Painting of Hot Dip Galvanized Steel - Duplex Systems

"Duplex Coating" is a term first introduced by JFH van Eijnsbergen, the eminent corrosion expert, in the early fifties. It describes the protection of steel by a layer of zinc which is overcoated by a non-metallic coating. The purpose is to provide additional corrosion resistance especially when required or when a pleasing appearance is necessary. The corrosion resisting life of a properly applied duplex coating is normally greater than the sum of the lives of the two individual coatings. Typically, in a severely aggressive climate, the increase factor is 1,8 to 2,0. In sea water it is 1,3 to 1,6 and in non-aggressive climates the factor is 2,0 to 2,7.

Effective protection by a duplex system is only possible if long term inter-coat adhesion is obtained by means of a paint coating which will not react chemically with the zinc substrate. Inadequate preparation and cleaning of the zinc surface, prior to the application of a compatible paint system or powder coating, is the main cause of premature failure. *(Refer to table 9).*

Because paint films are pervious, to a lesser or greater degree, water can penetrate, over a period of time, to the zinc surface and may react with the zinc. The solid corrosion products of zinc are approximately 20% greater in volume than the zinc from which they arise, whereas steel corrosion products have about twice the volume of the steel from which they are formed. In the case of duplex coatings, this can be beneficial since defects in the organic coating can be partially sealed and undercreep retarded. However, excessive attack at the interface will result in peeling or blistering, but usually to a lesser extent than when the more voluminous corrosion products of steel are produced.

Hot dip galvanized coatings on silicon killed steel are easier to paint than pure zinc coatings on continuouly galvanized sheets due to the presence of iron/zinc alloy layers. With thermally sprayed zinc coatings it is advisable to apply an initial sealer coat to prevent the absorption of the paint media into the pores of the zinc coating thus leaving a pigment-rich layer which will be prone to disintegration. Powder coating with polyesters, epoxy polyesters or epoxies is common practice.

17.1 WHEN TO PAINT HOT DIP GALVANIZED STEEL STRUCTURES

Existing Structures

The need to paint existing galvanized structures will occur once the galvanized coating is nearing the end of its protective life. Maintenance painting on a cleaned, weathered galvanized surface is normally more effective than when such painting is carried out on a rusted steel surface. This is because zinc corrosion products are easier to remove thus providing a more stable substrate. As with ungalvanized steel, maintenance painting is rarely up to the standard of an original paint coat. Epoxies, which have been specifically formulated for the maintenance painting of steel, will usually also be effective on weathered, but cleaned, galvanized surfaces. With the necessary foresight, however, costly maintenance painting could be avoided, or deferred, by applying a duplex coating in the first place. Frequently, maintenance painting of galvanized structural steel is carried out unnecessarily, due to the mistaken belief that surface “rust stains” present on the coating emanate from the steel substrate. It is important to appreciate that the iron/zinc alloys make up a large proportion of the overall coating. As gradual weathering takes place, rust staining, from these alloys is often observed, particularly in cases where extremely thick coatings, associated with the galvanizing of reactive silicon killed steel are present. The only conclusive test is to determine the actual thickness of the remaining coating by means of an electro magnetic thickness gauge. *(Refer also to Chapter 11).*

New Structures

By far the most satisfactory duplexing results are obtained by applying the paint system as soon as possible after galvanizing. Weathered galvanizing, which is suitably cleaned, can provide a satisfactory surface on which to apply paint but this should only be considered if material is situated on a site where corrosion is relatively mild and a stable weathered zinc surface has developed. Under no circumstances should the painting of freshly galvanized structures be deferred in a marine environment where the need to remove unstable zinc corrosion products, prior to painting, will render the system less effective. In the case of bolted structures, painting prior to erection provides a distinct benefit in that mating surfaces receive added protection while metal to metal contact is also prevented.

An alternative to applying the entire paint system immediately after galvanizing is to apply a suitable primer at this stage, followed by a compatible top coat on site. Some primers, such as calcium plumbate, are prone to handling damage while for satisfactory inter-coat adhesion the application of a top coat, on calcium plumbate, should not be delayed. Water borne modified acrylic co-polymer primers have proved to be far less prone to damage and they can also be satisfactorily overcoated at a later stage. The final coat should, however, be applied as soon as possible if primed material is delivered to a corrosive site.

Ideally, material should be fully painted at, or near to, the galvanizer's works where strict quality control procedures can be enforced. Transit damage to painted material is mainly the result of poor stacking and rough handling. The use of plastic spacers, or similar material, as well as nylon slings, for loading and off-loading, usually results in minimal damage to a correctly applied paint coating. The use of re-coatable paint products is recommended so that any coating damage that may occur during transit is readily repairable on site, either before or after erection.

