23. PAINTING OVER GALVANIZING

INTRODUCTION

The application of paint to galvanized surfaces(duplex coating) is often seen as a problem. Also, many out-of-date specifications exist for duplex coatings that are technically correct but very difficult to apply in practice.

Developments in paint technology, closer involvement of galvanizers in duplex coating development and application, and an increasing demand for very long life coating systems have resulted in better paint technology, better application techniques and better economies for duplex coating systems.

Galvanized stadium lighting poles are usually painted for aesthetics. Properly applied finished add substantially the maintenance free life of the structure.

WHY DUPLEX COATINGS?

The application of paint to galvanized surfaces has historically largely been done for aesthetic reasons. For heavy-duty applications, it has been found that the application of appropriately durable topcoats can increase the maintenance free life of a structural item by 200-400% over that of a similar item in the same environment that uses either paint or galvanizing independently.

A good practical example of the effectiveness of duplex coatings is with BlueScope Steel's Colorbond'" coatings used on sheet and coil products for roofing, cladding and manufactured products.
The remarkable durability on Colorbond' products is achieved with what are essentially quite thin coatings. The Zincalume™- substrate is typically around 20 microns in thickness and the Colorbond™ topcoat system is around 25 microns in thickness on the weather side of the sheeting yet maintenance free life well in excess of 20 years has been proven with this product, thanks to the use of high quality paints and very careful process control during application.

By combining heavy duty industrial paint coatings which are typically at least 100 microns in thickness, with hot dip galvanized coatings which are also around 100 microns in thickness, true zero maintenance coating systems can be produced for steel with corrosion free life expectancy in excess of 50 years.

HOW LONG IS FOREVER?

Is there a need for protective coatings to last more than 25 years? After all, hot dip galvanized coatings will generally last that long in other than marine or severe industrial environments. The fact is that 25 years is not a long time for a major building or infrastructure asset. On many projects, clients are calling for 25-year performance guarantees on the coatings and interest in 50-year coating life for significant infrastructures projects is increasing.

WHAT ARE THE PROBLEMS?

In one form or another, the use of paint over galvanizing goes back to the early part of last century. The technology used was not technology-based and the mechanisms of paint adhesion on metallic zinc coatings were poorly understood. It was not until the 1970's that research was carried out to better define the requirements.

Even in more recent times, basic problems such as the incompatibility of some paints with zinc coatings were not clearly identified, and the common sight of paint peeling off galvanized surfaces; guttering and railing in particular, created an attitude which still prevails, that galvanizing is difficult to

paint.

This navigation tower on Newcastle (NSW) Harbour was galvanized and painted to provide additional durability in a marine environment, and remains in good condition after 20 years in service

The common alkyd (linseed oil based) enamel paints are incompatible with zinc coatings with some very limited exceptions. The oil in the paint resin reacts with the zinc to form zinc soaps that cause delamination of the paint film from the zinc surface.

Special zinc primers, particularly two-pack vinyl-etch primers, were developed to provide a properly conditioned surface for subsequent painting. These vinyl etch primers are no longer used as they contained zinc tetroxychromate.

The application of these priming systems and subsequent top-coating can be done satisfactorily in a controlled environment on manufactured items. The application of duplex coatings on structural projects means that galvanizing and painting operations are largely independent of each other, and often done by different sub-contractors.

The galvanizer thus may have no input into the painting operation and the painter has no insight into the techniques used by the galvanizer that may affect the quality of the duplex system.
The standard galvanizing practice of quenching hot dip galvanized products in a chromate quench immediately after galvanizing to cool the steel and passivate the zinc surface to prevent premature oxidation can in fact be detrimental to the adhesion of the paint system.

One of the major problems associated with this separation of responsibilities is in the surface preparation prior to painting. Brush blasting is required to ensure that the hot dip galvanized surface is clean and free of oxidation prior to painting, however considerable damage can be done to the galvanized coating at this stage if the incorrect blasting media and procedures are used. A recommended specification for brush blasting of hot dip galvanized surfaces in contained elsewhere in this manual, but is included here.

SPECIFICATION FOR ABRASIVE BLASTING GALVANIZING PRIOR TO PAINTING
Where brush or sweep blasting is required to prepare a galvanized surface for painting, the following specification is recommended for inclusion in the total painting specification. Unlike grit blasting for steel, this procedure is intended to remove oxide film and surface contamination and lightly profile the surface with minimal reduction in the galvanized coating thickness (no more than 10 microns).

