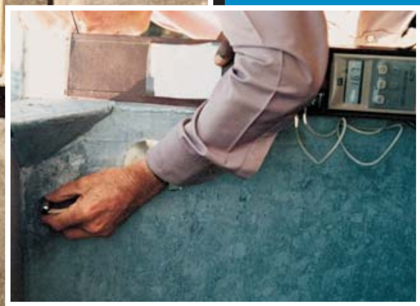
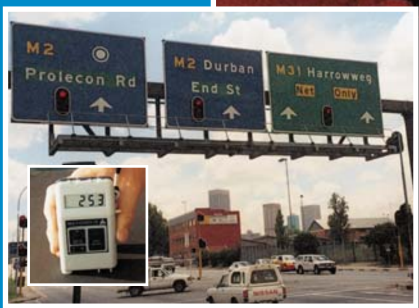
# COMPREHENSIVE GUIDELINES FOR THE INSPECTION AND REPAIR OF HOT DIP GALVANIZED COATINGS






HOT DIP GALVANIZERS ASSOCIATION
SOUTHERN AFRICA

The Association is a technical information centre established for the benefit of specifiers, consultants, end users and its members

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## 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.

## DEPENDABILITY

Ease of inspection and dependability in service are beneficial features of a hot dip galvanized coating. The cathodic protection of steel by zinc ensures that corrosion of the underlying steel cannot occur as long as zinc is present. Even at discontinuities on the coating, corrosion creep under the surrounding zinc is not possible.

## PREDICTABILITY

The durability of a hot dip galvanized coating is determined by the degree of corrosion of zinc in a specific environment and the thickness of the coating. Corrosion of zinc is normally uniform, thus durability of a hot dip galvanized coating is predictable in most applications.

## SUSTAINABLE

The enhanced service life of steel and iron components resulting directly from the hot dip galvanizing process, contributes to a conservation of resources and reduced energy consumption, thus promoting a more sustainable future.

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# Foreword

**"Practical Guidelines for the Inspection and Repair of Hot Dip Galvanized Coatings"**, has been compiled with reference to the new international specifications. These include:

**SANS 121 / ISO 1461** *Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods.*

**SANS 32 / EN 10240** *Internal and/or external protective coatings for steel tubes– Specification for hot dip galvanized coatings applied in automatic plants.*

**SANS 14713 / ISO 14713** *Protection against corrosion of iron and steel in structures – Zinc and aluminium coatings – Guidelines.*

The guidelines take into account recognised engineering principles, inspection practices and practical experience accumulated over the years by the Hot Dip Galvanizers Association of Southern Africa established in 1965.

The guidelines have been formulated for general information only and although practically enforceable, they are not intended as a substitute for competent professional examination and verification as to accuracy, suitability and/or applicability, by a trained HDGASA inspector.

The publication of the material contained in this booklet is not intended as a representation or warranty on the part of the Hot Dip Galvanizers Association of Southern Africa.

Anyone making use of this information assumes all liability arising from such use.

**Due to the frequent use of misleading terms such as "cold galvanizing" to describe zinc rich paint and electrogalvanizing for zinc electroplating, the specifier who requires hot dip galvanizing for corrosion control, should specify that all components shall be hot dip galvanized in accordance with the requirements of SANS 121 / ISO 1461 or SANS 32 / EN 10240 as applicable.**

# Introduction

Hot dip galvanizing is one of the most widely used methods of protecting steel from corrosion.

As a final step in the process, the hot dip galvanized coating is inspected for compliance with specifications. Interpretation of inspection results should be made with a clear understanding of the causes of the various conditions which may be encountered and their effects on the ultimate objective of providing corrosion protection.

This manual has been designed to assist in testing, inspection, and the interpretation of test results. It deals with numerous surface conditions, their origins, and their effects on protection from corrosion. This manual also considers undesirable design and fabricating features as well as unacceptable hot dip galvanizing practice. Although it is difficult to cover every condition, the manual covers many of the conditions frequently encountered in practice.

To effectively use this manual, inspectors should remember that the main **purpose of hot dip galvanizing is to protect steel from corrosion.** The length of time this protection can reasonably be expected to last is called its "service life or time to first maintenance". This is defined as the time taken for the appearance on an article of 5% surface rust. **The service life of a hot dip galvanized coating is directly proportional to the thickness of the coating. Corrosion protection is greater when the coating is thicker. Thus coating thickness is the single most important inspection check to determine the quality of a hot dip galvanized coating.**

**Coating thickness, however, is only one inspection aspect. Other features include the uniformity of the coating, coating adhesion and appearance. Possible brittleness and defects, which arise from incorrect design and fabrication, also need to be assessed by the inspectorate.**

While minimum specified standards must be satisfied, their relative importance varies according to the end use of the product. For example, the aesthetic appearance of hot dip galvanized structural steel in an obscured application is different from that where a product is used as an architectural feature. An awareness of the end use of the product and the capability of the hot dip galvanizing process is essential for good inspection.

Inspection of hot dip galvanized products, as the final step in the process, can be most effectively and efficiently conducted at the galvanizer's plant. Here, questions can be raised and answered quickly, inspection speeded up and, the time saved is beneficial.

Occasionally, due to rough handling and possible site modifications, which include cutting and welding, coating repairs become necessary. Repair procedures and the recommended repair materials are covered in this manual.

The quality standards to which reference is made in the following sections are in accordance with International and South African National Standards' specifications.

# Test Sample Selection

To effectively evaluate hot dip galvanized coatings, it is essential that randomly selected specimens be representative of an inspection lot. An inspection lot is a single order or batch awaiting despatch. For products required to comply with **SANS 121 / ISO 1461** the minimum number of articles from each inspection lot that forms the control sample shall be in accordance with **table 1 of the specification.**

**TABLE 1**

| Number of articles in the lot | Minimum number of articles in the control sample |
|---|---|
| 1 to 3 | All |
| 4 to 500 | 3 |
| 501 to 1200 | 5 |
| 1201 to 3200 | 8 |
| 3201 to 10 000 | 13 |
| > 10 000 | 20 |

Typically, the test unit for compliance with **SANS 32 / EN 10240** shall be, for each size, one tube per first 500 tubes and subsequently one per 1000 tubes for outside diameters greater than 21.3mm and one per 2000 tubes for smaller diameters.

Unless otherwise specified by the purchaser, an acceptance inspection **should be arranged and undertaken before the products leave the premises of the galvanizer.**

# Coating Thickness and Uniformity

The thickness of the hot dip galvanized coating is the primary factor in determining its life under given service conditions. The thicker the coating, the better corrosion protection it offers. For most atmospheric conditions, the relationship between corrosion protection and coating thickness is approximately linear, i.e., the service life is doubled if the coating thickness is doubled. There is however a limit to the maximum coating thickness that can be obtained.

The factors which influence overall coating thickness are a combination of several variables. The galvanizer can alter zinc temperature, time of immersion and rate of withdrawal from the molten zinc. These factors can be used to marginally alter coating thickness, particularly with reactive steels. The formation of the protective iron/zinc alloy layer is a diffusion process. As with all diffusion processes, the reaction proceeds rapidly at first and slows down as the layer becomes thicker. Higher bath temperatures and longer immersion times will generally produce thicker alloy layers.

