Design, specification, inspection of galvanized products

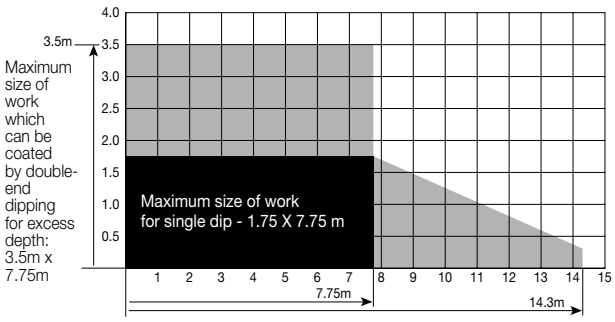
Consistently good galvanized steel products will be produced when the essential requirements listed are incorporated at the design and fabrication stages of production. Design features should be discussed with the galvanizer. Close liaison between design engineer, materials engineer, specifier, fabricator and galvanizer will ensure high quality galvanized products, minimum cost and faster delivery.

Size and shape

Facilities exist to galvanize components of virtually any size and shape. When an article is too big for single immersion in the largest bath available it may be possible to galvanize it by double-end dipping, depending on the handling facilities and layout of the galvanizing plant. Large cylindrical objects can often be galvanized by progressive dipping.

The chart below shows the dimensions of work that could theoretically be galvanized by double-end dipping in (for example) a bath 8m long x 2m deep, assuming that the width of the work also suits the bath.

Schematic indication of double-end dipping capacity of a galvanizing bath 8 metres long x 2 metres deep



Maximum size of work which can be coated by double end dipping for excess length – up to 14.3 m

The chart shows that a bath nominally 8m long x 2m deep could process work 7.75m x 3.5m, or long components of up to about 14m. Note that the chart is purely indicative and similar charts can be prepared for baths of different dimensions. The maximum sizes which a particular galvanizer can process should always be checked at the design stage.

Bath lengths of 12.5 metres are available.

Modular design

Large structures are also galvanized by designing in modules for later assembly by bolting or welding. Modular design techniques often produce economies in manufacture and assembly through simplified handling and transport.

Weld areas in structures assembled by welding after galvanizing must be repaired to give corrosion protection equivalent to the galvanized coating as described on page 45.

The size and shape of large or unusual structures should always be checked with the galvanizer early in the design process.

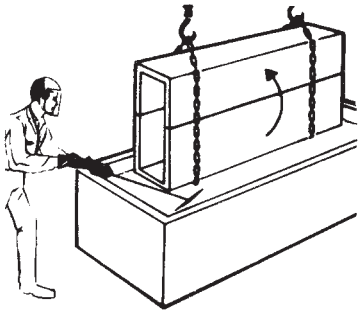
Materials suitable for galvanizing

All ferrous materials can be galvanized. Mild and low alloy steels and iron and steel castings are all regularly and successfully galvanized. Steel fabrications which incorporate stainless steel parts and fittings are also readily galvanized.

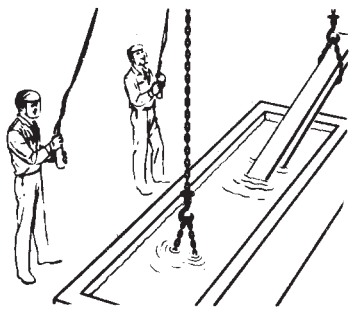
Soft-soldered assemblies cannot be galvanized. Brazed assemblies may be galvanized, but the galvanizer should be consulted at the design stage.

Castings. The galvanizing of sound stress-free castings with good surface finish will produce high quality galvanized coatings. The following rules should be applied in the design and preparation of castings for galvanizing:

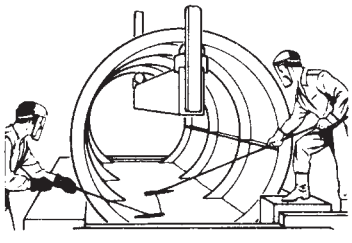
1 Design for uniform section thicknesses wherever possible.
2 Use large radii at junctions with webs, fillets and raised features such as cast-in part and pattern numbers.
3 Avoid deep recesses and sharp corners.
4 Large grey iron castings should be normalised by the fabricator.
5 Castings should be abrasive blast cleaned by the fabricator to remove foundry sand and surface carbon. Alternatively castings may be cleaned electrolytically using the Kolene process.