- Blast pressure 40 psi maximum
- Abrasive Grade 0.2-0.5mm (clean Ilmenite)
- Angle of blasting to surface 45”
- Distance from surface 300-400mnr
- Nozzle type minimum 10mm venturi type.

The challenge for all participants has been to develop systems and coating technology to allow the reliable application of high performance paint coatings to hot dip galvanized surfaces at a cost acceptable to the customer.

DUPLEX COATING DEVELOPMENTS ... THE STATE OF THE ART
There are three factors determining the quality and durability of duplex coatings which are in fact common for most paint systems:

- the condition of the galvanized surface
- the type of paint system used
- the quality of the application.

If these three elements are successfully integrated, exceptionally good performance can be expected with a much higher degree of coating reliability than could be expected with paint coatings applied directly over black steel “’.

The Condition of the Galvanized Surface
There are two ways the condition of the galvanized surface can he changed: either through natural weathering or through chemical or mechanical pre-treatment. Natural weathering is frequently put forward as a method of conditioning the surface for painting, with a period of 6 months frequently nominated as a desirable weathering period prior to painting. This is a strategy fraught with risk because of the environmental factors that will impact on the surface with time.

The following table shows typical changes in surface condition of zinc coatings over time when exposed to normal atmospheric weathering:

Exposure period	Surface condition	Surface chemistry
0 month	Newly galvanized	No oxidation products or chromate passivation film - >5µ
1 month	Zinc oxide film formation	ZnO and $Zn(OH)_2$
2-3 months	Zinc oxides and other metal oxides (aluminium)	Zinc and aluminium hydroxides and zinc oxy-chlorides in marine areas and zinc hydrosulfates in industrial areas
9 months	Zinc patina stabilised	Complex zinc carbonate-based patina – $ZnCO.3Zn(OH)_2$
9 months +	Insoluble zinc patina	Atmospheric pollutants accumulate on surface

The times can vary significantly depending on local environmental factors. As a result, natural weathering of the surface to condition the galvanized coating for painting is unreliable and logistically impractical for most construction projects.

Paints for duplex paint systems
The selection and suitability of paints for use over hot dip galvanized surfaces depends on five main parameters:
1. The design life of the coating in its environment and its aesthetic requirements.
2. The paint systems and method of application.
3. Occupational health/environmental regulations regarding composition and application of the product.
4. Transport, handling and erection of pre-painted steelwork to and at the construction site.
5. The major factor in the performance of duplex systems is to ensure good adhesion to the galvanized steel surface because the hot dip galvanized coating in itself provides superior anti-corrosion performance to the steel substrate.

Paints consist of four major components:
1. The binder
2. Pigments and extenders
3. Volatile products (solvents)
4. Additives (UV stabilisers, drying agents, surfactants, emulsifiers, dispersants).

It is beyond the scope of this article to deal with these in detail, but all are important in the formulation of suitable paint chemistry for duplex coatings. The binder generally determines the generic type of paint. i.e. Epoxy, alkyd, acrylic, vinyl, chlorinated rubber, polyurethane etc.

Within each of these generic types there are many sub-categories and hybrid resin combinations that are tailored to particular applications.

Pigments and extenders provide the colour and enhance the mechanical and weathering properties of the coating. i.e. Micaceous iron oxide, glass flake, zinc dust, titanium dioxide etc.

Volatile products evaporate from the coating after application and are used to control the viscosity, wetability of the substrate, film thickness characteristics and drying performance of the coating. The level of volatile compounds in paints will continue to decrease to meet local and international environmental standards.

Preparation	Method	Advantages	Problems
Rubbing or scouring with abrasive media	*Hand or mechanical buffer*	*Good for small parts or areas. Complete removal of surface compounds*	*Low productivity. Risk of excessive zinc removal. Access limited to open surfaces*
Brush or sweep blasting	*Surface blasted with fine abrasives using compressed air*	*Produces good surface for painting, can treat large surfaces quickly*	*Skilled operators required to prevent damage to galvanized coating.*
Heat treatment (Galvannealing)	*Heating to 650'C converts all free zinc to alloy layer and removes organic & hydrated contaminants*	*Excellent adhesion with appropriate paint systems*	*Relatively expensive on complex fabrications Requires large capital equipment and best suited to large scale treatment of sheet products*
Cold phosphating	*Brush application of phosphate etch solution (phosphoric acid based) followed by water rinsing*	*Best suited to small items in small quantities. Simple process*	*Low productivity. Careful rinsing required to remove all treatment residues*
Hot Phosphating	*Dipping or continuous Spray process used in conjunction with chromating and rinsing pre-treatments*	Low cost per unit treated. Consistent high quality. All surfaces treated	*High capital cost. Best suited to large volumes of manufactured products*
Chromating	*Dipping process usually done immediately after galvanizing to prevent 'white rusting*	*Simple and low cost process*	*Chromate not a suitable pre-treatment for most paint systems*

WHAT MAKES IT STICK?

