FREQUENTLY ASKED QUESTIONS ABOUT HOT DIP GALVANIZED COATINGS

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INTRODUCTION

Hot dip galvanizing of steel is technically a relatively simple process, but there are many aspects of the coating and its application that give rise to questions about its appearance and performance. This series of frequently asked questions about hot dip galvanized coatings has been assembled to cover some of the more common issues that arise.

FAQ 1 - HOW DO I REPAIR A GALVANIZED COATING?

When hot dip galvanized items are damaged by cutting or welding, it is recommended that the uncoated areas are repaired. There are a number of repair methods that are available and the galvanizing industry has used and evaluated a wide range of products for over 35 years.

There are a number of factors that have to be considered when repairing hot dip galvanized coatings. These are:

- The size of the area to be repaired
- The ease of use of the repair material
- The performance of the repair method with respect to the required performance of the hot dip galvanized coating

Zinc Rich Paint Repair

Almost all Australian galvanizers use Jotun Protective Coatings products for galvanizing repair, although any good quality epoxy zinc-rich paint system can be used.

For light duty applications, Jotun Galvanite, a one-pack, air drying zinc-rich primer can be used. The single pack system has good adhesion to prepared surfaces and can be handled after 2 hours (at 20°C).

Coating thickness per coat is typically 45 microns and two coats are required to ensure compatible coating thickness to the hot dip galvanized coatings.

Jotun's Barrier two-pack epoxy zinc rich system is recommended for heavy duty applications and full coating reinstatement. The two-pack system is touch dry in 15 minutes and hard dry in less than 2 hours at 20°C.

Two coats at 45 microns each are recommended to provide equivalent coatings thickness to hot dip galvanizing.

Tolerances for threaded components and moving parts need to be considered on galvanized items. The bolts used on these galvanized bolt cages have to be tapped oversize to accommodate the galvanized coating on the bolt shafts.

The recommended procedure for touch-up is as follows:

1. Power tool clean to *AS 1627:2 Class 3* to remove all welding scale, slag and corrosion products.
2. Degrease and remove all surface oil, grease or soil. (This step can be omitted on new welds where no organic contamination of the exposed steel has occurred.)
3. Apply two coats of Galvanite or Barrier to a minimum dry film thickness of 85 microns.
4. Observe good painting practice with respect to weather condition and application conditions. Ensure that steel surface is above Dew Point prior to application. Warm area to ensure surface dryness if temperature and humidity indicates Dew Point range has been reached.
5. Adhere to coating manufacturers' product data sheets for safety, mixing, pot life, application, overcoating and curing information.

6. If a close colour match is essential, apply a light coat of aluminium paint over repair area after drying. Rub over aluminium paint with a soft rag before drying to blend the repair into the surrounding galvanized coating appearance. NOTE: The aluminium paint is NOT an anti-corrosive coating and does not contribute to the performance of the repair.

Metallic Repair Coatings

There are various types of metallic repair materials available in the form of alloy 'sticks' which are applied by heating the area to be repaired and melting the repair material onto the area. Early repair sticks had a high lead content and did not reflect the characteristics of a galvanized coating.

Cominco of Canada has developed its Galvaguard repair alloy which has a higher zinc content and is claimed to be easier to use than previous repair alloys.

These repair alloys are best used for repairing welds and similar small areas on horizontal surfaces, which can be easily and quickly heated. A higher level of operator skill is required to affect successful repairs using Galvaguard or similar products. Supply of these proprietary products is sometimes problematical.

Hot dip galvanized coatings can tolerate very high temperatures for short periods. This simulated 'bushfire' test done on BlueScope Steels Sureline® galvanized steel power poles indicated that the coating was unaffected by bushfire duration exposure to heat.

Zinc metal spray is an effective repair method for larger areas, as it will apply a zinc coating of any required thickness. However, successful application requires a high quality surface preparation (Class 3) to ensure good adhesion. Specialised equipment and skilled operators are required to apply zinc metal spray coatings, but they provide a high quality repair solution where larger areas of the item have not galvanized due to design constraints in venting and draining.