The thickness of the outer zinc layer of the coating is independent of immersion time. Thickness of this layer is determined by the rate of withdrawal from the zinc bath and the degree of drain-off of molten zinc. A fast rate of withdrawal causes an article to "drag out" more zinc. This results in a heavier coating, although the distribution of the zinc layer may be uneven. Wiping of the coating during withdrawal materially reduces its thickness and thus its protective value. It is discouraged except where necessary for the smoothness demanded by conditions of service such as for small bore pipe and conduit.

Tubes hot dip galvanized in accordance with **SANS 32 / EN 10240** utilise steam blowing internally and an air ring externally (the blown process), to remove excess zinc. Some variation in internal coating thickness is acceptable within 50mm of tube ends. With fabricated articles, local differences in the drain-off, because of the shape of the article and the angle at which different surfaces leave the bath, may also result in some variation in coating thickness.

Other factors influencing the coating thickness may be beyond the control of the galvanizer.

The chemical composition of the steel plays a major role in determining the thickness and appearance of the final coating. Certain steel compositions tend to accelerate the growth of the iron/zinc alloy layer so that the hot dip galvanized coating may have a matte finish with little or no outer zinc layer. This coating also tends to be thicker than the typical bright hot dip galvanized coating. The galvanizer's control over this condition is limited. *Steels containing the elements, phosphorus in excess of 0.02%, or silicon from 0.03% to 0.15% and above 0.25% or combinations of both elements, are particularly prone to heavier coatings consisting mainly of iron/zinc alloys.* Due to the iron/zinc alloy growth in these coatings, extending to the outer surface, the final appearance of the coating can be dark grey in colour distributed evenly or unevenly over the surface.

The surface condition of the steel before hot dip galvanizing also affects the thickness and smoothness of the final coating. Steels which have been abrasive blast cleaned, or left to weather and rust for some time prior to hot dip galvanizing, can produce substantially thicker coatings than those normally produced on chemically cleaned steel.

The mass, shape and degree of cold working of components to be hot dip galvanized also influences coating thickness and uniformity. When a fabricated article consists of both heavy and light sections, a variation in coating thickness between the sections may result. Immersion time will vary according to the relationship of the surface area of an item to its mass. The galvanizer has little control over this situation.

Combining heavy and light sections in a single component may also result in unacceptable distortion (refer to HDGASA wall chart, "Design for Hot Dip Galvanizing" and "Facts About Hot Dip Galvanizing – Practical Guidelines).

**TABLE 2**

**MINIMUM COATING THICKNESS ON ARTICLES THAT ARE NOT CENTRIFUGED**

| | | SANS 121 / ISO 1461 | |
|---|---|---|---|
| | Category and thickness (t) mm | Local coating thickness µm* | Mean coating thickness µm* |
| PROFILES | t ≥ 6 | 70 | 85 |
| | 3 ≤ t < 6 | 55 | 70 |
| | 1.5 ≤ t < 3 | 45 | 55 |
| | t < 1.5 | 35 | 45 |
| CASTINGS | t ≥ 6 | 70 | 80 |
| | t < 6 | 60 | 70 |

* Local coating thickness is defined as the mean of the measurements taken within a specified reference area. Mean coating thickness is the control sample number average of the local coating thickness values from each reference area.

- Thickness legend - 3 ≤ t < 6 = thickness less than 6mm but greater and equal to 3mm.
- Where only one reference area is required according to size of the article, the mean coating thickness within that reference area shall be equal to the mean coating thickness given in the above table.

Since the time to the appearance of first rusting of the base steel is usually determined by the thinnest portion of the coating, an evaluation of galvanizing quality must take into account both the minimum thickness of the coating and its distribution. Specifications for hot dip galvanizing recognise that variations in coating thickness are inherent in the process. The minimum thickness is generally defined as an average or mean thickness of the coating on specimens tested and/or a minimum thickness for any individual specimen.

When measurements are taken to determine the uniformity and thickness of a hot dip galvanized coating, 5 or more coating thickness readings should be taken in each reference area. Reference areas should be taken approximately 100mm from the ends of the article to avoid end effects. Usually the end of an article which leaves the bath last will carry a thicker coating. This is particularly so towards the edge, where, at the time of drainage, the last few drops of zinc tend to agglomerate as a result of surface tension.

The minimum coating requirements specified in **SANS 121 / ISO 1461** for different material thicknesses on samples that are centrifuged. **Table 4** indicates the minimum coating requirements specified in **SANS 32 / EN 10240** for different classes of coating, for steel tubes manufactured by the blown process.

Specifications do not stipulate maximum upper coating thickness limits, but **excessively thick coatings on threaded articles are undesirable. In order to ensure effective tensioning, the coating thickness on fasteners should not exceed a maximum of 65μm, this applies particularly, to high strength bolts and nuts.**

**Variance in coating thickness.** A requirement for a thicker coating (25% greater than the standard in **table 2**) can be requested for components not centrifuged, without affecting specification conformity.

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

*Thicker coatings are more resistant to severe environmental conditions, but can be more brittle and may require special handling. The efficacy of corrosion protection of a hot dip galvanized coating (whether light or dull grey) is approximately proportional to coating thickness.*

**TABLE 3**

**MINIMUM COATING THICKNESS ON ARTICLES THAT ARE CENTRIFUGED**

| | Category and thickness/ diameter (t) or (ø) mm | SANS 121 / ISO 1461 Local coating thickness μm* | SANS 121 / ISO 1461 Mean coating thickness μm* |
|---|---|---|---|
| FASTENERS | ø ≥ 20 | 45 | 55 |
| FASTENERS | 6 ≤ ø < 20 | 35 | 45 |
| FASTENERS | ø < 6 | 20 | 25 |
| OTHER ARTICLES (INCLUDING CASTINGS) | t ≥ 3 | 45 | 55 |
| OTHER ARTICLES (INCLUDING CASTINGS) | t < 3 | 35 | 45 |

* Local coating thickness is defined as the mean of the measurements taken within a specified reference area. Mean coating thickness is the control sample number average of the local coating thickness values from each reference area.

- Thickness legend - 3 ≤ t < 6 = thickness less than 6mm but greater and equal to 3mm.
- Where only one reference area is required according to size of the article, the mean coating thickness within that reference area shall be equal to the mean coating thickness given in the above table.

# Thickness Testing

There are several methods to determine the thickness of the zinc coating on a hot dip galvanized article. The size, shape and number of pieces to be tested, will most likely dictate the methods of testing. The specified test methods are either destructive or non-destructive and are detailed in **SANS 121 / ISO 1461**. Identical methods are detailed in **SANS 32 / EN 10240**. The most practical tests are the non-destructive type, such as gauges utilising the electromagnetic principle.

