The way forward in passivation of galvanized steel coils

Until recently, passivation of galvanized steel strips generally involved the application of hexavalent chromium based compounds. Cr(VI) passivation was considered to provide superior corrosion protection in comparison to alternative non-toxic trivalent chromium and chromium free applications. However, significant environmental and health concerns led to the ban on Cr(VI) passivation in almost all industries within the European Union market. Newly developed Cr(III) coating systems offer better protection against corrosion and superior adhesion properties at thinner layers on galvanized steel strip.

As a result of the ban on Cr(VI) passivation, galvanizers have faced frequent issues related to the use of current Cr(III) or Cr-free (usually phosphorus or titanium) passivates. These alternative passivates require the application of thicker layers to achieve corrosion resistance comparable to Cr(VI) coatings. This causes a reduction in or the loss of adhesion properties, leading to organic coatings subsequently applied to the galvanized steel strips, such as paints or sealants, to deteriorate more quickly. Figure 1 depicts painted hot-dip galvanized surfaces with different thicknesses of passivation layers (the arrow indicates the increase in layer thickness) that were subjected to various stress tests including impact testing, bending and cutting. The level of paint deterioration increases with the thickness of the passivation layer. The thicker layers also result in increased discoloration or loss of transparency of the passivated surface.

To address this issue, Quaker Chemical has developed Primecoat™ – an innovative and effective non-toxic, fluoride-free water-based Cr(III) passivation system for galvanized steel strips. Under advanced test conditions, the new system achieves better corrosion protection at thinner layers than current products, provides significant improvement in adhesion properties for organic layers and gives galvanized steel strips a durable clear and transparent finish.

Figures 2 and 3 compare the passivation layer on a zinc-coated substrate of a standard Cr(III)-based passivate with that of the Quaker Primecoat™ (courtesy: voestalpine Stahl GmbH). Many current passivate products require the application of thick and porous layers. These allow chemicals and water to penetrate through defects and cracks, initiating corrosion. The thin layer of the Quaker Primecoat™ is highly dense, lessening the penetration of corrosive chemical components.

Corrosion resistance

Figure 4 displays the results of a neutral salt spray test (EN ISO 9227) on standard passivation and on the new Quaker Cr(III) products applied in different layer thicknesses to hot-dip galvanized plates. The tests confirmed far better corrosion protection for the next generation passivates. The layer thickness of 20 mg Cr/m² studied in the tests on products including chrome in the form of Cr(III) salt is a typical value for a thin layer, whereas 40 mg Cr/m² is a typical value for the thicker layers, as used in the industry today.

As the test demonstrates, a thin, 20 mg/m² layer of the Quaker Primecoat™ does not display any sign of corrosion until after more than 360 hours of steady spraying. In comparison, the industry standard Cr(III) product reaches the 5%-white rust limit after 48 to 72 hours.

Adhesion properties

In downstream processes, organic coatings such as paint, glue or sealants...
are applied to metal surfaces. From these coatings, superior adhesion to the substrates is required. Therefore end-users or processors of hot-dip galvanized strip expect more than just corrosion protection from the passivated material. However, the layer thicknesses applied today to reach the expected corrosion resistance are associated with reduced adhesion properties.

**Glues and sealants.** T-peel tests (DIN ISO 10365) were performed to compare the effect of industry standard passivation and Quaker Primecoat™ (figure 5). Whereas the coating – in this case a polysulfide sealant – bonded more strongly to the surface passivated by the new system, only partial cohesive bonding was achieved with current generation passivates. Further tests with a larger range of sealants, one-component and two-component structural adhesives have confirmed these results.

**Paints.** To check adhesion properties of organic coatings, T-bend tests were performed on galvanized strips coil-coated with a standard solvent-based topcoat. As shown in figure 6, after bending, the strips passivated with conventional product (examples Nos. 3, 4, and 5) show significantly greater delamination than the strips passivated with the Quaker Primecoat™ (examples Nos. 1 and 2).

**Application and surface finish**

The Quaker Primecoat™ does not involve any changes to the application process or require enhanced drying systems. The innovation only relates to the systems’ new chemistry. Even under borderline application conditions, a good surface finish is achieved without film formation or build-up on application rolls in squeegee or chemical coaters. The resulting passivated surfaces are transparent: no discoloration occurs on exposure to heat or after extended contact with process fluids in forming and drawing operations. The passivated layers are water-repellent due to a high contact angle (> 70°) with water and are not fingerprint-sensitive.

Even when applied in thin layers, the next generation Quaker Primecoat™ provide better performance than current products. Therefore the former can be
applied more economically. Field studies have indicated that with the new passivation products, overall chemical consumption can be reduced by up to 30%.

**Conclusions**

The performance of Quaker’s next generation Cr(III) systems represents a leap in the performance of non-toxic passivation systems. Thinner, more compact layers offer better corrosion protection than conventional Cr(III) or Cr-free products. Also adhesion performance proved to be high in tests with glues and paints and a wide range of layer thicknesses. The Quaker Primecoat™ is applicable with standard passivation equipment available in galvanizing lines. Specific enhanced drying conditions are not required. A transparent surface finish is achieved with no discoloration even at higher layer thicknesses. Non-toxic ingredients – i.e. fluoride-free solution and absence of heavy metals – reduce both toxicity and the risk of etching when being applied to common stainless steel qualities. Finally, an excellent cost-benefit ratio compared to other passivation products makes them a favourable choice for hot-dip galvanizing.

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**Figure 5.** Cohesive bonding tests with adhesives and sealants; right: Quaker Primecoat™; middle: standard passivation

**Figure 6.** Paint adhesion tests (T-bend test, 2 mm diameter); Nos. 1 and 2: Quaker Primecoat™; Nos. 3 – 5: standard passivation