FAQ 2 - WHAT TOLERANCES ARE REQUIRED ON MOVING PARTS THAT ARE HOT DIP GALVANIZED?

Introduction

There are many applications where galvanized components have to fit together after galvanizing and galvanizers receive regular inquiries about dealing with the clearances required. There are many factors that interact and the following information is to provide some basic rules for determining tolerances on moving parts.

Fasteners & Threaded Components

There are a large number of threaded components presented for hot dip galvanizing in the form of U bolts, rag bolts, foundation cages, studs and threaded attachments. Where possible, threaded components are centrifuged to 'spin-off' excess zinc. Where this is not possible because of the size of the item, mechanical cleaning of the threads is required after galvanizing. This is done by heating the threaded area* until the excess zinc starts to melt and then wire brushing the threads to remove excess zinc.

***Note:** The hot dip galvanized coating, because of its alloy layers, has a higher melting point that the free zinc that makes up the excess coating. Provided the item is not heated above about 550-600°C, there will be no damage to the majority of the galvanized coating.*

It is not recommended that nuts or internally threaded components be galvanized. Nuts must be tapped oversize for use on galvanized bolts. The dimensions for over tapping of female threads are as follows:

• 12 mm and smaller	0.40 mm
• Over 12 mm to 25 mm	0.53 mm
• Over 25 mm	0.79 mm

On larger diameter threaded items, where standard taps may not be available for over tapping, cutting threads on bolts 0.79 mm undersize will allow accommodation of the galvanized coating.

Theoretical Clearances

On most galvanized items that need to accommodate moving parts, the thickness of the galvanized coating is typically 100 microns or 1/10 mm. In an axle/socket arrangement, there are 4 such galvanized surfaces, which add a theoretical 400 microns (0.4 mm) to the surfaces in contact. On the full range of sections, from under 3 mm to over 10 mm, galvanized coatings may range from 50 microns on the lighter material to 150 microns on the heavier sections.

Practical Clearances

Galvanized coatings are specified in Australian and international standards in coating mass (grams per square metre) and not in thickness. They are commonly converted to thickness because it is easier to relate to for most specifiers as all paint coatings are specified in terms of thickness. In practice, galvanized coatings are not of uniform thickness. Hot dip galvanized coatings in particular can vary widely in coating thickness due to localised variations in steel composition, surface condition and orientation during the galvanizing process. These variations need to be accommodated with moving or closely fitting parts.

Radial Clearances

Radial clearances in socket and shafts should be not less than 1.6mm and preferably 2.0mm.

Double sided surfaces (hinges) should provide not less than 0.8 mm clearances prior to galvanizing to allow correct closing or mating of surfaces after galvanizing.

Moving part assemblies: Galvanizing moving part assemblies is not recommended. All components should be separated prior to galvanizing and assembled afterwards. Even if the assemblies are designed with adequate clearances, the surface tension effects of the molten zinc will trap excess zinc in joints. This will 'solder' moving parts together and is very difficult to remove without risking damage to the coating.

Closer fitting parts: Where tighter tolerances are required, machining of the bearing area of pins and shafts may be required after galvanizing. Because of the nature of the galvanized coating, which consists of a series of hard (harder than 250 grade steel) alloy layers coated with a soft free zinc layer, it is often possible to ream holes and sockets with correctly sized reamers to remove excess zinc without removing the galvanized coating entirely.

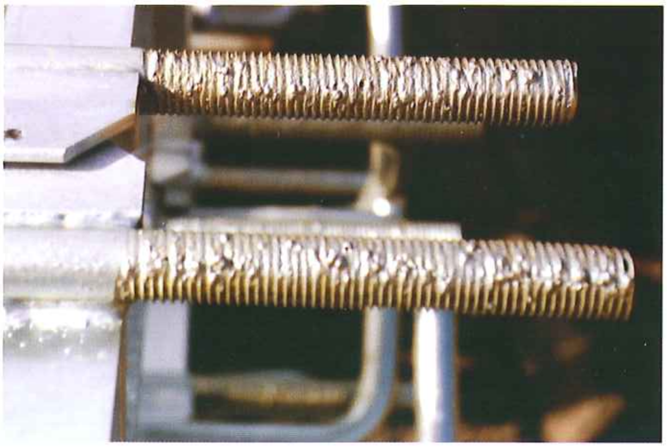
As long as there is an adequate zinc coating on one surface, and the uncoated steel surface is in intimate contact with it, then the zinc will cathodically protect the uncoated steel and prevent corrosion inside the assembly. This phenomenon is used universally with fasteners, where the close contact between the threads on a galvanized bolt and the uncoated female threads on the nut provide acceptable protection from corrosion.