Double-end dipping for excess depth



Double-end dipping for excess length



Progressive dipping

Combinations of ferrous materials and surfaces. There may be appreciable variation in the pickling times of various ferrous metals and differing surface conditions. Fabricated assemblies containing a mixture of materials and surfaces such as a combination of castings with other steels, or new or machined steel surfaces with rusted or scaled steel surfaces, must be abrasive blast cleaned to minimise differences in pickling time.

Omission of abrasive blast cleaning will result in combined under- and over-pickling of the different surfaces, producing poor quality galvanized coatings of unsatisfactory appearance.

Heavy mill scale on rolled steel surfaces should be removed by abrasive blast cleaning before galvanizing.

Thicker than normal galvanized coatings are produced when abrasive blast cleaned surfaces are galvanized as discussed on page 13.

Steel pipe for fabrication of galvanized assemblies should be specified by the fabricator when ordering from the merchant as 'Not oiled or painted'. Manufacturers produce steel pipe with clear varnish or black bituminous coatings which are by design extremely resistant to chemical removal and necessitate expensive manual stripping before pickling to ensure satisfactory galvanizing.

Heavy gauge seamless pipe must also be clearly specified in the unoiled, unpainted condition when ordering.

Weld areas. Due to the silicon content of some welding rods, weld areas may produce localised grey coatings when galvanized. The galvanized coating is likely to be slightly thicker in these areas and will have no detrimental effect on coating life.

As discussed on pages 13 and 42, the development of grey coatings due to silicon steels is entirely related to steel composition and cannot be controlled by the galvanizer. Even when these weld areas are ground flush prior to galvanizing, heavier grey coatings may still result.

Welding slags. Arc welding slags are chemically inert in acid cleaning solutions and must be mechanically removed before articles are delivered to the galvanizer The fabricator should remove these by chipping, wire brushing, flame cleaning, grinding or abrasive blast cleaning.

Welding electrode manufacturers supply general purpose electrodes coated with fluxes which produce virtually self-detaching slags and their use is recommended.

Good joint design with adequate access facilitates the welding process to produce sound continuous welds, avoiding locked-in slag, and easing slag removal.

Design and fabrication of components for galvanizing

Safety

Vessels or hollow structures which incorporate enclosed sections must have provision for adequate venting during galvanizing. At galvanizing temperatures any moisture present in closed sections is rapidly converted to superheated steam, generating explosive forces unless adequately vented to the atmosphere. For the safety of galvanizing personnel, equipment, and the work being galvanized it is essential that venting is provided.

Correct venting also ensures that the entire internal surface of work is properly galvanized and fully protected.

Closed vessels which are not to be galvanized inside, such as certain types of heat exchanger, must be provided with snorkel-type vent pipes long enough to project above the level of pickling, fluxing and galvanizing baths when the work is fully immersed. The exact venting requirement should be discussed with the galvanizer.

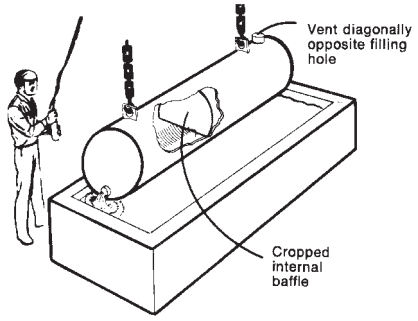
Venting, filling and draining

The following specific recommendations should be followed:

Tanks and closed vessels. As illustrated, design must allow for pickle acids, fluxes and molten zinc to enter, fill and flow upwards through the enclosed space and out through an opening at the highest point so that no air is trapped as the article is immersed. The design must also provide for complete drainage of both interior and exterior details during withdrawal.

