Hot Dip Galvanizing

The best protection inside and out

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galvanizers
ASSOCIATION OF AUSTRALIA

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About the GAA

The Galvanizers Association of Australia (GAA), established in 1963, is a not for profit industry association comprising the leading hot dip galvanizing companies throughout Australia.

We conduct research and compile case studies in various areas dealing with corrosion protection and hot dip galvanizing. We also stand on various Australian Standards' committees for galvanizing and related industries.

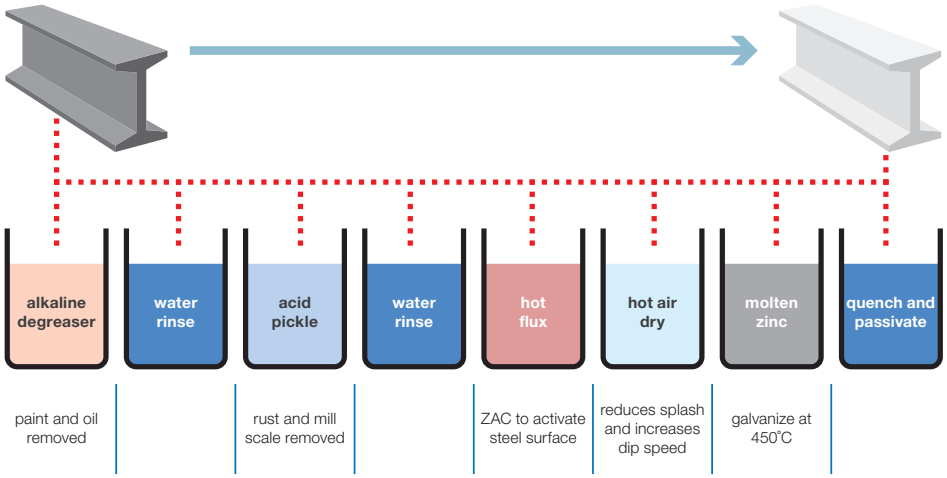
We provide free technical publications and information on all aspects of hot dip galvanizing; including the process, application, durability, design and painting of hot dip galvanized steel. We also conduct informative seminars for architects, engineers and many universities around Australia.

Cover: Craigieburn Train Maintenance Facility (Architect: HBO + EMTB, Photographer: Dianna Snape).

This page: Qantas Sound Wall, Sydney Airport by Woolacotts Consulting Engineers.

Hot dip galvanizing process

The hot dip galvanizing process starts by suspending steel articles and dipping them into a series of cleaning baths. Once cleaned, the steel is lowered at an angle into a bath of molten zinc. Immersing the steel on an angle allows air to escape from vented tubular shapes or pockets that may be within the design and permits the molten zinc to displace the air. The steel reacts with the molten zinc to form the galvanized coating. After being withdrawn from the zinc, the final step in most hot dip galvanizing processes is a quench to promote passivation of the zinc surface.

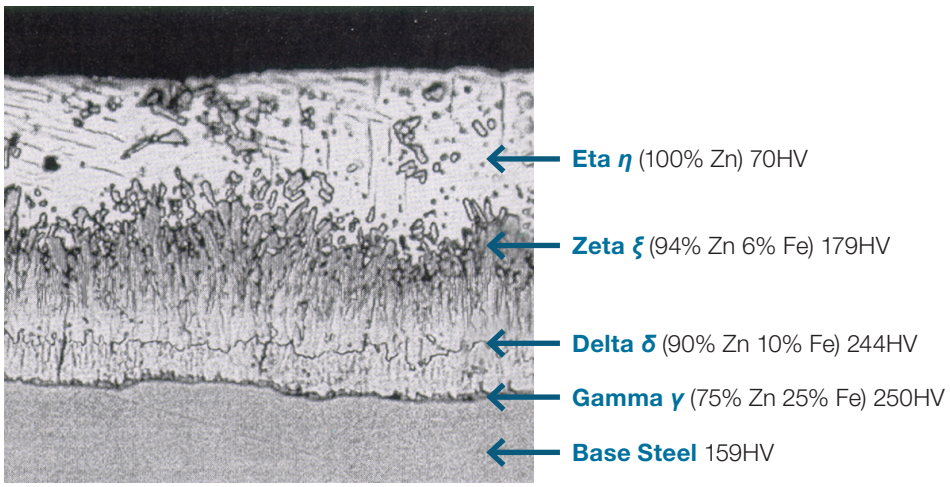


Structure of coating

The formation of the galvanized coating on the steel surface is a metallurgical reaction, where the zinc and steel combine to form a series of hard intermetallic layers. The outer layer is, typically, 100% zinc which covers the surface after withdrawal from the molten zinc bath.