### 1. Electromagnetic Testing Method.

Instruments, which rely on electromagnetic principles are probably the most widely used devices to determine the thickness of hot dip galvanized coatings. Electromagnetic instruments measure coating thickness in specifically-identified local areas of the article. The average thickness (and therefore mass) of the coating is calculated from measurements taken at a suitably large number of points distributed over a reference area on the surface of the article. There are a number of electromagnetic gauges which can be used to give accurate measurements of the zinc coating thickness. These gauges give reliable thickness readings provided they are properly calibrated and the manufacturer's instructions are observed. The most commonly used type of gauge is a portable electronic instrument. The gauge uses a temperature-compensated magnetic transducer to measure the magnetic flux changes that occur when the probe (a magnet) is separated from a ferrous metal substrate by a non-magnetic coating such as zinc. The output signal from the probe is proportional to the distance of separation and, therefore, to coating thickness. The probe signal is amplified and indicated on a meter calibrated to show coating thickness. These battery powered instruments have typical accuracies up to 5% and have the advantage of not requiring recalibration with probe orientation. Similar electromagnetic instruments with even greater accuracies are available for laboratory use.

The specification requires that the thickness gauges shall (in terms of **ISO 2178**) be -

- Capable of minimizing errors in reading caused by the magnetic permeability, dimensions, surface finish and curvature of the article being tested;

- Capable of measuring the thickness of the coating being tested within an accuracy of 10% or 1.5µm whichever is better[A], and

- Calibrated by taking readings at zero (or near zero) thickness and at thicknesses of at least 100µm, on suitable non-ferrous shims placed on acceptable standard pieces of metal of composition, thickness and shape similar to those of the articles under test.

To avoid possible errors in the use of magnetic instruments, certain precautions should be taken:

- *Follow the manufacturer's instructions. The instrument should be frequently recalibrated against non-magnetic film standards of known thickness.*

- *The base steel should be backed up with similar material if thinner than the critical thickness for the magnetic gauge or the instrument should be recalibrated on a substrate of similar thickness.*

- *Readings should not be taken near an edge, hole, or inside corner.*

- *Readings should not be taken on curved surfaces without additional calibration of the instrument.*

- *The test surface should be free from surface contaminants such as dirt, grease, and corrosion products.*

- *Test points should be taken in each reference area to avoid obvious peaks or irregularities in the coating.*

- *A sufficient number of readings should be taken to obtain a true average.*

**TABLE 4**

| MINIMUM COATING THICKNESS ON STEEL TUBES TO SANS 32 / EN 10240 | | | | |
|---|---|---|---|---|
| **COATING QUALITY** | | **A1** | **A2** | **A3** |
| **Mandatory** | Minimum local coating thickness on the inside surface except at the weld bead | 55µm | 55µm | 45µm |
| | Minimum local coating thickness on the inside surface at the weld bead | 28µm | 1) | 1) |
| **Options** | Minimum local coating thickness on the outside surface | 2) | 2) | 2) |
| **COATING QUALITY** | | **B1** | **B2** | **B3** |
| **Mandatory** | Minimum local coating thickness on the outside surface | 55µm 3) | 40µm | 25µm |

1) This requirement does not apply

2) This requirement applies when the purchaser specifies Option 1

3) Option 3 specified (if >55µm required, purchaser to specify according to SANS 121 / ISO 1461)

Coating qualities 'A' and 'B' refer to end application with quality 'A' being for gas and water installations and 'B' for other applications. The number following the quality letter refers to specific requirements in terms of coating thickness.

***NOTE:*** In South Africa, **SANS 32 / EN 10240** to quality A1 replaces the previous **SABS 763**, B4 coating.

**2. Testing threaded articles by fitting mating parts.**

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 **table 5.**

[A] *When curved surfaces are dealt with, particular care should be taken to ensure that the thickness gauge is capable of obtaining readings to an acceptable level of accuracy.*

On bolts greater than M24, undercutting of bolt threads is frequently preferred to only oversizing of nut threads.

Threaded articles shall fit their mating parts and, in the case of assemblies that contain both externally and internally threaded articles, it shall be possible to screw mating parts together by hand.

### 3. The Chemical Stripping (Gravimetric) Test (to ISO 1460).

This method is applied where material is inspected after hot dip galvanizing. Since this is a destructive test method, it is generally not suitable for the inspection of large or heavy items unless smaller or representative specimens can be substituted for them (see Test Sampling). The test specimen is cleaned with naphtha or other suitable organic solvent, rinsed with alcohol, dried and weighed. It is then stripped of the zinc coating by immersion in a solution containing 3.5g of hexamethylenetetramine and 500ml concentrated hydrochloric acid in 1litre of water. The stripping of the coating is complete when evolution of gas ceases. After washing and drying, the specimen is weighed; the differences in mass before and after stripping divided by the surface area of the test specimen gives the mass of coating per unit area. In the case of threaded articles, such as bolts and screws, the determination is made on an unthreaded portion of the article.

| TABLE 5 | |
|---|---|
| OVERSIZE TAPPING ALLOWANCE FOR HOT DIP GALVANIZED NUTS | |
| Nominal size of thread | Allowance (mm) |
| M8 to M12 | 0,33 |
| M16 to M24 | 0,38 |
| >M24 = M27 | 0,43 |
| >M27 = M30 | 0,47 |
| >M30 = M36 | 0,57 |
| >M36 = M48 | 0,76 |
| >M48 = M64 | 1,0 |

The stripping test gives an accurate average coating mass of the zinc coating. However, it does not provide any information on how evenly the coating is distributed.

To test compliance with **SANS 32 / EN 10240**, two test pieces shall be taken from the tube to be tested. These should be between 30 and 600cm$^2$ in surface area, with length between 50 and 150mm taken at least 600mm from the tube end.

### 4. Metallographic Examination.

Where the hot dip galvanized coating composition and thickness are of interest, microscopic examination is a reliable tool. This test is a requirement for the testing of compliance of Coating A1 to **SANS 32 / EN 10240**. This very accurate method uses a small polished and etched cross-section of the hot dip galvanized component to provide information about the relative thicknesses of the alloy and the free zinc layers which comprise the hot dip galvanized coating.

The following procedures should be adhered to –

- Water should not be used as a lubricant at any stage during the polishing procedure due to staining or mild corrosion of the galvanized layer.
- The etchant should be 2% (max) Nital, i.e. (2ml concentrated $HNO_3$ in 100ml of 95% ethanol or methanol).

Important disadvantages of this technique are that –

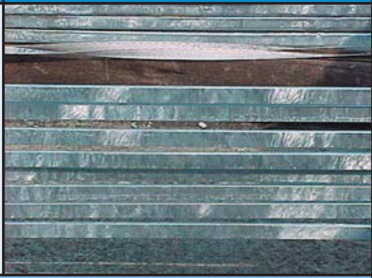
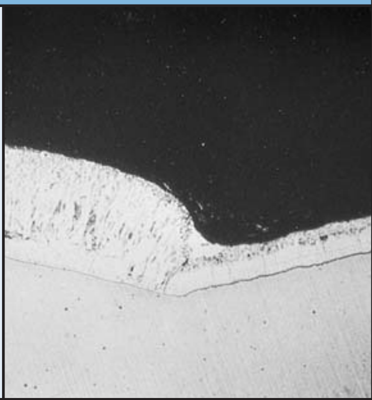
- Specimens cut from the hot dip galvanized article are required,
- Coating thickness measured only applies to a very limited area, it does not indicate the variation in coating distribution on the article and,
- It is necessary to examine a number of specimens to determine the average coating thickness on the hot dip galvanized article.

