

DESIGN FOR HOT DIP GALVANIZING

Corrosion prevention is an essential factor in the economic utilisation of steel. Provision of the appropriate protective coating can bring initial savings plus substantial economies in service, due to reduction or elimination of maintenance and lost service time, and by deferring the replacement date of structures and equipment. In suitable applications hot dip galvanizing provides ideal corrosion protection for steel – no other coating matches galvanizing's unique combination of low first cost, ease of inspection for coating quality, durability, predictable performance, low maintenance, and resistance to abrasion and mechanical damage.

INTRODUCTION

When designing a structure which is to be hot dip galvanized, it must be borne in mind that articles are immersed in and withdrawn from a bath of molten zinc heated to a temperature of about 450°C. Design and fabrication is required to conform to applicable standards which apply, regardless of whether a galvanizer or a painted coating is to be applied. In the case of galvanizing, some additional requirements which aid access and drainage of molten zinc, will improve the quality of the coating and also reduce costs.

With certain fabrications, holes which are present for other purposes may fulfill the requirements of venting of air and draining of zinc; in other cases it may be necessary to provide extra holes for this purpose.

For complete protection, molten zinc must be able to flow freely to all parts of the surfaces of a fabrication. With hollow sections or where there are internal compartments, the galvanizing of the internal surfaces eliminates any danger of hidden corrosion occurring in service.

Some general principles for guidance are:

- Holes both for venting and draining should be as large as possible. The absolute minimum hole sizes are given in Table 2.
- Holes for venting and draining should be diagonally opposite one another at the high point and low point of the fabrication as it is suspended for galvanizing (figure 10).
- With hollow sections sealed at the ends, holes should be provided, again diagonally opposite one another, as near as possible to the ends of the hollow member (figure 8). In some cases it may be more economical to provide "V" or "U" shaped notches (figure 9) in the ends of the tubes, or to grind corners of rectangular hollow sections. These procedures will provide ideal means for venting and draining.
- Where holes are provided in end plates or clamping pieces, they should be placed diagonally opposite to one another, off centre and as near as possible to the wall of the member to which the end plate is connected (figure 7).
- Internal and external stiffeners, baffles, diaphragms, gussets etc., should have the corners generally cropped with centre holes (particularly for "Road Sign Gantry" type configurations) to aid the flow of molten zinc and to prevent air entrapment (figure 2, 11 and 24 and detail X).
- Bolted joints are best made after hot dip galvanizing.

SIZE
Facilities exist to galvanize articles of virtually any size and shape (see list of members with kette sizes - available from the Hot Dip Galvanizers Association). When an article is too big for single immersion in the largest bath available it is possible to galvanize it by double-end dipping (table 1), depending on the handling facilities and layout of the galvanizing plant (check with the galvanizer). Large cylindrical objects can often be galvanized by progressive dipping (figure 1).

MODULAR DESIGN
Large structures are also hot dip 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 (see also Masking).

STEEL GRADE
It is possible to hot dip galvanize all structural steels and the ultimate coating thickness achieved is determined by steel analysis, immersion time and to a lesser degree, zinc temperature. In modern steel making practice, either aluminium or silicon is added to molten steel as de-oxidising agents. Aluminium ad-

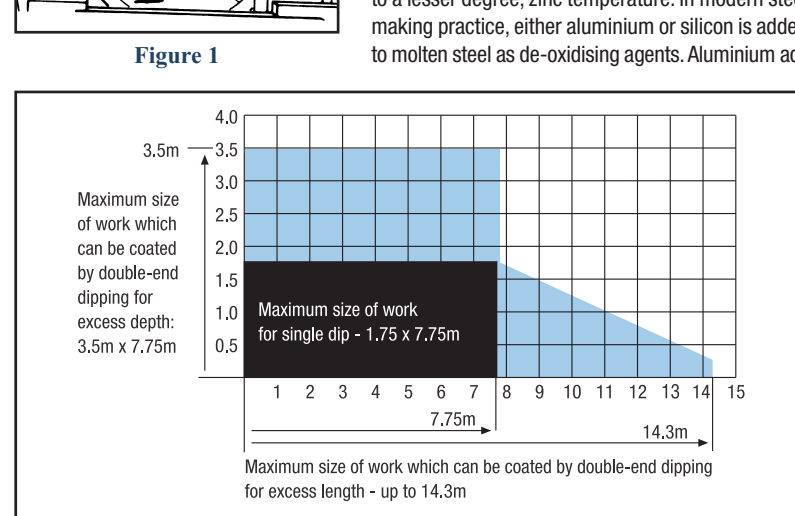


Table 1

ditions (as in aluminium-killed steel - Si less than 0.04%) has no effect on the structure and coating thickness. Silicon-killed steel with silicon (Si) ranging between 0.15 to 0.25% is ideal for heavy duty coatings. On either side of this range, excessively thick and brittle coatings can develop if extended immersion times in molten zinc cannot be avoided. The immersion cycle is determined by the configuration of the structure and thickness of the section. (The thicker the steel, the longer the immersion time). The impact of phosphorus (P) in steel can be severe regardless of the Si present. At levels below 0.015% P has little influence on coating growth. Above 0.02% the effect is extremely severe even when Aluminium-killed steel is galvanized. It is for this reason that hot dip galvanizing specifications provide for minimum coating thickness and no maximum limit is set. The specification does not stipulate a maximum upper coating thickness. (See NOTE 1 in "Specifying Hot Dip Galvanizing").

