HOT DIP GALVANIZERS ASSOCIATION SOUTHERN AFRICA

Code of Practice for Surface Preparation and Application of Organic Coatings

Applied to Hot Dip Galvanized
Steel (Sheet and Section) excluding In-line
Coil Coating (Duplex Systems)

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HDGASA 01-Rev1:2014

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INTRODUCTION

This Code of Practice has been prepared for specifiers, end-users, inspection authorities and painting applicators so as to comply with procedures necessary to ensure acceptable adhesion of paint to hot dip galvanized surfaces.

Referred to as a Duplex System

Paints with the same generic name but manufactured by different paint companies do not always have the same characteristics, properties and performance. It is therefore, most important that a complete paint system form one manufacturer be used.

A duplex system (hot dip galvanizing plus a top paint system) suitable for the environment to which it will be exposed, correctly applied in accordance with this Code, will give long term maintenance free service life and an aesthetically pleasing surface finish.

It is recommended that paint systems that comply with the appropriate requirements of Code of Practice No. HDGASA 02 rev1:2014 are applied.

1. SCOPE

This Code of Practice covers the jobbing application of organic coatings applied to continuous hot dip galvanized steel sheet, structural steel and pipes, which have been hot dip, galvanized.

2. GLOSSARY OF TERMS

Acceptable	Acceptable to the purchaser but in relation to meeting requirements of the Codes of Practice of the Hot Dip Galvanizers Association Southern Africa.
Adhesion	The strength of the bond between two interfaces. Frequently used in conjunction with a term denoting which interface e.g. substrate adhesion, inter-coat and top coat adhesion.
Cleaner	A material designed to remove contaminants.
Coating	A continuous film bonded to a surface for the purpose of protecting, decorating or identifying.

Coating Material	The material used to form a protective coating.
Defective	A product that fails to meet the requirements of the Code of Practice in one or more respects.
Degreasing	The removal of organic contaminants such as oil, grease and fats.
Dis-bonding	The loss of adhesion between two interfacing surfaces.
Drying Time	The time required, after application, for a thin paint film coating to convert from a liquid phase to a solid state.
Dry film thickness (DFT)	The thickness of a paint coating remaining on the surface when cured and hardened.
Duplex System	Two different type coatings used in combination. In this Code of Practice the term is used specifically to refer to the combination of hot dip galvanizing with 2 or more organic paint coatings.
Fish Eyes	Round or elliptical craters in a paint film caused by poor wetting of the substrate or occlusions of incompatible material such as oil spray.
Hot Dip Galvanizing	A formation of a coating of zinc and/or zinc iron alloys on iron and carbon steel products by dipping perfectly cleaned carbon steel or cast iron in zinc melt.
Induction Period	That time required, after mixing, for the components or multi-component paint coating to commence chemical reaction.
Lining	A coating applied to the inside surface of a vessel such as a pipe.
Orange Peel Effect	A dimpled finish resembling the surface of orange peel.
Over Coating Time	That time interval between application of one paint

coat and application of the next coat.

Passivation — The application of sodium di-sulphide, phosphate or similar solutions to prevent white rust on the newly hot dip galvanized surface.

Pot Life — The maximum time during which a coating material supplied as two separate components should be used after they have been mixed.

Run/Sags — An elongated swelling of excess paint that has run down the surface by gravitational force.

Silicon — A degassing and deoxidising element used in the manufacture of carbon steel that affects the reaction between the molten zinc and carbon steel during the formation of iron/zinc intermetallic alloys layers during hot dip galvanizing.

Spangle — A silver grey metallic appearance on the surface of the hot dip galvanized surface showing clear crystalline patterns with a range of size and brightness.

Carbon Steel — An alloy of iron, carbon and other elements and includes mild steel, cast iron and other iron based alloys suitable for hot dip galvanizing.

System — A combination of coating materials from one manufacturer that is compatible with each other and with the hot dip galvanized substrate when used in accordance with the manufacturer's instructions.

Time Window — That period of time between the minimum and maximum time intervals specified by the manufacturer of a paint system for over coating without special surface preparation requirements.

Water Break Free — The condition of a surface whereby clean potable water spread on the surface forms a continuous film without breaking up into islets of un-wetted surface.

White Rust	The white corrosion products of zinc oxide and zinc hydroxides that forms on “new” zinc when exposed to the atmosphere.
Wrinkle	A shrivelled appearance due to skin drying of an excessively thick film of paint.
V-Cut	Two straight cuts about 50mm long made by a sharp knife through the coating to the substrate such that the cuts cross each other at an angle of approximately 30º.

