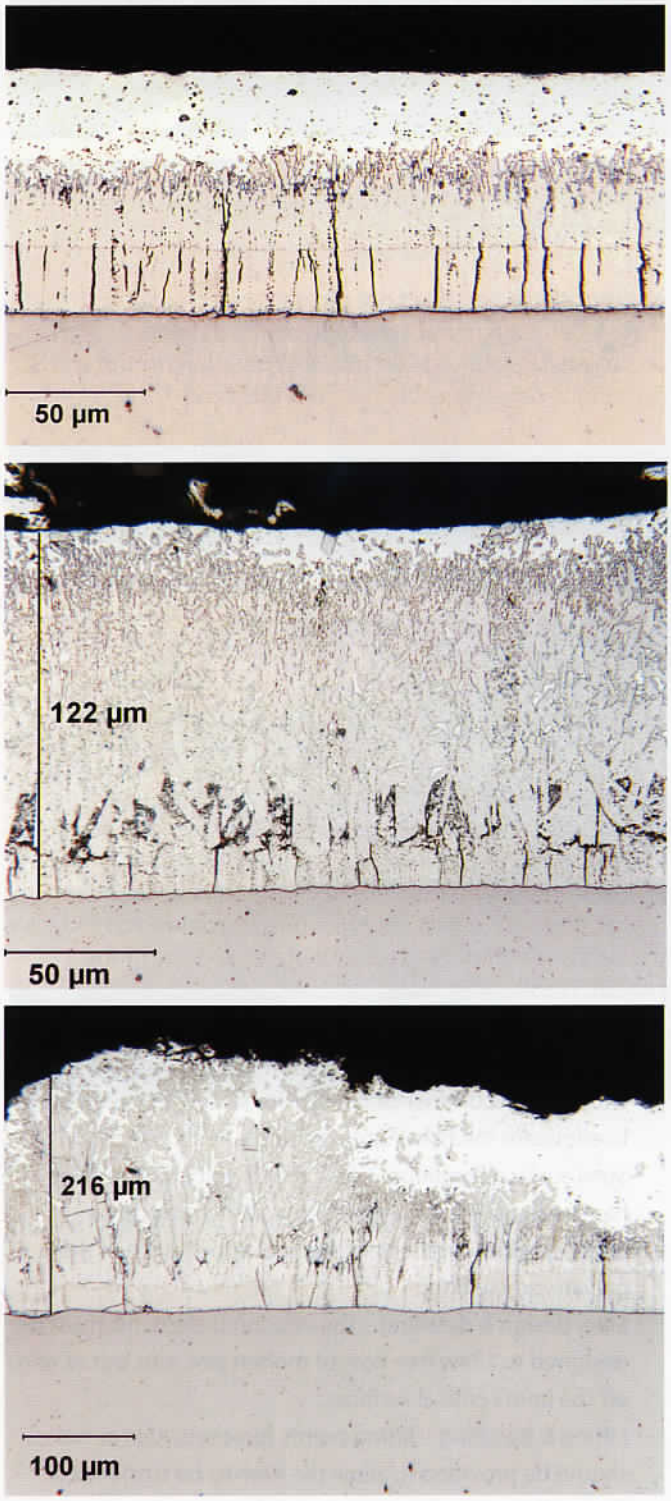
GALVANIZED ACHITECTURAL STRUCTURAL STEEL

Corrosion Management Staff



These micrographs show the effect of steel chemistry and surface condition on galvanized coating appearance. Top: Standard 'shiny' galvanized coating. Centre: Grey coating (no zinc in surface layer) is 100% zinc-iron alloy. Bottom: Flaring of reactive steel coating caused by surface stresses and chemical variations in the steel surface. Raised areas of the galvanized coating show up as striations on the surface.

INTRODUCTION

The hot dip galvanizing industry processes about 300,000 tonnes of fabricated steel annually throughout Australia. Traditionally, much of this fabricated steel has been for industrial or utility use on manufactured products such as grating, trailers and waste bins.

Over the past decade, another market has developed with the greater use of architectural structural steelwork, where the fabricated forms are much more complex and place higher demands on both the fabricators and galvanizers to deliver an acceptable product that meets the aesthetic needs of the designers and their clients.

This has followed the trend in Europe, where very large and complex hot dip galvanized structures have established new levels of architectural excellence, with hot dip galvanized coatings being used to complement the architectural aesthetics of these structures.

