36 - ZINC COATING PROCESSES -OTHER METHODS

Zinc-based coatings are the world's most widely used coatings for the protection of steel from corrosion.

These coatings are applied using differing technologies, giving rise to zinc coatings with differing mechanical and durability characteristics.

As the obvious reason for applying protective coatings to steel is to prevent it from corroding for as long as possible in its service environment, it is important that the characteristics of the coatings produced by these diverse processed be understood with respect to their relative durability.

There are 5 basic application processes, each of which is associated with alternative technologies. Each of these processes are best suited to particular classes of steel product and no one process is suitable for all types of steel coating. They are:

Hot dip processes: These involve the immersion of pre-treated steel in molten zinc or zinc alloys.

Chemical processes: These involve the electro-deposition of zinc or zinc alloys from a chemical solution in combination with the application of an electric current.

Applied processes: These involve the application of zinc in the form of zinc dust as a pigment in a paint coating, or as a momentarily molten metal spray using a hot metal spray gun.

Diffusion processes: These involve the heating of the steel to below the melting point of zinc while in close contact with zinc dust.

Mechanical processes: These involve the application of a zinc or zinc alloy coating to the surface of small steel parts by rumbling them in a rotating vessel causing the part-to-part impacts to apply an adherent zinc-based coating to the parts

Hot dip processes

The greatest percentage of steel that is zinc coated is processed immersing the steel in molten zinc or zinc alloy. There are two fundamental types of hot dipping processes; continuous and batch galvanizing.

Continuous galvanizing processes

Products such as sheet, wire and tube are commonly continuously galvanized by passing the steel sections through the molten metal during the manufacturing process at relatively high speed – up to 180 metres/minute with some products.

Continuous galvanizing and coating are efficient but have high capital costs. The zinc coating thickness is limited by the high speed of the process

Sheet and wire are fed into the galvanizing process from coils and re-coiled after galvanizing. Tube sections are coated externally after forming in straight lengths, or manufactured from steel coil that has previously been galvanized.

This process produces a galvanized coating that has specific characteristics. These are:

a. The coating is relatively thin and usually around 25 microns in thickness.
b. The coating is almost 100% zinc.
c. The alloying of the zinc to the steel is limited by the high speed of the continuous process. This creates a malleable coating that allows the pre-galvanized sections to be roll formed, bent or pressed in subsequent manufacturing operations.
d. The cutting and punching of the sections in manufacture results in all edges being uncoated. The cathodic protection provided by the zinc coating on adjacent surfaces prevents corrosion of these exposed steel areas.

BATCH GALVANIZING PROCESSES

Batch galvanizing involves processing the steel after fabrication. For larger fabricated items, these are suspended from chains, jigs or head frames to transport the fabricated steel items through the hot dip galvanizing process.

For small parts such as nails, screws and bolts, perforated baskets are used to transport the work through the process and centrifuge the excess zinc from the items as they exit the molten zinc.

The items being processes are immersed in the molten zinc for several minutes. This creates a galvanized coating with its own set of unique metallurgical characteristics. These are:

a. The coating largely comprised zinc-iron alloys arising from the longer immersion time in the molten zinc. The presence of this alloy layer results in a thicker coating usually no thinner than 50 microns on thin sections to more than 200 microns on heavy structural sections.
b. Because the steel items are immersed in molten zinc after fabrication, all surfaces and edges are coated.
c. The appearance of a batch galvanized coating is less smooth and uniform than that on a continuous galvanized product.
d. The alloy layers much are harder than pure zinc (approx. 4X). This gives the batch galvanized coating excellent abrasion resistance but lower flexibility that continuously galvanized coatings, making it unsuitable for forming after galvanizing.

CHEMICAL PROCESSES

Zinc electroplating is widely used to coat small parts, appliance components and builders hardware. The process involves passing the cleaned steel parts through a zinc-bearing solution containing other chemicals to assist in leveling or brightening the coating.

Zinc electroplated coatings are used on a wide range of builders hardware. The relatively thin, pure zinc coating is unsuitable for external applications.

While some proprietary processes can apply relatively heavy zinc plated coatings to steel components, the majority of zinc-electroplated products have coating thicknesses less that 10 microns, making them unsuitable for exterior use.

The characteristics of an electroplated zinc coating are:

a. The coating is bright and uniform. Some products such as screws may have a heavy chromate coating, giving them a brown/yellow appearance, to improve their corrosion resistance.
b. The coating is pure zinc and is quite soft.
c. The coating is relatively thin – usually less than 10 microns, and conforms closely to the surface profile of the steel item, making it suitable for use on small threaded components.

APPLIED PROCESSES

Zinc-rich paints

Zinc can be applied to steel surfaces as zinc-rich paint, where either organic or inorganic binders are heavily loaded with zinc dust as a pigment. Silicate binders are commonly used for inorganic zinc-rich paints and epoxies are the most common of the organic binders used in these paints.