3. **COMMON REQUIREMENTS**

3.1. Recommendations for suitable zinc compatible paint system to be applied to the hot dip galvanized carbon steel that meets the minimum requirements of HDGASA 01 Rev 1:2014. This Code of Practice covers duplex coating systems exposed to the following atmospheric conditions. Refer to ISO 9223:2012 for corrosivity categories applied to atmospheric environments.

* **Mild** urban and rural conditions where colour coding or visibility markings are required.
* **Server Industrial** conditions.
* **Select Marine** coastal conditions.
* **Mining** applications underground.
* **Immersion** – for the lining and coating of pipe carrying raw potable or recirculated water, gas or oil, but excluding very aggressive chemicals such as acids, bleach solutions, ferric chloride solutions and brine.

NB: Pipes should be joined by flanges or hydraulic couplings. Flanges and collars, where required, should be welded to the pipe before hot dip galvanizing.

3.2. The strength of the mechanical bond between the hot dip galvanized surface and the zinc compatible paint primer, shall meet the minimum requirement of the HDGASA 01 Rev 1:2014. Preparation of the hot dip galvanized substrate is critical for the bond between the zinc surface and the over-coated paint system.

3.3. The following items are controlled and monitored during the application of the paint system.

(a) Preparation of the hot dip galvanized surface to accept a zinc compatible paint primer.
(b) Wet (paint) film thickness.
(c) Dry (paint) film thickness. (DFT)
(d) Ensure mixing of multi pack products in the required ratio.
(e) Spray equipment and air supply must be free from oil and moisture.
(f) Hot dip galvanized surface temperature at > 5ºC above dew point.
(g) Relative humidity below 85%.
(h) Ambient temperature above 5ºC.
(I) No dirt deposits between coats.
(j) Packaging to avoid mechanical damage during transportation.

3.4. Strict quality control/assurance should be applied at the painting site to control the variables. (Appendix 2). These procedures require profile gauges, equipment for determining residual dust and debris, wet film thickness gauges, electromagnetic or permanent magnet type instruments to determine dry film thickness, hygrometers, surface and conventional thermometers and equipment to determine cross-hatch adhesion and pull-off adhesion.

4. SURFACE PREPARATION FOR DUPLEX SYSTEM

4.1. Contaminants and Physical Factors

The importance of correct surface preparation and the prevention of subsequent contamination prior to painting cannot be too strongly emphasised.

Nearly all failures in painting over hot dip galvanized steel occur because of inadequate surface preparation or recontamination of the reactive clean zinc surface before painting.

The contaminants to be removed include the following:

(a) Galvanizing residues and passivating products.
(b) Oil and grease.
(c) Perspiration and oil contamination from contact with hands.
(d) Dust and chemical pollution.

Essential inclusion as part of the pre-galvanizing inspection

(a) Rounding of sharp edges to a radius of 3mm or 50% of the steel thickness whichever is the lesser.
(b) Removal of weld spatter.
(c) Sealing of crevices, which will retain acid residues and water.
(d) Repaired areas to equal coating thickness of surrounding surfaces.

4.2. Preparation of Continuous Galvanized Sheet

4.2.1. Spangle

When thin film coatings are to be applied, the use of “flattened spangle” sheet is recommended for a smooth finish that will prevent thinning of the paint at the edges of the spangles.

4.2.2. Cut Edges

All cut edges should be rounded with a file or abrasive paper or scraped with a sharp tool to remove any burr and to round the edge.

4.3 Preparation of Fabricated Structural Steel

4.3.1 Prior to Hot Dip Galvanizing

Sharp edges should be rounded to a radius of 3mm, or 50% of the steel thickness, whichever is the lesser.

In hot dip galvanizing, zinc coatings tend to become thicker at sharp edges and burrs, and rounding by mechanical means is required.

All weld slag and spatter must be removed.

Note: Paint is a liquid material and tends to draw away from sharp edges by surface tension leaving an under thickness coating on the protrusions.

4.4 Preparation of the hot dip galvanized (zinc) surfaces

4.4.1 Chemical cleaning

Galvanized iron cleaner is supplied as a ready-for-use containing degreasing additives that removes temporary protective coating (passivation) from newly hot dip galvanised steel. Surface oxidation from old weathered galvanized steel must be removed during this pretreatment process.

a. Apply by bristle brush or spray to manageable areas and leave in contact with surface for at least three minutes.
b. Scrub off with bristle brush or broom and water to remove all traces of GALVANISED IRON CLEANER and other contaminants.
c. Check that the surface is water break-free. If not, or if it still appears dirty, re-apply GALVANISED IRON CLEANER and repeat the above procedure.
d. Allow to dry.
e. Once dried, prime the cleaned surface within 4 to 6 hours to prevent re-contamination of surface.

