White Rust

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Over the last decade, there has been a large increase in the use of galvanized cooling towers. Galvanized steel has become the most widely used material of construction in the industry. Galvanizing is a sacrificial coating that provides cathodic protection to steel. In order to provide extra corrosion protection for galvanized cooling towers, some tower manufacturers provide an extra barrier coating on galvanized surfaces. It has been recognized that hot dipped galvanized towers should not be used with all water conditions.

In past years when acid/chromate programs were used by the water treatment industry, the major concern was the loss of galvanizing due to the low pH excursions. pH recommendations for galvanized towers were to maintain pH's above 6.5. Little concern was shown for pH's on the alkaline side. Manufacturers of galvanized towers recommended high pH levels from 8.0 to 9.0. In most cases, the industry has now changed off of the acid/chromate program to more modern, non-polluting programs. With the advent of new polymers and corrosion inhibitors, most programs are now run with a minimum of acid addition or no acid addition at all. pH levels in cooling systems have gradually increased from 6.5 to 7.5 with acid chrome programs, to levels as high as 9.5 with the new alkaline polymer approach. In many cases where high levels of acid were used, softeners have now been installed to protect systems from scale. As the technology of the water treatment industry has changed, so have the problems. The industry has seen an increase in microbiological problems, outside contamination and corrosion. Within the last five years, the corrosion of galvanized steel has become a major concern. A very common term now used for the corrosion of galvanized metal is "white rust".

The term "white rust" refers to the premature, rapid loss of galvanized coating on cooling tower metal surfaces. "White rust" is evident if a white, waxy, sporadic deposit forms on wetted galvanized surfaces. This rapid loss of the galvanized metal will then result in the corrosion of the underlying steel. Instead of tower systems that will last 10 to 20 years, these systems will have a drastically shortened life span.

In order to better understand the formation of white rust, it is necessary to review the galvanizing process. In the galvanizing process, the steel to be coated is first cleaned in a caustic bath followed by pickling in a dilute hydrochloric or sulfuric acid bath. The steel is then subjected to a fluxing operation with a zinc ammonium chloride solution. This fluxing operation may be accomplished by one of two methods. Early galvanizing used the wet kettle method in which a floating layer of zinc ammonium chloride flux is placed on the surface of the molten zinc. The steel is then immersed into the molten zinc passing through the layer of flux, remaining in the molten bath until the temperature of the steel is the same as the molten zinc. The zinc bath is then swept free of the remaining flux and the sheet is removed. The sheet may then be immersed in a quench water bath to cool the sheet for handling. This quench water may be treated with sodium dichromate to provide further protection. In the dry kettle method, the steel sheet is first immersed in a kettle of zinc ammonium chloride flux and then removed and allowed to dry. The fluxed steel sheet is then dipped into the molten zinc bath. It is removed after heating and sent through the quench water bath. The dry kettle method was found to provide a higher quality surface using a much cleaner process. In the 1980's, the industry changed from general open-dip galvanized steel to continuous sheet galvanized steel.

It is believed that the change from the wet kettle method to the dry kettle method with continuous sheet steel has had an effect on the formation of white rust. Initial findings in research in this area have shown that the levels of aluminum and lead in the galvanizing have changed. With the wet kettle method, lead levels were 0.60% to 1.0% and aluminum levels were .005%. Levels of lead have dropped to .05% and levels of aluminum have increased to .40% since going to the continuous sheet galvanizing. This increase in aluminum and decrease in lead is believed to help increase the brightness of the metal surfaces; making a better looking product. The higher aluminum percentage is also necessary for better bonding of the zinc coating to the steel.

8287 214th Street West ♦ Lakeville, Minnesota 55044 ☎ 952-469-4965 Fax 952-469-1252

The cooling tower manufacturers do not believe that changes in the process or lead and aluminum levels have resulted in the increase in the problems with white rust. The industry has stated that aluminum levels have not changed and that the galvanized coating is actually twice as thick now that the G210 coating is being used. It is their contention that this problem is strictly the result of water quality and water treatment programs.

From experience, the water treatment industry knows that cooling water programs have run in the pH range of 8.0 to 8.5 for the last twenty years without having white rust problems. It has been documented that new towers added to existing systems using the same make-up water, chemical treatment and controls have developed white rust while the original units have not. To blame white rust strictly on water quality and water treatment, one has to believe the cooling tower manufacturer's statement that nothing has changed in the galvanizing industry in 20 years. When their own published literature states that pH's can run as high as 9.0, it is apparent that proper research has not been done by the cooling tower manufacturers. In this case, the cooling tower manufacturers are selling a product that fits their own needs and not one that fits their customer's needs.

Based on current information, white rust may form if the following conditions exist:

1. The galvanized coating is not properly passivated when the tower first starts up.
2. Recirculating cooling tower water is maintained at pH's above 8.0.
3. High alkalinity's.
4. Low calcium hardness levels, especially soft-water systems.
5. The lack of phosphate based corrosion inhibitor.

It is no longer a question of “will white rust occur" because in most situations it will. It is now extremely important that it be prevented. With proper education and cooperation, white rust need not be a problem. The following steps will help prevent the white rust:

1. Provide a secondary barrier coating such as an epoxy or coaltar type.
2. Run the cooling water treatment program at pH's between 7.0 and 8.0. This may require pH control.
3. Make sure the galvanized tower is properly passivated upon system start-up. This may require very low cycles of concentration or acid feed to keep pH's below 8.0 for two to three months. The system may then be cycled up to normal levels. Acid feed can also be discontinued.
4. Incorporate into the water treatment program a phosphate based product which includes proper dispersants.

Whether white rust is a product of changes in galvanizing or changes in water treatment programs or a combination of both is not the problem. The cooling tower manufacturers must sell a product that fits the needs of the ultimate consumer. The water treatment industry must educate that customer on proper protection of that cooling system and then provide a proper water treatment program.

REFERENCES

1. White Rust Report, Associated Laboratories
2. "White Rust" on Galvanized Steel Cooling Towers, BAC
3. Painting Hot Dip Galvanized Steel, John F. Malone, Materials Performance, May 1992
4. Update on White Rust Corrosion and Control, Keith M. Johnson and Joseph B. Mihelic, Tech Paper, February 1991
5. White Rust, Maxey Brooke, Materials Performance, March 1992