# Surface Conditions (SC)

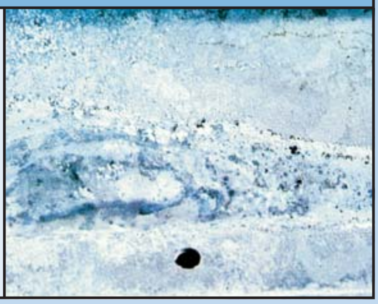
| SC | WHAT IS THIS? | CAUSE | EFFECT / REMEDY / RESPONSIBILITY | EXAMPLE |
|---|---|---|---|---|
| 1 | **APPEARANCE OF SODIUM DICHROMATE**<br>A small amount of Sodium Dichromate is generally added to the quench water bath for passivation. | Although the recommended quantity of Sodium Dichromate is about 0.15 to 0.3%, occasionally when topping up, more is added. This often results in a dark yellow to brown colour on the galvanized surface. The darker colour will provide enhanced initial corrosion protection. | This can be accepted since there is no adverse effect on corrosion control.<br>The galvanizer should maintain the concentration of Sodium Dichromate at about 0.15 to 0.3%. |  |
| 2 | **ASH DEPOSITS**<br>Ash deposits are grey, non-metallic deposits consisting of zinc oxide that have been deposited on the hot dip galvanized coating. | Zinc oxide deposits can take place when the component is dipped or when it is removed from the bath. | This can be accepted or negotiated dependent on functional requirements since the coating is normally intact underneath the ash deposits. If required, ash must be removed by the galvanizer and the coating thickness verified for conformance to the specification requirements.<br>In the case of liquid conveyance pipes, all ash should be removed. |  |
| 3 | **BARE SPOTS**<br>Although excluded from SANS 121:2011 (ISO 1461:2009), bare spots of about 5mm$^2$ (2.2 x 2.2mm), due to small localised flaws, are adequately protected by the sacrificial properties of zinc and will have very little effect on the service life of the coating. | There are several causes of bare spots. These include:<br>• **Overdrying:** If the time between fluxing and hot dip galvanizing is prolonged or the drying temperature is too high, the barrier protection provided by the flux may be lost. This is indicated by a rusty appearance on the ungalvanized article, which can result in coating discontinuities after hot dip galvanizing.<br>• **Excess Aluminium:** A condition sometimes referred to as black spots may occur if the aluminium content of a bath becomes too high. No trouble should be experienced if flux concentration is correct and the aluminium content of the bath is maintained below approximately 0.007%.<br>• **Further causes are:** Blowouts, flux deposits, stains and inclusions, mechanical damage, touch marks, uncoated surfaces caused - by surface contaminants, scale or sand; welds and weld spatter. *See Surface Conditions 5, 15, 17, 28, 31, 32, 33 and 34.* | Where necessary, such spots may be repaired using one of the specified repair methods. Gross uncoated areas are a cause for rejection.<br>The galvanizer should avoid overdrying and maintain the correct level of aluminium content in the kettle. |  |
| 4 | **BLASTING DAMAGE**<br>Sweep blasting (done correctly) substantially increases paint adhesion and final coating appearance. However, done incorrectly it can result in coating damage. | Incorrect nozzle pressure; nozzle angle; sweeping distance; size of abrasive and recycling of grit. | This is cause for rejection as a hot dip galvanized coating will be partially or fully destroyed by excessive blasting.<br>*Refer to the HDGASA Code of Practice.* |  |
| 5 | **BLOWOUTS**<br>Staining and coating defects around unsealed weld areas and vent holes. Similar to stains caused by weeping.<br>*See Surface Condition 26* | Pre-treatment chemicals penetrating sealed overlap areas through the required vent holes and escaping during immersion in the molten zinc. This effect tends to damage the flux coatings, causing localised uncoated areas. | This can be accepted once repaired after cleaning.<br>The designer and fabricator should take this into account during the design and manufacturing phase of the project. |  |

| SC | WHAT IS THIS? | CAUSE | EFFECT / REMEDY / RESPONSIBILITY | EXAMPLE |
|---|---|---|---|---|
| 6 | **CLOGGED HOLES**<br>Zinc film clogging or partly bridging holes. | Molten zinc has a high surface tension and will not easily drain from holes under 8mm in diameter. | This can be accepted once the item has been cleaned if required.<br>The Designer should make the holes as large as possible.<br>The removal of molten zinc over the bath by the galvanizer will reduce the likelihood of clogging. |  |
| 7 | **CLOGGED THREADS**<br>Threaded components or attachments have threads clogged with zinc. | Insufficient centrifuging or poor drainage of threaded attachments on withdrawal from the galvanizing bath. | This should be rejected and then cleaned by the galvanizer. The correct centrifuging equipment or post galvanizing thread cleaning by heating and wire brushing or oversize tapping of nuts, will generally remove clogging.<br>If necessary, specify delivery of bolts and nuts in nutted up form. |  |
| 8 | **DAMAGED COATINGS CAUSED BY WELDING OR NON-CONVENTIONAL FIXING METHODS DURING ERECTION** | Conventional drilling and bolting after hot dip galvanizing is preferred. Should welding or a non-conventional method of fixing be used, which results in damage to the coating, an approved repair method is necessary. | Coating repair can be done by zinc metal spraying or a zinc rich paint or epoxy, providing the product conforms to the requirements of the specification. |  |
| 9 | **DISCOLOURATION AFTER HOT DIP GALVANIZING CAUSED BY GRINDING OR OTHER RESIDUES** | Material stored in contact with rusty steel or iron filings, can cause surface rust staining. | This can be accepted as once the cause has been removed the stains will gradually disappear. The Fabricator should clean if possible. |  |
| 10 | **DISTORTION**<br>Distortion is the unwanted warping that occasionally becomes evident after hot dip galvanizing. | The hot dip galvanizing process occurs at a molten zinc temperature of 450°C. This is at the lower end of the stress relieving temperature for treating steel. Thus, any inherent rolling or welding stresses in the fabrication are likely to be released. This may result in a dimensional change, i.e. distortion. | The Designer has the following options available: use symmetrical designs; use sections of similar thickness; stiffen unsupported thin wall sections; use preformed members with the correct minimum bend radii; use balanced or staggered welding techniques; make use of temporary braces on thin walled sections such as troughs, cylinders and angle frames.<br>Stress Relief assembly prior to hot dip galvanizing.<br>The galvanizer should avoid quenching after galvanizing.<br>The components can be straightened after hot dip galvanizing. |  |
| 11 | **DRAINAGE SPIKES**<br>Spikes and teardrops of zinc often appear along the edge of a component after hot dip galvanizing. | The edge most likely to have these spikes is the last to leave the bath on withdrawal. This applies particularly to complex fabrications. | Drainage spikes are easily removed at the bath while still molten but any solidified spikes should be removed by careful fettling by the galvanizer prior to release. |  |