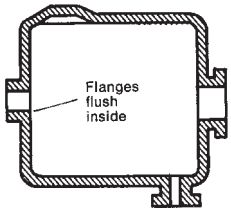
A filling hole as large as the design will allow and a minimum of 50 mm diameter for each 0.5 cubic metres should be provided. A vent hole of equal dimensions should be provided diagonally opposite the filling hole to allow the escape of enclosed air and to facilitate draining.

Tanks and closed vessels should have at least one filling/draining hole with a vent diagonally opposite. Baffles should be cropped.



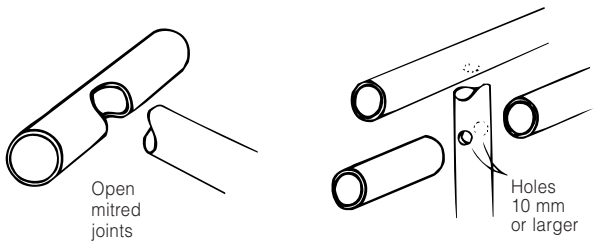
Internal baffles in tanks should be cropped on the bottom or provided with suitable drainage holes to permit free flow of molten zinc. Access ports, bosses and openings should be finished flush inside.

Openings should finish flush inside and should be positioned so that all pickle acid and molten zinc can be drained out during the galvanizing operation.



Hollow structurals and fabricated columns.

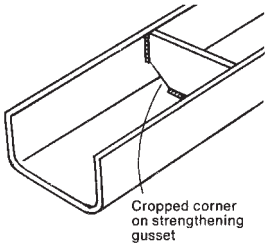
Closed sections must never be included in tubular fabrications. Vent holes at least 25% of internal diameter or diagonal dimension and a minimum of 10 mm diameter should be provided by the fabricator at locations agreed with the galvanizer.

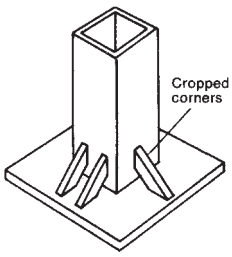


All welded sections in fabricated pipework should be interconnected with open tee or mitre joints. Alternatively each closed section must be provided with a vent hole of not less than 10 mm diameter. Pipe ends or flanges should always be left open, or provided with removable vent plugs.

Closing of unwanted vent holes. Small vent holes which are necessary for galvanizing but not wanted in the finished job may be closed by hammering in lead plugs after galvanizing and filing off flush with surrounding surfaces, or by the use of threaded plugs. Threads may need re-tapping after galvanizing.

Welded strengthening gussets on fabricated columns and strengthening gussets in members fabricated from channel sections should have corners cropped to allow free flow of zinc during galvanizing as illustrated.



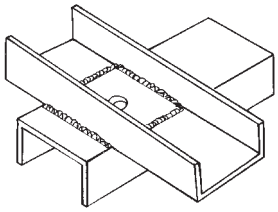


Overlapping surfaces. Narrow gaps between plates and in particular, overlapping surfaces and back-to-back angles and channels should be avoided. As discussed on page 35 under 'Safety', any pickle acid or rinse water trapped in narrow gaps between members is rapidly converted to superheated steam at galvanizing temperatures, with the possibility of an explosion.

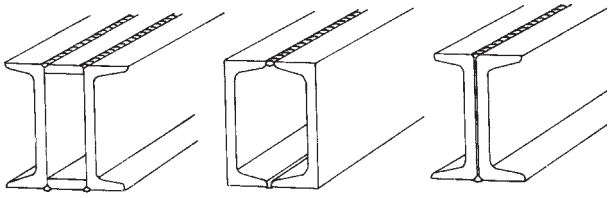
Where small overlapping areas are unavoidable, edges should be sealed after consultation with the galvanizer, by a continuous pore-free weld to prevent penetration of pickle acid. For the safety of galvanizing personnel the sealed area **must** be provided with a vent hole for every 100 cm^2 of sealed area according to the following table:

Steel plate thickness	Vent hole size
Up to 6 mm	At least 6 mm diameter
Over 6 mm	Hole diameter to match or exceed plate thickness

To prevent the possiblity of an explosion during galvanizing, a vent hole must be provided for every 100 cm^2 of sealed area, as specified in the table above.



