Galvanized Steel and White Rust
Galvanized steel has been used for decades to fabricate cooling towers. The zinc coating on galvanized steel provides considerable corrosion resistance to the underlying metal. It acts both as a mechanical barrier against corrosion and, under the right conditions, forms a tight, non-porous, protective film that gives the galvanized surface a dull, gray, weathered appearance. This corrosion resistant film forms reliably as new galvanized steel is exposed to atmospheric conditions, which explains why galvanized is so widely used for outdoor structures. However, it is not as certain the protective film will form on continuously wetted surfaces, such as found in cooling tower basins. When this protective layer does not form properly, white rust often occurs.

White rust is the name given to a yellowish to white, voluminous, porous deposit that can form on the surface of galvanized steel. White rust is less corrosion resistant than the protective film that gives properly passivated galvanized surfaces a dull, gray appearance.

Corrosion Damage Resulting from White Rust
The breaks in the zinc coating that occur when galvanizing degrades to form white rust allow the underlying steel to be exposed to water. As the zinc layer disappears, corrosion of the underlying steel starts to occur, and characteristic reddish iron rust spots appear. White rust formation increases the short- and long-term corrosion rates on galvanized tower components and should be avoided.

Potential Causes of White Rust in Towers
There have been numerous studies into the factors that cause white rust formation, many with conflicting opinions. Some of the factors suggested include

- Increased use of hot dipped galvanized sheet metal over hot dipped fabricated parts in tower construction
- Reduced thickness of the galvanizing layer on heavy mill galvanized (HMG) steel stock versus hot dipped galvanizing
- Relative amounts of aluminum and lead in the galvanizing bath used to form HMG stock
- Chromate rinsing used for passivating galvanized steel at the mills is not as prevalent due to environmental concerns

Several water treatment factors have been shown to contribute to white rust formation. These factors include

- Tower water pH levels less than 6.0 or greater than 8.3
- Lean waters or aggressive bulk water chemistries
  - Softened water or low calcium levels (< 50 ppm)
  - High sulfates, chlorides or nitrates (> 250 ppm)
- Use of high levels of chlorine and other oxidizing biocides
Confirming the Presence of White Rust
Due to the presence of carbonate in white rust, white rust deposits will show bubbling in the presence of acid. Care must be taken when visually diagnosing white rust deposits to potentially avoid confusing them with calcium or other carbonate-based deposits. It is always recommended to have a sample analyzed to confirm the presence of white rust. If a significant amount of zinc and carbonate are in the deposit, white rust is present.

Minimizing White Rust Formation
Galvanized steel is most susceptible to white rust when newly put into service. Once white rust has developed it may be difficult to stop its continued formation in alkaline pH conditions. Short-term reduction of cooling water pH with acid and re-passivation can be tried, but may not work in all cases. The best way to minimize white rust is to properly select and prepare a new galvanized tower before and during startup. Proper tower selection is an important first step. It is **highly recommended** that the intended use, expected water characteristics, and desired lifespan be thoroughly discussed with the consulting engineer, cooling tower manufacturer, and water treatment company so they can provide the appropriate recommendations. Considerations may include alternate materials, coatings, and startup procedures. In some cases, it may be best to use stainless steel for the tower basin or tube bundles, instead of galvanized, or have the galvanized metal pre-coated with corrosion resistant coatings, such as epoxies or special rubber-based coatings. The cooling tower manufacturer should only use galvanized steel that has been passivated with a chromate rinse before tower fabrication. Studies and experience show that galvanized steel that has been chromate rinsed after the galvanizing process is less susceptible to white rust. Proper pre-cleaning and tower passivation steps should be specified.

Recommendations for New Galvanized Towers
1. Minimize damage to the zinc coating during installation of the tower.
2. Remove oils, grease, welding flux, general dirt, and debris before putting the tower into service. Avoid the use of wire brushes or hard-edged tools that could scratch the zinc coating.
3. Allow the tower to weather in a relatively dry environment for approximately four to six weeks, or until the characteristic dull gray metal appearance develops, before placing into service.
4. Pre-treat with a passivation solution before placing into service. Normally, at least 100 ppm calcium hardness should be present for best results. Consult Chem-Aqua Engineering for best pre-treatment recommendations.
5. **Important**: bypass the tower for any cleaning of the system using high alkaline, acidic, or phosphonate-based cleaners. If the tower cannot be bypassed, do not use cleaning chemicals that lower the pH to below six or raise it to above eight as this can initiate zinc corrosion or strip the galvanized coating completely.
6. **Important**: maintain the tower water pH between 7.0 - 8.0 during the first eight weeks of operation. Tower water hardness and total alkalinity (M-alkalinity) must be maintained between 100 - 300 ppm.
7. If normal cycled cooling pH will exceed 8.0, then increase bleed to maintain at 8.0 or below for the first eight weeks. In cases where it is not practical or possible to maintain the pH below 8.0 by increased bleed, then temporary pH control using acid feed or dealkalizers should be employed. After this initial seasoning, the pH can then be allowed to increase to normal levels.
8. Additional monitoring is needed if using pH control or dealkalizers are employed to ensure the pH does not drop below minimum recommended limits. Even momentary low pH excursions can damage the galvanized coating.
9. Use normal inhibitor levels during this seasoning phase. Elevated inhibitor levels are not recommended. The chemical feed and bleed control system must be installed and fully functional at startup. Ensure that bleed flow restriction from dirt, debris, or clogged strainers does not occur and maintain proper bleed control, inhibitor levels, and microbiological control.

Unfortunately, due to limitations and complexities of water chemistries and other variables, there are no solutions that can absolutely guarantee prevention of white rust. Even with the best care taken, white rust can still occur.