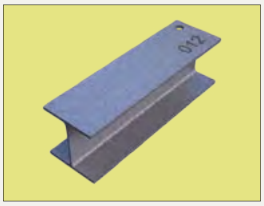
Design Guide for Hot Dip Galvanizing – best practice for venting and draining

galvanizers
ASSOCIATION OF AUSTRALIA

Contents

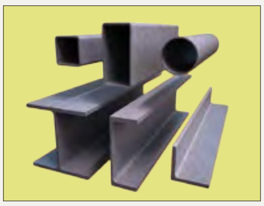
Introduction 3



Importance of Venting and Draining 4
- Purpose
- Safety
- Quality
- Aesthetics

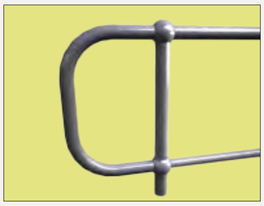
General Principles 6
- Hanging & Handling
- Hole Position
- Hole Size
- Size & Weight
- Distortion

Structural Sections 13
- Hollow Sections
- Hot-rolled Sections



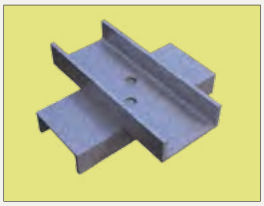
Frames and Fabrications 19

Handrails/ Balustrades 25



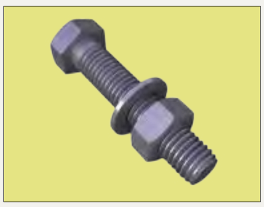
Hollow Vessels 28

Overlapping Surfaces 29



Moving Parts 32

Threaded Items 33



Appendices 34

Introduction

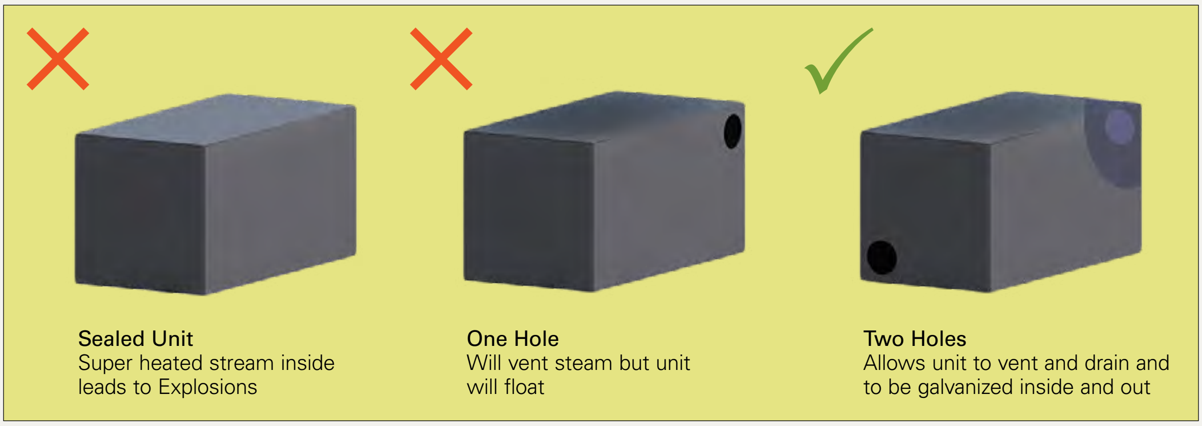
It is important to consider the corrosion protection of ferrous articles when they are being designed. The key factors to consider when designing for hot dip galvanizing are the design's impact on:

- Safety during the process
- Quality of the coating
- Aesthetics

This guide provides general information on basic design and detailing practice, including venting and draining, to assist in the safe and quality hot dip galvanizing of articles.

Importance of Venting and Draining

Figure 1: Purpose of Venting and Draining



Purpose

Formation of the hot dip galvanized coating occurs from the reaction of ferrous metal and molten zinc. The ferrous metal needs to have a clean, unoxidised surface for the molten zinc to react with it.

The purpose of venting and draining is to ensure the article can be immersed and withdrawn from each stage in the process in a safe, efficient and effective manner. Both the pre-treatment solutions (to clean the article) and the molten zinc must be able to flow freely into and around the article so contact is made with all surfaces and all air is displaced. In turn, the liquids must then be able to flow out of and run off the article.