Zinc Metal Sprayed Coatings
The damaged area is to be lightly blasted using preferably a pencil blasting nozzle or the surrounding coating should be masked in order to limit damage.

A zinc metal sprayed coating is then applied to the abrasive blasted surface to a 100µm thickness or equal to the surrounding coating thickness, if a duplex coating is to be applied. The repaired area is then wet brushed, (preferably stainless steel) to remove loosely adhering over sprayed zinc. Wet brushing provides the added benefit of sealing the pores that may be present in the sprayed coating.

Zinc Rich Epoxy or Zinc Rich Paint
The defective area shall be blasted as above or abraded with abrasive paper (roughness 80 grit). All dust and debris must be completely removed. In the event of moisture being present, all surfaces are to be properly dried.

A zinc rich paint or epoxy containing greater than 80% zinc in the dry film, should be applied to a DFT of 100µm (overlapping the bare spot by 5mm) or equal to the surrounding coating thickness, if a duplex coating is to be applied.

BENDING AND FORMING AFTER HOT DIP GALVANIZING
Components which have been hot dip galvanized should not be bent or formed by applying heat above the melting temperature of zinc as this can cause embrittlement due to intergranular liquid zinc penetration between steel crystal boundaries.

FABRICATION DEFECTS
Burns
Unlike a paint coating, burns will be overcoated by hot dip galvanizing but the removal of a burn after galvanizing may result in the presence of a small uncoated surface and for this reason, burns must be removed prior to galvanizing.

| Tube Dia | GUIDELINES FOR MINIMUM VENT AND DRAINAGE HOLESIZES - REQUIRED BY SECTION LENGTH | | | | | | | | | | | |
|----------------|---|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|--|
| | ≤ 50 | 80 - 76 | 89 | 102 - 114 | 127 - 152 | 165 | 219 | 245 | 273 | 324 | 355 | |
| RHS Sizes (mm) | 50 x 30 | 80 x 40 | 80 x 80 | 90 x 90 | 160 x 80 | 90 x 100 | 180 x 180 | 200 x 200 | 300 x 200 | 400 x 200 | 300 x 300 | |
| | 60 x 40 | 70 x 70 | 120 x 60 | 120 x 80 | 120 x 120 | 150 x 150 | 250 x 150 | 220 x 220 | 250 x 250 | 450 x 250 | | |
| | 50 x 50 | 100 x 50 | 100 x 100 | 150 x 100 | 150 x 100 | | | | | 340 x 200 | | |
| | 60 x 60 | 76 x 76 | | | 140 x 140 | | | | | | | |

Table 2

RELIABILITY
The hot dip galvanized coating is formed by a metallurgical reaction between suitably cleaned steel and molten zinc. This results in the formation of a series of iron/zinc alloys which are overcoated with relatively pure zinc. The process entails total immersion of components in both pretreatment chemicals and molten zinc. This ensures uniform protection and coating reliability even on surfaces which would be inaccessible for coating by other methods.