Back-to-back channels should be avoided. C below is potentially dangerous because of the risk of explosion.

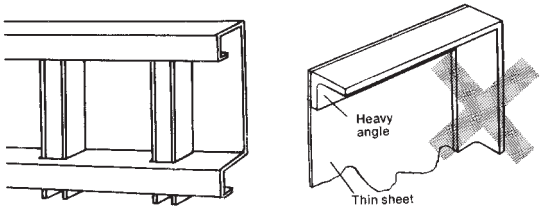


Dimensional stability

In certain cases, fabricated assemblies may be liable to loss of shape at galvanizing temperatures due to the release of stresses induced during manufacture of the steel and in subsequent fabricating operations. These stresses may be compounded by bad design incorporating unequal thicknesses or non-symmetrical sections. Observance of the following recommendations will improve dimensional stability:

1 Avoid designs which require double-end dipping to fit into the galvanizing bath. It is preferable to build assemblies and sub-assemblies in suitable modules so that they can be immersed quickly and fully in a single dip.
2 Use symmetrical sections in preference to angles or channels.
3 Use sections of near equal thickness at joints.
4 Bend members to the largest acceptable radii.
5 Accurately preform parts to avoid force or restraint during joining.
6 Continuously weld joints if possible using balanced welding techniques to reduce uneven thermal stresses. Balanced, staggered welding is permissible. For staggered welding of material of 3 mm and lighter, weld centres should be closer than 100 mm.
7 Design castings to conform to the rules listed on page 33. Large grey iron castings should always be normalised by the fabricator and then abrasive blast cleaned prior to galvanizing.

ASTM A384-59 'Recommended practice for safeguarding against warpage and distortion during galvanizing of steel assemblies' gives further information. Advice on design to minimise distortion is available from the galvanizer.



Use of symmetrical sections minimises distortion during galvanizing. Avoid combinations of thick and thin materials.

Clearance for moving parts

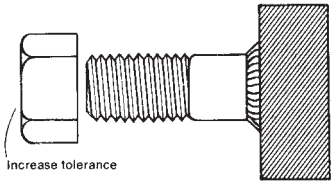
Moving parts such as drop handles, hinges, shackles and shafts must incorporate minimum radial clearances as detailed below:

Shaft or spindle size	Minimum radial clearance
Up to 10 mm diameter	1.0 mm
10 to 30 mm diameter	2.0 mm
Over 30 mm diameter	2.5 mm

Galvanized threads

When assemblies to be galvanized incorporate threaded components, the tolerance normally allowed on internal threads must be increased to provide for the thickness of the galvanized coating on external threads. Standard practice is to tap nuts oversize after galvanizing, according to figures in the table on page 48.

Nuts for galvanized studs must be tapped oversize. The galvanized coating on the stud provides corrosion protection for the internal tread.



For economy, nuts are sometimes galvanized as blanks and threads are tapped after galvanizing. Uncoated internal threads are acceptable since the zinc coating on the external thread provides full corrosion protection.

Bolted assemblies should be presented for galvanizing in the disassembled condition. Nuts and bolts or studs for galvanizing should also be supplied disassembled.

When internal pre-tapped threads included in components are required not to be galvanized they may be plugged temporarily by means of bolts or studs screwed fully in, after discussion with the galvanizer.

For safety reasons, high strength bolts must not be welded to galvanized structures for use as high strength studs. Galvanized bolts and the bolting of galvanized structures are discussed in detail commencing on page 47.

Handling parts for galvanizing

Parts may require suspension holes if there is no convenient point to attach a jig or hook. No special requirements apply if the work can be handled by chains, baskets, tongs or racks. Your galvanizer will advise of necessary provision to suit the handling equipment available.

Large pipe sections, open top tanks and similar structures may require cross stays to maintain the shape of the article during handling and galvanizing.

Marking for identification

For temporary identification, water soluble paints or markings are recommended. Oil-based paints should not be used as they must be removed manually before galvanizing.