17.2 SURFACE PREPARATION FOR DUPLEX COATING

A zinc surface totally free from contami-

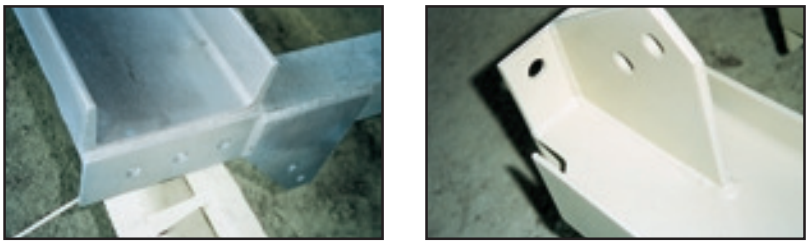

Figure 114. Sweep blasted hot dip galvanized coating followed by an appropriate paint system.

nants is an essential pre-requisite for the satisfactory painting of galvanized steel. Nearly all failures occur because of inadequate preparation of the surface or re-contamination, after cleaning and prior to painting, of the reactive zinc surface. **Failure to inform the galvanizer that subsequent painting is to take place will usually result in the provision of a coating which has been passivated in a sodium dichromate solution, and this may adversely influence paint adhesion. Likewise, zinc protuberances and lumps, which may be acceptable on galvanized surfaces, will not be removed if the galvanizer is unaware of the requirement to paint.**

Surface Roughness of Zinc Coating
As in the case with a paint coating applied directly onto steel, weld spatter, slag and steel surface defects will be apparent after hot dip galvanizing if prior removal is not carried out.

Irregularities in the surface of a galvanized coating may consist of small dross particles, zinc oxide, surface flux deposits and stains from unsealed interstitial spaces. Localised lumps may occur where drainage of excess zinc, during withdrawal from the galvanizing bath, was incomplete. Generally, these features do not reduce corrosion resistance of the galvanized coating but, if duplex systems are to be applied, they will appear more prominent after painting and may locally reduce paint coating thickness.

A locally thinner paint film over a small dross particle, or a zinc droplet, is less critical than a thin paint film on a protuberance on steel since the zinc corrosion products, formed after the thin paint area has corroded away, will prevent accelerated corrosion provided good adhesion of the overall paint film is maintained. This has been demonstrated, for example, in the case of powder coatings where the presence of pinholes had no influence on the corrosion resistance of the duplex system upon atmospheric exposure. In severely corrosive immersed conditions, however, thinner localised paint films should not be tolerated.

Sweep Blasting
Sweep blasting is a method often used for preparing galvanized surfaces for painting. There is no doubt that, if this process is carried out correctly, excellent adhesion can be obtained. The use of an ultra-fine non-metallic grit and low nozzle pressure are essential but, if contaminated or powdery abrasive material is used, sweep blasting can do more harm than good. High nozzle blasting pressure and the use of unsuitable abrasives can result in the delamination of the iron/zinc alloy layers particularly when heavy zinc coatings, associated with the galvanizing of silicon killed steel, are present. The process is less effective for products such as grid flooring where inaccessible surfaces are under blasted while exposed edges are inclined to be overblasted. Sweep blasting should only be used for the surface preparation of galvanized steel if the correct equipment and materials are available and operated by trained personnel *(figure 114).*

Chemical Cleaning
Zinc has a tendency to attract contaminants, such as oil and dust. All contaminants should be removed by cleaning with an approved solvent detergent degreaser. Failure to do this is the main cause of duplex failures. Galvanized cleaners, which contain abrasives, have been shown to be effective provided scrubbing is adequate. Abrasive components tend to settle out in containers which have been standing and thorough mixing, prior to use, is recommended. After degreasing, bristle brushing and thorough washing and rinsing with running potable water is essential in order to remove all traces of the cleaning chemicals. The zinc surface should then be "water break free" and once this stage is reached, and the zinc surface is dry, painting should commence as soon as possible.

Chemical Conversion Coatings
Chemical pre-treatment is designed to provide a strong, durable and long lasting bond between metallic and non-metallic coatings and also to prevent or retard undesirable chemical or physical action between the two coatings. The most widely used pre-treatment chemicals are phosphates and chromates and these are used extensively for the painting of sheet and also for powder coating. Certain products have been developed which contain a small addition of copper salts which give the zinc coating a dark grey colour. The advantage of these formulations is that it is possible to establish that all surfaces have been treated merely by visual inspection. These formulations have been shown to promote excellent adhesion, although it can be argued that copper salts are theoretically harmful when in contact with a zinc coating. Experience in the United Kingdom has shown that this only applies if the subsequent organic coating deteriorates or has been applied to a surface where the pre-treatment chemical is continuing to react.

