



## Water Talk

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### *Water Testing and Interpretation*

Water is routinely analyzed to determine the concentration of impurities, which may contribute to corrosion, scale, deposits, sludge and silt. Analyses are also done to measure the level of water treatment being applied to the cooling system, boiler, closed recirculating loop, or other water systems. We must, therefore, decide which impurities are significant and in need of control and which tests will be needed for the measurement of treatment level. We must also establish a test frequency. Finally, the actual test results must be compared with the prescribed limits and any deviation from these limits must be properly interpreted in order that corrective measures can be taken. Although the type of test, frequency and control limits will vary, depending upon the system being treated, the principles remain the same. For the following discussion, a typical open recirculating cooling tower system will be used. However, the same observations apply to boilers and other types of systems as well.

#### **Controlling Water Constituents**

Some constituents in makeup water can contribute to the corrosion process or to form scale and deposits. On the other hand, the same scale forming constituents can be utilized as an inhibitor of the corrosion process. In an open recirculating cooling system, the necessary cooling is accomplished by evaporation at the cooling tower. The water evaporation process has a concentrating effect on all of the constituents present in the system water. As the system continues to operate, these constituents will increase in concentration, finally reaching a point when water treatment chemicals alone cannot adequately protect the cooling system. Depending upon the type and amount of constituents originally present, a concentration limit can be established. The system water is then maintained below this limit by bleeding off a portion of the concentrated system water. Constituents which must be controlled include calcium hardness, bicarbonate alkalinity, silica and

total dissolved solids. Because the evaporating effect of the cooling tower will concentrate all of the original constituents, it is not necessary to test for all of them. Rather, the most critical constituents are determined and used to set the concentration limit for all constituents. For example, calcium hardness and alkalinity are typically considered critical constituents and it has been determined that a concentration of 4 times the original makeup water level is the limit. Further, we know that the chloride ion is less affected by other conditions within the system. Therefore, the chloride ion should be monitored on a routine basis to determine the evaporation ratio of the system water and, also, because of its corrosive characteristics. The chloride test can be used as a control and set its limit at four times the chloride concentration in the makeup. Generally, total dissolved solids are used as the bleedoff control and are easily, but indirectly determined by measuring the conductivity of the water.

To summarize the concept of controlling water constituents, the concentration of critical constituents is controlled by bleedoff and the amount of bleedoff is adjusted to maintain the concentration of the system water below an established limit. This control level is set by the solubility limit of the critical constituents. When analyzing the water it is best to test for the critical constituents and the controlling parameters, which are chloride ion and conductivity.

#### **Control of Treatments**

In addition to controlling water constituents, which are originally present in the system, it is also important to control the level of water treatment chemicals. In this case, always monitor the treatment by testing for one or more of the components. The level of treatment in the system will be affected by such factors as the amount added, also referred to as the feedrate, and by the bleedoff rate. Further, the inhibition of the corrosion, scale and deposit

formation processes will consume the treatment chemicals. Depending upon the type of treatment applied, components, such as, organic phosphonate, phosphate, molybdate, or zinc should be monitored. A certain minimum level of treatment must be maintained in order to obtain the desired protection. A maximum level will also be established, primarily for economic reasons. However, in some cases, excessive treatment levels can be detrimental. Thus, a control range is generally prescribed within the minimum and maximum limits deemed to be optimum for the specific treatment.

### Control of pH

Many treatment programs require that the cooling water pH be controlled below the natural level of 8.3 to 9.2. This is done to prevent the precipitation of corrosion inhibitors or reduce an excessive scaling tendency. Corrosion inhibitors, such as zinc or orthophosphate, are more stable and effective in a pH range of 7.0 to 8.0. In some locations having makeup water with high scale formation tendencies or in systems with high temperature heat exchangers, controlling the pH in the range of 8.0 to 8.5 is necessary to maximize the performance of the molybdate or all organic type treatments.

### Interpretation of Test Results

Each treatment program has established control parameters for the optimum performance of the product. For the example being discussed below, the control limits for a stabilized phosphate treatment program would be as follows:

<u>Parameter</u>	<u>Limit</u>
Calcium hardness	900 ppm
Orthophosphate (PO <sub>4</sub> )	8-12 ppm
pH	7.4 – 7.6

The example system is a 1000 ton refrigeration cooling system located in a city having high hardness and high alkalinity in the makeup water. A stabilized phosphate product with pH control is selected as the best treatment program.

The makeup water analysis is as follows:

Calcium hardness	225 ppm
Total alkalinity	245 ppm
Silica as SiO <sub>2</sub>	15 ppm
Chloride as NaCl	45 ppm
Conductivity	800 □ mho/cm

Calcium hardness is the limiting constituent which must be maintained at or below 900 ppm. At a concentration ratio of 4 (AKA cycles of concentration) the cooling water analysis would appear as follows:

	<u>Makeup</u>	<u>Cooling</u>
Calcium hardness	225 ppm	900 ppm
Total Alkalinity	245 ppm	980 ppm
Silica	15 ppm	60 ppm
Chloride as NaCl	45 ppm	180 ppm
Conductivity	800	3200
pH		8.9
Langelier Saturation Index		3.2

The Langelier Saturation Index indicates excessive scale and deposit formation problems. After application of the stabilized phosphate program, the cooling water analysis is as follows:

	<u>Cooling</u>
Calcium hardness	900 ppm
Total Alkalinity	160 ppm
Silica	60 ppm
Chloride as NaCl	180 ppm
Conductivity	3200
pH	7.5
Langelier Saturation Index	1.0
Phosphate as PO <sub>4</sub>	8 ppm

The above cooling water analysis using a stabilized phosphate program is passivating with respect to corrosion control and has a low potential for scale formation.

The tests that should be run on a routine basis are calcium hardness, total alkalinity, chloride, conductivity and pH. The conductivity and pH values should be compared to the values on the controlling instruments. The chloride value should be compared to the makeup chloride value to determine the concentration ratio. The calcium hardness value should be compared to the upper limit of 900 ppm. The total alkalinity value should be in the range of 140 to 180 ppm, which compares to a pH 7.4 to 7.6. Finally, the treatment residuals for orthophosphate and organic phosphonate should be monitored and compared to the specified range for the product.