Safety

Immersion of a sealed article into molten zinc will result in any trapped moisture becoming super-heated steam inside the article and will lead to an explosion (Figure 1). Any trapped fluid from the pre-treatment will expand rapidly when dipped in molten zinc and is also a safety concern.

Trapped air due to an inadequately vented area of an article has two effects on galvanizing:

1) Will stop the pre-treatment solutions from cleaning that section of article and/or prevent zinc contacting the surface so the galvanized coating will not form, creating a bare spot.
2) Can cause the article to float in the zinc bath, due to the similar densities of molten zinc and steel. For hollow sections, a general rule is if an article contains more than 15% of its internal volume as air, it will not sink in the molten zinc.

Hence, vent holes need to be provided to allow air and moisture to escape.

The density and viscosity of molten zinc are also important factors in allowing adequate drainage of molten zinc from articles.

Quality

The size of holes for venting and draining, as well as their placement, has an impact on immersion and withdrawal.

Trapped air and fluid, as well as being a safety concern, can cause quality issues (for example, bare spots on the surface). Larger holes allow faster flow of zinc in and out of the article, making immersion and withdrawal easier. This results in a better quality finish.

Slow flowing zinc from inadequate holes tends to produce unsightly zinc runs and pimples.

Inadequate venting and draining of steel with a more reactive chemistry will grow thicker, duller and more brittle coatings if the article can only be immersed and withdrawn slowly from the bath.

If the molten zinc is not readily drained from in or around the article, it may become excessive dead weight on the article or the lifting equipment. This can cause dimensional instability for thin walled hollow vessels (e.g. tanks).

Aesthetics

Factors affecting the quality of the hot dip galvanized coating may also impact on aesthetics.

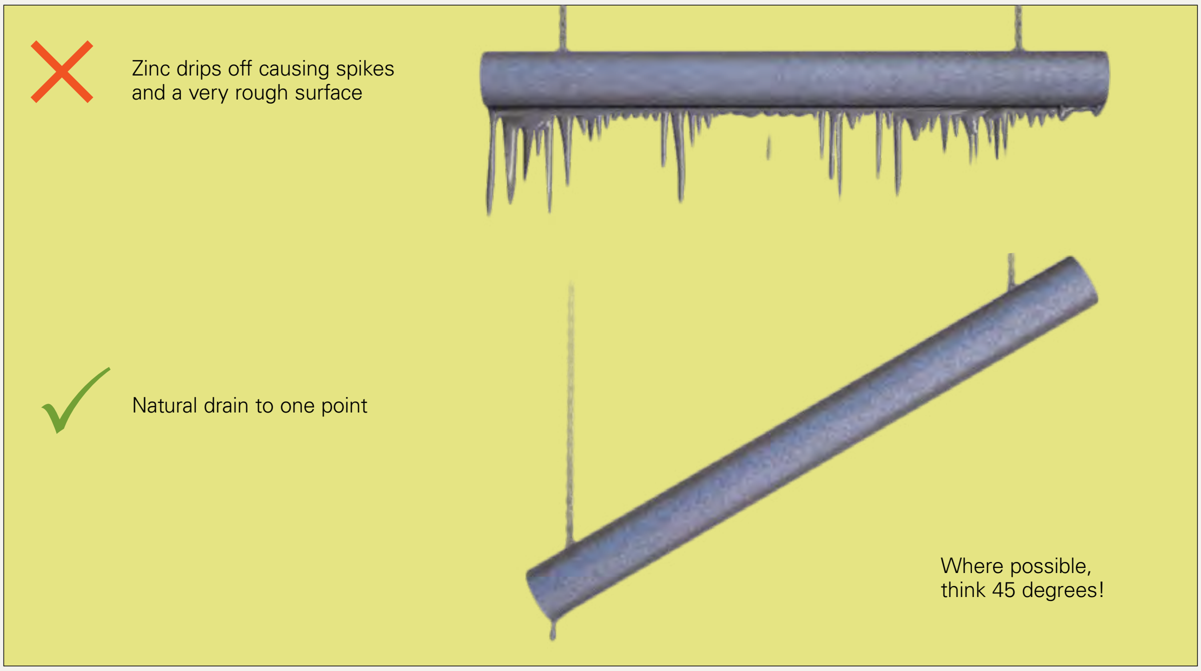
Hole placement for venting and draining may be an aesthetic issue and should be addressed at the design stage of the article. For example, the choice of hollow or open structural sections will effect the amount, type and location of venting and draining needed in order for the article to be safely galvanized.

