

Design, specification, inspection of galvanized products

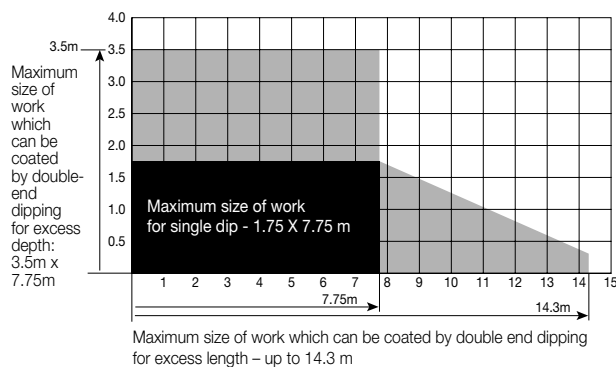
Consistently good galvanized steel products will be produced when the essential requirements listed are incorporated at the design and fabrication stages of production. Design features should be discussed with the galvanizer. Close liaison between design engineer, materials engineer, specifier, fabricator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



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.

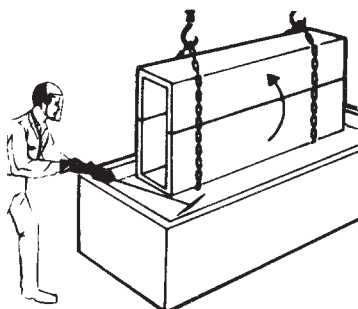
Materials suitable for galvanizing

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.

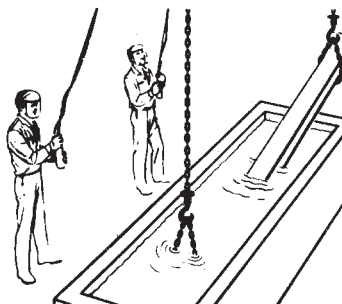
Soft-soldered assemblies cannot be galvanized. Brazed assemblies may be galvanized, but the galvanizer should be consulted at the design stage.

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:

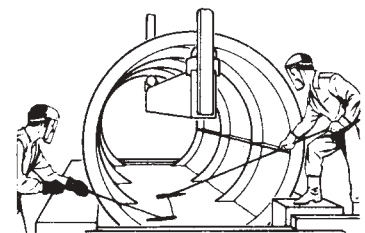
- 1 Design for uniform section thicknesses wherever possible.
- 2 Use large radii at junctions with webs, fillets and raised features such as cast-in part and pattern numbers.
- 3 Avoid deep recesses and sharp corners.
- 4 Large grey iron castings should be normalised by the fabricator.
- 5 Castings 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



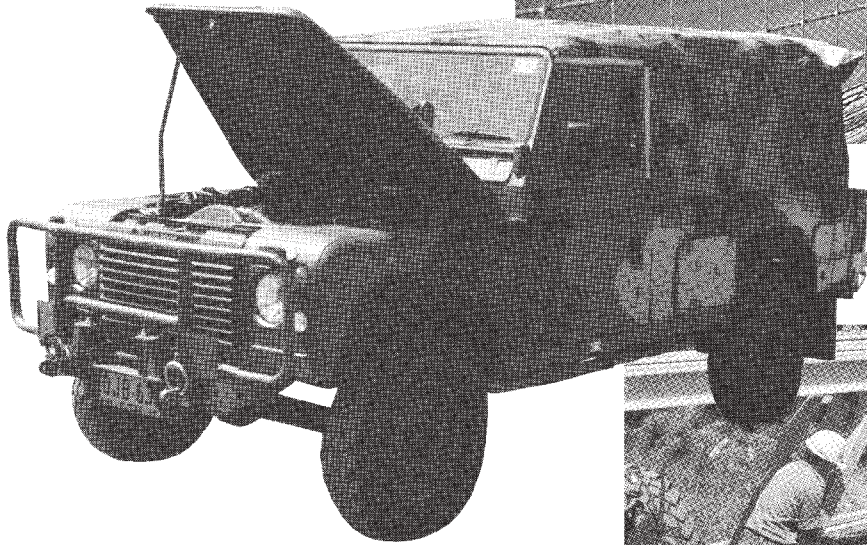
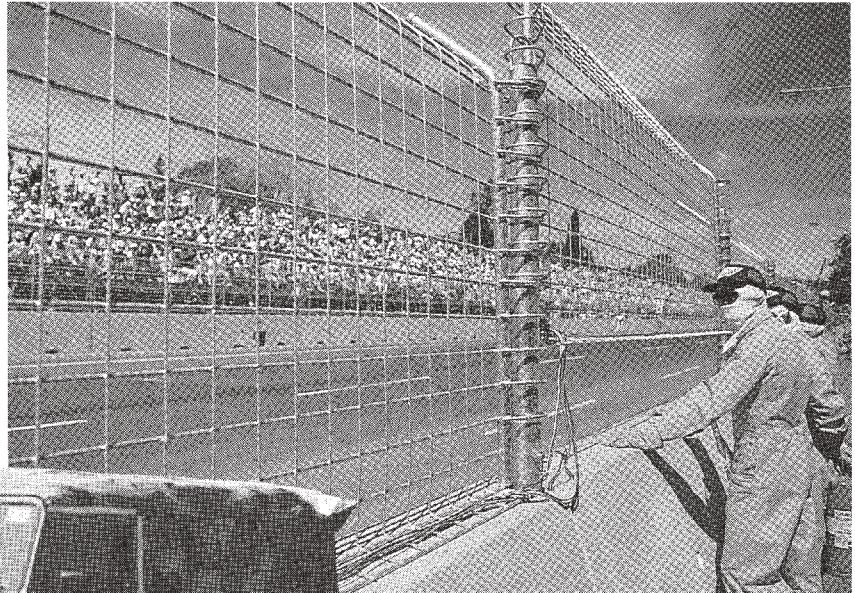
Double-end dipping for excess length



