

# Zinc Metal Build-up and the Effect of Anode Area in Acid Chloride Zinc Plating Baths ... *Myth vs. Truth*

By Jeff Grodecki / Technical Support Manager, Columbia Chemical Corp.

## *The Myth*

Over the years, many acid chloride zinc platers have been misinformed by suppliers or have otherwise assumed that zinc metal can be raised or lowered through manipulation of the zinc anode area. This technique is definitely true for alkaline cyanide-free zinc plating, since zinc metal in the alkaline plating bath can be raised by adding zinc anodes or lowered by pulling zinc anodes/substituting for steel; however it may have created misinformation for acid chloride zinc plating. Low or inadequate anode area will actually cause the zinc metal to climb in acid chloride zinc baths.

Due to the fragile world economy and increased commodity costs now seen throughout the industry, some acid chloride zinc plating companies are trying to reduce their usage of zinc metal by cutting the overall anode area in the plating tank – but with less than positive results. In fact, doing so will likely make matters worse, resulting in extra expense and aggravation.

## *The Truth*

Zinc metal in the acid chloride zinc plating process is introduced into solution through electrolysis. Electrical current passes through the anode, through the conductive plating solution and completes the circuit at the cathode. During electrolysis, oxidation occurs at the anode and reduction occurs at the cathode. It is the oxidation at the anode that becomes an issue when trying to reduce the overall surface area of the zinc anode. Adequate surface area is needed to allow for even current distribution throughout the entire anode.

When zinc metal climbs in an acid chloride zinc plating solution, quality of the finished work can suffer. Elevated zinc metal concentration will increase cathode efficiency. An increase in cathode efficiency will greatly decrease covering and throwing power, causing excessive zinc thickness in the high current density areas while producing thin and dull zinc plate in the lows. High zinc metal can also cause over-plating in the high current density area, resulting in chipping and flaking of the zinc deposit.

To compensate for the higher operating concentration of zinc metal, platers must use the proprietary additions at a higher rate than recommended. These additives are designed and formulated to produce a soft, bright and uniform zinc deposit, but when used at higher-than-recommended rates they raise costs and cause other problems. They are formulated with wetting agents and surfactants that reduce the surface tension of the plating solution. As more and more product is added, the surface tension of the plating solution is lowered even further, reducing dragout which in turn causes the zinc metal concentration to climb at an even faster rate.

## Reaching Equilibrium

Zinc metal rises in acid chloride zinc plating solutions until a state of equilibrium is reached. Because the zinc anode is 100% efficient and the cathode is only 85% to 95% efficient, more zinc dissolves off of the anodes than is being plated onto the parts. Some of this excess zinc is removed through solution dragout when the plated parts are removed. Simply stated, equilibrium is reached when the zinc lost from solution dragout equals the excess zinc dissolved off the anodes.

Dragout influences zinc metal in the bath more than any other factor. Zinc metal in plating tanks with low dragout, typically in rack operations, will naturally reach higher levels than in high dragout/barrel operations. A typical acid chloride zinc *rack* line runs in the 4 to 6 opg (30 to 45 g/l) range, whereas a typical *barrel* line runs at 2.5 to 3.5 opg (19 to 26 g/l) range.

## Conclusion

In most instances, the amount of zinc metal in barrel plating solutions with adequate anode area reaches an acceptable equilibrium, allowing platers to focus on other things. But due to the low dragout in many rack plating tanks, zinc metal can reach levels that adversely affect the plating results as described above. Reducing the zinc anode area in an attempt to reduce zinc metal in a rack line, or to try and save money in a barrel line will only hurt the situation! The only practical method of reducing the zinc metal concentration in the plating solution is to cut the bath, and the best way to minimize zinc build-up and avoid costly bath cuts is to provide more zinc anode area – not less!

## A Case Study

In an attempt to reduce costs in a high-production barrel line, the zinc anode area was reduced by pulling approximately 50% of the zinc anode baskets. The zinc climbed from 3.0 opg to 4.4 opg over a 12-week period. During this time, the high current density plating speed increased but there was an overall loss of brightness and zinc thickness in the low current density. The bath became too efficient and the problem could not be solved using Colsid™ Carrier, Colsid™ Brightener, adjustments to pH, chloride or bath temperature.

This problem was corrected when the original anode area was replaced, along with additional anode baskets. The anode area after the correction was approximately 2 to 1 to cathode surface area. In other words, there was about 2 square-feet of zinc anode area for every 1 square-foot of plated parts.

The additional anode area enabled the zinc metal to drop back down naturally, avoiding the extra expense and effort of cutting the plating solution. If this barrel line had continued to operate at low zinc anode area, the zinc metal would have continued to climb, resulting in increased consumption of proprietary additives and more frequent bath cuts.

The chart below shows the difference between low zinc anode area and adequate 2:1 zinc anode to cathode area:

