11. DESIGNING FOR GALVANIZING

INTRODUCTION

The successful hot dip galvanizing of fabricated steelwork is heavily dependent on its design. To be satisfactorily galvanized, the fabrication must be immersed in a series of pre-treatment baths to prepare the surface for galvanizing, and then be immersed in a bath of molten zinc.

The cross bracing in this tin-walled spiral welded pipe p;revents the ends from sagging under their own weight during galvanizing.

If the pre-treatment chemicals and the molten zinc cannot get access to all surfaces of the fabrication, it will not be galvanized in areas that are not accessible.

Fabrication techniques can also either create or alleviate problems in the galvanizing process.

Industrial galvanizers Australian Galvanizing Division technical sales staff are available to advise on design, and will assist with design detailing prior to fabrication to ensure that a high quality hot-dip galvanized coating is applied to customers' projects.

IMPORTANT DESIGN FACTORS

There are a number of fundamental considerations when designing a steel fabrication for hot-dip galvanizing. The key issues are:

- The molten zinc will not react with the steel to form the galvanized coating unless the surface of the steel is perfectly clean.
- The hot-dip galvanized coating will not form unless the zinc can intimately contact the steel.
- The hot-dip galvanized coating will not form unless the steel is heated to 450-455°C.
- Items larger than the galvanizing bath in two dimensions cannot be galvanized.
- The density of steel is 7850 kg/m^3. The density of molten zinc is 6620 kg/m^3. If a hollow section traps 18% of its internal volume as air, it will not sink in the molten zinc.
- Steel sections of differing section thickness heat up and cool down at different rates. Unbalanced sections causing differential heating and cooling will increase the risk of distortion.
- Structural grades of steel lose 50% of their yield strength at galvanizing temperatures. The design of the fabrications for galvanizing must take this into account to prevent sagging or bending under self-loads.
- Overlapping surfaces should be fully sealed. Large overlapping surfaces exceeding 400 cm^2 should be provided with vent holes.
- The size of the item that can be galvanized will be governed by the size of the galvanizing bath. Long items can be galvanized by double-end dipping but items large than the galvanizing bath in two dimensions cannot be galvanized.

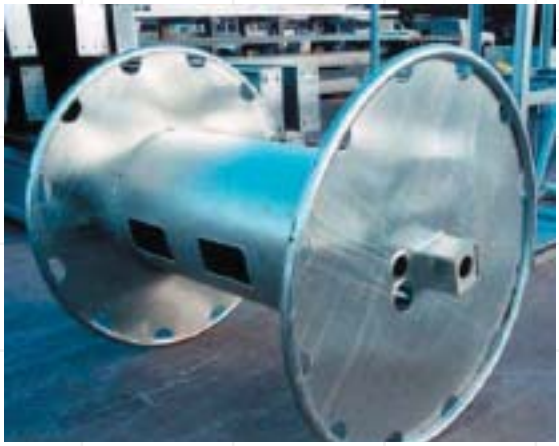
For standard fabrications, a basic set of design rules should be applied. These design steps do not add to the fabrication cost but will ensure a good quality outcome. These are;

- Gussets and stiffeners should be cropped.
- End plates or base plates on columns. Universal sections should have vent/drain holes in the corners of the web/flange connection and hollow sections should have vent/drain holes in the internal extremities.
- Outward facing channels and angles in fabricated frames eliminate the need for vent and drain holes, contrary to inward facing sections.
- Terminating bracing short of adjacent flanges eliminates the need for cropping or vent holes.

VENTING AND DRAINING RULES

One of the most common issues in designing fabrications for hot dip galvanizing is ensuring that fabrications are vented and drained correctly. All steel to be galvanized needs to be immersed in molten zinc and the zinc needs to be able to flow freely into and out of all hollow sections and corners
The flow of molten zinc into, off, and out of the fabrication is one of the most important factors in determining the final quality of the coating. Inadequate venting and draining can cause the following galvanized coating defects:

- Misses in the coating caused by air locks preventing molten zinc contacting the steel surface.
- Puddling of zinc in corners, wasting zinc and interfering with subsequent assembly
- Ash trapped on zinc surface causing surface defects
- Irregularities in surface appearance caused by erratic immersion and withdrawal because of the item floating or trapping zinc internally
- Thick zinc runs on surface caused by zinc freezing during draining
- Steel is only about 15% heavier than zinc. A relatively small amount of air trapped inside a hollow section will prevent the section from sinking in the molten zinc
- Any water trapped inside a hollow section will expand 1750 times its original volume as steam and generate pressures as high as 50 MPa (7250 psi).



Good design for galvanizing on this cable spool produces a high quality result. All hollow sections are well ventilated and drained, as is the flange rim.

By lifting long items in chains connected to cleats or lifting lugs allows steep withdrawal angles and avoids chain touch marks on the fabrication.

BASIC VENTING RULES

- No vent hole should be smaller than 8 mm
- The preferred minimum size is 12 mm
- About 200 grams of zinc ash will be produced for each square metre of steel surface galvanized. This ash is a powder and will not pass through small openings. Venting large internal areas required larger vent holes to allow ash to escape
- Hollow vessels require 1250 mm^2 of vent hole for each cubic metre of enclosed volume. This means that a 40 mm^2 diameter hole is required for each cubic metre of volume
- Hollow sections such as tube, RHS and SHS require minimum vent hole area equivalent to 25% of the section' diagonal cross section
- Vent holes should be at the edges of hollow sections

BASIC DRAINING RULES

- No drain hole should be less than 10 mm
- Preferred minimum drain hole size is 25 mm
- Large hollow sections (tanks, pressure vessels) require a 100 mm diameter drain hole for each cubic metre of enclosed volume
- Drain holes should be at the edges of hollow sections.
- Hollow sections such as tube, RHS and SHS require minimum drain hole area equivalent to 25% of the section' diagonal cross section. The preferred design option is to leave the ends of tubes, RHS and SHS open.

TABLE OF VENT AND DRAIN HOLE SIZES FOR VARIOUS HOLLOW SECTIONS – RECOMMENDED MINIMUMS

Circular Hollow Section Nominal bore mm	Rectangular Hollow Section Size mm	Square Hollow Section Size mm	Vent Hole Diameter mm	
			Single	Double
8				8
10				10
15				10
20		13x13		10
25		16x16		10
32		19x19		10
40	38x19	25x25		10
50	38x25	32x32	12	2x10
65	64x38, 76x38	51x51	16	2x12
80	76x51, 89x38	64x64	20	2x14
100	102x51, 102x76	76x76	25	2x18
	127x51, 127x64	89x89	25	2x18
125	27x76, 152x76	102x102	32	2x22
150	152x102	127x127	38	2x27
200	203x102, 203x152	152x152	50	2x35
250	254x152	203x203	63	2x45
300	305x203	254x254	75	2x54
350	305x254	305x305	88	2x63
400			100	2x70

TABLE OF VENT AND DRAIN HOLES FOR TANKS AND PRESSURE VESSELS

Capacity - litres	Single drain hole diam mm.	Double drain hole diam. mm	Vent hole diam. mm
500	80		25
1000	115	2x80	40
1500	140	2x100	45
2000	160	2x115	55
2500	175	2x125	60
3000	200	2x140	70
3500	225	2x150	75
4000	225	2x160	80
4500	240	2x170	85
5000	250	2x175	90
5500	265	2x185	95
6000	280	2x200	100
7000	300	2x220	110
8000	325	2x225	115
9000	350	2x240	120
10000	350	2x250	125

AVOIDING DISTORTION

When steel sections or fabrications are immersed in molten zinc, their temperature is raised to that of the molten zinc which is typically 455°C. The rate at which the steel will reach this temperature across its entire surface will depend on:

- the thickness of the sections used in fabricating the item
- the rate at which the item can be immersed in the molten zinc
- the total mass of the item
- the dimension of the item - large items exceeding bath dimension require double-dipping.

At galvanizing temperatures, there is no change to steel's metallurgical micro-structure and the galvanizing process is not hot enough to have any affect on the mechanical properties of the steel after galvanizing.

Large and complex fabrications can be hot dip galvanized by double dipping. This large spiral staircase is half-way through the dipping process.

However, at galvanizing temperatures, the yield strength of steel is lowered by approximately 50%. If the adjacent steel is not at the same temperature and any stresses exist, the weaker area will be subject to movement by the stronger area. There is a responsibility on the designer, the fabricator and the galvanizer to co-operate in ensuring that distortion risks are minimised or eliminated.

USE DESIGN AND FABRICATION TECHNIQUES TO AVOID DISTORTION

This pipe bracing has been correctly designed with multiple vent and drain holes at each end of the hollow sections.