| SC | WHAT IS THIS? | CAUSE | EFFECT / REMEDY / RESPONSIBILITY | EXAMPLE |
|---|---|---|---|---|
| 12 | **DULL GREY OR MOTTLED COATING APPEARANCE** Dull grey or mottled coatings can appear as a dark grey circular pattern, a localised dull path, or may extend over the entire surface of the component. | This appearance indicates the presence of extensive iron / zinc alloy phase growth, caused by steels with high reactive levels of Silicon and Phosphorus. | Although not as aesthetically pleasing, a dull grey coating provides similar or better corrosion protection. |  |
| 13 | **ENTRAPMENT OF ASH** Ash which has not been removed from the surface of the molten zinc prior to immersion of steel can be trapped on the steel surface as it is immersed and result in an uncoated surface beneath the trapped ash. | Inadequate skimming of ash from the molten zinc surface prior to dipping. | On removal of entrapped ash, small uncoated surfaces shall be repaired according to the requirements of SANS 121: 2011 (ISO 1461:2009) by the Galvanizer.<br>Large defects greater than 0.5% of total surface area or single spots over $10cm^2$ are a cause for rejection and require stripping and re-galvanizing. |  |
| 14 | **FLAKING OR DELAMINATION OF COATING** No adhesion of zinc to the steel surface or a thick, rough coating. | High phosphorus content greater than 0.02% can cause the entire coating to delaminate from the steel. | The Designer should use a steel that has a phosphorus content of lower than 0.02%. |  |
| 15 | **FLUX DEPOSITS, STAINS AND INCLUSIONS** Flux deposits or stains from the galvanizing process may adhere to the steel or become included in the coating. Flux residues are black, brown, grey or yellowish non-metallic deposits consisting mainly of ammonium chloride. | Flux deposits or stains may occur as a result of excessive "dusting" with ammonium chloride on withdrawal from the molten zinc. Flux inclusions can occur when a surface flux blanket is applied to the zinc surface (wet galvanizing). Flux blankets are normally only used for specialised processes, e.g. galvanizing tubes and fasteners. | Flux deposits or stains should be removed by the galvanizer and the underlying coating measured to determine whether it conforms to the minimum requirements of the specification. |  |
| 16 | **DISCOLOURATION OF THE PAINT COATING OVER HOT DIP GALVANIZING AFTER EXPOSURE TO THE ENVIRONMENT** | Inadequate repair of a damaged surface on the hot dip galvanized coating prior to the application of a paint coating. | It is the installers responsibility to ensure the correct repair materials and application procedures are used when touching up cut or welded hot dip galvanized components and prior to painting. Where corrosion control has been compromised the job should be rejected. |  |
| 17 | **MECHANICAL DAMAGE** Mechanical handling or transport damage can occur, particularly with extremely thick coatings. | The use of chains, wire ropes, dragging or dropping of the component onto a hard surface, can cause mechanical damage. This is particularly relevant with thick coatings. | This can be accepted and repaired by the galvanizer or builder if necessary. Warning labels highlighting possible damage if manhandled, should be attached by the galvanizer before the component is transported. The use of nylon lifting slings is recommended. |  |

| SC | WHAT IS THIS? | CAUSE | EFFECT / REMEDY / RESPONSIBILITY | EXAMPLE |
|---|---|---|---|---|
| 18 | **OXIDE LINES**<br>Light aluminium oxide film lines on a hot dip galvanized surface. | Due to the shape and / or drainage conditions of some components, the hoist crane has stopped and started upon withdrawal of the items from the molten zinc. | This can be accepted as it has no effect on corrosion resistance, with the overall appearance becoming uniform in time. |  |
| 19 | **PIMPLES OR BLISTERS**<br>Pimples or blisters formed during hot dip galvanizing are usually associated with surface imperfections such as dross inclusions. | Dross pimples result from agitation of the dross layer at the bottom of the bath or from dragging material through the dross layer. They appear as small, hard lumps on an otherwise normal galvanized surface. Blisters may be formed by hydrogen, which is absorbed during pickling and diffused at galvanizing temperatures. | This can be accepted since dross pimples represent minor disturbances in coating uniformity and do not affect corrosion resistance. Smooth if sufficiently sharp to create the risk of injury.<br>The galvanizer should avoid disturbing the dross layer at the bottom by controlling immersion depth and drossing regularly. |  |
| 20 | **REACTIVE AND NON-REACTIVE STEELS, WELDED TOGETHER**<br>Variations in coating thicknesses can arise when reactive and non-reactive steels are welded together. Efforts to increase coating thickness on the less reactive steel may result in an undesirably thick and brittle coating on the most reactive steel. | This difference in coating thickness is brought about by a combination of a more reactive silicon killed steel and / or high phosphorus, resulting in a thicker coating and a less reactive aluminium killed steel, resulting in a coating thickness sometimes below that required in the specification.<br>Should the galvanizer be asked to regalvanize in accordance with the specification, the resultant coating thickness on the reactive steel will be excessively thick, resulting in a brittle coating more susceptible to damage. | The fabricator should select the same steel for fabricating on a component.<br>If need be, accept a concession request by the galvanizer when the thinner coating is possibly below specification. |  |
| 21 | **REMOVAL OF ZINC COATING BY EXCESSIVE CLEANING**<br>Unless otherwise agreed, the galvanizer will limit cleaning of the final coating by mechanical means to that required in the specification. | Excessive cleaning of the coating by mechanical methods can result in uncoated areas. | Care should be exercised by the galvanizer to avoid over cleaning. If corrosion control has been compromised, i.e. exposed areas greater than tolerance; reject.<br>Alternatively repair in accordance with standards. |  |
| 22 | **ROLLING DEFECTS IN STEEL**<br>These defects may be broadly classified as surface discontinuities in the steel that have been elongated during rolling. | Steel may occasionally include laminations, laps, folds and non-metallic impurities, which result in slivers rolled into the metal surface. Defects of this type are sometimes detected before or after pickling, but may only become apparent after hot dip galvanizing. | This can be accepted, as minor surface defects will not adversely influence coating life.<br>Surface flaws in the base material may be removed by local grinding after hot dip galvanizing followed by repair of the affected surface. |  |
| 23 | **ROUGH COATINGS, CAUSED BY STEEL SURFACE CONDITIONS** | Rough surfaces, typical of coatings on corroded steel surfaces, can be hot dip galvanized satisfactorily. The coating will however, reflect the texture of the substrate. Other causes of rough surfaces include uneven cold working, over pickling, a high galvanizing temperature and / or extended immersion in the molten zinc. | This can be accepted as the rougher surface will produce a thicker coating and result in a longer service life. |  |