Adhesion is the factor determining the success or otherwise of duplex systems. While by their nature there is little risk of premature rusting and structural deterioration should duplex topcoats fail, the major synergistic benefit of duplex systems depends on the two coatings working together in their mutual benefit for the design life of the system.

Adhesion in duplex systems depends on the chemical and physical behavior of the underside of the paint film and the surface of the galvanizing. With better surface analysis tools available to the researcher, and the increased awareness of the importance of surface chemistry in the behavior of materials, a clearer understanding of what happens at the interface is assisting in the development of better duplex coatings.

There has been much fundamental research done in this area, and in summary the following forces are considered to be important in influencing adhesion of paint to galvanizing or other metal substrates.

1. The bonding forces in the very thin (sub-micron) boundary zone
2. The thermodynamic forces relating to the surface energies of the two materials.
3. Electrostatic forces which are a measure of the energy required to remove a coating from its substrate. The energy involved to do this should exceed that required to break down the molecular bonds in the polymers.
4. Mechanical adhesion forces.

Thus the mechanism of adhesion is a combination of atomic and molecular bonding, wetting angles, electrostatic and mechanical keying forces. Coating developments focus on each of these areas to improve the adhesion performance of paint over galvanizing.

CURRENT DEVELOPMENTS

A great deal of test work and duplex coating evaluation has been done, particularly by the Dutch Galvanizing Institute in severe atmospheric exposure condition (industrial/marine) and a number of systems have provided very good performance with the following conclusions:

1. Brush blasting of the galvanized surface resulted in very good adhesion of all paints tested.
2. The epoxy and polyurethane paints did not adhere well to weathered zinc surfaces. Chlorinated rubber, polyvinyl and water borne acrylic paints had acceptable adhesion.
3. All paints adhered satisfactorily to newly galvanized surfaces.

To date, all of the spray applied duplex systems that have excellent performance in service are multi-stage processes requiring brush blasting or chemical pre-treatment, priming and top-coating. While this approach provides the performance required, the additional cost of applying what is essentially a full scale paint system over the top of hot dip galvanizing puts the costs for a duplex system to level that many end-users deem to be unacceptable.

As duplex coatings in the context of this document are applied to structural steel or steel fabrications in a contracting or jobbing environment, the logistics of timing of galvanizing and painting. pre-treatment and application are vital components in ensuring an economical and reliable coating job.

Thus, the focus of duplex coating developments in Australia has been to develop coating systems that are surface tolerant on hot dip galvanized surfaces and are easy to apply. Much test work has been done both in Australia and in Europe on defining the best conditions in which to paint hot dip galvanizing. It has been shown conclusively through work done by Industrial Galvanizers Corporation in the development of polyester powder coatings and solvent based paint systems that very good results are obtained if the hot dip galvanized coating is painted as soon as possible after galvanizing and the work is not chromate quenched after galvanizing. The elimination of any special surface preparation prior to painting saves the cost of brush blasting which is typically at least $10/m^2$.

While this application technology has been well proven and has been available commercially since the 1980's, the tight time limits between galvanizing and painting pose logistic problems in practice.

These can be as follows:

- Site limitations precluding painting on the galvanizer's site
- Unsuitable weather conditions during scheduled painting periods
- Production scheduling from fabricator effecting timing of galvanizing
- Requirement to store work in batches prior to painting for efficient transport.

The development of more surface tolerant coating for use over galvanizing is aimed at eliminating any surface preparation over either chromate quenched or unquenched galvanizing and also to eliminate the need for priming systems so that a finish coat can be applied in a single coat.

Poor surface preparation (no primer used) combined with paint application on damp galvanized steel resulted in this paint failure caused by water blisters under the paint film.

The means to do this already exists and has been well proven over the past 20 years. Water based acrylic coatings have been used successfully in Australia over hot dip galvanizing. These readily available premium house paints, while having low chemical and abrasion resistance, have excellent UV resistance and good adhesion to galvanized surfaces.