The gamma, delta and zeta alloy layers are all harder than the base steel they are metallurgically bonded to, which gives hot dip galvanizing its great abrasion resistance.

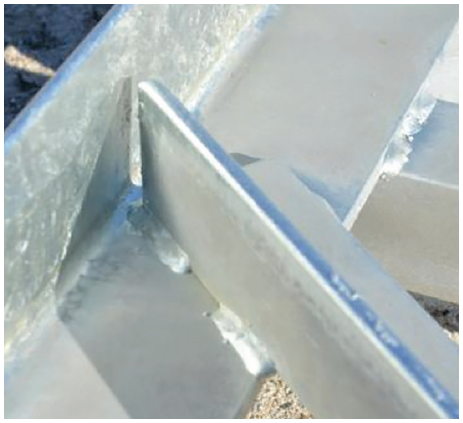
The galvanizing process naturally produces coatings on the corners and edges which are at least as thick as the coating on the rest of the article. As the reaction between iron and zinc is a diffusion reaction, the crystalline structure of the coating forms perpendicular to the steel surface.



Specification of hot dip galvanizing

AS/NZS 4680 is the Australian/New Zealand Standard for hot dip galvanized coatings on fabricated iron and steel articles. It specifies the requirements of the coating and includes information on coating mass and thickness, appearance and freedom from defects as well as suitable repair methods.

Compliance to Standard is easily confirmed.



Good design allows for higher quality coatings and increased durability.

Inside of Craigieburn Train Maintenance Facility.

Coating thickness

AS/NZS 4680 provides requirements for coating thickness, based on the steel article thickness. A requirement for the 2025 edition of AS/NZS 4680 introduces new coating thicknesses for ultra-low reactive steels, commonly found on laser plate steels.

Inspection

Inspecting galvanized steel is a simple process. Zinc will not adhere to or react with unclean steel; therefore, a visual inspection of the product provides a good assessment of the quality of the coating. The coating thickness is usually tested using a magnetic thickness gauge. The testing and sampling requirements are contained in the appropriate specification for the product (AS/NZS 4680 and AS/NZS 1214).

Freedom from defects

The primary purpose of galvanized coatings is to protect against corrosion and aesthetics are usually a secondary requirement. However, the coating must be free from sharp points, undue roughness and uncoated areas. The integrity of the coating can be determined by simple visual inspection and coating thickness measurements. A galvanized coating should be sufficiently adherent to withstand normal handling during transport and erection.

Table 1: Nominal average coating thickness and mass from a selected range of steel types and thicknesses

	Steel thickness and Nominal minimum galvanized coating thickness and mass							
Steel type	**> 6 mm**		**> 3 mm to ≤ 6 mm**		**≥ 1.5 mm to ≤ 3 mm**		**< 1.5 mm**	
	Thickness (µm)	Mass (g/m^2)	Thickness (µm)	Mass (g/m^2)	Thickness (µm)	Mass (g/m^2)	Thickness (µm)	Mass (g/m^2)
Normal	85	600	70	500	55	390	45	320
Ultra-low Reactive	70	500	55	390	45	320	NA	NA