- Design and fabricate sections of uniform steel thickness.
- Use symmetrical designs where possible, and avoid asymmetrical designs where cleats or plates are welded to one side only of a beam or RHS section.
- Avoid designs that require fabrications with a large surface area of thin plate to be double-dip galvanized.
- During fabrication use balanced or staggered welding techniques to avoid uneven locked-in stresses.
- If cutting a plate to size, ensure all sides are cut using the same technique. Guillotine is the preferred cutting technique.
- Ensure that the structural design of the item is sufficient to support its own weight at 50% of the steel specified yield strength. Consider temporary bracing if potential to yield exists.
- Ensure that venting and draining holes are adequate. This will allow the item to be immersed and withdrawn from the molten zinc as quickly as possible.
- During fabrication, accurately pre-form parts to avoid force or restraint during welding.
- Consider (or consult your galvanizer) the hanging requirements for the hot dip galvanizing process. This will ensure the fabrication is adequately supported throughout the process.
- The faster the fabrication can be immersed in the zinc, the more uniformly it will be heated to galvanizing temperature and the risk of distortion will be significantly reduced.. This will be determined by its overall design, venting and draining characteristics and ease of handling.

ITEMS THAT ARE PRONE TO DISTORTION

Most steel sections and fabrications that are hot dip galvanized never give rise to distortion problems. However, certain types of products have a high risk of losing dimensional stability during the galvanizing process. Some examples are:

- Thin (6 mm and under) flat sheet and plate will almost always ripple or buckle unless it is ribbed or corrugated. Flat steel sheet used for box trailer floors will always buckle when the trailer is galvanized. The ribbed sections of the same thickness (1 mm) used for the side sections will rarely buckle.
- Long lengths of light wall pipe (spiral or seam welded) or other long, thin sections can be prone to bending during the galvanizing process. As the yield strength of the steel is halved at galvanizing temperature, long lengths of light section can bend or distort under their own weight. This can be avoided by designing dipping equipment that supports the product or by adequate hanging or support points along the length of the section.
- Floor plate welded to heavier structural framework render the fabrication prone to distortion because of differential expansion and contraction of the plate and structural sections. The framework and the plate should be galvanized separately and then mechanically fixed.
- Welded beams with a flange to web thickness ratio of greater than 2:1, particularly long beams that need to be double-dipped, may present a risk of distortion. Web depths exceeding 800 mm should also be treated with caution, particularly where web thickness is 10 mm or less. Your galvanizer should be consulted at the design stage to ensure satisfactory processing of these types of products as the handling of the sections through the galvanizing process is critical to achieving satisfactory result.
- Fabrications containing large areas of asymmetrical welds (e.g. crane beams). The welding stresses built into these fabrications will significantly increase the risk of distortion as the temperature of the galvanizing process will stress relieve the fabrication.

Large fabrications can be galvanized by double-end dipping as long as they do not exceed galvanizing bath size in two dimensions.

These usiversal beams have been masked on the top flange to prevent the galvanized coating forming. This has been implemented by the galvanizer to allow shear studs to be welded to the beams on site. The galvanized coating interferes with the resistance welding of these connections.

In most cases, distortion risks can be minimised or designed out of fabrications in consultation with the galvanizer.

CLEARANCES FOR MOVING PARTS

The surface tension of molten zinc is such that it will not flow feely in or out of gaps of 1 mm or less. When moving parts are incorporated into fabricated assemblies to be subsequently galvanized, a clearance of at least 2 mm should be provided.

If the parts are galvanized separately, a smaller clearance of 1 mm can be used.

DESIGN FOR HANDLING

All items to be galvanized must be able to be suspended or supported through the galvanizing process. Small or short items are suspended by wire or hooks from the galvanizing head frames. Smooth items such as tube may require holes to allow wiring up of the items.

Long sections such as beams, columns or large pipes are best provided with lifting lugs to avoid chain marks on the galvanized surface. To best support long slender items during galvanizing the location of lifting lugs can be advised by the galvanizer.

Where regular quantities of standard products are to be galvanized, special galvanizing jigs can be designed to facilitate productivity and ensure uniform quality.

SUMMARY

Good design for galvanizing is also good anti-corrosion design, as the fabrications will facilitate the good drainage of the items in service if they are exposed to the elements.

Consultation with Industrial Galvanizers' technical sales staff at the design stage will also ensure that items can be galvanized most efficiently and at the lowest cost.

3-D fabrications made up of complex hollow sections require careful design detailing to ensure they can be successfully hot dip galvanized, because of the venting and draining requirements of the individual elements.

Large hollow vessels such as this water tank require large vent and drain holes to ensure that molten zinc can flow in and out. A tank of this size would hold nearly 15 tonnes of molten zinc.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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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