A high level of steel surface cleanliness is required for best results with such paints, with those having

organic binders more tolerant of lower levels of surface condition that the inorganic systems.

Zinc rich paints are well suited to the coating of large structures and for on-site application to structural steelwork of all types.

Steel roofing is now almost 100% Zincalume (zinc-aluminium alloy) coated, and combined with a proprietary paint coating for added appearance and durability. The zinc-aluminium alloy has excellent corrosion resistance for this application.

Zinc metal spraying

Metal sprayed coating are applied by passing zinc dust or wire through an electric arc or gas flame. This melts the metal and deposits the molten metal on the steel's surface. A very high level (Class 3) of steel surface cleanliness is recommended for metal spray applications. Metal sprayed coating have the following characteristics:

a. The coating consists of flattened droplets of zinc mechanically bonded to the steel surface. Some of the zinc (up to 30%) is converted to zinc oxide during the high temperature application process.
b. Very thick (up to 500 micron) coatings can be applied.
c. The newly applied coating is rough and porous. Sealing of the metal-sprayed coating with a polymer coating is recommended for aggressive environments.
d. Only the external surfaces of fabrications can be readily coated.
e. The zinc dust/wire can be alloyed with other metals such as aluminium to improve corrosion resistance.
f. A metal spray gun can deposit approximately 30 kg of zinc per hour with overspray losses up to 30%, depending on the shape of the fabrication. Typical application rate is around 1 kg/m^2. This is a higher cost process than other zinc coating processes.
g. Low heat transfer to the steel minimises distortion risks on thin steel sections.

DIFFUSION PROCESSES

The process of Sherardizing is a diffusion process, where small parts are tumbled in a zinc/sand mixture at a temperature of around 380°C. It is rarely used today because of its low productivity as processing a batch of parts weighing a few hundred kg may take up to 3 hours, with zinc recovery of around 50%

It is well suited to small parts and threaded fasteners, as the coating conforms closely to the surface profile. The items are best cleaned by grit blasting prior to coating. The characteristics of a Sherardized coating are:

a. Coatings applied are typically between 15 and 30 microns in thickness.
b. The coating is 100% alloy layer containing no free zinc. It has a matt gray appearance.
c. The coating is metallurgically bonded to the surface.
d. The coating has good abrasion resistance

MECHANICAL PROCESSES

Mechanical plating of zinc and zinc alloys is now widely used for the protective coating of high strength fasteners such as self-drilling TEC screws. Batches of components are cleaned of oxide deposits and organic contamination and loaded into a rotating barrel with a carefully controlled mixture of metal dust and reaction chemicals.

The batch is processed for about 20 minutes. Glass beads are also used to assist in peening the metal

particles on to the surface. Because of the autogenous nature of the process, the steel items being mechanically plated need to be manufactured from higher strength steel grades to prevent mechanical deformation during the plating process. Zinc-tin alloys mixtures are commonly used in Australia on roofing fasteners to improve their corrosion resistance.

The process is well suited to automation and large numbers of parts can be mechanically plated efficiently in an automated facility.

The characteristics of a mechanically plated coating are:

a. Applied at room temperature
b. Zinc alloy coatings can be used that are difficult to apply by other methods.
c. The coating conforms closely to the profile of the part.
d. The mechanically plated coatings are relatively thin – usually less than 20 microns.
e. The coating may be thinner on edges and corners due to the mechanical impacts intrinsic to the process.

The characteristic that determined durability of zinc coatings in any given environment is the thickness of the coating. This will be dealt with in detail elsewhere in this manual.

SUMMARY

Australian and international standards have been developed for each of the commonly used zinc-coating processes. These standards define coating thickness with respect to the various product classifications. This can, in turn, be used to determine the appropriate coating for a particular durability or manufacturing requirement.

Mechanical plating peens zinc or zinc alloy particles into the steel surface. It is effective on small fasteners where, particularly self-drilling screw where cutting edges must be maintained.

Hot dip galvanizing after fabrication applies a heavy zinc-based coating to a wide range of manufactured products. The zinc-iron alloy layers in the coating provide it with additional abrasion resistance.

Continuous galvanizing processes have been developed for a large range of smaller hollow sections. Some are galvanized externally only and typical coating thickness is approximately 20 microns.


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.

PUBLISHER:
Industrial Galvanizers Australian Galvanizing Division,
PO Box 503, MOOROOKA
QLD 4105
Ph: 07 38597418

EDITOR:
John Robinson,
Mount Townsend Solutions Pty Ltd
PO Box 355, JESMOND NSW 2299
Ph: 0411 886 884
Email: mt.solutions@optusnet.com.au

LAYOUT AND DESIGN:
Adrian Edmunds,
Nodding Dog Design
Ph: 0402 260 734
Email: adrian@noddingdogdesign.com
Web: www.noddingdogdesign.com