Conclusion

When designing for clearances after galvanizing, a factor of a minimum of 4x over the expected coating thickness should be applied, after adding up all the surfaces involved in the assembly.

Example

Item - Heavy shaft and bush.
Number of surfaces - Shaft 2, bush 2 = 4
Expected coating thickness - 125 microns
Clearance required - 4 x 125 x 4 = 2000 microns (2.0 mm)



Threads will normally be clogged with zinc after hot dip galvanizing and will require cleaning. Heating to the zinc melting temperature of 420o + and wire brushing will remove the excess zinc.

FAQ 3 - WHAT SIZE VENT AND DRAIN HOLES ARE NEEDED FOR HOT DIP GALVANIZING HOLLOW SECTIONS?

One of the most common issues in designing fabrications for hot dip galvanizing is ensuring that fabrications are vented and drained correctly. All steel to be galvanized needs to be immersed in molten zinc and the zinc needs to be able to flow freely into and out of all hollow sections and corners.

The flow of molten zinc into, off, and out of the fabrication is one of the most important factors in determining the final quality of the coating. Inadequate venting and draining can cause the following galvanized coating defects:

- Misses in the coating caused by air locks preventing molten zinc contacting the steel surface
- Puddling of zinc in corners, wasting zinc and interfering with subsequent assembly
- Ash trapped on zinc surface causing surface defects

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

Basic Venting Rules

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

Basic Draining Rules

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

Table of Vent & Drain Holes For Hollow Sections

Circular Hollow Section Nominal Bore	Rectangular Hollow Section (Size mm)	Square Hollow Section (Size mm)	Vent Hole Diameter	
			Single Hole	Double Hole
8	-	-	8	-
10	-	-	10	-
15	-	-	10	-
20	-	13 x 13	10	-
25	-	16 x 16	10	-
32	-	19 x 19	10	-
40	38 x 19	25 x 25	10	-
50	38 x 25	32 x 32	12	2 x 10
65	64 x 30 – 76 x 38	51 x 51	16	2 x 12
80	76 x 51 - 89 x 38	64 x 64	20	2 x 14
100	102 x 51 – 102 x 76	76 x 76	25	2 x 18
-	127 x 51 – 127 x 64	89 x 89	25	2 x 18
125	127 x 76 – 152 x 76	102 x 102	32	2 x 22
150	152 x 102	127 x 127	38	2 x 27
200	203 x 102 – 203 x 152	152 x 152	50	2 x 35
250	254 x 152	202 x 203	63	2 x 45
300	305 x 203	254 x 254	75	2 x 54
350	305 x 254	305 x 305	88	2 x 63
400	-	-	100	2 x 70

Table of Vent & Drain Holes For Tanks & Pressure Vessels

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

FAQ 4 - DOES THE HOT DIP GALVANIZING PROCESS AFFECT STEEL STRENGTH?

Introduction

Over the past 25 years steel makers worldwide have developed new structural grade steels with higher yield and tensile strengths. These developments have enabled manufacturers to design their steel products using lighter-section steels which in turn reduce the production, transport and erection costs of the finished product. Prior to these developments, the steel fabrications which were most commonly galvanized were manufactured from Grade 250 MPa hot rolled structural steels. Today, standard structural steel grades are 300-350 MPa and many cold-formed light structural open and hollow sections have tensile ratings in the order of 500 MPa.