| SC | WHAT IS THIS? | CAUSE | EFFECT / REMEDY / RESPONSIBILITY | EXAMPLE |
|---|---|---|---|---|
| 24 | **ROUGH, HEAVY COATINGS CAUSED BY A ROUCH SURFACE AND/OR THE CHEMICAL COMPOSITION OF THE STEEL – "TREE BARK EFFECT"** | Hot dip galvanized components showing markedly rough surfaces. This can include coatings that have a generally rough surface and, in some cases, groove type surface configurations, "tree bark effect" caused by variations in surface steel analysis. | The thicker coating produced will provide greater corrosion protection; except when the coating tends to flake off or delaminate *(see surface condition 14).* |  |
| 25 | **ROUGH HEAVY COATINGS CAUSED BY INSUFFICENT CENTRIFUGING** | Efficient centrifuging will generally remove excess zinc and provide a smooth and attractive exterior. | Provided the steel / casting surface is reasonably smooth, correctly centrifuged articles will provide an acceptable finish.<br>Should the surface not be reasonably smooth; it should be rejected. |  |
| 26 | **STAINS CAUSED BY WEEPING** | The salts from acid or flux that have penetrated porous welding or between contact surfaces during pickling, can weep after hot dip galvanizing and water quenching, providing a stained area. | Weld seepage stains are not a cause for rejection. The stains can be easily removed by means of bristle brushing. Should the component be destined for a corrosive area, the crevice may be sealed after cleaning. |  |
| 27 | **TIGHTHLY ADHERENT LUMPS OF ZINC ON THE INSIDE OF HEAVY WALLED STEEL PIPING** | Heavy walls and thick flanges used in the manufacture of piping can act as a heat sink when immersed in molten zinc. This effect considerably lengthens the immersion time. Occasionally the galvanizer will remove the pipes before all the zinc has melted from the inside of the pipe. | The inspector should reject this. The galvanizer should ensure all zinc has been removed from the inside of the pipe by longer immersion times.<br>The item can be cleaned or repaired if acceptable to the customer. |  |
| 28 | **TOUCH MARKS**<br>The zinc in the galvanizing bath should have free access to all component surfaces otherwise small uncoated or damaged areas can result. | Articles entering the galvanizing bath should not be in tight contact with each other. Jigging wire should also be loosely attached to eliminate wire marks. Where a component has been resting on jigging or dipping equipment, an uncoated area or touch mark could appear. | The galvanizer should minimise contact between components and jig connections (loosen jigging wire). Small components can be centrifuged.<br>These areas should be repaired if within allowable limits. |  |
| 29 | **TYPICAL SPANGLED HOT DIP GALVANIZED COATING**<br>A typical hot dip galvanized surface is shown in the example. The surface is silver grey in colour and not necessarily, but often has, a spangled effect (zinc crystals) in a range of sizes. | Surface appearances may vary according to the chemical composition of the steel. Cooling rate has a direct effect on the surface brightness and spangle size. Faster cooling usually results in a brighter coating with a smaller spangle size. | Not rejectable if coating thickness within allowance limits. |  |

| SC | WHAT IS THIS? | CAUSE | EFFECT / REMEDY / RESPONSIBILITY | EXAMPLE |
|---|---|---|---|---|
| 30 | **UNEVEN DRAINAGE**<br>Uneven drainage results in an uneven or lumpy area on which zinc build up has occurred. | This can occur over the entire surface or in isolated areas. Uneven drainage also includes drips on the ends of parts, runs near holes. A cause may be high withdrawal speed and / or the galvanizing temperature being too low. | This condition does not adversely affect coating performance and is acceptable.<br>However, protuberances and lumps which interfere with mating surfaces are unacceptable. |  |
| 31 | **UNCOATED SURFACES CAUSED BY STEEL SURFACE CONTAMINANTS OR ENTRAPPED AIR** | Residues (such as oil based paint, grease, oil or labels) on the steel surface or incorrectly positioned vent holes, can result in localised ungalvanized areas in an otherwise continuous galvanized coating. Uncoated areas often manifest themselves as black or very dark coloured spots. | To avoid uncoated surfaces, ensure all paint or grease is removed prior to hot dip galvanizing. Make use of suitable marking pens for temporary identification. Correctly position adequately sized vent holes.<br>Uncoated areas within the limits of 0.5% of total area or single areas of 10cm2 or less can be repaired. Larger areas are rejectable. |  |
| 32 | **UNGALVANIZED SURFACES CAUSED BY SCALE OR SAND** | Sand on cast iron or scale on the steel surface is generally caused by the process used to form or roll the product. A localised ungalvanized area in an otherwise continuous coating can occur if scale or sand from the moulding or rolling is not removed by acid pickling or abrasive blasting. | These ungalvanized areas may occur in a linear pattern on angles, channels or other rolled products. They can also appear on cast iron products.<br>Uncoated areas within the limits of 0.5% of total area or single areas of $10cm^2$ or less can be repaired. Larger areas are rejectable. |  |
| 33 | **UNGALVANIZED AREA IN THE VICINITY OF A WELD** | A localised ungalvanized area near a weld can be caused by weld slag deposit, weld porosity or weld undercut. Oxide deposits and residues from welding are resistant to normal pickling acids and must be removed before the work is pickled and hot dip galvanized. | Weld slag deposits should not be accepted prior to galvanizing and must be removed by the fabricator by means of abrasive blast cleaning. The deposit can also be removed by proper chipping or wire brushing.<br>Shielded arc welding as opposed to stick welding is preferred for components which are to be hot dip galvanized.<br>Since corrosion control is compromised, this is rejectable; but may be repaired after negotiation. |  |
| 34 | **WELD SPATTER**<br>Weld spatter is oxidised, normally spherical expelled weld metal, that is fused (or not) onto the surrounding material during welding. | Weld spatter is caused by weld pool explosions when improper welding parameters are used, or if the material is dirty or contaminated. | Loosely adherent weld spatter should be removed by the fabricator prior to hot dip galvanizing. Although not acceptable in terms of the specification, the presence of tightly adherent weld spatter after hot dip galvanizing will not affect the corrosion resistant properties of the coating. |  |
| 35 | **WET STORAGE STAIN OR WHITE RUST**<br>Wet storage stain or white rust (as it is commonly called) is a white voluminous deposit that is occasionally found on the surface of a freshly galvanized coating. | Wet storage stain (zinc hydroxide) is formed on freshly galvanized surfaces which are in close contact in the presence of moisture. | Wet storage stain ceases when the cause is eliminated, i.e. the objects are separated and dried. Once it has been removed (with a nylon bristle brush) an evaluation is possible. If the coating thickness at the affected area is equal to, or greater than the minimum required in the specification, it is not a cause for rejection. The customer is to exercise caution during transport and storage to eliminate the susceptibility to wet storage stain. |  |

| SC | WHAT IS THIS? | CAUSE | EFFECT / REMEDY / RESPONSIBILITY | EXAMPLE |
|---|---|---|---|---|
| 36 | **ZINC METAL SPRAYED REPAIR APPLIED TO INADEQUATELY BLASTED SURFACES OR NOT WIRE BRUSHED AFTER APPLICATION** | In order for zinc metal spraying to adhere on applications, the damaged galvanized surface must be adequately roughened by sweep blasting or other approved methods. As it is difficult not to overspray, excess zinc metal spray loosely adheres to the surrounding coating. | The fabricator or galvanizer must prepare the surface for repair by roughening the surface by sweep blasting or some other approved method. Loosely applied zinc metal sprayed coating at the perimeter of the repair should be removed by wire brushing. If not removed, there is no compromise in the corrosion resistance. |  |
| | | | | |
| 37 | **ZINC SPLATTER** Splashes and flakes of loosely adherent zinc, caused by moisture on the steel surface when hot dip galvanizing. | When hot dip galvanizing on unusually deep fabrications by double dipping, moisture on the surface of the steel contacts with the molten zinc causing splashes of zinc to loosely adhere to the already hot dip galvanized surface. | The loosely adherent zinc splashes are easily removed and should be prior to release. An experienced galvanizer can ensure the coating overlap on double end dipped surface, is not visible. |  |

# Reference Areas

The number and position of reference areas and their sizes for the electro-magnetic test method shall be chosen with regard to the shape, varying material thickness and size of the article/s in order to obtain a result as representative as possible.