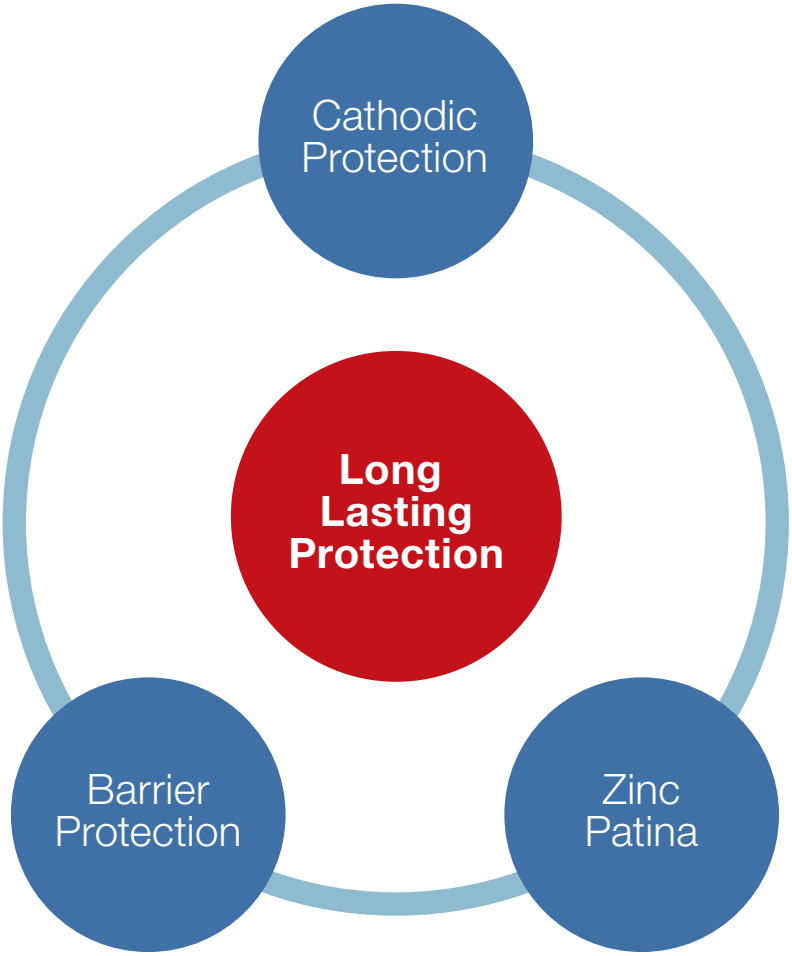
Three types of protection

Barrier protection, cathodic protection and the zinc patina are what provide the galvanized coating with its long-lasting protection.

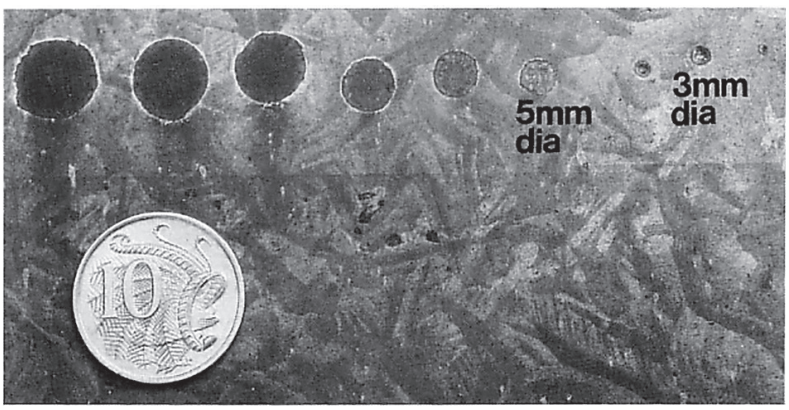
1 The galvanized coating provides complete coverage of all steel surfaces and acts as a **barrier** protecting the steel from the surrounding environment.

2 The galvanized coating **cathodically protects** the steel from coating imperfections caused by accidental abrasion, cutting, drilling, or bending.

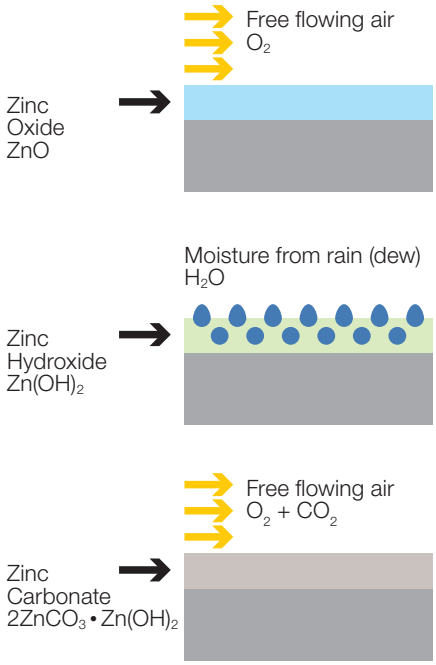
3 The **zinc patina** is insoluble and passive, which slows the corrosion rate of the zinc. The zinc patina is a critical part of the galvanized coating's longevity and requires natural wet and dry cycles to form.