The availability of good hanging points for the article is another factor that will improve aesthetics.

Any specific requirements with regards to aesthetics should be discussed with the galvanizer during the design stage or prior to fabrication.

General Principles

Figure 2: Hanging for Drainage Quality



Hanging and Handling

Facilities exist to galvanize components of virtually any size and shape, depending on handling equipment and layout of the galvanizing plant.

Most articles to be hot dip galvanized will be suspended from a jig and/or overhead crane using wires, chains, brackets or hooks while being processed.

The maximum size and weight that a particular galvanizer can process should always be checked at the design stage.

A directory listing the dimensions of all galvanizing baths operated by GAA members is available on the website: **www.gaa.com.au**

Adequate hanging points should be provided, e.g. suspension holes or lugs, taking into consideration article size and the lifting capacity of equipment.

For long, straight sections, 2 lifting lugs are preferred to avoid wire or chain marks.

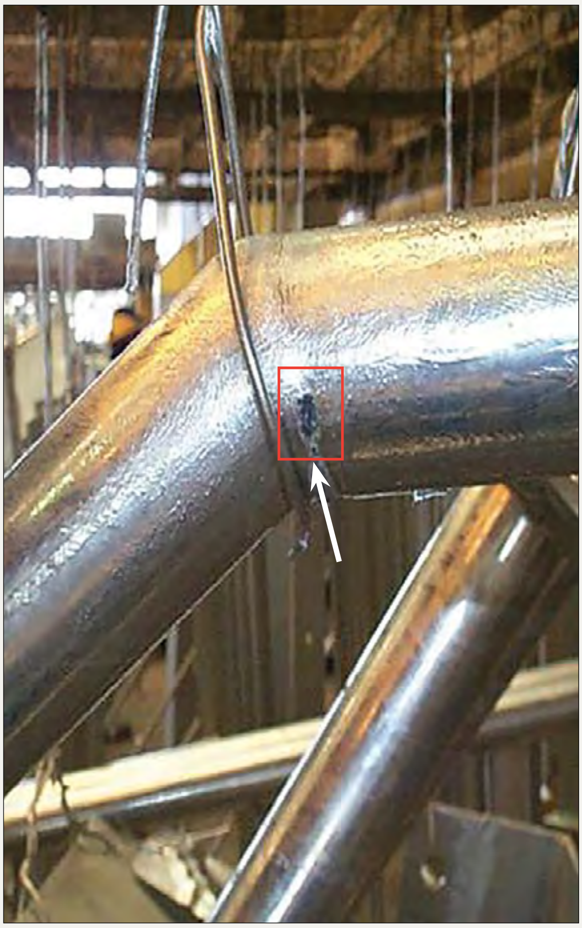
Where possible, articles are hung on a 45° angle (approximately) to ensure efficient drainage of pre-treatment solutions and molten zinc. This avoids rough surfaces and lets the air escape from the highest point, preventing explosions.

Long items will often be withdrawn from the bath at a shallow angle to avoid the lower submerged end from touching the bottom of the kettle. A shallow withdrawal angle causes the zinc to flow off at a slower rate leading to a heavier zinc layer on the top surface and greater quantities of ash trapped on the bottom surface of the steel article.

Small items such as fasteners, nuts and brackets may be placed into baskets rather than hung. See *'Centrifuging process'* for more information.

Items longer or deeper than the bath size may be galvanized by using a double-dipping method. See *'Double dipping process'* for more information. In these cases, material handling considerations will impact on cost. A better method may be to use bolted connections or modules for assembling post galvanizing.

Figure 3: Touch marks may not be avoidable with chains and wires



Hole Position

The location of the vent and drain holes shall be determined by the shape of the fabrication and the angle at which it is suspended for galvanizing, as well as the enclosed volume of zinc in the fabrication when draining. A good rule of thumb for the designer is to think of items being lowered into and lifted from the galvanizing bath at an approximate 45° angle as discussed in Figure 2.

- Holes should be placed as close to corners and/or connections as practical.
- Holes must be located as close to the high and low points of hollow sections as possible to prevent air locks, entrapment of pre-treatment chemicals and zinc puddling.
- Holes should be orientated in the same plane as the fabrication.
- Holes **should not** be located in the centre of end plates and connections.
- Holes should be diagonally opposed where possible.