The number of reference areas, dependant upon the size of the individual articles in the control sample, shall be as follows:

a) For articles with significant surface[B] area greater than 2m², at least three reference areas shall be taken on each control sample.

b) For articles with a total significant surface area greater than 2m², manufactured from material of several different thickness', at least three reference areas shall be taken on each specific material thickness.

c) For articles with significant surface area between 1 000mm² and up to and including 2m² inclusive, each article in the control sample shall have at least one reference area.

d) For articles with a total significant surface area between 1 000mm² and up to and including 2m² inclusive, manufactured from material of several different thickness', each different material thickness, representing the control sample shall have at least one reference area, per material thickness.

e) For articles with less than 1 000mm² of significant surface area, enough articles shall be grouped together to provide at least 1 000mm² surface for an individual reference area. The number of reference areas shall be as given in the last column of **table 1.** Hence, the total number of articles tested equals the number of articles required to provide one reference area multiplied by the appropriate number from the last column of **table 1** related to the size of the lot (or the total number of articles galvanized if that is less). Alternatively, sampling procedures selected from **SANS 2859-1 / ISO 2859-1** shall be used.

**Note:** 2m² is typically
200cm x 100cm and
1 000mm² is typically
10cm x 1cm.

For case a) and b) on each article taken separately in the control sample, the local coating thickness within the reference area shall be equal to or greater than the mean coating thickness values given in **table 2 or 3** or the local coating thickness values given in **table 4.**

In cases c) to e) the coating thickness on each reference area shall be equal to or greater than the local coating thickness values given in **table 2, 3 or 4** as appropriate. The mean coating thickness on all reference areas on material of equal thickness in a sample shall be equal to or greater than the mean coating thickness values given in **table 2** or **3** as appropriate.

When more than five articles have to be taken to make up a reference area of at least 1 000 mm², a single magnetic measurement shall be taken on each article if a suitable area of significant surface exists: if not, the gravimetric test shall be used.

Within each reference area, which should be at least 1 000 mm², a minimum of five magnetic test readings shall be taken. If any of the individual readings is lower than the values in **table 2** or **3,** this is irrelevant as only the mean value over the whole of each reference area is required to be equal to or greater than the local thickness given in the table.

Thickness measurements shall not be taken on cut surfaces or areas less than 10mm from edges, flame cut surfaces or corners.

# Uniformity Testing

Variations in coating thickness are not usually of concern with materials hot dip galvanized after fabrication provided the minimum coating thickness requirements are satisfied, (except for fasteners - see note on maximum coating thickness below **table 3**.) Where the coating thickness is not uniform, the service life of the galvanized coating will generally be governed by the amount of zinc available at the place where the coating is thinnest rather than by the overall or average thickness of the coating.

Standard magnetic measuring instruments are quick and convenient methods for determining local coating thickness. By taking a number of readings on a hot dip galvanized surface, uniformity as well as actual thickness can be easily checked.

If small specimens are available, it may be possible to use the Preece test as a measure of coating uniformity. This test provides limited information as to the coating thickness, but serves only to locate the thinnest spot in a zinc coating by chemically removing the zinc.

There are many limitations on the use of the Preece test; consequently, it is no longer referred to in specifications for hot dip galvanizing after fabrication. When this test is applied, its scope and limitations should be well understood and no attempt should be made to draw undue inference from the test results.

# Adhesion of the Coating

Adhesion is concerned with the practical conditions of transportation, erection and service. The hot dip galvanized coating should be sufficiently adherent to withstand handling consistent with the nature and the thickness of the coating in normal use of the article, without peeling or flaking. Bending or forming, other than mild straightening after hot dip galvanizing, is not considered to be normal handling.

When certain grades of steel or very heavy steel sections are hot dip galvanized, coatings may occur, which are thicker than usual. The galvanizer has limited control over the development of thicker coatings. Thick coatings are a function of the chemical composition of the steel or the longer immersion time required for massive items. Heavy hot dip galvanized coatings, usually greater than 250mm thick, may be more brittle than a typical coating. Consequently, application and interpretation of the standard adhesion tests must take this into account. The requirements for transportation, handling and erection should be evaluated against the additional corrosion protection afforded by the thicker coating.

# Testing Adhesion

Testing adhesion is not necessarily a true measure of the adhesive strength of the metallurgical bonding of the hot dip galvanized coating to the base steel. It serves, however, as an indicator of the adhesive properties of the coating.

**Paring Test.** This simple but effective test is conducted by cutting or prying the hot dip galvanized coating with a sharp knife. Considerable pressure is exerted in a manner tending to remove a portion of the coating. Adherence is considered satisfactory when it is possible to remove only small particles of the coating.

It should not be possible to peel any portion of the coating in the form of a layer so as to expose the underlying iron or steel in advance of the knife point. Although not mentioned in **SANS 121 / ISO 1461**, this test has shown practical significance as a test for adhesion.

For compliance with **SANS 32 / EN 10240**, the most popular test is cold flattening in accordance with **SANS 8492 / ISO 8492**. Test pieces not less than 40mm in length are flattened between parallel flat platens as shown in **table 6.** No cracking or flaking of the coating shall occur on the surface away from the cut surface.

**TABLE 6**

**DEGREE OF FLATTENING FOR TESTING COATING ADHERENCE FOR TUBES**

| Tube type | Distance between platens |
|---|---|
| Square | 75% of side |
| Rectangular tube | 75% of shorter side |
| Round ≤ 21.3mm | 85% of outside diameter |
| Round > 21.3 ≤ 48.3mm | 80% of outside diameter |
| Round > 48.3 ≤ 76.1mm | 75% of outside diameter |
| Round > 76.1 ≤ 114.3mm | 70% of outside diameter |
| Round > 114.3mm | 65% of outside diameter |

# Appearance

The ability of a hot dip galvanized coating to meet its primary objective of providing corrosion protection should be the chief criteria in evaluating the coating's acceptability.

The basic finish requirements of the hot dip galvanized coating are that it be:

- relatively smooth,
- continuous,
- free from gross imperfections,
- free from sharp points (that can cause injury), and
- free from uncoated areas[c].

The above points are of particular importance when a subsequent organic coating (duplex coating) is to be applied. Smoothness and lack of roughness achieved by mechanically wiped products, such as continuously galvanized sheeting or wire, are not to be used as the criteria for accessing batch hot dip galvanized products. Roughness and smoothness are relative terms where the end use of the product must be the determining factor in setting tolerances.