VENTING, FILLING AND DRAINAGE

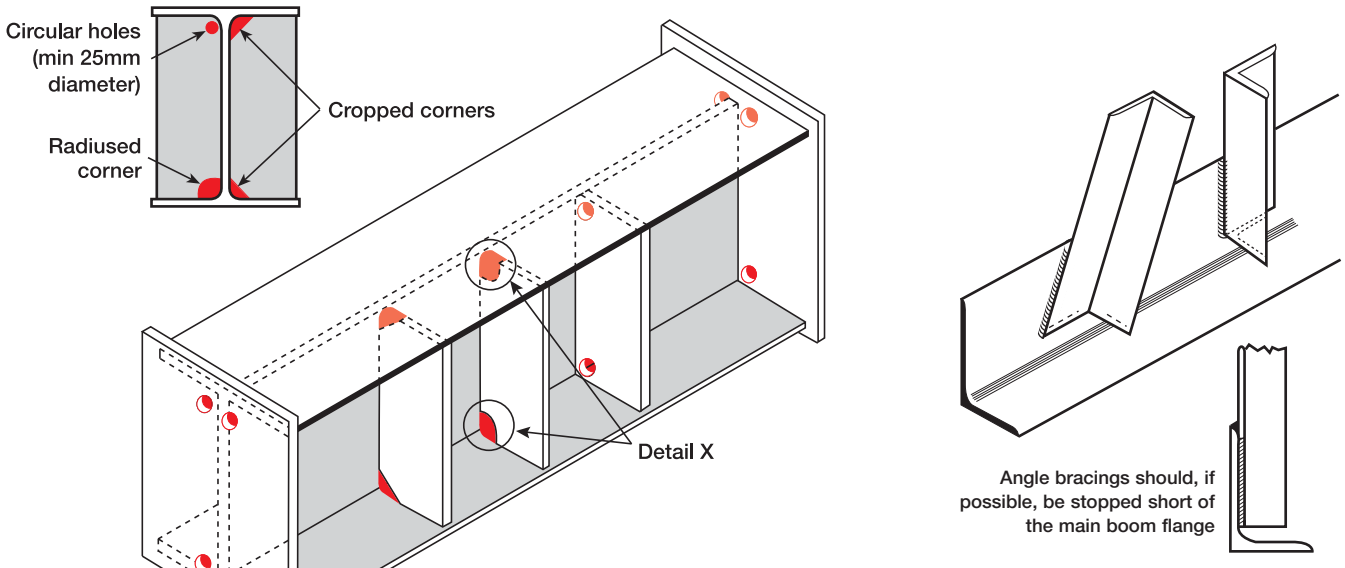


Figure 2

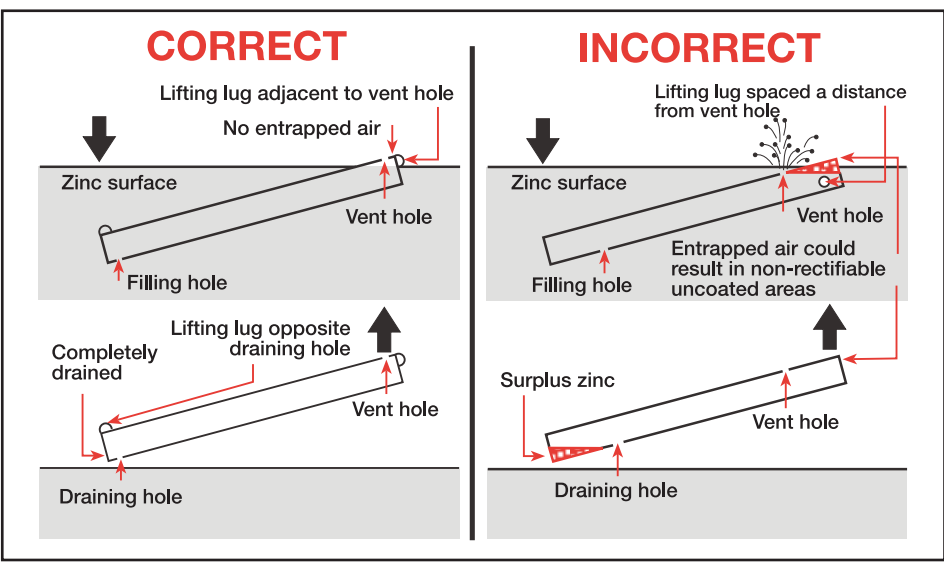


Figure 4

External stiffeners, welded gussets and webs on columns and beams and gussets in channel sections should have their corners cropped. The gaps created should be as large as possible (detail X is preferable) without compromising structural strength. If welding is required around the edge created, a radused corner is desirable to facilitate continuity of the weld around the cut end to the other side. Circular holes are less effective: if used, they should be as close to corners and edges as practicable. Where more convenient, the cropped corners or holes may be in the main beam. Consultation with the galvanizer, regarding the appropriate vent and drainage hole sizes is recommended.

WELDED PIPE SECTIONS
Closed sections must never be incorporated in a fabrication. Sections should be interconnected using open mitred joints as illustrated in figure 4, or interconnecting holes should be drilled before fabrication as in figure 5.

Alternatively external holes may be positioned as in figure 6, a method which is often preferred by the galvanizer, since quick visual inspection shows that the work is safe to galvanize.

Pipe ends can be left open, or provided with removable plugs (see unwanted vent holes).

SMALL TUBULAR FABRICATIONS
Small tubular fabrications must be vented, preferably with holes not less than 10mm diameter (see table 2).

UNWANTED VENT HOLES
These may be closed by hammering in lead plugs after galvanizing and filing off flush with surrounding surfaces.

TUBULAR FABRICATIONS/HOLLOW STRUCTURALS
Drain/vent hole sizes should be preferably 25% of internal diameter or diagonal dimension for sections yielding a maximum cross sectional area of 180cm². This percentage can be dependent on the shape of the fabrication, therefore consultation with the galvanizer at the design stage is recommended. FOR MUCH IMPROVED COATING QUALITY, REDUCED COATING GROWTH, PROVIDING AN IMPROVED AESTHETICALLY PLEASING APPEARANCE, APPROPRIATELY SIZED AND POSITIONED HOLE, DRAIN AND VENT HOLES CAN MAKE A HUGE CONTRIBUTION.