Much research has been done on the effect of hot dip galvanizing on steel strength, some of it in recent times as more of the higher strength steel has been introduced. The following data encapsulates the results of testing done on the effect of galvanizing on steels in the 5000 MPa strength range.

Test 1 Product: HAT70-P hot rolled, with black finish manufactured by BlueScope steel.

HA70T-P hot rolled steel has guaranteed minimum yield strength of 450 MPa and a minimum hardness of 70 HRB. The typical yield strength is between 520 to 610 MPa. The typical tensile strength is between 530 to 620 MPa. This steel is normally used in shelving, automotive parts and more recently for purlins.

The test procedure involved cutting eleven pieces from a of 3.0mm thick black HA70T-P steel coil. Six of the pieces were hot dip galvanized in accordance with AS 4680-2006..

Test 2 Product: GALVASPAN G450 Zinc Coated, Structural Grade Manufactured By Bluescope Steel

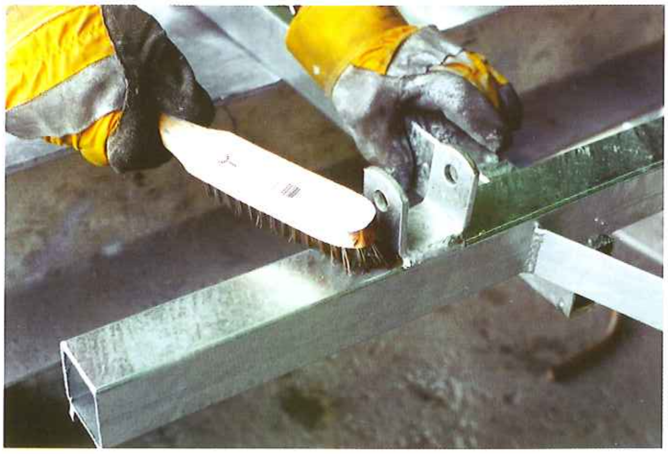
GALVASPAN G450 has guaranteed minimum yield strength of 450 MPa and is an in-line hot dip zinc coated structural grade steel. The typical yield strength is between 470 to 550 MPa. The typical tensile strength is between 510 to 600 MPa. This steel is normally roll formed into products such as purlins, girts and light structural profiles.

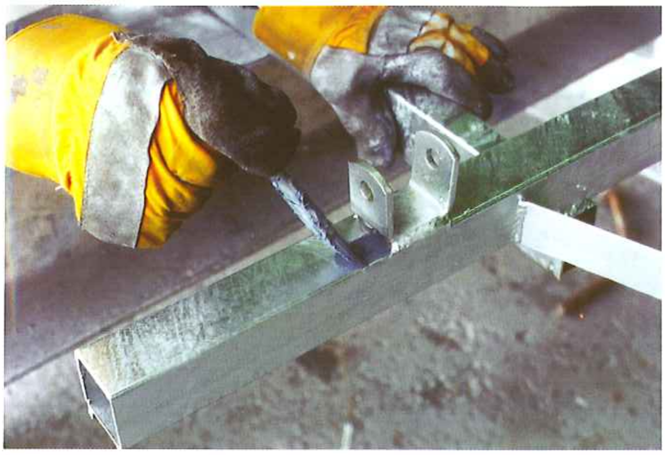
The test procedure involved cutting six pieces from a single length of a roll-formed Z25024 purlin, which had been roll formed by BHP Building Products. The steel thickness was 2.4 mm. Three of the pieces were acid pickled (to completely remove the Z350 mill applied zinc coating) and hot dip galvanized in accordance with *AS 4680-2006*. The remaining pieces were left in the mill applied Z350 Zinc coating (as rolled) finish.

All sections were tested at the BlueScope Steel Port Kembla Technical Services department.

Test 3 Product: OneSteel Grade 500 Plus (Microalloyed and TEMPCORE) reinforcing bar

OneSteel Grade 500 PLUS reinforcing bar is manufactured in straight lengths using the TEMPCORE process (quenching and tempering) and in coil for using micro-alloying of the





Repair of hot dip galvanized coatings can be readily done using high quality epoxy zinc rick paint by wire brushing and applying the ZRP to at least the equivalent thickness of the galvanize coating.

steel. This product has a guaranteed minimum yield strength of 500 MPa. All steel reinforcing products are designed to be bent in accordance with relevant design codes for concrete construction.