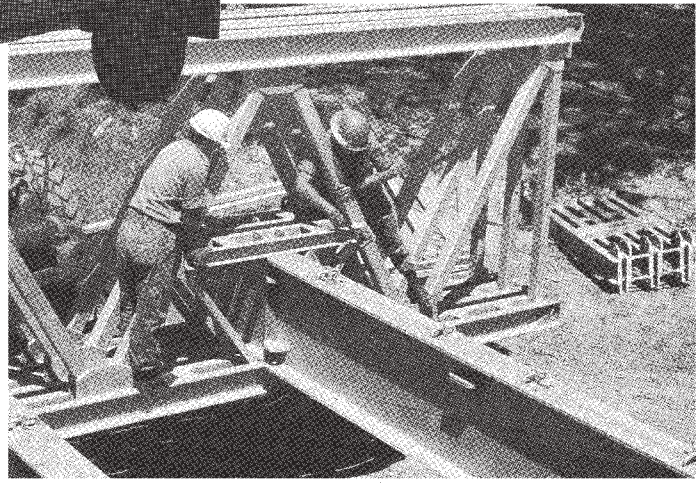
Progressive dipping

Right, galvanized steel weldmesh provides a "scatter shield" above temporary concrete barriers, Australian Grand Prix, Adelaide.

Below, Australian Army specification Land Rover features a hot dip galvanized chassis for protection against Australia's varied environmental and climatic conditions as well as the Army's demanding service requirements.



Below, the Army's modular bridging system is similar but superior to the old Bailey Bridge. Only galvanizing can handle rough treatment and tough field conditions.



Below, Adelaide's O-Bahn high-speed guided busway system. Galvanized steel clips are used to fasten the concrete tracks to concrete sleepers. All steelwork in the system is galvanized.



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 uncoiled, 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.

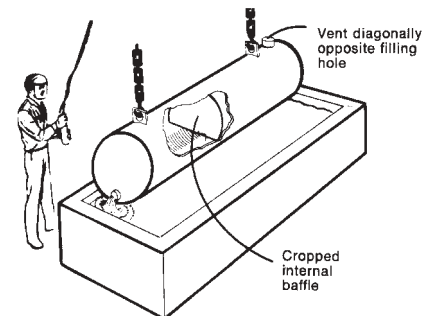
Venting, filling and draining

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.

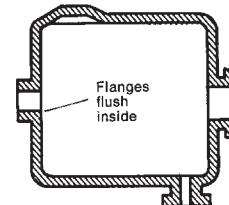
A filling hole as large as the design will allow and a minimum of 50 mm diameter for each 0.5 cubic metres should be provided. A vent hole of equal dimensions should be provided diagonally opposite the filling hole to allow the escape of enclosed air and to facilitate draining.

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



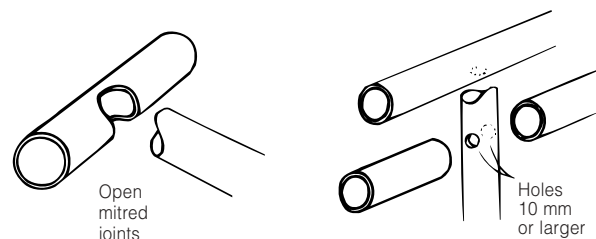
Internal baffles in tanks should be cropped on the bottom or provided with suitable drainage holes to permit free flow of molten zinc. Access ports, bosses and openings should be finished flush inside.

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.

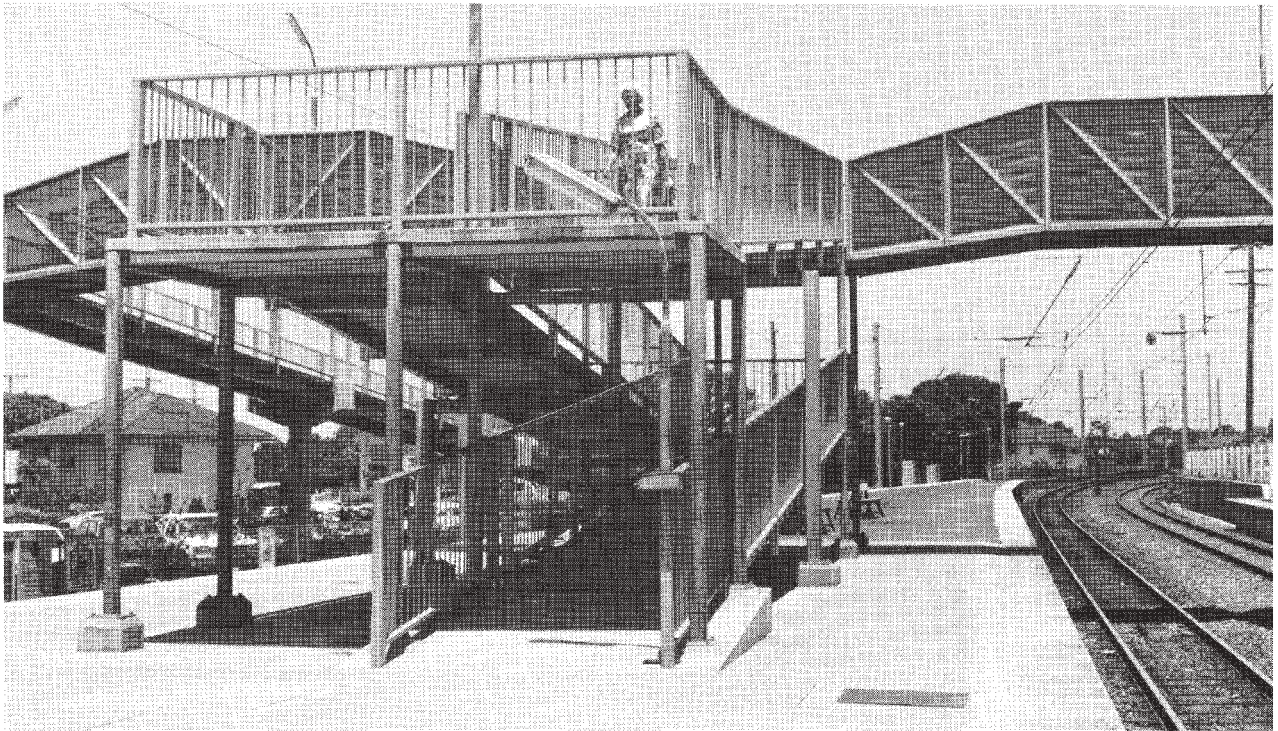


Hollow structurals and fabricated columns.