17.3 SYSTEM SELECTION

In selecting a suitable system it is recommended that all products, wherever possible, are purchased from the same paint manufacturer. This will ensure compatibility. Certain paint formulae should not be applied directly onto zinc surfaces. Amongst others, alkyds may result in saponification with the formation of formic acid which will attack the zinc substrate and result in long-term adhesion failure. Some paints applied onto suitably cleaned zinc surfaces will provide good adhesion between the zinc coating and the paint without the application of a primer. This is particularly true if zinc surfaces are correctly sweep blasted prior to painting. Excellent adhesion of certain specially formulated high build epoxy and polyurethane coatings can now be achieved without the use of a primer or tie coat.

Primers
Primers which are applied onto suitably cleaned galvanized surfaces and which have proved extremely successful in providing the required long term adhesion between the organic coating and the zinc substrate include:

- Twin component, solvent carried, epoxy amine primer containing zinc oxides and silicates.
- Single pack water borne modified acrylic copolymer primers. Such primers should not be used where permanent saturation, in service, is anticipated.

Finishing Coats
The material to be used will be determined by the conditions to be encountered in service. Polyamide cured high-build epoxy coatings have been used successfully in the corrosive mining industry but problems associated with abrasion and age embrittlement have been encountered with certain products. High-build, high volume solids, twin pack, aluminium filled epoxies are successfully applied to primed galvanized surfaces. These products can be supplied with micacious iron oxide (m.i.o.) pigments, or straight colour pigments, if chalking is not a disadvantage. They are also used successfully for maintenance painting. Polyurethanes are becoming popular in situations where bright colour and gloss retention is a requirement. Over-coating with chlorinated rubber has been successful but this product is, in many cases, being superseded by high-build vinyl coatings. Considerable success has been achieved with specially formulated epoxy tars which, when applied to suitably prepared zinc surfaces, can provide long-term maintenance free protection even in situations of permanent saturation. For more detailed information, refer to the Association's publications Specification for the Performance Requirements of Coating Systems and Code of Practice For Surface Preparation and Application of Organic Coatings. For continuously coated galvanized sheet, r*efer to Chapter 5.*

RELIABILITY

The hot dip galvanized coating is formed by a metallurgical reaction between suitably cleaned steel and molten zinc. This results in the formation of a series of iron/zinc alloys which are overcoated with relatively pure zinc. The process entails total immersion of components in both pretreatment chemicals and molten zinc. This ensures uniform protection and coating reliability even on surfaces which would be inaccessible for coating by other methods.

DEPENDABILITY

Ease of inspection and dependability in service are beneficial features of a hot dip galvanized coating. The cathodic protection of steel by zinc ensures that corrosion of the underlying steel cannot occur as long as zinc is present. Even at discontinuities on the coating, corrosion creep under the surrounding zinc is not possible.

PREDICTABILITY

The durability of a hot dip galvanized coating is determined by the degree of corrosion of zinc in a specific environment and the thickness of the coating. Corrosion of zinc is normally uniform, thus durability of a hot dip galvanized coating is predictable in most applications.

MEMBER'S LABEL

HOT DIP GALVANIZING HAS BEEN USED TO PROTECT STEEL FROM CORROSION FOR MORE THAN 160 YEARS. APPLICATIONS FOR WHICH HOT DIP GALVANIZING IS SUITABLE ARE NUMEROUS AND VARIED AND THE DEMAND CONTINUES TO INCREASE.

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PUBLICATIONS AVAILABLE FROM THE ASSOCIATION

- Association Journal – Hot Dip Galvanizing Today.
- Steel Protection by Hot Dip Galvanizing and Duplex Systems.
- Practical Guidelines for the Inspection and Repair of Hot Dip Galvanized Coatings.
- Specification for the Performance Requirements of Duplex Coating Systems.
- Code of Practice for Surface Preparation and Application of Organic Coatings Applied to New Unweathered Hot Dip Galvanized Steel.
- Guidelines for the Use of Hot Dip Galvanized Products in the Mining Industry.
- Wall Chart - Design for Hot Dip Galvanizing.
- Directory for Specifiers and Buyers
- Guidelines for Buried Hot Dip Galvanized Conveyance Piping.
- Guidelines for the Use of Hot Dip Galvanized Piping for Water Conveyance.