Samples from a number of different steel heats, in sizes of 12, 24 and 36 mm diameter with both TEMPCORE and micro-alloyed chemistry were tested, with samples galvanized in both straight lengths and after bending. Control samples from each batch were tested in conjunction with the galvanized samples.

RESULTS

Averaging of the results of the yield strengths of the uncoated sections and the results for the galvanized sections of the HA70T-P indicated a difference of 0.4%. As this variation is less than 1% it is considered to be within the accuracy tolerance of the testing and steelmaking procedures.

Averaging of the results of the yield strengths of the uncoated sections and the results for the galvanized sections of the GALVASPAN G450 indicated a difference is 0.6%. As this variation is less than 1% it is considered to be within the accuracy tolerance of the testing and steelmaking procedures.

Averaging the results of the OneSteel 500Plus reinforcing bar yield strengths indicated a small increase in yield strength from 592 MPa to 602 MPa or 1.45%, after galvanizing the reinforcing bar. This variation is within the acceptance limits for this product.

SUMMARY

These tests verify that hot dip galvanizing has no effect on the mechanical properties of standard grades of steel. This is consistent with principles associated with steel metallurgy as the temperatures involved in the galvanizing process are well below the transition range fort structural steels.

FAQ 5 - GALVANIZING THREADED SECTIONS - WHAT NEEDS TO BE DONE?

Introduction

The galvanizing of threaded fasteners is well established, and is done in specialised galvanizing facilities that centrifuge the fasteners to remove excess zinc from the threads. Australian Standards (*AS1214*) nominates the required clearances on nuts for use with galvanized bolts to accommodate the additional coating applied to the threads.

The problems associated with the galvanizing of internal threads on nuts are solved by galvanizing the nut blanks and tapping them afterwards. The intimate contact between the galvanized thread on the bolt and the uncoated steel on the thread on the nut provides an acceptable level of protection from corrosion.