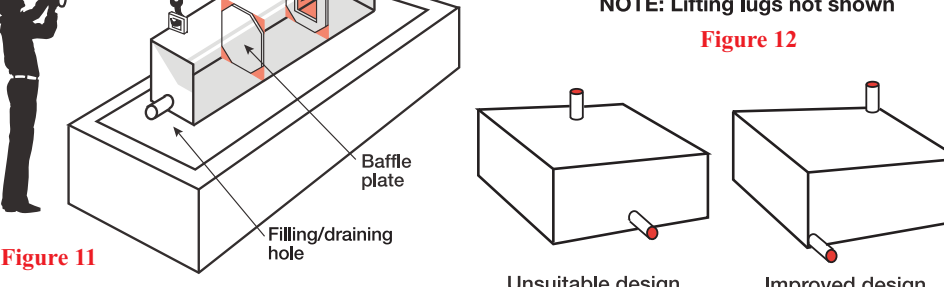


Figure 6

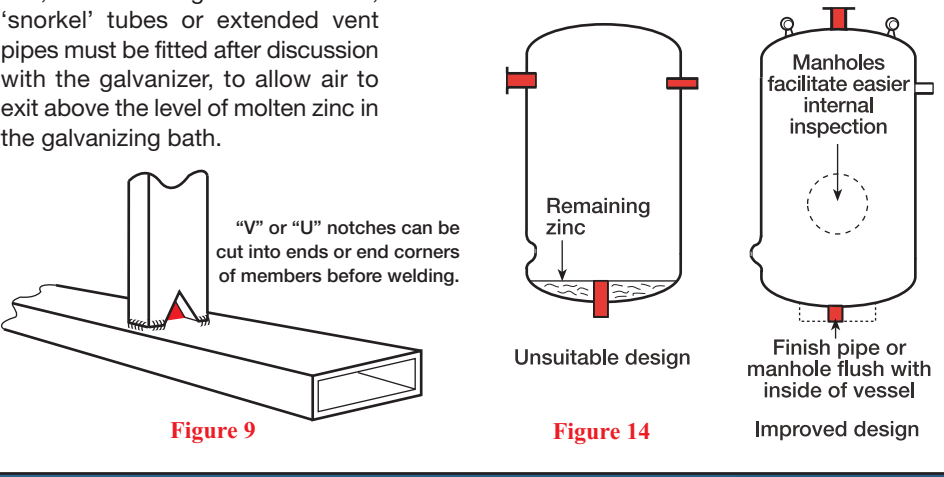


Figure 8

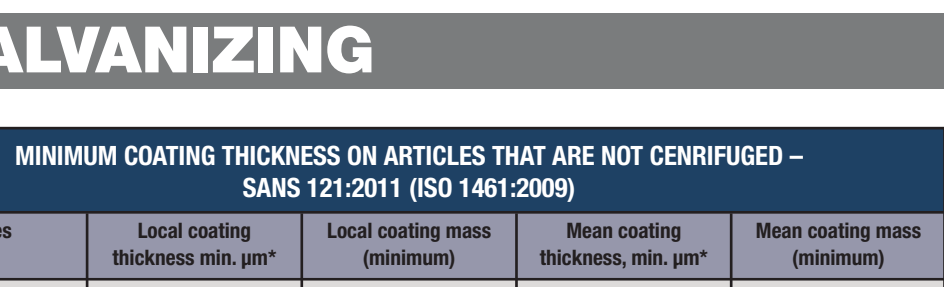


Figure 9

TANKS AND CLOSED VESSELS
When both internal and external surfaces are to be hot dip galvanized at least one filling and draining hole must be provided, with a vent hole diagonally opposite to allow the exit of air during immersion. For each 0.5 cubic metres of volume, provide one fill/drain hole of minimum size ø60mm and vent hole of minimum size ø40mm.
Internal baffles should be cropped as illustrated or as per detail X above, especially for structures such as "Road Sign Gables" which also require considerably larger centre holes in baffle plates and base plates. Manholes or pipes should finish flush inside to prevent trapping excess zinc.
Lifting lugs should be provided opposite the biggest and most accessible filling / draining hole and adjacent to the vent hole on the opposite end (see figure 10). The lugs must be designed to accommodate the excess mass of molten zinc within the cylinder / pipe on withdrawal.
Large vessels require an appropriate size man-hole in the baffle.
When vessels and heat exchangers etc., are not to be galvanized inside, "snorkle" tubes or extended vent pipes must be fitted after discussion with the galvanizer, to allow air to exit above the level of molten zinc in the galvanizing bath.
"V" or "U" notches can be cut into ends or end corners of members before welding.
Manholes facilitate easier internal inspection.
Finish pipe or manhole flush with inside of vessel improved design.

