this work is to evaluate a coating that possesses properties similar to cadmium, the high Zn alloys (Zn/Ni, Zn/Fe and Zn/Co) only posses the excellent corrosion properties, but not the lubricity or solderability characteristics. There is a significant amount of data about the high Zn alloys in the literature, and we will focus on the alkaline Sn/Zn process.[10,11]

Introduction to Tin/Zinc

Combining the barrier protection offered by tin with the galvanic protection of zinc, without the bulky corrosion products associated with pure zinc or high percentage zinc alloy deposits, tin/zinc electrodeposits containing 20-30% zinc offer outstanding corrosion protection for steel and other substrates. Since the 1940s, tin/zinc alloys have been plated from cyanide electrolytes, it is not surprising that a number of applications for this alloy have been known for many years.[12] Since the mid-1960s, however, the use of tin/zinc has declined considerably, and now the coating is not used extensively. Although this is in part attributable to the unpopularity of cyanide plating solutions, it is more probable that cyanide tin/zinc plating solutions are very difficult to operate, requiring significant control and service.

Plating Process

In general, alloy plating processes are harder to control than single metal plating processes. This newly developed tin/zinc process follows the same tendencies, however, statistical experimental design techniques employed during process development have made this alloy process easier to control than most others. The electroplating solution is a mixture of potassium stannate, potassium hydroxide, potassium zincate, complexing agent and grain refiner.

Tables 11 and 12 give typical electrolyte composition and operating parameters required to give a deposit containing 20-25% zinc, with the balance tin. Operating parameters, such as solution composition, temperature and current density, can each affect composition of the deposit. The concentrations of tin and zinc in the solution have a direct effect on the composition of the deposit.

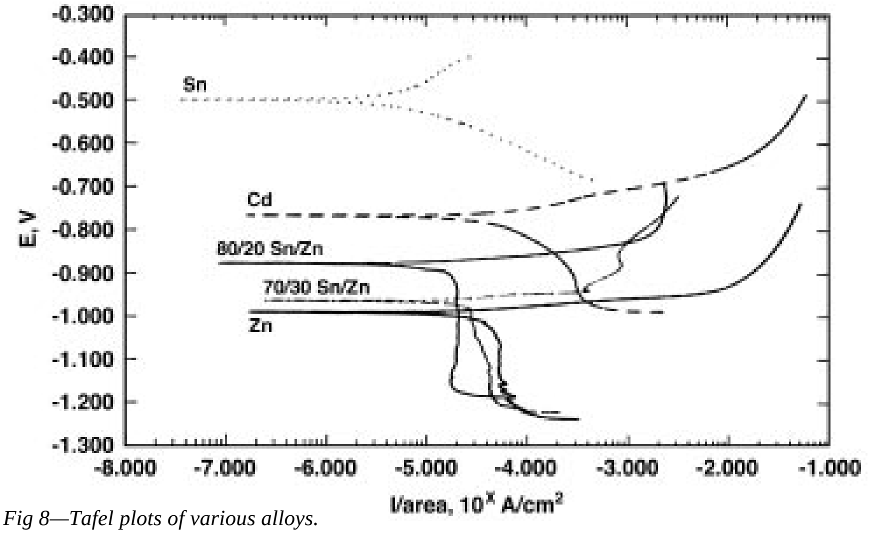

Fig 8—Tafel plots of various alloys.

Table 11
Solution Composition, Tin/Zinc

Material	Rack (g/L)	Barrel (g/L)
Tin Metal	53-68	45-55
Zinc Metal	0.8-2.5	1.5-2.75
Free KOH	15-60	30-60
Complexor	220-350 ml/L	220-350 ml/L
Grain Refiner	1-2 ml/L	1-2 ml/L

Table 12
Operating Parameters, Tin/Zinc

Parameter	Rack	Barrel
Temperature	49-55 °C	45-50 °C
Cathode CD	0.5-3.3 A/dm≤	0.2-1.0A/dm≤
Voltage		4-8 Volts
Filtration		Continuous
Anodes		Stainless Steel, 304 or 316
Tank		Polypropylene or polyethylene
Heaters		Stainless steel or Teflon

An increase in either concentration is reflected in an increase in the percentage of that metal in the deposit. This is shown in Figure 4, which also shows the effect of temperature on alloy composition. At lower temperature, less tin and more zinc is deposited inconsequential of the amount of zinc in solution. At higher temperatures, more tin is deposited. Figure 5 shows a more detailed effect of temperature and current density on the composition of the alloy. At higher temperature and current density, the tin concentration in the deposit increases.

Unlike the cyanide process where free caustic has a significant effect on the zinc content in the alloy, the non-cyanide alkaline process does not have that problem. Figure 6 shows the effect of free caustic on the composition of the alloy with the temperature, complexor and zinc content held constant at 60 °C, 300 ml/L and 2.25, g/L respectively. Very little change in the alloy composition over this range of free caustic is observed. There is a trend that, with higher free caustic, more zinc in the deposit is observed.

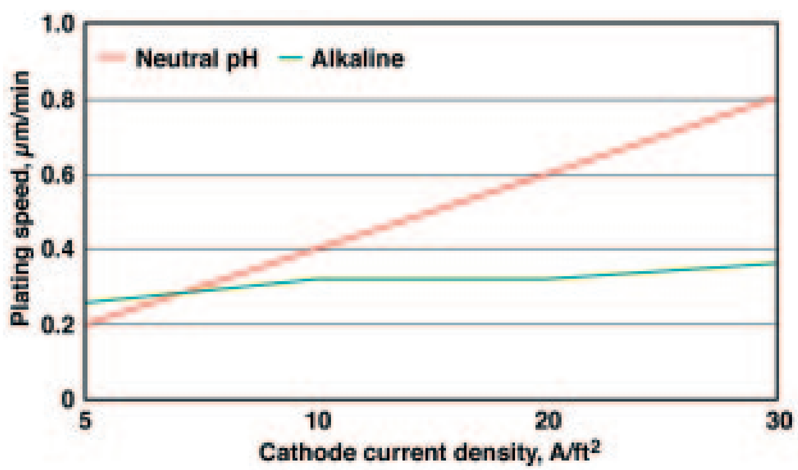

Fig 9—Plating rate of various Sn/Zn alloys.