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.

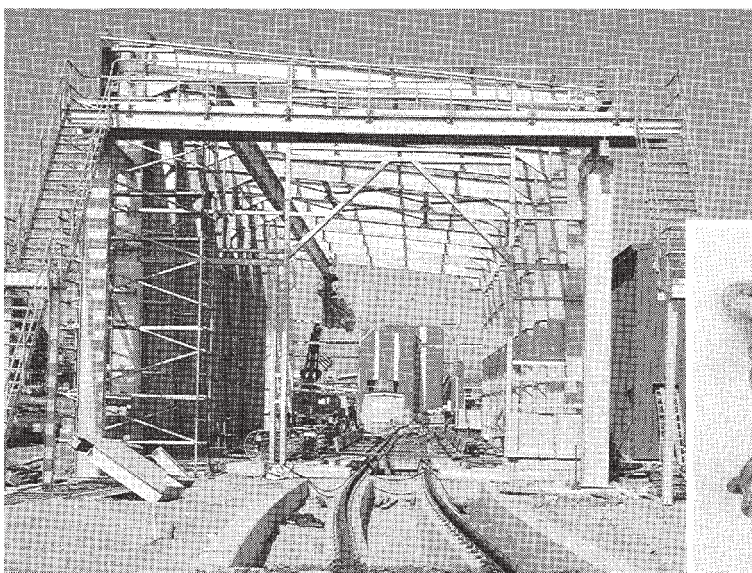
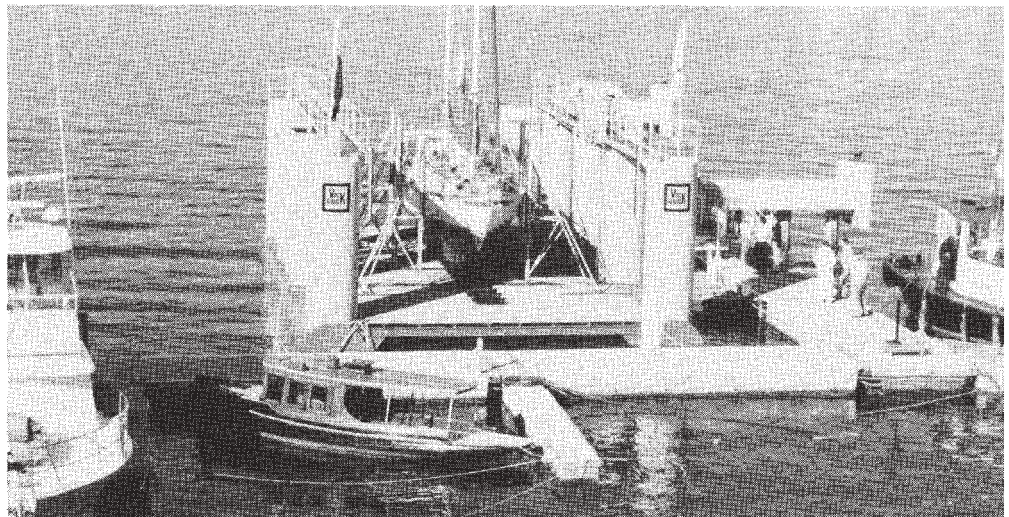


All welded sections in fabricated pipework should be interconnected with open tee or mitre joints. Alternatively each closed section must be provided with a vent hole of not less than 10 mm diameter. Pipe ends or flanges should always be left open, or provided with removable vent plugs.



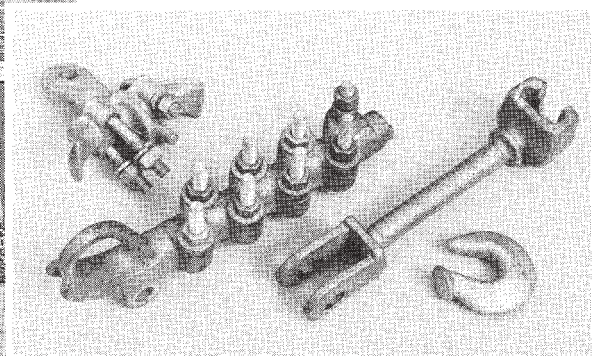
Above, galvanized steel footbridge at Northgate Station, Brisbane, Queensland, built from welded steel structural modules, galvanized after fabrication. Longest module, spanning the tracks at right, is 12.3 metres long. Pre-fabrication allowed erection with minimum disruption to traffic.

Right, floating drydock for small craft is 17 metres long and weighs 45 tonnes. Work deck and most ancillary steelwork is galvanized.



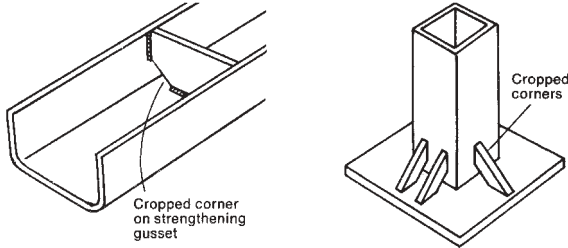
Left, steel framework for the rail dump station, part of the coal loader complex at Koorangang Island, Newcastle, NSW is hot dip galvanized for long term freedom from maintenance.

Below, steel power transmission pole line hardware is galvanized for fit-and-forget corrosion protection. Threads are galvanized to provide matched protection.



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.

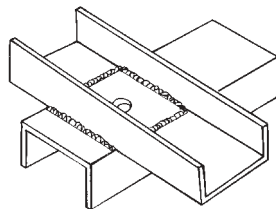


Overlapping surfaces. Narrow gaps between plates and in particular, overlapping surfaces and back-to-back angles should be avoided. As discussed on page 35 under 'Safety', any pickle acid or rinse water trapped in narrow gaps between members is rapidly converted to superheated steam at galvanizing temperatures,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

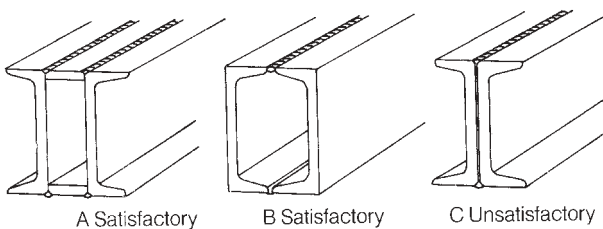
Where small overlapping areas are unavoidable, edges should be sealed after consultation with the galvanizer, by a continuous pore-free weld to prevent penetration of pickle acid. For the safety of galvanizing personnel the sealed area **must** be provided with a vent hole for every 100 cm² of sealed 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 possibility of an explosion during galvanizing, a vent hole must be provided for every 100 cm² 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.



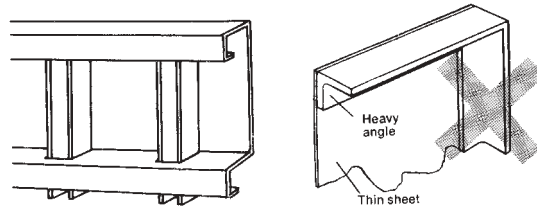
Dimensional stability

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

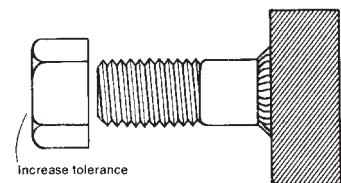
Moving parts such as drop handles, hinges, shackles and shafts must incorporate minimum radial clearances as detailed below:

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 thread.



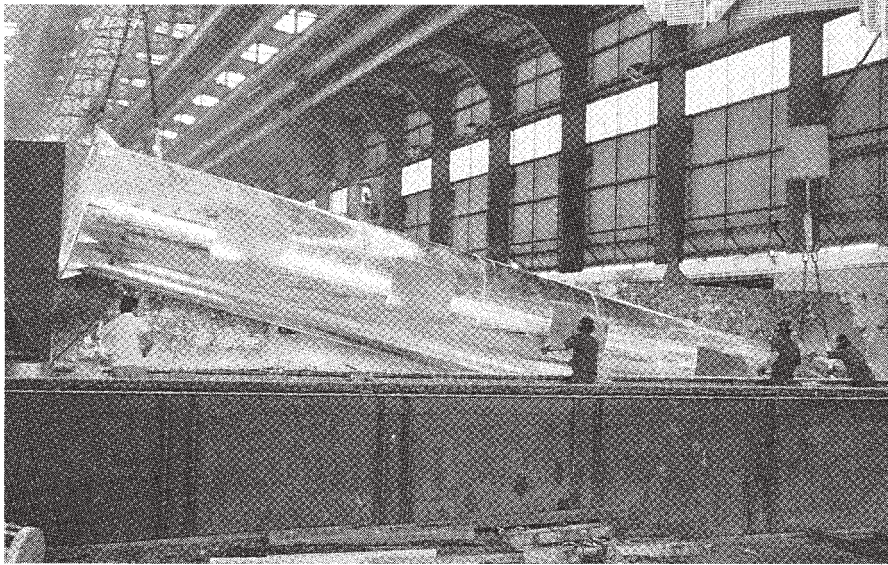
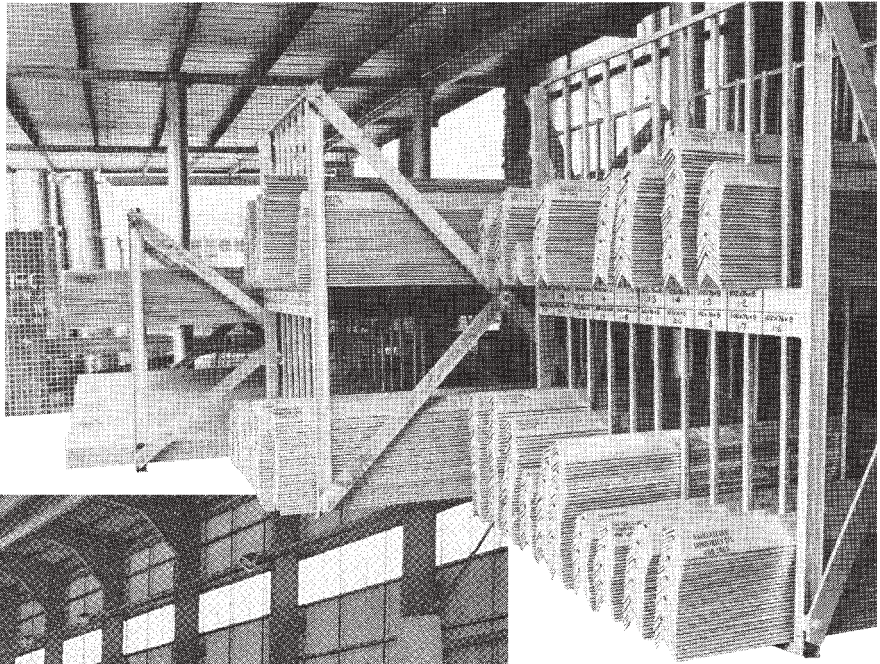
For economy, nuts are sometimes galvanized as blanks and threads are tapped after galvanizing. Uncoated internal threads are acceptable since the zinc coating on the external thread provides full corrosion protection.

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

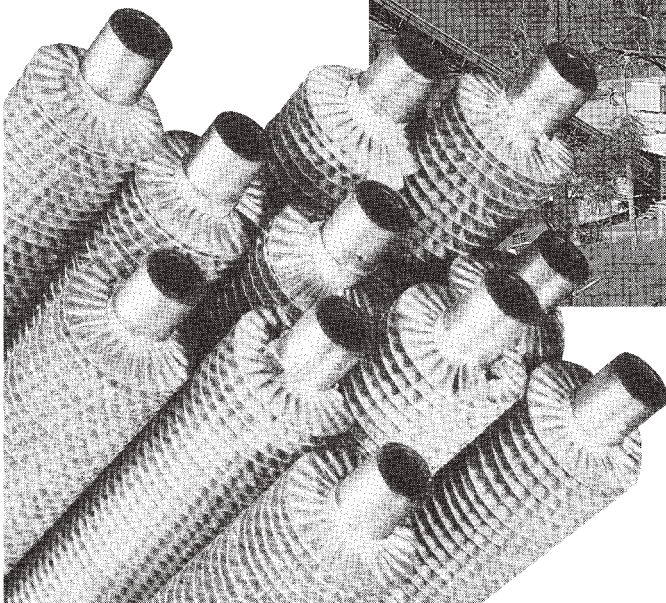
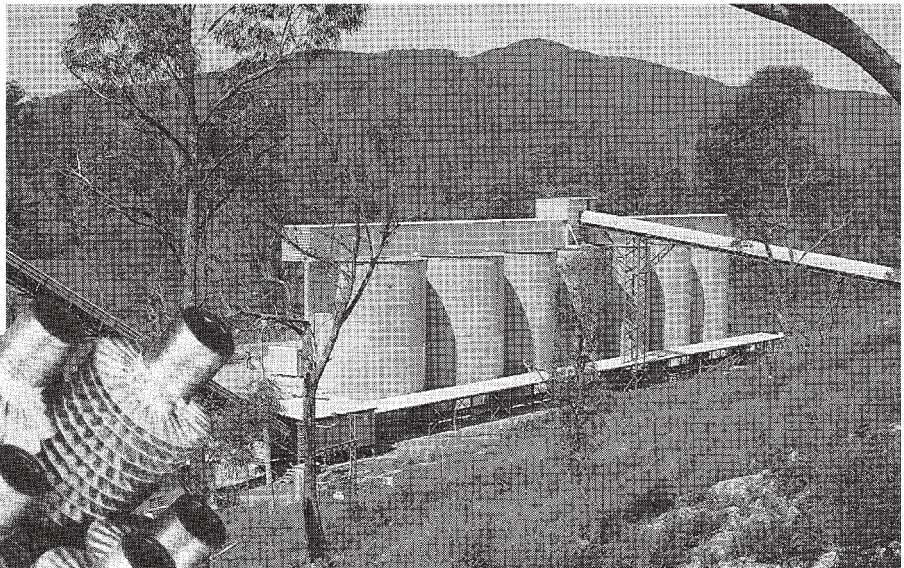
When internal pre-tapped threads included in components are required not to be galvanized they may be plugged temporarily by means of bolts or studs screwed fully in, after discussion with the galvanizer.

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.

Right, the use of galvanized lintels or arch bars in new buildings is mandatory in many municipalities and as a result they are widely available as an economic, stock item.



Above, large steel 'window tube', used on the end of a coal stacking conveyor, is galvanized because no other coating provides the same combination of corrosion protection and abrasion resistance.



Above, gravel silos are also galvanized for optimum combination of corrosion and abrasion resistance. Bolted design allows disassembly and relocation.

Left, heat exchanger fins are crimped onto tubes during manufacture. The molten zin of the galvanizing bath 'solders' fins to tubes during galvanizing, providing an essential heat-transfer path.

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 discussed 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.

Standard specification for hot dip galvanized coatings

This specification has been prepared by the galvanizing industry through its technical working group, in consultation with industry and a number of consulting engineering groups. It is intended to be used in conjunction with Australian/New Zealand Standard 4680 and is designed for simple insertion into specifiers' overall materials specifications.

NOTE

- 1 Prior to commencement of design it is recommended that the designer/fabricator refer to Australian/New Zealand Standard 4680 Appendix C 'Recommended procedures for design and preparation of materials prior to galvanizing', and to the chapter on Design in the manual 'Hot Dip Galvanizing', produced by Galvanizers Association of Australia.
- 2 The designer is referred to the recommendations contained in Appendix D of AS/NZS 4680 to minimise distortion and reduce the likelihood of embrittlement occurring.
- 3 High strength low alloy steels, particularly those containing silicon can, when galvanized, produce brittle coatings which are thicker and different in colour to normal coatings. The high silicon content in weld deposits made by automatic welding processes may result in thicker coatings being formed on these areas. These coating characteristics are usually beyond the control of the galvanizer.
- 4 If the galvanized coating is to be subsequently painted or if an architectural finish or any other special treatment is required, these requirements should be brought to the attention of the galvanizer at the time of enquiry and order.

SCOPE

This specification covers the galvanized coating applied to general steel articles, structural sections, angles, channels, beams, columns, fabricated steel assemblies, threaded fasteners and other steel components.

This specification does not apply to the galvanized coating on semi-finished products such as wire, tube or sheet galvanized in specialised or automatic plants.

RELEVANT STANDARDS

AS 1214-1983 Hot dip galvanized coatings on threaded fasteners.

AS 1627-1989 Part 1 Cleaning using liquid solvents and alkaline solutions.

AS 1627-1989 Part 4 Abrasive blast cleaning.

AS 1627-1975 Part 5 Pickling steel surfaces (in part).

AS/NZS 4680-1999 Hot-dip galvanized (zinc) coatings on fabricated ferrous articles.

GENERAL

The galvanized coating on all steel articles on the following drawings and material lists shall conform to the requirements of AS/NZS 4680-1999 and as specified herein.

Drawings: _____

Items: _____

FABRICATION

Care shall be taken to avoid fabrication techniques which could cause distortion or embrittlement of the steel.

All welding slag and burrs shall be removed prior to delivery to the galvanizer

Holes and/or lifting lugs to facilitate handling, venting and draining during the galvanizing process shall be provided at positions as agreed between the designer and the galvanizer.

Unsuitable marking paints shall be avoided and consultation by the fabricator with the galvanizer about removal of grease, oil, paint and other deleterious materials shall be undertaken prior to fabrication.

SURFACE PREPARATION

Surface contaminants and coatings, which cannot be removed by the normal chemical-cleaning process in the galvanizing operation shall be removed by abrasive blast cleaning or some other suitable method.

Steelwork shall be precleaned in accordance with the requirements of AS 1627 Part 1 followed by acid pickling, in accordance with the requirements of AS 1627 Part 5. Abrasive blast cleaning to Class 2 finish in accordance with the requirements of AS 1627 Part 4 may be used.

GALVANIZING

All articles to be galvanized shall be handled in such a manner as to avoid any mechanical damage and to minimise distortion. (See Note 2 above)

Design features that may lead to difficulties during galvanizing should be pointed out prior to galvanizing.

Galvanizing parameters such as galvanizing temperature, time of immersion, and withdrawal speed shall be employed to suit the requirements of the article.

The composition of the zinc in the galvanizing bath shall not be less than 98.0% zinc.

COATING REQUIREMENTS

1 Thickness

The thickness of the galvanized coating shall conform with Table 1 in AS/NZS 4680:

Table 1. Requirements for coating thickness and mass for articles that are not centrifuged

Steel Thickness mm	Local coating thickness minimum μm	Average coating thickness minimum μm	Average coating mass minimum g/m^2
A1.5	35	45	320
>1.5 A3	45	55	390
>3 A6	55	70	500
>6	70	85	600

Note: 1 g/m^2 coating mass = 0.14 μm coating thickness.

The thickness of the galvanized coatings on threaded fasteners shall conform with Table 2 in AS 1214:

Table 2. Requirements for coating thickness and mass for articles that are centrifuged

Thickness of articles (all components including castings) mm	Local coating thickness minimum μm	Average coating thickness minimum μm	Average coating mass minimum g/m^2
<8	25	35	250
B8	40	55	390

Notes: 1. For requirements for threaded fasteners refer to AS 1214. 2. 1 g/m^2 coating mass = 0.14 μm coating thickness.

The thickness of the galvanized coating shall first be tested by the purchaser/designer at the galvanizer's works, using an approved magnetic measuring device. In the event of any dispute, an independent test shall be carried out in accordance with AS/NZS 4680, Appendix G.

2 Surface Finish

The galvanized coating shall be continuous, adherent, as smooth and evenly distributed as possible, and free from any defect that is detrimental to the stated end use of the coated article. On silicon killed steels, the coating may be dull grey, provided the coating is sound and continuous. (See Note 3)

The integrity of the coating shall be determined by visual inspection and coating thickness measurements.

Where slip factors are required to enable high strength friction grip bolting, where shown, these shall be obtained after galvanizing by suitable mechanical treatment of the faying surfaces.

Where a paint finish is to be applied to the galvanized coating, all spikes shall be removed and all edges shall be free from lumps and runs. (See Note 4 at left).

3 Adhesion

The galvanized coating shall be sufficiently adherent to withstand normal handling during transport and erection.

INSPECTION

Inspection shall be carried out at the galvanizer's works by a designated party, or at some other place as agreed between fabricator and galvanizer.

CERTIFICATE

When requested by the purchaser/designer, a certificate shall be provided stating that the galvanizing complies with the requirements of AS/NZS 4680.

TRANSPORT AND STORAGE

Galvanized components shall, wherever possible, be transported and stored under dry, well-ventilated conditions to prevent the formation of wet storage staining following the recommendations contained in AS/NZS 4680 Appendix F.

A chromate passivation treatment after galvanizing may be used to minimise the wet storage staining which may occur on articles unable to be stored in dry, well-ventilated conditions.

Any wet storage staining shall be removed by the galvanizer if formed prior to leaving the galvanizer's plant, unless late pick-up or acceptance of delivery has necessitated the material being stored in unfavourable conditions. Provided the coating thickness complies with the requirements of AS/NZS 4680, no further remedial action is required to the stained areas.

WELDING

Where galvanized steel is to be welded, adequate ventilation shall be provided. If adequate ventilation is not available, supplementary air circulation shall be provided. In confined spaces a respirator shall be used.

Grinding of edges prior to welding may be permitted to reduce zinc oxide fumes formed during welding and eliminate weld porosity which can sometimes occur.

All uncoated weld areas shall be reinstated – see Coating Reinstatement.

COATING REINSTATEMENT

Areas of significant surface that are uncoated shall, by agreement between the purchaser and the galvanizer, be reinstated by following the recommendations contained in AS/NZS 4680, Appendix E, or by other methods nominated by the galvanizer and approved by the contractor. Similar repair methods shall be used for areas damaged by welding or flame cutting, or during handling, transport and erection.

The size of the area able to be repaired shall be relevant to the size of the object and the conditions of service but shall normally be in accordance with the provisions of AS/NZS 4680, Appendix E.

SWEEP (BRUSH) BLAST CLEANING OF GALVANIZED STEEL PRIOR TO PAINTING

Refer AS/NZS 4680 Appendix I

GENERAL INFORMATION ON FACTORS THAT AFFECT THE CORROSION OF GALVANIZED STEEL

Refer AS/NZS 4680 Appendix H

Standards for galvanized products

Galvanized products should be specified in accordance with the appropriate national standards, which have been drawn up to provide minimum standards to ensure optimum performance of galvanized products and to give guidance in selection, application, and design.

AS2312 'Guide to the protection of iron and steel against exterior atmospheric corrosion' is a particularly valuable reference in the selection of the most practical, economic coating in particular applications.

Relevant Australian standards

- AS1214-1983** Hot dip galvanized coatings on threaded fasteners.
- AS/NZS 4680 -1999** Hot-dip galvanized (zinc) coatings on fabricated ferrous articles.
- AS 2312-1994** Guide to the protection of iron and steel against exterior atmospheric corrosion.

New Zealand standards

- AS/NZS 4680 -1999** Hot dip galvanized (zinc) coatings on fabricated - ferrous articles.
- Works Consultancy Services CD 306**
Specification for hot dip galvanizing on structural steel work.
- Works Consultancy Services CD 307**
Specification for protection of structural steel work.

British standards

- BS/EN/ISO 1461:1999** Hot-dipped galvanized coatings on fabricated iron and steel articles - Specifications and Test methods.

American (ASTM) standards

- A 90** Methods of test for weight of coating on zinc-coated (galvanized) iron and steel articles.
- A 123** Zinc (hot galvanized) coatings on products fabricated from rolled, pressed, and forged steel, steel shapes, plates, bars, and strip.
- A 143** Recommended practice for safeguarding against embrittlement of hot-dip galvanized structural steel products and procedure for detecting embrittlement.
- A 153** Zinc coating (hot-dip) on iron and steel hardware.
- A 384** Practice for safeguarding against warpage and distortion during hot-dip galvanizing of steel assemblies.
- A 385** Standard practice for providing high quality zinc coatings (Hot dip).
- A 767** Standard specification for zinc coated (galvanized) steel bars for concrete reinforcement.

Inspection of galvanized products

Visual inspection is the simplest and most important means of assessing the quality of galvanized coatings. A useful characteristic of the galvanizing process is that if the coating is continuous and has a satisfactory appearance it will be sound and adherent, with a zinc coating mass of at least 600 g/m² on fabricated articles over 6 mm thick, as discussed in more detail on page 13.

Appearance

A galvanized coating is normally smooth, continuous and free from gross surface imperfections and inclusions. While the heavy zinc coating on general galvanized articles should be

smooth and continuous it cannot be compared for surface smoothness to continuously galvanized sheet steel or wire since these are produced by processes which permit close control of coating thickness and appearance.

Differences in the lustre and colour of galvanized coatings do not significantly affect corrosion resistance and the presence or absence of spangle has no effect on coating performance. As discussed under 'Dull grey coating' below, uniform or patchy matt grey galvanized coatings give equal or better life than normal bright or spangled coatings.

It is recommended that inspection of galvanized work should be carried out by a designated party at the galvanizer's works in accordance with the following guidelines, and tested when necessary as detailed under 'Non-destructive testing for coating thickness', page 45.

Variations in appearance and their relationship to coating quality

Variations in appearance of galvanized coatings listed below and their influence on coating quality are discussed on following pages.

Dull grey coating

General comment: Acceptable.



A dull grey appearance is caused by growth of the zinc-iron alloy layers through to the surface of the galvanized coating. Grey coatings may appear as localized dull patches or lacework patterns on an otherwise normal galvanized coating or may extend over the entire surface.

Dull grey coatings usually occur on steels with relatively high silicon content which are highly reactive to molten zinc as discussed under 'Composition of steel' page 15.

Welds made with steel filler rods containing silicon may also produce localised grey areas in an otherwise normal galvanized coating, as discussed on page 35.

Dull grey coatings are often thicker than the normal bright or spangled coatings and therefore give longer life. It is rarely possible for the galvanizer to minimise or control the development of dull grey coatings which is dependent basically on steel composition.

Blisters

General comment: Small intact blisters acceptable.

Extremely rare. Small blisters in galvanized coatings are due to hydrogen absorbed by the steel during pickling being expelled as a result of the heat of the galvanizing process. Their occurrence is due to the nature of the steel and is outside the control of the galvanizer. Blisters do not reduce the corrosion resistance of the coating.

Rust stains

General comment: Acceptable when present as a surface stain.



Rust staining on the surface of galvanized coatings is usually due to contact with or drainage from other corroded steel surfaces. Steel filings or saw-chips produced during erection and fabrication operations should be removed from galvanized surfaces to prevent possible localised rust staining. Rust staining may also be caused by the weeping of pickling acid from seams and joints causing damage to the galvanized coating, and in such cases requires a modification in design as discussed under 'Overlapping surfaces' on page 37.

A thin brown surface staining sometimes occurs in service when the galvanized coating comprises entirely zinc-iron alloys as discussed under 'Dull grey coating' page 42. Staining arises from corrosion of the iron content of the zinc-iron alloy coating and is therefore outside the control of the galvanizer. It has no effect on the corrosion resistance of the coating. Long term exposure testing has shown that the corrosion resistance of zinc-iron alloys is similar to that of normal galvanized coatings.

General roughness and thick coatings on welds.

General comment: Acceptable, unless otherwise agreed.



Rough galvanized coatings usually result from uneven growth of zinc-iron alloys because of the composition or surface condition of the steel. Where welding electrodes containing silicon have been used, the galvanized coating on the weld area may be thicker than normal and may also be brittle. Rough coatings of this type are usually thicker than normal and therefore provide longer protective life.

General roughness may also be caused by over-pickling, prolonged immersion in the galvanizing bath, or excessive bath temperature, factors which are frequently dictated by the nature of the work and may be beyond the control of the galvanizer.

In architectural applications where a rough finish is aesthetically or functionally unacceptable, the steel composition and surface preparation should be closely specified and the galvanizer consulted at an early stage. It is rarely possible for the galvanizer to effect any later improvement.

Lumpiness and runs

General comment: Acceptable unless otherwise specified.



Australian/New Zealand Standard 4680 'Hot dip galvanized (zinc) coatings on fabricated ferrous articles' demands that a galvanized coating shall be 'smooth' but points out that smoothness is a relative term and that coatings on fabricated articles should not be judged by the same standards as those applied to continuously galvanized products such as sheet steel and wire, since these are produced by processes which permit a high degree of control over coating thickness and appearance. Lumps and runs arising from uneven drainage are not detrimental to coating life.

When zinc drainage spikes are present on galvanized articles and their size and position is such that there is a danger they may be knocked off in service removing the coating down to the alloy layers, they should be filed off by the galvanizer and, where necessary, the coating should be repaired as described on page 45.

For architectural applications the galvanizer can sometimes achieve a smoother finish than the normal commercial coating, depending on the shape and nature of the product. The steel should be carefully specified and the galvanizer consulted at the design stage and advised when the order is placed. Extra cost may be involved.

Pimples

General comment: May be grounds for rejection depending on size and extent.

Pimples are caused by inclusions of dross in the coating. Dross, which comprises zinc-iron alloy particles, has a similar



corrosion rate to the galvanized coating and its presence as finely dispersed pimples is not objectionable. Gross inclusions may be grounds for rejection as they tend to embrittle the coating.

Bare spots

General comment: Acceptable if small in area and suitably repaired, depending on the nature of the product.



Small localised flaws up to about 3 mm wide in a galvanized coating are usually self-healing because of the cathodic protection provided by the surrounding coating as discussed under Cathodic Protection on pages 9, 10 and 11. They have little effect on the life of the coating.

Australian/New Zealand Standard 4680 Appendix E 'Renovation of damaged or uncoated areas' specifies that "... the sum total of the damaged or uncoated areas shall not exceed 0.5% of the total surface area or 250cm², whichever is the lesser, and no individual damaged or uncoated areas greater than 40cm². However, as an exception, uncoated areas greater than 40cm², which have been caused by unavoidable air locks during the galvanizing operation, shall be repaired." Repair methods which accord with AS/NZS 4680 Appendix E are detailed on page 45.

Bare spots may be caused by under-preparation by the galvanizer and by a number of factors outside his control, and for which he cannot be responsible, including the presence of residual welding slags, rolling defects such as laps, folds and laminations in the steel, and non-metallic impurities rolled into the steel surface.