MINIMUM COATING THICKNESS ON ARTICLES THAT ARE NOT CENFRIGUED - SANS 121:2011 (ISO 1461:2009)

| Profiles | Local coating thickness min. µm* | Local coating mass (minimum) | Mean coating thickness, min. µm* | Mean coating mass (minimum) |
|------------------------|----------------------------------|------------------------------|----------------------------------|-----------------------------|
| Steel > 6mm | 70 | 505 | 85 | 610 |
| Steel > 3mm to ≤ 6mm | 55 | 395 | 70 | 505 |
| Steel ≤ 1.5mm to ≤ 3mm | 45 | 325 | 55 | 395 |
| Steel < 1.5mm | 35 | 250 | 45 | 325 |

MINIMUM COATING THICKNESS ON ARTICLES THAT ARE CENTRIFUGED TO SANS 121:2011 (ISO 1461:2009)

| Diameter of the article | Local coating thickness min. µm* | Local coating mass (minimum) | Mean coating thickness min. µm* | Mean coating mass (minimum) |
|-------------------------|----------------------------------|------------------------------|---------------------------------|-----------------------------|
| > 6mm diameter | 40 | 285 | 50 | 360 |
| ≤ 6mm diameter | 20 | 145 | 25 | 180 |

NOTE
Where steel composition does not include moderate to high reactivity, thicker coatings are not always easily achieved.

IN THE CASE OF LARGE CANTERS, THE GALVANIZER SHOULD BE INVOLVED AT THE PROGRAMMING STAGE WITH THE FABRICATOR AND THE END USER. Hot dip galvanizing is normally the final process after fabrication and prior to delivery and erection. If sufficient time for galvanizing and inspection is not provided in the overall programme, costly delays may occur at the erection stage.

WELDING, HANDLING, MASKING, IDENTIFICATION, MINIMIZING DISTORTION AND CLEARANCE FOR MOVING PARTS

MASKING
Masking materials have been developed, which if applied prior to hot dip galvanizing, will prevent the formation of the galvanized coating on surfaces where it is not desired. Contact the Association for further information.

COMBINATIONS OF FERROUS SURFACES
Fabrications containing a combination of castings and steels, or rusted and mill scaled surfaces must be abrasive blast cleaned before galvanizing.

WELD SLAG
Weld slag must be removed by abrasive blast cleaning, de-scaling, chipping, grinding, flame cleaning or a pneumatic needle gun.

PROVISION FOR HANDLING
Work not suitable for handling with chains, baskets, hooks or jigs must be provided with suspension holes or lifting lugs (see figure 10). If in doubt check with the galvanizer.

IN CASE OF DOUBLE-SIDED FIELD WELDS, THE WELD MUST BE CONTINUED AROUND THE ENDS OF THE SHEET TO PREVENT THE PENETRATION OF ACID INTO ANY CONCEALABLE CREVICE.

MATERIALS SUITABLE FOR HOT DIP GALVANIZING
All ferrous materials are suitable, including sound stress-free castings.

Brazed assemblies may be hot dip galvanized but check first with galvanizer. Assemblies soft soldered or aluminium riveted cannot be hot dip galvanized.

DISTORTION
Distortion can be minimised by:

- Use of symmetrical designs.
- Use of sections of a similar thickness (figure 16).
- Use of stiffened unsupported steel sections, particularly when steel is less than 3 - 4mm thick.
- Use of preformed members with the correct minimum bend radius to minimise stress.
- Use of balanced or staggered welding techniques to minimise stresses.
- Large open fabrications, thin walled trough sections and tanks may require temporary cross stays to prevent distortion during hot dip galvanizing.
- Maximising fill, drain and vent hole sizes and optimising their positions.
- Complete and rapid immersion of the item in the galvanizing bath, i.e no double end dipping.
- Air cooling after hot dip galvanizing in preference to water quenching.

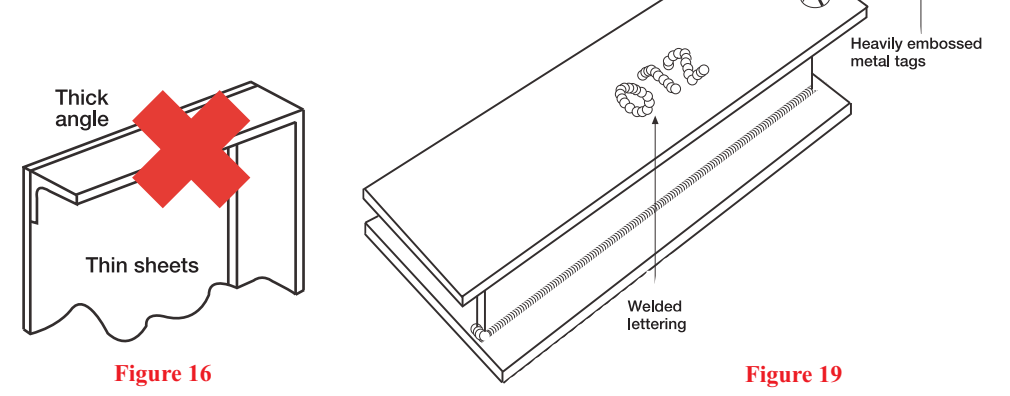


Figure 16

OVERLAPPING SURFACES
A minimum gap of at least 2mm between plates, overlapping surfaces and back-to-back angles and channels, must be provided (figure 21).
When small overlaps are unavoidable, seal edges by welding.
In circumstances where seal welding is not practical, a degree of temporary surface staining at crevices may be apparent after hot dip galvanizing and quenching. This is often incorrectly described as acid staining. Clean with a bristle brush and mild detergent if necessary. Crevices of this nature can be sealed after hot dip galvanizing with an appropriate sealant.