For permanent identification, intended to remain legible after galvanizing, the fabricator should provide heavily punched or embossed figures either on the work or on steel (not aluminium) tags wired to the work.

Design for maximum corrosion protection

Galvanized coatings provide outstanding corrosion protection for steel. Treatment of design details in accordance with good corrosion design practice as discussed below will further increase the life of galvanized steel fabrications.

Many of the design requirements for good galvanizing detailed earlier, such as the provision of flush-finished internal flanges in tanks and vessels will also ensure good drainage in service and optimum corrosion resistance.

Fabricated assemblies should be designed to eliminate undrained areas which will collect water and sediment in service, producing localised corrosion pockets. The following rules should be followed:

1 Use butt welds in preference to lap welds.
2 Where lap welds are used face joints downwards to avoid collection of moisture and sediment.
3 Avoid use of horizontal boxed sections, ledges, seams and flat undrained areas.
4 Use rounded internal corners rather than squared corners in vessels and containers to avoid build up of sediment.
5 Design to eliminate crevices and unnecessary openings.
6 Avoid contact of galvanized surfaces with brass or copper as discussed under ‘Galvanic corrosion’, page 22.
7 Provide ventilation where possible in condensation areas.
8 Under conditions of extreme humidity use an inhibitive jointing compound such as Dulux Foster C1 Mastic or equivalent between contacting galvanized surfaces such as roof overlaps.
9 Provide maintenance access where anticipated service life of certain components is less than that of the complete structure.

Galvanizing design aids

As an aid to designers and specifiers, Galvanizers Association of Australia publishes and distributes free of charge the colour wall chart ‘Design for Galvanizing’.

GAA also provides the video ‘Hot dip galvanizing, Part 1: Insuring steel’s future’, and ‘Part 2: Design and fabrication for galvanizing’.

Contact GAA, Level 5, 124 Exhibition Street, Melbourne, Victoria 3000.

Metallurgical aspects of design

The galvanizing process has no effect on the mechanical properties of the structural steels commonly galvanized. In susceptible steels the galvanizing process may accelerate the onset of strain ageing which, with ageing, would occur naturally due to earlier cold working operations.

Strain ageing can be avoided by the use of non-susceptible steels, or when susceptible steels must be used, by adopting the procedures specified in relevant standards, as dicussed in more detail on pages 15 and 17.

Minimum edge distances for holes in structural members

In bolted connections minimum edge distances from the centre of any bolt to the edge of a plate or the flange of a rolled section should be used as specified in the table below, taken from the Australian Standard 4100 ‘Steel structures’.

Sheared or hand flame-cut edge,	Rolled plate, machine flame-cut, sawn or planed edge flat bar or section,	Rolled edge of a rolled flat bar or section,
$1.75d_f$	$1.50d_f$	$1.25d_f$

Note. Edge distance may also be affected by clause 9.3.2.4, AS 4100

Inspection of work before despatch to the galvanizer

Fabricated assemblies, castings and other components for galvanizing should be inspected before despatch to the galvanizer to ensure that the following points conform to design requirements detailed earlier. This may avoid costly rectification and delays at the galvanizing plant.

Size and shape. Check that work is suitably sized and dimensioned for the handling and galvanizing facilities of the selected galvanizer. It may be too late to make changes to the design, but it is costly to despatch work which the galvanizer cannot process.

Structural steel. Check that bending, punching and shearing have been carried out in conformity with the recommendations on page 17.

Satisfactory galvanizing

Observance of the points listed below and described in more detail on previous pages will ensure optimum galvanized product quality and minimise extra costs or delays:

1 Check that closed vessels and hollow structures are vented for safety and satisfactory galvanizing.
2 Check that welding slags have been removed.
3 Check that assemblies comprising castings and steels of widely differing surface conditions have been abrasive blast cleaned to minimise differences in galvanized finish.
4 Check that castings are abrasive blast cleaned before despatch unless otherwise arranged. Check that large grey iron castings have been normalised.
5 Check that appropriate temporary or permanent markings are provided.