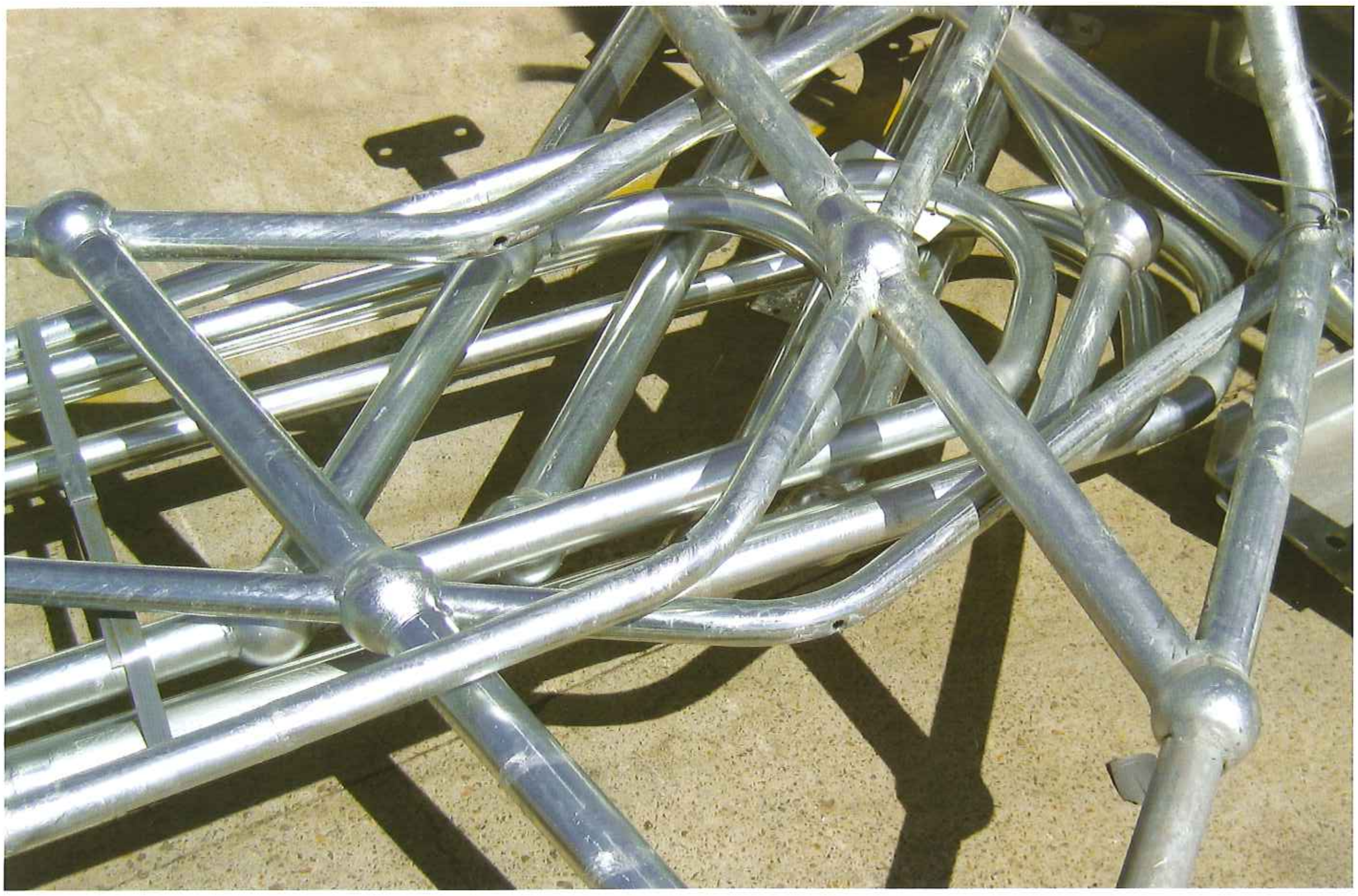
The galvanizing of other threaded components such as bolt cages and threaded assemblies, tapped holes and socket attachments, is an issue of concern to both galvanizers and their clients. These items are frequently included in fabricated assemblies and may be rendered unserviceable unless provision to deal with the cleaning of threaded item is dealt with.

Methods of Dealing With Threaded Components for Galvanizing

External Threads

When items are withdrawn from the galvanizing bath, the excess molten zinc drains off the work. On threaded items, much of this zinc is trapped in the threads and forms a thick buildup on the bottom side of the thread.

There are a number of options available to the galvanizer for dealing with the cleaning of these threads. These are:



Complex hollow sections like these handrail systems need to be vented and drained appropriately. Internal vent holes will eliminate the need for visible vent holes in the fabrication.

1. Fettling the threaded sections while the zinc is still molten to bump or brush the threaded section to shake the free zinc of the threads.
2. Heating the threaded section with a gas torch to re-melt the free zinc and wire brush the thread clean. This does not affect coating durability as most of the coating is a zinc-iron alloy with a higher melting point (650°C versus 420°C) and provided the area is not overheated, only the free zinc will be removed.
3. Re-tapping the threads. This will remove the coating and is time consuming and access issues may make it impractical.
4. Protecting the threads prior to galvanizing to prevent them being galvanized. This can be done with proprietary stop-off materials. High temperature tapes from specialist suppliers like 3M can be used to mask threads. These procedures will leave the threaded elements ungalvanized.

Internal Threads

Internal threads on sockets, nipples and tapped holes will always fill up with zinc on the down-side of the hole as it exits the galvanizing bath. The options for cleaning internal threads are limited to tapping out the threads after galvanizing.

The best methods of preventing zinc build-up in internal threads, is by preventing the zinc coming in contact with the threads. This can be done in a number of ways. These include:

1. Inserting a stud or bolt in the hole prior to galvanizing. This can be removed after galvanizing and may require heating with a gas torch to free the fastener and allow it to be screwed out.
2. Using a suitable high temperature sealant in small threaded holes that can be used to block off the hole. This can be mechanically removed after galvanizing.
3. Using a proprietary stop-off product.