LARGER OVERLAPPING SURFACES
If contacting surfaces cannot be avoided, one diameter 10mm hole is to be provided in one of the members for every 100cm² of overlap area and the perimeter of the contacting area should be continuously welded (figure 23). A vent hole in one member will ensure the safety of galvanizing personnel and prevent damage to the article.

STRENGTHENING GUSSETS AND WEBS
Welded strengthening gussets and webs on columns and beams, and strengthening gussets in members fabricated from channel or I-beam sections should have corners cropped or hot (figures 2 & 24).
To prevent the entrapment of air in pockets and corners allowing complete access of pickle acids and molten zinc to the entire surface of the work,
To facilitate drainage during withdrawal from degreaser, acid solutions, rinsewater, flux and molten zinc.

CLEARANCE FOR MOVING PARTS
Drop handles, hinges, shackles, shafts and spindles require a minimum radial clearance, to allow for the thickness of the hot dip galvanized coating (see below).
Shaft or spindle size

| | |
|---------------------|-------------|
| Up to 30mm diameter | 2.0mm |
| Over 30mm diameter | 2.0 - 2.5mm |

The galvanized coating on the bolt provides corrosion protection for the internal thread on the nut.
Nuts tapered slightly after hot dip galvanizing (see residual coating)
Galvanized stud or bolt

IDENTIFICATION MARKINGS
For permanent identification use heavily embossed, punched or welded lettering. For temporary identification use heavily embossed metal tags wired to the work, water soluble paint or the correct marking pen.
Do not use enamel/paints, adhesive labels or any other coating that cannot be readily removed by degreasing or pickling. If present, these coatings require to be removed by paint stripper, grinder or abrasive blasting prior to pickling and hot dip galvanizing. An appropriate marking pen which is easily removable in the cleaning process is available (contact the Association).

INSPECTION OF WORK BEFORE DESPATCH TO THE GALVANIZER
Fabricated assemblies, castings and other components for hot dip galvanizing should be inspected and any significant surfaces identified, before despatch to the galvanizer to ensure that the following points conform to design requirements. This may avoid costly re-identification and delays at the galvanizing plant.

STRUCTURAL STEEL
Check that punching, shearing and bending have been carried out in conformity with the recommendations above.
SATISFACTORY HOT DIP GALVANIZING
Observance of the points listed above will ensure optimum hot dip galvanized product quality and minimise extra costs or delays.

- Check that closed vessels and tubular fabrications are vented with appropriate size holes, for safety and satisfactory hot dip galvanizing.
- Check that welding slag and spatter have been completely removed (anti-spatter agents are highly recommended).
- Check that assemblies comprising castings and steels of widely differing surface conditions have been abrasive blast cleaned. This will minimize differences in the coating.
- Check that castings are abrasive blast cleaned before despatch unless otherwise arranged.
- Check that large grey iron castings have been normalised.
- Check that all temporary fabrication markings are easily removed by the galvanizing process and that permanent identification markings (if necessary) have been provided.
- Check that an appropriate marking pen which is easily removed, has been used. Contact the Association.