The hot dip galvanized coating should be continuous to provide optimum corrosion protection. Handling techniques for hot dip galvanized articles may require the use of chain slings, wire or other holding devices to immerse the material into the galvanizing bath if suitable lifting fixtures are not provided on the item. Chains, wire and special jigs used to handle the items may leave a mark on

[c] *To be essentially free from uncoated areas is best described in* **SABS 763** *4.3.2 b). "The area of an individual bare spot or thin area shall not exceed 5mm². The combined area of bare spots or thin areas shall not exceed 25mm² per metre of length or per square metre of surface of an article."*

the hot dip galvanized item. These marks are not always detrimental and reason for rejection. Should these marks, be greater than 5mm$^2$ per chain mark and expose the bare steel, suitable repair should be carried out using the procedures indicated in **SANS 121 / ISO 1461.** See also "Coating Repair Procedures".

Differences in the lustre and colour of hot dip galvanized coatings do not affect corrosion resistance and the presence or absence of spangle has no effect on coating performance. The well-known spangled effect found on some hot dip galvanized surfaces is simply a factor of primary crystallisation. It is chiefly dependant upon the zinc bath chemistry, the rate of cooling, the method of pickling, the steel chemistry, and the thickness of the coating. In fact, dull grey or patchy matte grey hot dip galvanized coatings give service lives equal to or greater than bright or spangled coatings. Variations in coating appearance or finish are important only to the extent that they will affect corrosion performance or the intended use of the article. The primary function of a hot dip galvanized coating is corrosion protection. Specific requirements beyond the standard set out in **SANS 121 / ISO 1461**, shall be communicated to the galvanizer in writing or discussed at the contract review, prior to the work being hot dip galvanized.

The information supplied may include –

a) The composition and any properties of the metal that may affect the quality of the hot dip galvanized coating.

b) Identification of significant surfaces[B].

[B] *A significant surface can be defined as a surface which impacts on the performance of that article.*

c) A visual standard should be established if a special finish is required.

d) Any particular treatments that are required or not required before or after the process.

e) A variance in coating thickness. See notes below **table 3**.

f) The acceptable method of repair, if this is found to be necessary – see also "Coating Repair Procedures".

# Removal of Wet Storage Stain (White Rust)

Although in extreme cases the protective value of the coating may be impaired, wet storage stain attack is often superficial despite the relative bulkiness of the corrosion product. Where 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 and blend in with the surrounding zinc surface as a result of normal weathering in service.

When the affected area will not be fully exposed in service or when it will be subjected to a humid environment, wet storage staining must be removed, even if it is superficial. This is essential for the basic zinc carbonate film to form. The formation of this zinc carbonate film is necessary to ensure long term service life.

Light deposits can be removed by cleaning with a stiff bristle (not wire) brush. Heavier deposits can be removed by brushing with a 5% solution of sodium or potassium dichromate with the addition of 0.1% by volume of concentrated sulphuric acid. Alternatively, a 10% solution of acetic acid can be used. These solutions are applied with a stiff brush and left for about 30 seconds before thoroughly rinsing and drying.

Unless present prior to shipment from the galvanizer, the development of wet storage stain is not the responsibility of the galvanizer. The customer must exercise proper caution during transportation and storage to protect against wet storage staining.

# Coating Repair Procedures

### BY THE GALVANIZER

In terms of **SANS 121 / ISO 1461** a galvanizer may repair a coating by either zinc metal spraying or zinc rich epoxy or paint. The latter method must conform to certain requirements in the specification. The preferred method of repair is by zinc metal spraying. Repair will only be necessary if bare spots are present, usually caused by inadequate cleaning, air entrapment or if mechanical damage has occurred.

The total uncoated areas for renovation by the galvanizer shall not exceed 0,5% of the total area of the component.

For articles equal to an area of 2m$^2$; 0,5% represents a maximum area of 100cm$^2$ or 100mm x 100mm.

For articles equal to an area of 10 000mm$^2$; 0,5% represents a maximum area of 50mm$^2$ or 7mm x 7mm.

No individual repair area shall exceed 10cm$^2$ or 10mm x 100mm.

If uncoated areas are greater than 0,5%, the article shall be regalvanized, unless otherwise agreed between the purchaser and the galvanizer.

### Zinc Metal Thermal Sprayed Coatings

#### Method

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.

The coating thickness on the renovated areas shall be a minimum of 100µm, unless the purchaser advises the galvanizer otherwise. The coating repair should overlap the surrounding zinc by about 5mm. The repaired area is then wire brushed (preferably stainless steel) to remove loosely adhering over sprayed zinc. Wire brushing provides the added benefit of sealing the pores that may be present in the sprayed coating.

### Zinc Rich Epoxy or Zinc Rich Paint

#### Method

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 zinc rich epoxy conforming to ISO 3549 should be applied. The coating thickness on the renovated areas shall be a minimum of 100µm, unless the purchaser advises the galvanizer otherwise. The paint coating should overlap the surrounding zinc by about 5mm.

The preferred product is a two or three component zinc rich epoxy.

## SITE REPAIRS

The preferred method of repair is by zinc metal thermal spraying. Due to the remoteness of most sites, however, and the unavailability of metal spraying equipment, repairs by zinc rich epoxy or zinc rich paint have to date generally been more popular.

Site repairs should be limited to small coating defects and areas that have been cut or welded on site.

Should excessive amounts of grease or oil be present at the affected area, it should be removed by means of an approved solvent. All residues are to be thoroughly removed by washing with clean water.

The affected area should then be abraded with abrasive paper (roughness 80 grit) or alternatively thoroughly cleaned using, preferably a stainless steel brush. All dust and debris should be completely removed.

Repair can now be carried out using an approved product.

Single pack zinc rich paints are good materials and can easily be applied. They, however, require several coats to achieve a reasonable repair. Multiple coats will also necessitate longer drying times between coats.

Until recently, the approved products for repair were only available in large containers. Due to the large quantities involved and short pot life when mixed, the products proved to be expensive and wasteful.

Products are now available in two component form, packed for convenience in handy, easy to use squish packs. Two of these products are approved and available from the Hot Dip Galvanizers Association of Southern Africa and all of its members.

# APPENDIX A

## Applicable Standards

| | |
|---|---|
| **SANS 121 / ISO 1461** | *Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods* |
| **SANS 32 / EN 10240** | *Internal and/or external protective coatings for steel tubes – Specification for hot dip galvanized coatings applied in automatic plants.* |
| **SANS 14713 / ISO 14713** | *Protection against corrosion of iron and steel in structures – Zinc and aluminium coatings – Guidelines.* |
| **SANS 2178 / ISO 2178** | *Non-magnetic coatings on magnetic substrates - Measurement of coating thickness – Magnetic method.* |
| **ISO 1460** | *Metallic coatings – Hot dip galvanized coatings on ferrous materials – Gravimetric determination of the mass per unit area.* |
| **SANS 8492 / ISO 8492** | *Metallic materials – Tube – Flattening test.* |

**The Hot Dip Galvanizers Association of Southern Africa is indebted to the American Galvanizers Association and Industrial Galvanizers Corporation (Pty) Ltd of Australia, for permission to include some of the contents of their publication on inspection after hot dip galvanizing.**