Wet storage stain or bulky white deposit

General comment: Not the galvanizer's responsibility unless present before first shipment. Acceptable if non-adherent deposit is removed and the coating meets coating mass requirements.

A bulky white or grey deposit, known as wet storage stain may form on the surface of closely stacked freshly galvanized articles which become damp under poorly ventilated conditions during storage or transit. In extreme cases, the protective value of the zinc coating may be seriously impaired but the attack is often very light despite the bulky appearance of the deposit.

Initiation and development of wet storage staining on new galvanized surfaces is readily prevented as detailed on page 22 by attention to conditions of storage and transport and by application of a chromate passivation treatment.

Where the surface staining is light and smooth without growth of the zinc oxide layer as judged by lightly rubbing fingertips across the surface, the staining will gradually disappear in service and blend in with the surrounding zinc surface as a result of normal weathering.

When the affected area will not be fully exposed in service, particularly on the underside of steelwork and in condensation areas, or when it will be subject to a humid environment, wet storage staining must be removed as

detailed below, even if it is superficial. Removal is necessary to allow formation of the basic zinc carbonate film which normally contributes to the corrosion resistance of galvanized coatings.



Medium to heavy buildup of white corrosion product must be removed to allow formation of a basic zinc carbonate film in service. Light deposits can be removed by brushing with a stiff bristle brush. Heavier deposits can be removed by brushing with a 5 percent solution of sodium or potassium dichromate with the addition of 0.1 percent by volume of concentrated sulphuric acid. This is applied with a stiff brush and left for about 30 seconds before thorough rinsing and drying.

A check should be made to ensure that the coating thickness in affected areas is not less than the minimum specified in relevant standards for the various classes of galvanized coatings as detailed on page 42.

In extreme cases, where heavy white deposit or red rust has been allowed to form as a result of prolonged storage under poor conditions, corrosion products must be removed by thorough wire brushing and the damaged area repaired as detailed on page 45.

Dark spots/Flux staining

General comments: Acceptable if flux residues have been removed.

Smuts of dirt may be picked up on the surface of the galvanized coating from floors and trucks or from contact with other articles. These smuts are readily washed off to reveal a sound coating and are not harmful.



Where a flux blanket is used in the galvanizing process, stale flux may adhere to the surface of the work during immersion and appear as a black inclusion in the coating. Such inclusions tend to pick up moisture forming a corrosive solution and coatings containing them should be rejected.

Black stains or deposits of flux picked up on the surface as

the object is withdrawn from galvanizing the bath do not warrant rejection provided the underlying coating is sound and the deposit is removed.

Non-destructive testing for coating thickness

Magnetic gauges provide simple non-destructive testing methods for coating thickness which are reliable and more convenient than the physical tests given under the various national standards listed on page 42.

Most gauges described are compact and can be used very quickly. They give coating thickness readings over very small areas and several readings should be taken and averaged. Uniformity as well as actual thickness can thus be easily checked.

These magnetic gauges give reliable thickness readings although some require frequent recalibration against non-magnetic coatings of known thickness and the makers' instructions are followed precisely. Accurate readings cannot be obtained near edges of work and obvious peaks or irregularities in the coating should be avoided. Surface curvature, surface area and steel thickness all affect readings in a predictable manner and allowances must be made.

Guidance on the use of these instruments is given in ASTM E376-68T 'Measuring coating thickness by magnetic field or eddy current (electromagnetic) test methods'.

Calibration curves for corrected readings and additional information on these important non-destructive testing methods are available free of charge from Galvanizers Association of Australia, 124 Exhibition Street, Melbourne Victoria 3000.

Minitector Model 156, Mitutoyo Neo-derm, and Minitest 500

The Minitector, Neo-derm and Minitest are small portable battery powered units which operate by measuring the changes in magnetic flux which occur when a magnet is separated from contact with a ferrous metal.

Positector 2000

The Positector 2000 is an easy-to-use digital readout single-point coating measurement instrument which works on a magnetic field simulation principle. It needs no calibration and gives accurate results unaffected by shock, vibration, or temperature.

Elcometer thickness gauge 101

This Elcometer contains a horseshoe magnet with its two poles exposed and works on a magnetic induction principle. When the instrument is placed with both poles touching the surface to be tested, changes of magnetic field brought about by variations in coating thickness move the bar magnet and the pointer. A mean thickness reading is given over the two points of contact.

The Inspector magnetic balance

The magnetic balance is based on the calibration of magnetic attraction to the steel beneath a coating. The same principle is used by pull-off type gauges, but the magnetic balance gives a stable reading and incorporates a counterbalanced magnet, allowing use in any position.

Pull-off type gauges

Simple pull-off magnetic thickness testing gauges such as the Tinsley Pencil Gauge and the Elcometer Pull-off Gauge Model 157 are convenient and inexpensive, but require greater operator skill and in general do not provide the accuracy of the gauges described above.

Reconditioning damaged surfaces in galvanized steel

When severe damage to the galvanized coating has occurred during welding or as the result of rough handling in transport or erection, protection must be restored.

Small areas of the basis steel exposed through mechanical damage to galvanized coatings are protected from corrosion cathodically by the surrounding coating and may not need repair, depending on the nature of the product and the environment to which it is exposed. Small exposed areas normally have little effect on the life of the coating as discussed under 'Bare spots,' page 44 and 'Cathodic protection,' page 11.

Repair methods

The coating repair methods detailed below are in accordance with Australian/New Zealand Standard 4680 Appendix E 'Renovation of damaged or uncoated areas'.

Zinc rich paints. The application of an organic zinc rich paint is the most rapid and convenient method of repair. The paint should conform to AS/NZS 3750.9:1994 'Zinc rich organic priming paint' applied in two coats by brush to provide a total film thickness of 100 µm and for optimum performance should contain not less than 92% zinc in the dried paint film.

Where colour matching is required aluminium paint may be applied over the hardened zinc rich paint.

Zinc metal spraying. In certain circumstances, by prior agreement, zinc metal spraying may be used as a method of coating repair. The damaged area must be grit blasted to Class 3 followed by zinc metal spraying to a coating thickness equivalent to that of the undamaged coating, and seal coated using an aluminium vinyl paint.