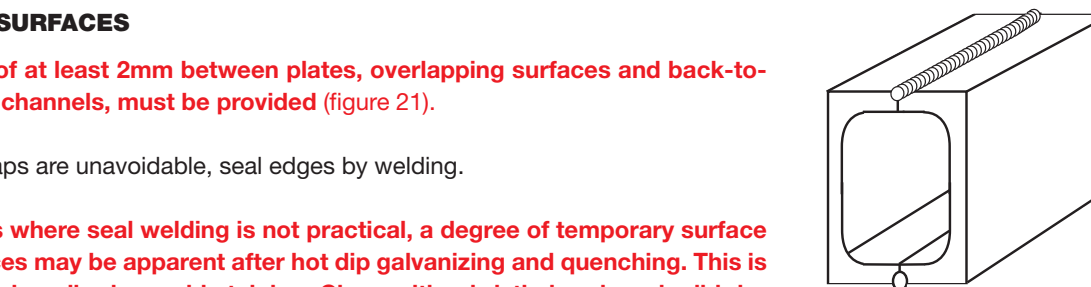


Figure 21

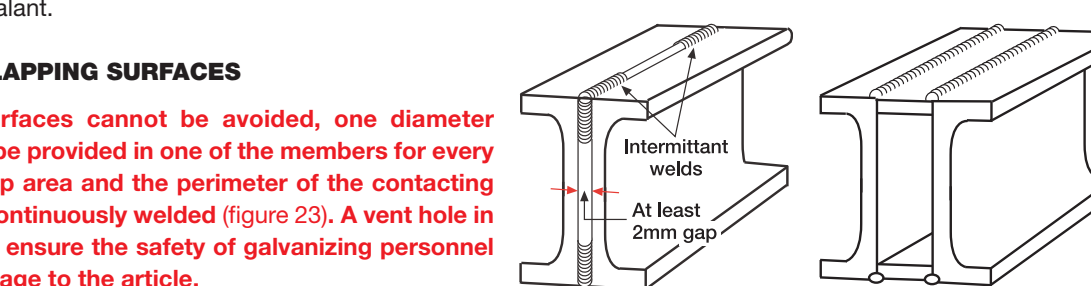


Figure 22

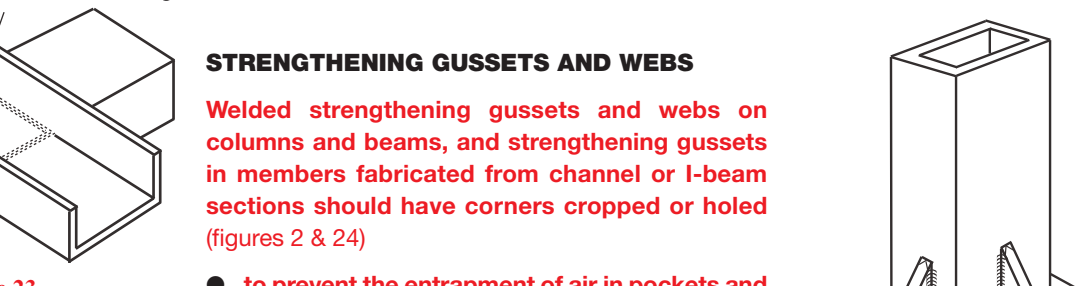


Figure 23

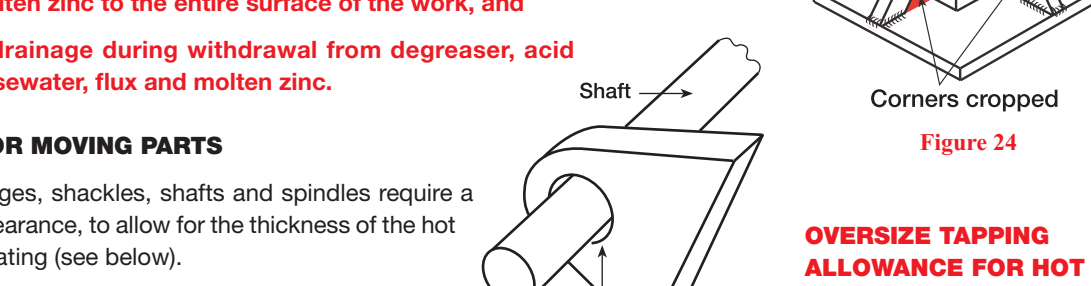


Figure 24

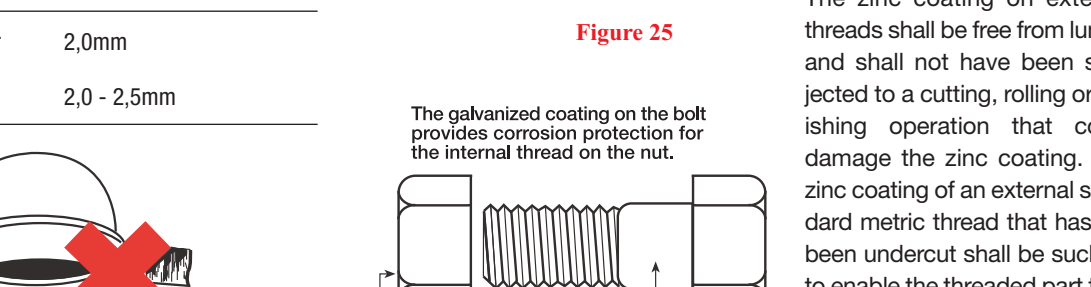


Figure 25

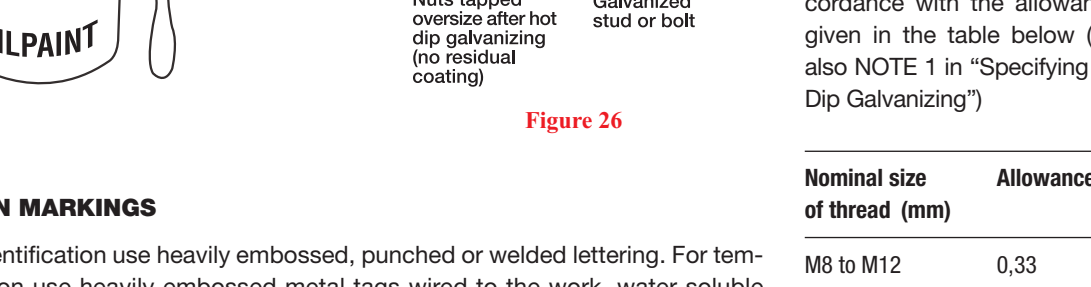


Figure 26

OVERSIZE TAPPING ALLOWANCE FOR HOT DIP GALVANIZED NUTS
The zinc coating on external threads shall be free from lumps and shall not have been subjected to a cutting, rolling or finishing operation that could damage the zinc coating. The zinc coating of an external standard metric thread that has not been undercut shall be such as to enable the threaded part to fit an oversized tapped nut in accordance with the allowances given in the table below (See also NOTE 1 in "Specifying Hot Dip Galvanizing")

