Uses & Applications of Phosphates in Cooling Water Treatment

Cooling of industrial processes and equipment is typically accomplished using cooling water sourced from rivers, lakes, or wells, using either once-through or open recirculating (cooling tower) systems. In either type system, but especially in open recirculating systems, treatment of the cooling water is required to maintain efficient cooling. Without treatment, scale forms in the cooling system and the system corrodes, leading to serious performance issues:

1. Less efficient heat transfer (cooling),
2. Sludge formation,
3. Higher pumping pressures, and/or
4. Corrosion of piping leading to pipe failure and additional sludge formation.

<u>Scale Formation</u>

Calcium and other slightly soluble minerals are continuously introduced into both once through and open recirculating cooling systems and are the primary cause of scale formation. In both systems, but especially in open recirculating systems, the calcium concentration increases due to evaporation of the cooling water (the primary means of removing heat from the system). Higher concentrations of calcium can exceed the solubility limit of calcium carbonate, calcium silicate, magnesium silicate, calcium sulfate, or other insoluble salts, resulting in sludge and scale. The scale not only impedes heat transfer through contact surfaces, it also promotes corrosion under and immediately around the scale.

To inhibit scale formation, a combination of phosphates and phosphonates, or phosphates and other polymeric additives, are frequently used. One common scheme includes:

- Orthophosphate 2-10 ppm
- Polyphosphate 2-10 ppm
- Phosphonate 2-10 ppm
- pH 6.5-8.5

Orthophosphates are normally added in the form of phosphoric acid, monosodium phosphate, or disodium phosphate and function by controlling the pH. Orthophosphates also react with calcium, for instance, to form hydroxyapatite, which is softer and more easily dispersed than calcium carbonate or calcium silicate. It is also important to note that orthophosphate is formed due to hydrolysis of polyphosphate, so actual orthophosphate addition may not be necessary. Orthophosphates are strong buffers in the neutral to slightly acidic pH ranges and help to keep the desired system pH to prevent excessive mineral precipitation and keeping the pH in a less corrosive range.

Polyphosphates are added both to chelate calcium and magnesium and to help disperse any precipitates, keeping the precipitates small and well dispersed in the cooling water. Common polyphosphates used in cooling water are tetrapotassium pyrophosphate, tetrasodium pyrophosphate, sodium tripolyphosphate, or sodium hexametaphosphate. Sodium hexametaphosphate can also be used in conjunction with zinc salts to improve corrosion resistance. Other treatment schemes include higher levels of inorganic phosphates combined with higher levels of either phosphonates or polyacrylates, along with adjustment of the desired

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pH range. The phosphate functionality is still the same, but the formulations are adjusted to accommodate calcium levels, blow down rates, and other dissolved salts.

Corrosion

Corrosion in cooling systems is typically due to evaporation of low alkalinity make-up water, making it more acidic due to concentration, and more corrosive. High alkalinity make-up water becomes more alkaline due to the same evaporation/concentration process, which makes dissolved minerals less soluble, leading to scale formation and ultimately under deposit corrosion. Phosphates added in the proper ratio of trisodium and monosodium help buffer pH to keep it between the low pH corrosive range and the high pH scale forming range, as cooling water is concentrated by evaporation. Phosphates also help prevent hard mineral scale from forming on high heat transfer surfaces.

Phosphate Systems

Phosphates are normally added to cooling water in conjunction with other treatment chemicals in liquid formulations supplied by water treatment specialists. Because the phosphate combination and other components of the system must work synergistically, use of a competent, skilled water treatment specialist is recommended.

Uses & Applications of Phosphates in Boiler Water Treatment

Boiler water treatment systems are used to handle many adverse conditions due to the extreme temperatures and related pressures of boiler systems. Some of these conditions include scale/deposits that form on the inside walls of piping and corrosive boiler feedwater. These adverse conditions, if left untreated, could result in:

1. Less efficient heat transfer,
2. Heat exchanger tube failures,
3. Higher pump head pressures, and/or
4. Corrosion leading to pipe failure.

All of these effects can impact the overall reliability and efficiency of the boiler system. One way to combat this is through the use of phosphates. Phosphate treatment of boiler water systems is recommended if the following situations are present:

1. Inability to frequently monitor piping of water system (infrequent shutdown/cleanouts),
2. High quality feedwater is not available, and/or
3. Low water treatment costs are necessary.

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Boiler Feedwater

A key to protecting the boiler system is to treat the boiler feedwater entering the system. Boiler feedwater can be protected from corrosive conditions through coordinated phosphate/pH control treatment. Phosphate buffers the boiler water, reducing the chance of large pH swings due to the development of caustic concentrations. In phosphate treatment, excess caustic combines with disodium phosphate to form trisodium phosphate. Therefore, adequate disodium phosphate must be available to combine with all of the free caustic in order to form trisodium phosphate. A slightly basic pH should be maintained in the boiler feedwater system. The American Society for Mechanical Engineers (ASME) suggests feed water to be kept at a pH of 8.3-10.5. Sodium phosphates help fulfill this requirement.

Boiler System

In the boiler system piping, scale can be formed by salts with low solubility. One of the worst types of scale buildup is calcium carbonate, commonly known as limestone. Scale buildup inhibits heat transfer, which in turn raises tube metal temperature resulting in potentially increased corrosive conditions.

Sodium phosphates are often used in boiler systems to prevent this build-up. When added at correct dosage levels the phosphate will react with the calcium carbonate and form Hydroxyapetite. Hydroxyapetite is softer than other deposits and will remain in suspension as long as it is kept in circulation. It can then be removed via routine blow down of the system.

Deposits, or sludge, arrive from the boiler water and enters the system as suspended solids. They can become attached to piping when boiler systems are drained at high temperatures. Once deposits are attached to the piping, they attract and bind additional solid particles found in the water. Sodium hexametaphosphate is a scrubbing agent that can help remove these deposits.

Phosphates can be fed into the system in solution with other water conditioning chemicals. There are several water treatments companies which have specific programs that include phosphates for boiler water treatment.

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