Only hot dip galvanizing can provide barrier protection to this bridge rail, inside and out.



The galvanized steel test piece has had circular areas of the coating removed before exposure in a severe industrial environment. Sacrificial protection is provided by the surrounding galvanized coating and has prevented corrosion of the exposed circles up to 3mm diameter and minimised corrosion of the 5mm circle. Larger circles also exhibit corrosion-free annular areas adjacent to the surrounding coating.

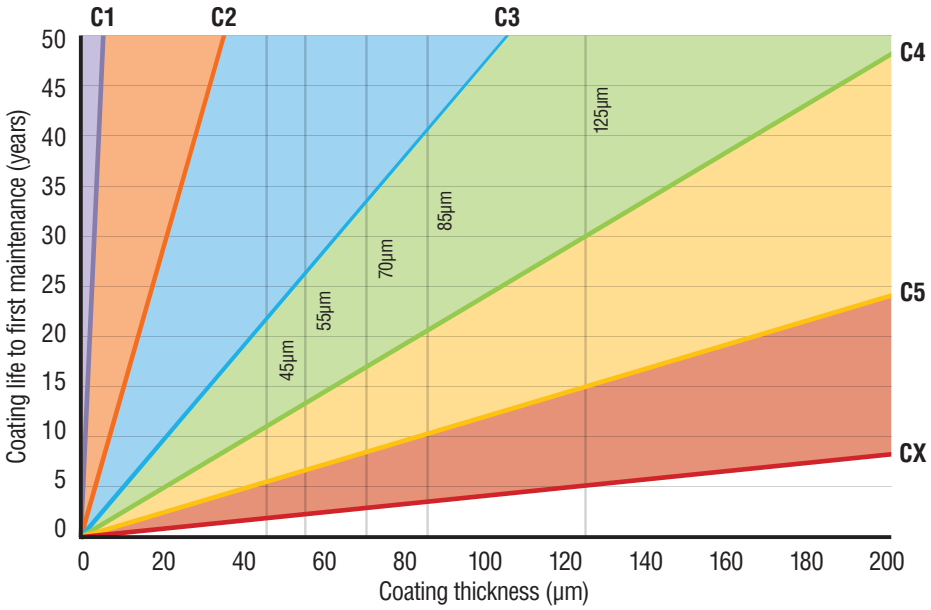


Above: The zinc patina begins its development with exposure to oxygen in the atmosphere. Moisture from rain or humid air reacts with this layer to form zinc hydroxide. This layer then reacts with carbon dioxide present in the atmosphere to form the tightly adherent, insoluble zinc patina.

Durability of hot dip galvanized coatings

Hot dip galvanizing has proven to be more serviceable and predictable than all other steel protective coatings in the Australian atmosphere. Its excellent performance is due to its inherent corrosion resistance, high tolerance to mechanical damage and inertness to the high UV levels prevailing over all of Australia.

The corrosivity of atmospheric environments have been widely researched and the corrosion rates of both steel and zinc are classified in Australian Standards as a function of the temperature, relative humidity, the amount of airborne salinity and the amount of airborne pollution present. AS 4312 defines the corrosivity categories for Australia, while AS/NZS 2312.2 provides detailed guidance on design and durability of hot dip galvanized coatings for each of these categories.



The life of a hot dip galvanized coating is (to a first approximation) proportional to its thickness, which is normally a function of the article's steel thickness.

The chart shows that steel with an initial coating thickness of 85µm in a C4 corrosivity zone will have an expected life to first maintenance of 20–40 years.