The use of hot dip galvanizing as the finish on this steelwork has the benefit of reducing initial coating costs while not compromising the longevity of the structure, as well as providing an anti-corrosion coating that is highly resistant to damage and vandalism.

However, hot dip galvanized coatings are essentially industrial protective coatings that are applied to a wide range of fabricated steel products, manufactured from an equally wide range of steel sections of varying chemistry and surface condition. These matters need to be taken into consideration if a consistently high level of surface finish is required in structures where the galvanized coating is required to complement the architectural characteristics of the structure.

FACTORS AFFECTING SURFACE FINISH & APPEARANCE

Hot dip galvanized coatings are applied to steel after fabrication. This has the advantage of ensuring that all edges, corners, welds and internal surfaces are uniformly coated with a relatively heavy zinc-based coating.

However, most of these fabricated items are two or three-dimensional and may contain hollow sections, gussets and other design details. In addition, these items may be fabricated from different types of steel sections; hot rolled merchant sections or universal section, tubular or rectangular hollow sections or roll formed sections.

Each of these elements will have variations in steel chemistry and surface profile. Hot rolled sections have a relatively rough surface arising from the mill scale embedded in the surface during the hot rolling process.

Tubular and roll formed sections will generally have a smoother surface that is relatively free of mill scale, as some of the final processing of these products is done at ambient temperatures. On the other hand, cold-working of the steel gives rise to surface stresses that will also change the way the steel reacts with the molten zinc during the hot dip galvanizing process.

Any one of these factors can affect the appearance of the galvanized coating. If the item is not designed to allow free flow of molten zinc out of, and off, the fabrication during its withdrawal from the galvanizing bath, the coating will contain drips, runs and drainage spikes and may also have uncoated areas due to airlocks in unventilated corners or zinc puddles in undrained corners.

In addition, the handling of the fabrication through the galvanizing process needs to be considered. Lifting points should be provided (in consultation with the galvanizer) so that the finished coating is not marred by touch-marks caused by contact with chains or jigs.

CHARACTERISTICS OF THE GALVANIZING PROCESS

Hot dip galvanizing differs from other zinc coating processes in a number of ways. The most significant is that the steel components being coated remain in the zinc alloy bath for a relatively long time – typically 5-10 minutes – depending on the size and shape of the fabrication.

Most continuous galvanizing processes used for coating wire, sheet and tube have much shorter immersion times in their respective zinc alloy baths – typically less that 10 seconds.

Galvanized coatings are formed by a metallurgical reaction between the steel and the zinc. This reaction occurs when the steel reaches the temperature of the molten zinc – 455°C. This reaction forms a zinc-iron alloy of crystalline form, that grows from the steel's surface. The thickness of this alloy layer is determined by the time the steel is immersed in the molten zinc alloy, the steel's chemistry, its surface condition and section thickness. On structural sections, this alloy layer is typically about 80 microns in thickness, but may exceed 200 microns on reactive steel. The characteristic shiny appearance of newly galvanized steel is due to the zinc layer that covers the zinc-iron alloy layer as the steel emerges from the molten zinc bath.

It is this alloy layer that provides that additional thickness typical of hot dip galvanized coatings. The alloy layer on continuously galvanized products is very thin – less than 5 microns. The balance of the coating on these products is zinc, the coating thickness of which is determined by the surface tension of the zinc and process control procedures, that wipe excess zinc from the surface to give a final controlled thickness that is typically about 25 microns and is smooth and uniform in appearance.

Steels containing higher levels of silicon (a deoxidizing agent in the steelmaking process) and phosphorous (a residual element arising from the raw materials used in steelmaking), will react more vigorously with the molten zinc alloy and may give rise to hot dip galvanized coatings that are 100% zinc-iron alloy. These types of coatings have a characteristic silver-grey appearance or may be partly shiny and partly grey.

These variations in surface appearance are obviously undesirable if the hot dip galvanized coating is to be used for architectural applications.

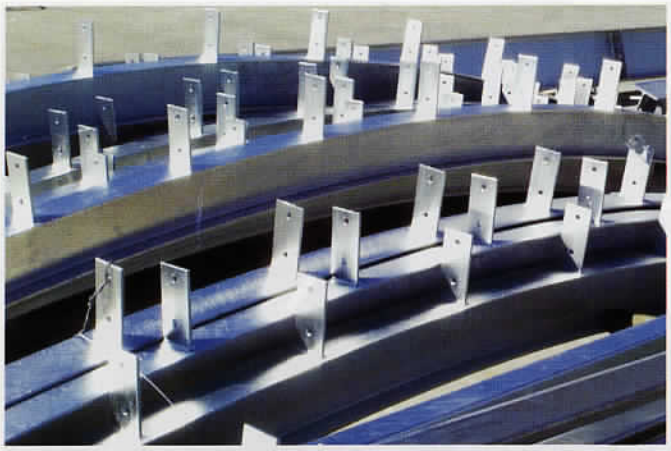
Another characteristic of hot dip galvanized coatings is that they will contain minor surface irregularities arising from components in the molten zinc and variations in surface condition and surface chemistry of the steel.

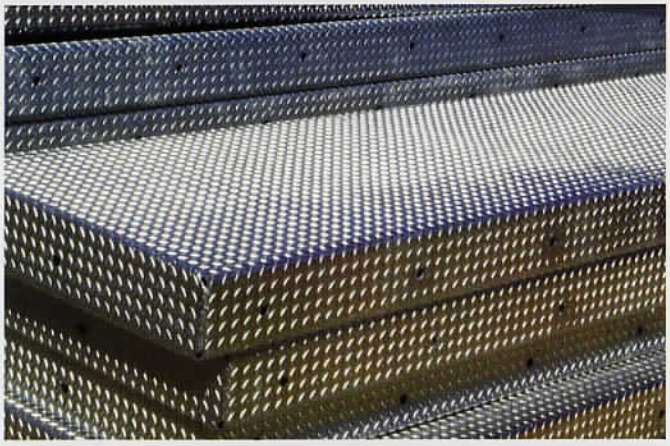
Welded areas will almost always produce heavier hot dip galvanized coatings than adjacent steel sections as weld metal is high in silicon – again used as a deoxidising agent in the welding wire.

ACHIEVING ARCHITECTURALLY ACCEPTABLE HOT DIP GALVANIZED FINISHES

Where a consistent and acceptable architectural self-finish is required, or where hot dip galvanized surfaces are specified to be painted for architectural purposes, there are a number of special requirements that should be considered from design through to delivery. All of these issues need to involve the galvanizer and the fabricator at early stages of the project. These will include:

- Steel specification – ensure that the steel chemistry is within the recommended range for silicon & phosphorous to eliminate the risk of grey coatings.
- Steel surface condition – steel that is rusty or steel that has been subject to heavy cold-working may cause unacceptable variations in the final appearance of the galvanized coating.
- Steel design & detailing – the structural elements must be designed to allow free flow of molten zinc into, out of, and off the item's critical surfaces.
- Lifting & handling – lifting points (brackets, lugs or holes) should be provided to allow the item to be suspended during the galvanizing process without causing touch marks from chains or jigs. The item also needs to be able to be manipulated so that it is withdrawn from the galvanizing bath at a steep enough angle to optimised drainage of the molten zinc off its critical surfaces.





These three examples show how a high standard of hot dip galvanized finish can be achieved if design and steel chemistry are properly specified. Top: Exposed curved roof beams. Centre: 3D checker plate platforms. Bottom: External pipe bracing.

- Dressing of the galvanized coating during the inspection process should be minimised. Areas that are buffed or ground to remove spikes or lumps will oxidise at a different rate in service and give rise to variations in the appearance of the galvanized coating. This is not an issue if the galvanized coating is to be painted.
- Transport – the use of hardwood dunnage during transport & storage, specifically in periods of wet weather, may give rise to staining of the galvanized coating from the tannin in the timber, that is difficult to remove.
- Storage of galvanized items on site must ensure that they are properly drained & well ventilated. Galvanized items that are tightly nested & stored in wet or damp conditions will be subject to white rusting that will seriously affect the appearance of the galvanized coating through the development of heavily oxidised areas that are dark grey & etched into the surface of the galvanized coating.

COST

There will generally be little cost impact in the provision of an architecturally acceptable hot dip galvanized coating unless the galvanizer has to make special provisions for handling the work through the galvanizing process. For example, it may be necessary to limit the number of items galvanized at a time to allow a high level of attention to be given to the items as they emerge from the molten zinc. This reduction in productivity will incur a proportional increase in processing cost.