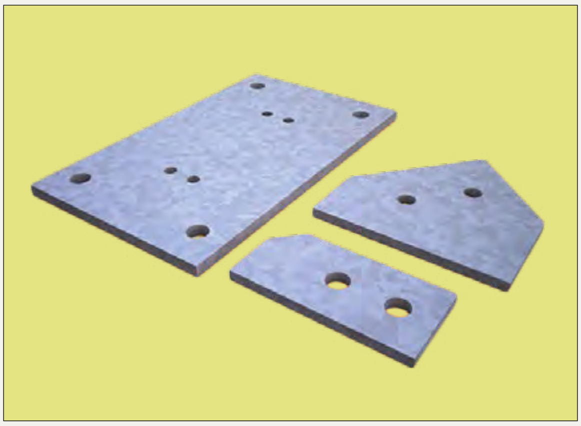
Hole Size

Dimensions of holes shall be determined by the trapped volume of air in the fabrication and the surface area of the steel in the vented area. Each square metre of steel surface produces approximately 200g of zinc ash, which must be able to escape through the holes.

- Minimum hole size is ø10mm
- Hole diameters should be at least the same size as the steel thickness.
- Having bigger holes (where feasible) is always better for the galvanizing outcome.

Refer to *'Hollow Sections'* for applicable hole size charts.

Refer to *'Hollow Vessels'* for applicable hole size chart.



Size and Weight

i. Centrifuge process

Small items are placed into a basket to be dipped and centrifuged. The size of baskets, centrifuges and other equipment will vary, just like general galvanizing baths.

Typically this process involves all the same stages as the general galvanizing process with the added centrifuging (or spinning) stage that occurs after withdrawal from the molten zinc. The centrifuging (or spinning) removes the excess zinc from the small articles, including from any threads or holes.

The coating thickness and mass requirements differ from other batch galvanized pieces due to the spinning process removing excess zinc.

Note: Not all galvanizers have centrifuge facilities and not all small items will be galvanized via the centrifuge process.

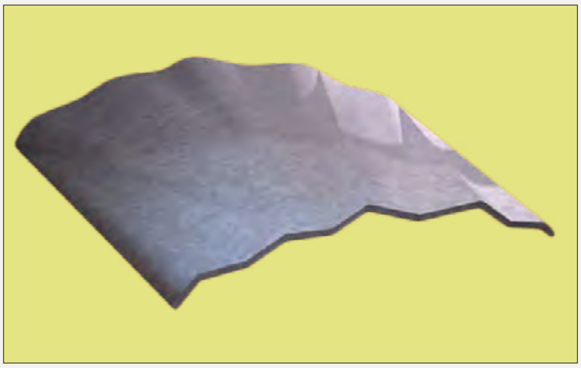
ii. Double dipping process

Double dipping is a term used to describe the process of galvanizing an item which is longer, wider or deeper than the relevant available bath dimensions. In this procedure, the item is lowered into the bath so that half or more of its 'over dimension' is immersed in the molten zinc.

When the galvanized coating has been achieved on the immersed section, the item is withdrawn from the bath and adjusted in handling so that the ungalvanized portion can be immersed in the molten zinc.

In the double dipping procedure an overlap of zinc coating will occur and this will normally have to be addressed in the case of visually obvious structural elements, in particular any requirements for architecturally exposed structural steelwork should be identified prior to order. In addition, double dipping increases the possibility of distortion (dimensional instability) of fabricated items. Guidance in these cases should be sought from the galvanizer.

Distortion (Dimensional Stability)



When steel sections or fabrications are immersed in molten zinc, their temperature is raised to that of the molten zinc, which is typically 450°C. The rate at which the steel reaches this temperature across its entire surface will depend on:

- the thickness of the individual sections making up the item,
- the total mass of the item,
- the dimension of the item, and
- speed of immersion.

At galvanizing temperatures, there is no change to structural steel's metallurgical microstructure and the process is not hot enough to have any heat treating effects on the mechanical properties of most structural steels after galvanizing.

However, at galvanizing temperatures, the yield strength of steel is temporarily lowered by approximately 50%. If any attached 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 distortion risks are minimised or eliminated.

