Inorganic zinc (IOZ) coatings, predominantly primers, have been universally recognized as very corrosion-resistant for use on carbon steel (CS) structures as well as other metals and concrete. This well-deserved recognition dates back as far as the early 1940s in Australia. As these products have become more accepted into the mainstream coating industry, however, there have been far too many problems with coating systems applied over these primers. These problems predominantly take the form of blisters and delaminations of topcoats applied over the IOZ primers. Cohesive splitting of the IOZ primers can also occur after applying organic topcoats.

IOZ primer formulations have not changed appreciably since their introduction. Some additives now offer improved application and cure characteristics, but the basic curing mechanisms have not changed. What has changed is the industry’s concentration on faster production techniques when IOZ/organic topcoat systems are applied on CS. This article examines the basic curing mechanisms and presents several practical suggestions for enhancing the cure of three different types of IOZ primers.

Although the numerous modifications of IOZ primers feature additives such as polyvinyl butyral and ceramic pigments, the basic curing mechanisms all involve the reaction of polysilicic acid to form a silicate matrix that binds the zinc particles to each other and to the CS substrate. What is different is the manner in which this silicate matrix forms. According to Munger, the stages of cure of the three most common types of IOZ primers are as follows.

**Postcured IOZ**

The first step involves the evaporation of water from the applied film, leaving the zinc pigments and an alkaline film. Under ambient conditions of ≥50°F (10°C), this evaporation stage takes only a few minutes and leaves a fairly hard coating on
the substrate. It is not, however, cured to an insoluble state.

As soon as the applied film is dry (turns from a glossy look to a matte finish), an acid postcuring solution must be applied to thoroughly wet out the surface with the curing compound.

There is an immediate reaction between the acid-curing solution and both the zinc particles and the steel substrate. The reaction creates a silica matrix insoluble to water and unaffected by exposure to weather.

The coating gradually cures over many months as carbon dioxide (CO₂) and water react on the coating. This produces a reaction between the silica matrix and the zinc ions, which are formed by carbonic acid (H₂CO₃).

It is important to remember that these curing reactions leave soluble salts on the surface, which must be removed with clean fresh water prior to applying any topcoat.

**Waterborne Self-Cured IOZ**

The first stage of self-curing involves evaporating water from the applied film so that the alkali silicate and the polysilicic acid can react fairly quickly with the zinc. During this drying phase, air temperature (min. 50°F), relative humidity (RH), and air movement are critical to the proper curing of the applied film. The applied film must be protected from rewetting by dew, rain, etc.

The second stage involves the reaction of the zinc and steel ions with the silicate or the polysilicic acid polymer. This combination forms the insoluble silicate matrix, which holds the zinc powder in place.

The third reaction takes place over a long period of time as the applied dry film continues to react with moisture and CO₂ from the air. The reaction forms zinc carbonates and zinc hydroxides that fill the porosities of the zinc film and increase hardness.

**Solvent-Borne Self-Cured IOZ**

These coatings are commonly based on prehydrolyzed organic silicates, which are converted into an inorganic silicate matrix through the curing process. The first stage is again an evaporation of the liquid portion of the applied film; however, solvent is evaporated in this case.

The second stage involves the creation of polymeric acid when moisture from the air reacts with the silicate. The polysilicic acid continues to react with the zinc and metal ions to form an insoluble film on the substrate. The film appears to be cured at this stage, but it is not fully cured until it becomes water-insoluble.

The final reaction once again occurs over a period of time. The polysilicic acid continues to react with moisture from the atmosphere and the zinc and metal ions. This reaction forms an increasingly hard film packed with zinc carbonates and zinc hydroxides, yielding a solvent- and water-resistant film.

**Practical Suggestions**

Postcured IOZ primers are ready for topcoating within a relatively short time after application of the postcuring solution. The by-products of the postcuring reaction are water-soluble, however, and must be removed by power-washing or scrubbing with bristle brushes. If they are not removed, the topcoats will not adhere properly to the zinc primer and osmotic blisters will begin to develop in the topcoat.

Self-cured waterborne IOZ primers may or may not be ready for topcoating in a relatively short period of time. They are very dependent on warm air flowing over the surface of the applied film; this process releases all of the water from the applied film before the curing reaction can take place. Generally, no curing occurs at temperatures <50°F. Temperatures <40°F (4°C) produce essentially no curing. High RH also delays the curing reaction because the residual water in the applied film evaporates very slowly, particularly when the RH is >90%.

Solvent-borne self-cured IOZ primers are the most user-friendly of the three types of IOZ primers. They wet the substrate best and do not require quite the same degree of substrate cleanliness. However, the curing mechanism is also highly dependent on a combination of moisture and temperature to reach a level of cure sufficient to withstand the curing stresses of high-build topcoats, particularly epoxy. They cure very slowly at <50°F and 50% RH, although they can be successfully applied at those ambient conditions. The film appears hard, but it is not thoroughly cured. Misting the dry film with fresh water and allowing it to dry can accelerate the curing reaction. Every time it is misted and dried, a separate cure cycle ends and the film becomes packed with more zinc carbonates and zinc hydroxides, which increase the film’s hardness. The water should not be allowed to remain on the surface for long periods of time because the zinc will begin to act as an anode, possibly forming early freckle or pepper rust.

**Summary**

IOZ primers are truly workhorses in a protective coating system, but only when they are allowed to cure properly. The best advice anyone can give about them is “Follow the manufacturer’s instructions, or use an organic primer instead.”

**Reference**