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TECHNICAL BULLETIN

White Rust

Galvanized steel has been the most popular material of construction for cooling towers for several decades. The most common variety of galvanized steel currently in use for cooling tower manufacture is G210 which consists of a layer of zinc with an average thickness of 1.8 mils on each side of the steel and a very thin layer of iron-aluminum-zinc alloy at the interface between the zinc and the steel. During the early life of a cooling tower the zinc layer acts as a barrier coating, protecting the underlying steel by insulating it from contact with the system water. Since it is more reactive then steel, the zinc layer is not expected to last for the lifetime of the tower and eventually corrodes away. The corrosion is not uniform and steel may become exposed to the system water at high stress locations while substantial zinc remains in low stress regions. At this time the remaining zinc begins to act as a sacrificial anode and significant corrosion of the exposed steel is delayed until the zinc corrodes to the point where a large percentage of the steel surface is exposed to the water. If the interior of the tower is inspected frequently, a new zinc coating, which will restore the barrier and cathodic protection, can be applied before significant corrosion of the underlying steel begins. Replacement zinc coatings cannot be expected to last as long as the original galvanizing however and a tower will typically need recoating every to years.

Under ideal conditions, zinc in contact with water will form a protective coating that has been identified as basic zinc carbonate (3Zn(OH)2-ZnCO3-H2O). Systems in which such a coating is maintained have been known to retain their galvanizing for more than ten years. In recent years, however, many cooling tower owners have been plagued by formation of a different type of coating, often on new towers, that is thick, white and waxy. A similar phenomenon, long known to the galvanizing industry as “White Rust” or “Wet Storage Staining”, gave this relatively new cooling tower malady its name. White Rust in cooling towers consists of nearly pure zinc carbonate (ZnCO3) which, unlike basic zinc carbonate, does not protect the underlying zinc. Thus White Rust is always accompanied by rapid deterioration of the galvanizing, resulting in complete loss within two years if unchecked.

The crucial factor promoting White Rust from a water treaters standpoint is the concentration of carbonate ion (CO3-2) in the system water. Carbonate ion is formed when makeup water containing bicarbonate ion (HCO3-) is recycled in a cooling tower. The process is accompanied by a rise in pH, a measure of hydrogen ion (H+) concentration. Carbonate ion first appears at a pH of about 8.4 and the concentration rises exponentially between 8.4 – 9.0. In addition, many public water utilities now add sodium carbonate to the water supply. Ironically, this is done to reduce the corrosion rate of lead solder joints within drinking water lines. Thus, many water supplies in our region already have pHs as high as 8.2. The pH of this water rises above 8.4 after only a modest degree of recycling

A considerable body of evidence, some in which has already been published, has been gathered to indicate that changes in the galvanizing process and composition of the zinc coating on galvanized steel towers have also been crucial to the increased frequency of White Rust in recent years. Some tower manufacturers dispute this evidence. The controversy should not detract from the facts upon which manufacturers and water treaters agree. These are the galvanized steel towers now being produced that use alkaline makeup water are likely to experience White Rust unless some measures are taken to prevent it.

One approach to White Rust prevention is removal of the carbonate ions from system water through pH control. The least expensive form of pH control is through feed of sulfuric acid.

Sulfuric acid is an extremely corrosive material and must be used with reliable feed and control equipment and safety precautions by trained personnel. Nevertheless, it is a very widely used water treatment chemical, especially in the western United Stated. Less hazardous and corrosive acids are also available at several times the cost of sulfuric acid. Additional advantages of pH control are increased biocide effectiveness and the possibility of higher cycles of concentration without scale formation. It should be noted that some cooling tower manufacturers recommend against acid feed due to the possibility of accidental overfeed which could quickly remove all of the galvanizing from a tower sump. For the sake of completeness we should also mention that the system pH can be kept below 8.4 if the tower water is not recycled. Although this results in two or more times as much water consumption, some tower owners have chosen this route.

It has been reported that by operating a tower at a pH of 7.8 for a period of weeks or months beginning at initial start-up, a passive coating will form on the zinc which will withstand a rise to higher pH. Anecdotal evidence suggests that this passive coating may not be long lived, particularly where pH excursions as high as 9 are common, and that the passivation process will require frequent repetition. Clearly, more research is needed in this area. In any case, this approach requires at least temporary use of pH control which is again in defiance of some manufacturers' recommendations.

Studies have indicated that orthophosphate, polyphosphates and/or high levels of triazoles are effective at preventing White Rust. Neither of these studies has documented White Rust control above a pH of 8.5, however, and in each case control was more effective at pHs below 8 than at 8.5. Orthophosphate and polyphosphates have a long history in water treatment, particularly in boilers. Their use in cooling water has been replaced to a large degree by molybdate because they promote algae growth and can cause formation of calcium phosphate scale if nor controlled carefully. Triazoles are still quite popular in conjunction with molybdate. Both can be used at the high pH that results when cooling water is recycled many times without promoting scale formation. The risk of calcium phosphate scale formation increases exponentially with pH. Since scale prevention is arguably the primary function of water treatment, we return to pH control as an advisable adjunct to use of orthophosphate and polyphosphates. New treatments for White Rust prevention are under investigation by have not yet been documented.

For tower buyers who do not wish to bypass manufacturers recommendations or risk scaling condensers with calcium phosphate, stainless steel or fiberglass reinforced polyester are alternative materials of construction that deserve serious consideration. The cost of towers made of these materials has fallen in recent years relative to galvanized steel towers. Another alternative is an inert barrier coating on top of galvanizing. Some tower manufacturers offer a factory applied barrier coating. Many types of replacement barrier coatings, some which provide cathodic protection as well, are available to tower owners whether or not they have purchased the factory-applied coating. Periodic recoating of tower sumps allows continuation of safe and inexpensive water treatment program with low water consumption. In Australia, where the government plays a larger role in cooling tower operation, inert barrier coatings are required by law on all galvanized steel towers.

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