| Nominal size of thread (mm) | Allowance |
|-----------------------------|-----------|
| M8 to M12 | 0.33 |
| M16 to M24 | 0.38 |

On bolts greater than M24, undercutting of bolt threads is frequently preferred to oversizing of nut threads. The allowance should be increased to 0.4mm.

THE HOT DIP GALVANIZERS ASSOCIATION OF SOUTHERN AFRICA

Introduction
The Hot Dip Galvanizers Association of Southern Africa was founded in 1965 and its membership represents the majority of the available hot dip galvanizing capacity of Southern Africa.
The Vision
To position the Hot Dip Galvanizers Association of Southern Africa, comprising all its members and other interested parties, as a professional organization serving the interests of all parties dependent upon the hot dip galvanizing industry.

Charter Statement
The primary role of the Hot Dip Galvanizers Association of Southern Africa is to promote a higher level of acceptance of, and confidence in, hot dip galvanized products and offerings on a national basis. The Association is the vehicle that provides all of its members with technical know-how and marketing support in order to grow the quality and acceptability of hot dip galvanizing in the marketplace.
Publications Available from the Association
● Association Magazine - Hot Dip Galvanizing Today (Free publication quarterly)
● Steel Protection By Hot Dip Galvanizing and Duplex Coating Systems.
● Practical Guidelines for the Inspection and Repair of Hot Dip Galvanized Coatings.
● HDGASAI-1999 Code of Practice for Surface Preparation and Application of Organic Coatings Applied to New Unweathered Hot Dip Galvanized Steel.
● HDGASAI-2006 Hot Dip Galvanizing and Duplex Coating Protection Specifications.
● Hot Dip Galvanizing for Architectural Purposes Check List.
● Wall Chart - Design for Hot Dip Galvanizing.
● Facts About Hot Dip Galvanizing.
Please visit our website www.hdgasa.org.za for Information Sheets, Case Studies and other technical information.

Participating in development projects on behalf of industry by providing assistance in the form of technical consulting, practical recommendations and assistance with the preparation of design specifications.
Providing assistance with quality control during fabrication and hot dip galvanizing.
Disseminating technical knowledge by providing a consulting and training service as well as the publication of technical literature.
Providing financial and education for member companies to ensure a high standard of quality and service throughout the galvanizing industry.

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SPECIFYING HOT DIP GALVANIZING

The galvanizer acts as a sub-contractor to a steel fabricator and as such, his contractual relationship is normally with the fabricator, not with the ultimate user or specifier. It is important, therefore, that the users' or specifiers' requirements for hot dip galvanizing are made clear to the fabricator and that all instructions are channelled (in writing) via the fabricator to the galvanizer. Alternatively, the selected galvanizer should be invited to participate in the initial project team meetings, when surface finishes as in duplex coatings or "Architectural Hot Dip Galvanizing", are crucial.

To ensure compliance in all aspects of the standard, specifiers and customers on enquiry should request a certificate of conformance to ISO10474 such as the SABS Mark Scheme. For technical support from the HDGASA a member of the Association, is preferred.
When hot dip galvanizing is specified, the surface of the base steel is completely covered with a relatively uniform coating of zinc and the minimum thickness specified is related to the thickness of the steel being hot dip galvanized, as shown in table 3.

HOT DIP GALVANIZING SPECIFICATIONS
SANS121 (ISO1461:2009): Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods.
SANS32 (EN10240:1997): Internal and/or external protective coatings for steel tubes - Specification for hot dip galvanized coatings applied in automatic plants.

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NOTE
Where steel composition does not include moderate to high reactivity, thicker coatings are not always easily achieved.

The specification does not stipulate a maximum upper coating thickness limitation, however, excessively thick coatings on threaded articles are undesirable. In order to ensure effective lamination an appropriately oversized nut must be screwed on to the bolt for quality assurance purposes, this applies particularly to high strength bolts.
Lead Times
As a general guide, most articles can be hot dip galvanized and returned to the fabricator within 7 days after receipt.

IN THE CASE OF LARGE CANTERS, THE GALVANIZER SHOULD BE INVOLVED AT THE PROGRAMMING STAGE WITH THE FABRICATOR AND THE END USER. Hot dip galvanizing is normally the final process after fabrication and prior to delivery and erection. If sufficient time for galvanizing and inspection is not provided in the overall programme, costly delays may occur at the erection stage.