Table 2 Life to first maintenance of hot dip galvanized steel complying to AS/NZS 4680 (normal steels)

AS/NZS 4680 (normal steels)				AS/NZS 2312.2				
Steel thickness	Coating mass and thickness			Corrosivity category and zinc corrosion rates (µm/y)[a] & Life to first maintenance (years)				
mm	g/m²	µm	Designation	CX 8.4 – ≤ 25	C5 4.2 – ≤ 8.4	C4 2.1 – ≤ 4.2	C3 0.7 – ≤ 2.1	C2 0.1 – ≤ 0.7
> 6.0	600	85	HDG600	3-10	10-20	20-40	40->100	>100
> 3.0 to ≤ 6.0	500	70	HDG500	2-8	8-16	16-33	33-100	>100
≥ 1.5 to ≤ 3.0	390	55	HDG390	2-6	6-13	13-26	26-78	78->100
< 1.5	320	45	HDG320	1-5	5-10	10-21	21-64	64->100
>> 6.0[b]	900[b]	125[b]	HDG900[b]	5-15	15-30	30-60	60->100	>100

Notes:

a. Corrosivity categories and first year zinc corrosion rates are defined in AS 4312 and AS/NZS 2312 Part 2. ISO 9224 also provides steady-state corrosion rates that allow for significantly increased durability estimates where the steady-state corrosion rates dominate the local corrosion rates. See also the GAA/GANZ Guide to the Durability of Hot Dip Galvanizing.

b. This designation for hot dip galvanized coatings thicker than 85 µm is not detailed in AS/NZS 4680, however by agreement with the galvanizer and where the steel has suitable chemical properties and appropriate thickness, a specification may be written for thicker coatings. By way of example, hot rolled sections above 10 mm in thickness are often suitable. See GAA/GANZ Advisory Note AN 02 for more information.

Table 3 Life to first maintenance of hot dip galvanized steel complying to AS/NZS 4680 (ultra-low reactive steels)

AS/NZS 4680 (ultra-low reactive steels)				AS/NZS 2312.2				
Steel thickness	Coating mass and thickness			Corrosivity category and zinc corrosion rates (µm/y) & Life to first maintenance (years)				
mm	g/m²	µm	Designation	CX 8.4 – ≤ 25	C5 4.2 – ≤ 8.4	C4 2.1 – ≤ 4.2	C3 0.7 – ≤ 2.1	C2 0.1 – ≤ 0.7
> 6.0	500	70	HDG500	2-8	8-16	16-33	33-100	>100
> 3.0 to ≤ 6.0	390	55	HDG390	2-6	6-13	13-26	26-78	78->100
≥ 1.5 to ≤ 3.0	320	45	HDG320	1-5	5-10	10-21	21-64	64->100

Note:

Ultra-low reactive steels are those that exhibit low reactivity with zinc. In most cases the durability reduction due to the naturally thinner coating is not significant. Options to obtain a thicker coating via blasting or duplex coating are discussed in AS/NZS 4680 and GAA/GANZ Advisory Note AN 02.

Sustainability and circularity benefits

Hot dip galvanizing has a low initial cost and is nearly always the cheapest long term cost solution for corrosion protection of steel.

Hot dip galvanized steel can provide innovative solutions that optimise durability and facilitate circularity of steel structures and components. These solutions can be easily implemented within the Make, Use, Reuse, Remake and Recycle circularity options.

Any item that has been originally hot dip galvanized can be regalvanized an infinite number of times without loss of properties. Often even steel structures that were not originally hot dip galvanized can be prepared and hot dip galvanized to facilitate the Reuse phase, providing significant carbon footprint savings.

Painting over hot dip galvanizing

Painting of hot dip galvanized steel (known as duplex coatings) is sometimes required for decorative purposes, to provide an identifying colour or to enhance the service life of the article. AS/NZS 2312.2 provides a range of duplex systems that provide both aesthetic and increased durability options.

The GAA can provide guidelines which direct specifiers and applicators to recommended paint systems and advice on surface preparation and application practices that will provide a durable paint finish over galvanizing for a particular application. Where a paint or similar type coating is to be applied to the galvanized coating, the galvanizer should be advised at the time of order.

The Moment by Damien Vick. Paint over galvanized steel sculpture in Melbourne, Australia.

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Design Manual website

GAA website

We provide information, publications and assistance on all aspects of design, performance and applications of hot dip galvanizing.

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