Basic design rules for avoiding distortion

1) Maximise the uniformity of heat transfer into and out of the steel.
    a. Ensure venting and draining is adequate. This will allow the article to be immersed in and withdrawn from the molten zinc as quickly as possible.
    b. Minimise section thickness variations wherever possible in the fabrication.
2) Minimise the effect of stresses while the article is in the molten zinc.
    a. Use symmetrically rolled sections in preference to angle or channel frames. I-beams are preferred to angles or channels.
    b. Ensure assembly and welding techniques minimise stresses in components making up the article.
        i. If cutting plate to size, ensure all sides are cut using the same technique. Guillotine is the preferred cutting technique.
        ii. Bend members to the largest acceptable radii to minimize local stress concentration.
        iii. Accurately pre-form members of an assembly so it is not necessary to force, spring or bend them into position during joining.
        iv. Continuously weld joints using balanced welding techniques to reduce uneven thermal stresses.
        v. Staggered welding techniques to produce a structural weld are acceptable.
        vi. For staggered welding of material 4mm or less, weld centres should be closer than 100mm.

Figure 4: Thick + Thin = Distortion

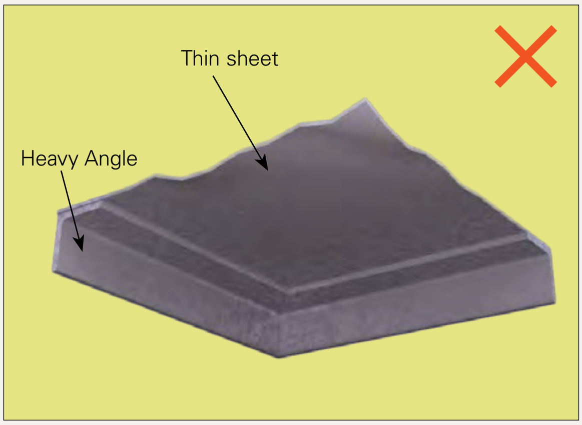


Figure 5: Avoid Distortion with Good Design

3) Avoid designs that require double dipping. It is preferable to build assemblies and sub-assemblies in suitable modules allowing for quick immersion and galvanized in a single dip so the entire article can expand and contract uniformly.
4) Ensure the structural design of the item is sufficient to support its own weight at 50% of the steel's specified yield strength.
5) Avoid using large areas of thin (under 8mm), unbraced flat plate.
6) Use temporary bracing or reinforcing on thin-walled and asymmetrical designs.

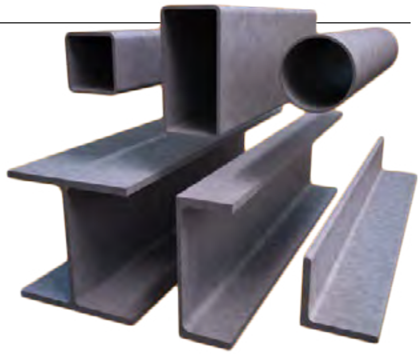
Risk of distortion for various items

Low risk: All hot rolled structural sections, fabrications containing angles, channels and universal hot rolled sections, tube and RHS sections and fabrications, ribbed or corrugated plate sections, grating, and heavy plate (over 16mm).

Medium risk: Light section roll formed products, long light walled conduit and tubing, fabrications containing asymmetrical weldments or steel of significantly different thickness, medium plate (8-16mm), and some double dipped items.

High risk: Thin sheet and plate (under 8mm depending on shape, area and bracing), floor-plate, deep plate web girders, platforms containing floor-plate, long channel sections with multiple weldments (cleats) on one side of web.

Structural Sections



Hollow Sections

Basic venting and draining rules for hollow sections

Size of holes

- Holes shall be appropriately sized for the size of the section to be galvanized. See Table 1 to Table 3 for the minimum recommendations for standard hollow sections.
- Vent holes shall be at least 10mm in diameter or the same thickness as the steel section.
- The length of the hollow section should also be taken into consideration for the required hole size. The hollow vessel rule (Table 4) may need to be applied for some longer lengths or larger volumes.
- Large hollow vessels require a vent and drain hole for every 0.5m^3 of enclosed volume, each being a minimum of 50mm in diameter. See Table 4.
- Hollow sections (pipe/CHS, RHS and SHS) require vent and drain holes, each with a diameter equivalent to at least 25% of their diagonal cross section length or multiple holes (for both venting and draining) of equivalent minimum cross sectional area.
- The preferred design option (Open Ends Preferred A in Figure 5) is to leave the ends of hollow sections completely open. This will improve the aesthetic quality of the fabrication.
- Where open ends cannot be provided, the provision of at least two holes positioned opposite each other. (as shown in Figure 7 and the Preferred B option in Figure 8)
- Holes located in the centre of a hollow section, as shown in Figure 7 and 8, are unsatisfactory.