Special Threaded Items

Galvanizing of larger manufactured threaded items such as roof bolts, threaded rod, foundation bolts and post-tensioning rods can be done successfully if the volume justifies the set-up cost for specialised thread cleaning operations. Some of Industrial Galvanizers' plants in Australia, Asia and the USA have the capability to efficiently galvanize long, threaded items to a high standard.

This is done by either installing special progressive galvanizing equipment that removes the excess zinc from the threads as part of the galvanizing process, efficient post cleaning systems that remove the excess zinc by heating the threaded sections and brushing, or vibrating the items.

Hot dip galvanizing remains the best way to provide a heavy duty anti-corrosion coating to threaded items, with the additional advantage that the zinc has self-lubrication properties along with a hardness that equals or exceeds that of the base steel.

Cautionary Note

Some common pipe fittings such as threaded nipples and sockets are sometimes manufactured from free-machining steel and not from the parent steel from which the pipes or tubes to which they are attached are made. Free machining steel contains high levels of sulfur to deliberately weaken the steel so that it machines easily and forms small chips during the machining process. This type of steel is not suitable for hot dip galvanizing as it may be attacked by both the acids in the pickling pre-treatment operations, or by the molten zinc. In some cases, all the threads may be eroded off the fitting in the galvanizing process.

FAQ 6 – HOW MUCH HEAT CAN A GALVANIZED COATING TOLERATE?

Galvanized items are sometimes used for applications where the steel is subjected to either intermittent or permanent higher temperatures. Zinc has a relatively low melting point – only 420°C. When it reacts with steel to form the galvanized coating, the zinc-iron alloy that is formed has a higher melting point of around 650°C.

Large hollow sections require significant provision for venting and draining. These holes are adequate for venting (letting the air out but too small for draining and letting the molten zinc in and out) in these large tubular fabrications.

Zinc is also unusual among metals in that it vaporizes (turns to gas) at the relatively low temperature of around 950°C. This characteristic is used in the manufacture of zinc dust and zinc oxide.

Galvanized coatings can handle higher temperatures (up to 250°C) in dry heat conditions in intermittent exposures, but are not well suited to continuous exposure to temperatures of this level. It is for this reason that items such as automobile mufflers are generally manufactured from aluminized coated steel sheet.

When galvanized coatings are heated to over 350°C, a solid state reaction will be initiated between the steel and any free zinc (the shiny surface zone) in the galvanized coating. This will convert the coating into 100% zinc iron alloy, gives it a frosted gray appearance. This is done deliberately in the sheet galvanizing industry to produce a 100% zinc-iron alloy surface which is better for painting because the microscopically rougher surface provides very good coating adhesion.

This type of coating is widely used in the white goods industry and is marketed by BlueScope Steel as its Zincanneal coating.

Galvanized coatings do not perform well for hot water storage, where water temperatures are in the order of 70 °C. Corrosion rates of the zinc are increased and there is evidence that a polarity reversal takes place with the steel at that temperature and the zinc becomes cathodic to the steel and can increase the corrosion of the base steel.

In short-term exposures to much higher temperatures, galvanized coatings perform very well. Significant research has been none by the Bushfire Co-operative Research Centre for BlueScope Steel to determine hot dip galvanized steel poles performed when exposed to bushfires.

Bushfires can produce very hot fires but they are generally for short local duration as the fire front moves forward. Typical exposure time to maximum bushfire flame temperatures is less than 2 minutes. The combination of the reflectivity of the galvanized surface, and the heat sink provided by the mass of the steel to which the hot dip galvanizing is applied has shown galvanized steel to give excellent performance, with virtually no effect on the coating.

This superior performance of hot dip galvanized power poles has seen power distribution authorities moving to the use of galvanized steel power poles in bushfire prone areas in preference to timber. Although the steel poles have a significantly higher cost, their ability to maintain power supplies in bushfires far outweighs other factors in the selection process.