Some polyurethane systems applied directly to freshly galvanized surfaces have been used in the USA but the reliability factors associated with these duplex coatings are not at a level that would recommend their use.

Development work done in the late 1980's as a joint venture by Industrial Galvanizers and Wattyl resulted Wattyl Superetch being recognized as an excellent standard priming system for zinc coatings. Accelerated weathering tests have given salt spray resistance consistently in excess of 1000 hours for a 20 micron Superetch coating over hot dip galvanizing, with most samples easily exceeding 2000 hours salt spray resistance.

The Superetch primer is a single pack epoxy etch primer with the following characteristics:
Positives
- excellent adhesion to galvanized surfaces
- easy application
- fast drying - touch dry in 1 hour
- economical - low cost per litre, high coverage rates
- long weathering performance - does not need overcoating immediately: ideal for pre-construction priming.
- suitable for overcoating with a wide range of topcoats.

Negatives
- Must not be applied to thicknesses in excess of manufacturer's recommendations (20 microns)
- Must be used with compatible topcoats - sensitive to attack by some solvents.
- Not well suited for brush application.
- Not as good as epoxy primers such as Wattyl Sigma EP Universal Primer for heavy-duty (marine) applications

The development of compatible primers such as Superetch has simplified the application of duplex

systems and has been used successfully for 20 years with no field failures yet recorded.
The ultimate goal of single coat application over as-galvanized surfaces is achievable with some coatings and test work done by Industrial galvanizers has shown that moisture cured urethanes can be used in this role.

Single coat paint system for galvanizing is well within reach of currently available technologies. Water based acrylics (familiar to most as house paints such as Wattyl Solarguard, Taubmans Sunproof and Dulux Weathershield) give very good performance when applied directly over galvanized surfaces that are free of oil and grease. While these paints have excellent weathering characteristics (colour and gloss retention and UV resistance), they have relatively poor abrasion and chemical resistance. They do however perform well as architectural finish coats on galvanizing where they will be only exposed to standard environmental exposure.

Moisture cured urethanes have also been found to perform very well when applied directly over hot dip galvanized surfaces. They are relatively costly and the technology is US based so manufacture in Australia is subject to licensing arrangements that have led to some supply uncertainties.

SUMMARY

For a variety of reasons, there has been a significant increase in the tonnage of hot dip galvanized fabricated steelwork specified to be painted after galvanizing. Industrial Galvanizers has been actively involved in the specification and application of duplex coatings for over 20 years. This has included major infrastructure projects with the most stringent quality requirements such as steelwork on the Sydney 2000 Olympic site at Homebush Bay, NSW.

Given an understanding of the technical requirements associated with surface preparation and generic paint selection, very good results can be obtained. The resulting coating system offers long-term durability that will see out the design life of any project to which it is applied.


INDUSTRIAL GALVANIZERS
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SPECIFIERS MANUAL

01 - SPECIFIERS MANUAL — THIRD EDITION

Industrial Galvanizers Australian Galvanizing Division (IGAG) operates nine galvanizing plants around Australia, ranging in size from large structural galvanizing facilities to specialised small plants designed to process small parts.

The Australian Galvanizing Division has galvanized in excess of 2 million tonnes of steel products in Australia since its first plant was commissioned in 1965 and is recognized for its ability to handle complex and difficult projects, as well as routine contracts.

This experience has been collated in the Specifiers Design Manual, to assist those involved in the design of steel products and projects to better understanding the galvanizing process and allow the most durable and cost-effective solutions to be delivered to these products and projects. All sections of this Third Edition have been completely updated and additional sections have been included to provide additional technical information related to the use of hot dip galvanized steel.

In addition to its Australian Galvanizing operations, Industrial Galvanizers Corporation has a network of manufacturing operations in Australia, as well as galvanizing and manufacturing businesses throughout Asia and in the USA.

The company's staff in all these locations will be pleased to assist with advice on design and performance of hot dip galvanized coatings and products. Contact details for each of these locations are located elsewhere in this manual.

This edition of the Industrial Galvanizers Specifiers Manual has been produced in both html and .pdf formats for ease of access and distribution and all documents in the Manual are in .pdf format and can be printed if paper documents are required.

The Specifiers Manual is also accessible in its entirety on the company's web site at www.ingal.com.au.

Additional copies of the Specifiers Manual are available on CD on request.

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