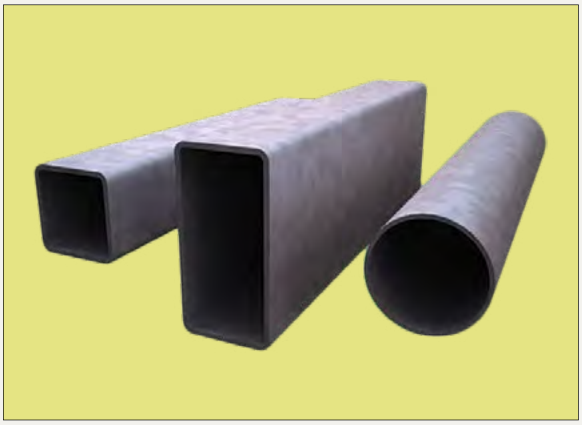
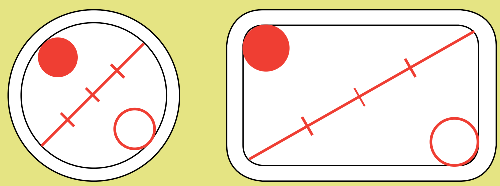


Figure 6: Diagonal Cross Sections



Hole size to be a minimum of 25% of the internal diagonal

Figure 7: Hollow Section Ends - Inside View

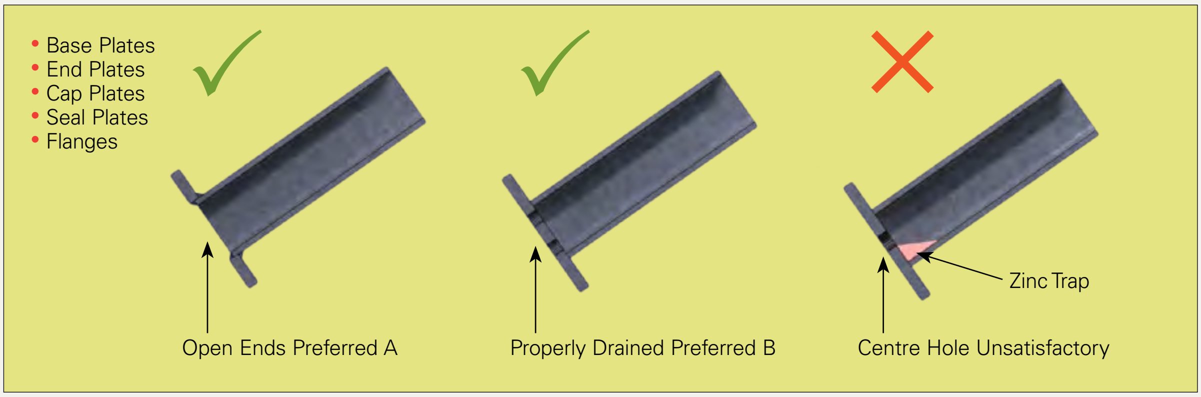
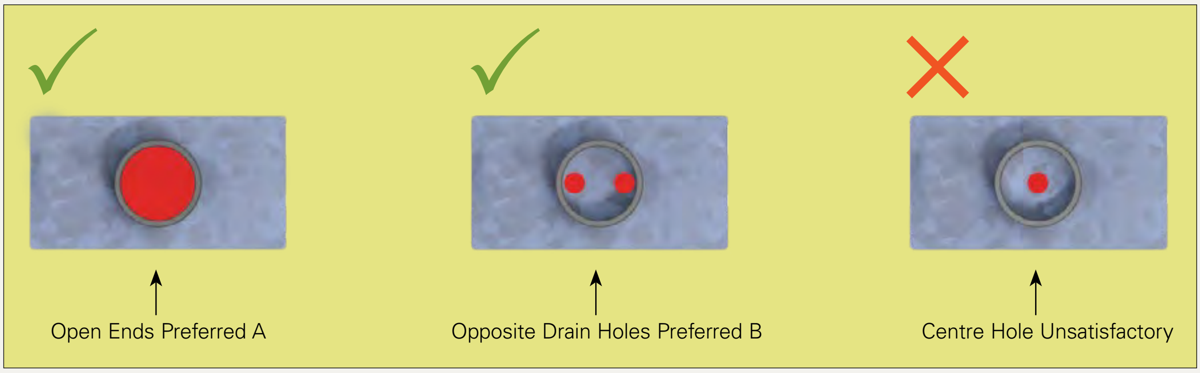