THE PRACTICAL REALITIES OF ARCHITECTURAL GALVANIZED COATINGS

The hot dip galvanizing process will never produce 'chrome plated' finishes on structural steel fabrications. The coating will always have surface irregularities to a greater or lesser degree, and at the time of specification, realistic benchmarks need to be established between the client and the galvanizer to ensure that what is expected of the hot dip galvanized coating is deliverable.

Where hot dip galvanized coatings are to be painted for architectural reasons, and buffing or linishing of the galvanized coating is not desirable, high gloss finishes may highlight surface irregularities, so lower gloss coatings may be a better option. A very good solution for painting over hot dip galvanized surfaces is to use hammer tone finishes that easily accommodate surface variations in the galvanized coating.

Communication between the stakeholders is the key to achieving good results. The number of variables in the hot dip galvanizing process need to be understood and managed and this cannot be done after the fabrication has been delivered to the galvanizer for processing.

CASE STUDY
SUTERS ARCHITECTS – JOAN SUTHERLAND PERFORMING ARTS CENTRE

Originally opened in 1990, the Joan Sutherland Performing Arts Centre in Penrith, NSW, fulfils a significant role in the cultural and social life of Western Sydney.

The Suters Architects team was commissioned to design the extensions that were needed to accommodate a burgeoning population demanding cultural services. The development has included a new conservatorium, foyer, exhibition space and 400 seat theatre. Essential to the brief from Penrith City Council to incorporate an Ecologically Sustainable Design (ESD) to function in a Penrith summer. This challenge posed considerable difficulties for Suters Architects, namely, to produce a mixed-mode system of cooling air that firstly used less energy, and secondly, was required less often than a standard device for a space of this size.

In addition to the ESD aspects of the project, exposed structural steelwork was incorporated as one of the major aesthetic design elements, as well as being used in engineering the ESD performance into the structure.

For maximum durability, Suters Architects specified hot dip galvanized coating for all of the external structural steel, and in addition, specified a significant proportion of this steelwork to be painted after galvanizing with a simple yet effective acrylic topcoat system.

The specification documents detailed the surface finish required on the steelwork to be painted, as well as nominating the 'uniformity of finish' requirements for hot dip galvanized components that were to remain unpainted.

Penrith Council's Facilities Operations Manager Gary Deane says the Suters team have done a great job in respecting the initiatives of the Council's 'Sustainable Penrith' policy, which was adopted several years ago and has seen the construction of a number of ESD buildings in the area.

Externally, the structure is designed to read like a lantern at night, with uplights illuminating the foyer so that patrons approaching across the piazza can look at the visual story of the mural from a distance, with the internal columns expressing the structural rhythm of the artwork, before entering the building and experiencing the space more intimately. Hot dip galvanizing was chosen to provide longevity and durability to the expressed steel structure of the building in terms of improving the performance of the applied paint coatings to the steel and taking into account the difficulties of long-term maintenance of steel at high levels.

The Joan Sutherland Performing Arts Centre - Penrith NSW - Designed by Suters Architects is a good example of detailed coating specifications ensuring that an acceptable architectual standard of finish was obtained on the galvanized structual steel used throughout the project.

Projects such as the Joan Sutherland Performing Arts Centre go a long way towards changing the perception of environmental innovation being a style-free zone. The building is a testament to the fact that good design and eco-sustainable technology can coexist in a beautiful structure, which will be serving its cultural purposes and the community of Penrith for years to come, keeping people cool without the costing the earth.

For more information on this project, contact: Suters Architects, Suite 118 Lower Deck, Jones Bay Wharf, 26-32 Pirrama Road, PYRMONT NSW 2009, Ph: 02 9660 7100, Fax: 02 9660 7199, Web: www.sutersarchitects.com.au.

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CORROSION MANAGEMENT

CORROSION MANAGEMENT is published for those interested in the specification, application and performance of protective coating systems.

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Cover: BlueScope Steel's Sureline™ galvanized steel power poles under bushfire testing at the Bushfire CRC's field testing facility at Mogo, NSW. All types of bushfire events can be simulated at this facility, used for testing of a variety of building materials.

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These timber poles have been burnt through at the ground line as a result of a grass fire. Coatings & Bushfires feature - Page 4.

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Coatings & Bushfires

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