivated test coupons exposed to cooling water in a bypass rack for a specified period. Test coupons are available in a variety of alloys to match the materials of construction found in the cooling water system. The absence of heat transfer on the test specimens makes the coupons an imperfect evaluation of the corrosion rate. However, the correlation of the coupon test results with the actual corrosivity of the cooling water is well accepted in the industry. A robust corrosion monitoring program includes coupons with a 30-day exposure period to evaluate the chemical treatment program efficiency and a 90-day exposure period to evaluate the system.

Instantaneous corrosion measurements determine metal loss from corrosion by the method of linear polarization. The correlation of the linear polarization at low applied electric potentials to the corrosion rate allows a measurement of the instantaneous corrosion rate. The obvious advantage of instantaneous corrosion meters is the availability of real-time corrosion rate data as compared to corrosion coupons. Frequently, there is a poor correlation between instantaneous corrosion measurements and corrosion coupon test results. This lack of correlation does not invalidate either test methodology. More important, both methods measure different aspects of cooling water corrosivity. The dynamic aspect of the instantaneous corrosion meter allows its use during system upsets such as an acid overfeed, chlorine overfeed or loss of inhibitor treatment. Plant personnel can utilize the instantaneous corrosion meter as an effective tool to correlate system variations with changes in the corrosion rate, optimize cooling water inhibitor treatment programs or evaluate the performance of new cooling water treatment programs.

Slime evaluations. Operations personnel seldom conduct any assessment of bio-fouling or sessile bacteria populations. One qualitative method to measure *sessile bacteria* (slime) is using a stainless steel mesh coupon in the first position of a coupon bypass rack. Weekly visual inspection includes wiping the mesh coupon clean to qualitatively assess the color and amount of slime or rinsing the exposed mesh coupon in demineralized water and conducting an anaerobic dip slide test to obtain a more quantitative measure of the sessile bacteria population.

Models for fouling. The state-of-the-art deposition and fouling monitoring equipment is a model heat exchanger that simulates the heat-exchanger environment, including cooling water linear velocity, surface temperature, heat flux and tube metallurgy. This device uses a side-stream flow of the cooling water to track changes in the heat transfer rate over time, thus providing a more accurate measure of chemical or biological fouling than test specimens in bypass coupon racks. The flexibility of the *model heat exchanger* to match the real-time or most severe operating conditions makes it the best tool to evaluate the risk on non-conformances, optimize cooling water inhibitor treatment programs or evaluate the performance of new cooling water treatment programs.

Creating a *comprehensive heat exchanger database* allows comparing design specifications to measured operating conditions such as flow and inlet and outlet cooling water temperature. With such information, plant personnel can identify heat exchangers at a high risk of fouling or failure. A robust system optimization program

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yields development of a predictive methodology that proactively replace heat exchangers and avoid unplanned outages.

Next month. In Part 2, we will investigate how to monitor the quality of the cooling water system.

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Monitor cooling water quality—Part 2

Operations personnel are responsible for monitoring cooling water to ensure system reliability. Core focus areas include testing water quality and chemical inhibitor concentrations.

Water quality monitoring. Water quality parameters include pH, calcium hardness, conductivity, iron, copper and turbidity. Some plants monitor cooling water for process contamination, e.g., hydrocarbons or ammonia. Technology advances have produced new and improved testing equipment, including field-based spectrophotometers, colorimeters, titrators, immunoassay methods, fluorometers and electrochemical devices. Typically, operators conduct pH, calcium hardness, conductivity and turbidity tests twice per day, and iron and copper tests once per week. Frequency of contaminant testing is based on specific operating conditions.

Chemical inhibitor monitoring. Chemical treatment programs inhibit corrosion, control deposition and limit microbiological fouling in the cooling water circuit. Concentrations of corrosion inhibitors, deposit control agents and biocides are the second level of monitoring.

Corrosion inhibitors are classified by their mechanism of action, e.g., anodic, cathodic or adsorption inhibitors. Cathodic inhibitors such as zinc interrupt the corrosion reaction by precipitating inorganic inhibitor on the carbon steel surface at the cathode. Anodic inhibitors such as orthophosphate interrupt the corrosion reaction by promoting the formation of a protective, passive oxide film on carbon steel surfaces. Adsorption inhibitors such as azole form complexes on copper alloy surfaces producing a film-type barrier to corrosions.

Most chemical treatment programs include a combination of corrosion inhibitors for optimal protection. Spectrophotometry is the most common method to measure concentrations of azole, orthophosphate, phosphonate and molybdenum.

The most common **deposit control agents** are polymers. Suppliers have developed titrations and spectrophotometric methods to measure the concentration of polymers. However, these methods are vulnerable to interference from turbidity and process contaminants in the cooling water. In addition, they may have poor reproducibility and do not measure the amount of "free" or unreacted polymer.Polymer manufacturers have introduced polymers that have a "tag" built into the polymer that reacts with an immunoassay test. These tests measure unreacted polymer concentration; however, their accuracy is limited to ±20%.

The most common **oxidizing biocide** chemicals are chlorine and bromine. Spectrophotometric and colorimetric methods measure the free available oxidant in the cooling water return, allowing operators optimal control of the microbiological activity in the cooling water circuit. In some systems, refinery operators can track increases in the difference between the free and total chlorine concentrations to identify process leaks.

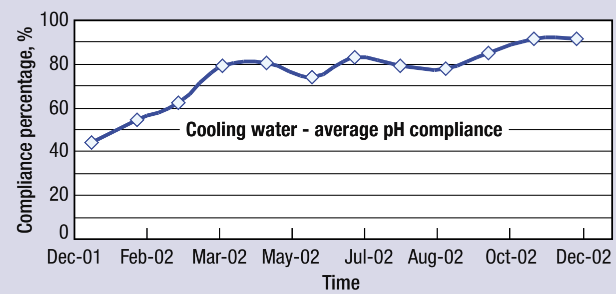

FIG. 2 Compliance trends of cooling water pH over time.

Online water quality monitoring. Conformance of water quality (Fig. 2) to specification limits directly correlates with equipment reliability within the cooling water circuit. To optimize conformance, online instrumentation can provide a means to monitor and control chemical feed by applying a feedback control algorithm.

Online oxidation-reduction potential (ORP) meters or online chlorine analyzers measure and control oxidizing biocide feedrates. Online pH instruments measure and control the acid feedrate. Conductivity correlates with the total concentration of dissolved solids in the cooling water; making online conductivity instrumentation an effective method to maintain the waterside efficiency and control the risk of deposition within cooling water circuits. Implementing effective monitoring practices is critical to improving conformance to specification limits, lowering water and chemical consumption and increasing system reliability. **HP**

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