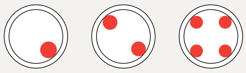
Figure 8: End Plates for Hollow Sections



Location of holes

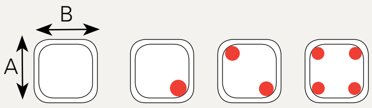
- Vent and drain holes shall be located as close as possible to the high and low points of the hollow section when hung to prevent air locks, entrapment of pre-treatment solutions and zinc pooling as well as being oriented in the same plane as the fabrication (Figure 7).
- Holes **must not** be located in the centre of end plates and connections. This will cause cleaning fluids to be trapped and result in uncoated surfaces inside the plate or connection as well as potential 'blowouts' where the cleaning fluids are expelled from the hole under pressure creating bare spots on the finished article. On withdrawal from the galvanizing bath, centre located holes will trap zinc (Figure 7).
- Hollow sections connected together require external vent and drain holes as close to the connection as possible. Internal venting may also be used to ensure pre-treatment solutions and zinc can flow freely through the sections and steam generated from any liquids remaining inside the sections can be efficiently vented. For more information on internal venting, see *'Using Hollow Section'*.

Table 1: Standard Holes Sizes for CHS/Pipe



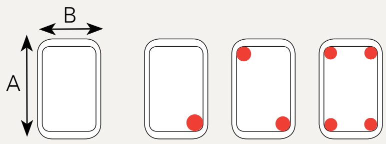
NB	Outside Diameter (mm)	1 Hole ø (mm)	2 Holes ø (mm)	4 Holes ø (mm)
20	26.9	10	10	10
25	33.7	10	10	10
32	42.4	11	10	10
40	48.3	12	10	10
50	60.3	15	11	10
65	76.1	19	13	10
80	88.9	22	16	11
90	101.6	25	18	13
100	114.4	30	20	14
125	139.7	35	25	17
150	165.1	45	30	22
	168.3	45	30	22
	219.1	55	40	30
	273.1	70	50	35
	323.9	85	60	40
	355.6	90	65	45
	406.4	105	75	55
	457	115	85	60
	508	130	90	65

Table 2: Standard Holes Sizes for SHS



A x B (mm)	1 Hole ø (mm)	2 Holes ø (mm)	4 Holes ø (mm)
20 x 20	10	10	10
25 x 25	10	10	10
30 x 30	11	10	10
35 x 35	12	10	10
40 x 40	14	10	10
50 x 50	18	13	10
65 x 65	25	16	11
75 x 75	25	19	13
89 x 89	35	22	16
90 x 90	35	25	16
100 x 100	35	25	18
125 x 125	45	35	22
150 x 150	55	40	30
200 x 200	75	50	35
250 x 250	90	65	45
300 x 300	110	75	55
350 x 350	125	90	65
400 x 400	145	100	75

Table 3: Standard Holes Sizes for RHS



A x B (mm)	1 Hole ø (mm)	2 Holes ø (mm)	4 Holes ø (mm)
50 x 25	14	10	10
65 x 35	18	13	10
75 x 25	20	14	10
75 x 50	25	16	11
100 x 50	30	20	14
125 x 75	40	30	18
150 x 50	40	30	20
150 x 100	45	35	25
200 x 100	60	40	30
250 x 150	75	55	40
300 x 200	90	65	45
350 x 250	110	80	55
400 x 200	115	80	60
400 x 300	125	90	65

Note: '1 hole', '2 holes' and '4 holes' means the number of holes in each otherwise unopen end.

galvanizers
ASSOCIATION OF AUSTRALIA

GAA website

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

Level 5
124 Exhibition Street
Melbourne Victoria 3000

Telephone **03 9654 1266**
Email **gaa@gaa.com.au**
Web **gaa.com.au**