4.4.2 **Sweep Blast Cleaning**

Tests have shown that abrasion of the surface of hot dip galvanized silicon killed steel is generally unnecessary, since the alloy growth imparts a sufficiently rough profile. Notwithstanding this contaminants must be removed.

However, in cases of smooth, bright hot dip galvanized surfaces, it may be necessary to create a profile by mechanical means. In the case of small areas, this can be done by manual or mechanical abrasion with medium-fine abrasive paper (80 grit paper) using an orbital sander. Do not use a high-speed disc sander.

On large surfaces, the process of sweep blast cleaning is employed. It is not the same as normal blast cleaning of mild steel prior to painting. Normal blast cleaning, as used on mild steel, has the potential to remove the hot dip galvanized layer and does not form part of this Code of Practice.

The parameters for sweep blast cleaning are as follows:

(a) Equipment and air supply free of oil and moisture.
(b) Nozzle pressure – not greater than 300kPa recommended 2 to 2.5kPa.
(c) Nozzle angle to the surface being cleaned - 30º- 60º to the sweep blasted surface with a sweeping type action.
(d) Sweeping distance 600 to 1000mm.
(e) Sweep blast material, referred to as **Grane**t, consists of ultrafine non-metallic grit – not less than 0,2mm and not greater than 0,8mm.
(f) Garnet must not be recycled.
(g) Sweep blasted zinc surface must be free from all contaminants including oil and dust.

Similar results can be achieved with water blast cleaning using a water pressure not greater than 15MPa, an angle of blast of about 30º and with injection of ultrafine abrasive as described above.

The advantage of water blast cleaning is that detergent can be injected into the system as well as abrasive so that degreasing and creating of a profile can be carried out simultaneously.

Due to the high energy of the water, the amount of abrasive required is much less than in the case of sweep blast cleaning. The equipment must be designed to resist the reaction forces on the nozzle of the lance.

Once the hot dip galvanized surfaces are cleaned and dried the zinc compatible paint primer must be applied within 4 to 6 hours. This requirement is necessary due to the cleaned zinc surface is reactive and subject to corrosion form zinc oxide and/or zinc hydroxide.

4.5 Preparation of Pipes

Physical Factors

Recommendations given in 4.3.1 apply equally to pipes. In E.R.W. pipes, the interior weld must be scarfed during manufacture to be flush with the pipe wall. Exterior welds should have a smooth profile.

4.5.1 Degreasing

Degreasing of pipes is best carried out by high pressure water blast cleaning equipment with specially designed lances to run the full length of the inside of the pipe.

The equipment should be so designed that detergent can be applied through flexible hoses, which can then be switched to clean potable water.

The nozzle should operate at an angle of 30º to the wall of the pipe. Water pressure should not be greater than 15MPa.

Firstly apply a suitable degreasing agent or detergent that will rapidly dissolve the grease. Allow 2-5 minutes to react then wash off with a high-pressure water jet at less than 15MPa using clean potable water.

It is recommended that the pipe should be constantly rotated at a steady speed during the cleaning process in order to ensure that the whole surface is

cleaned. If the pipe is maintained at about 5º to horizontal, it will assist in good drainage.

Blow clean, warm air through the pipe until water is removed. Once fully dried, apply the appropriate lining materials.

The outside surface of the pipes should be similarly treated. In this case flanges should be carefully examined for weld spatter, blobs of zinc and similar protuberances, which should be removed as described in 4.3.1.

4.5.2 Sweep Blast Cleaning

Refer to Section 4.4.2

4.5.3 Preparation of nuts, bolts and other fasteners use the method described in 4.4.1.

5 APPLICATION OF COATINGS

Painting should be carried out within 4 to 6 hours after cleaning and drying. All paints shall be applied in strict accordance with the manufacturer's instructions. In the case of nuts, bolts and other fasteners, care must be taken to ensure that all edges are well coated with the adequate thickness of the system being applied.

6 REPAIRS TO PAINT COATINGS DAMAGED IN TRANSPORTATION

Refer to Information Sheet No12 "Hot dip galvanizing & duplex coat repair procedure"

To repair coatings damaged during transportation, handling or erection, the following procedures should be followed:

6.5 Abrade the damaged area with medium grade abrasive paper (320 grade) for 20mm around the damaged area.
6.6 Remove all dust and debris.
6.7 In the case of two component materials such as epoxies, wipe the surface with methyl ethyl ketone and allow drying.
6.8 For acrylic, vinyl or chlorinated rubber paints, omit this step as the strong solvent will dissolve the coating.
6.9 If bare steel is exposed, apply galvpatch to conform to the surrounding zinc followed by the same manufacturer that supplied the original system.

6.10 If the coating is damaged only down to the zinc surface, then repair with the same system as originally applied after preparation of the surface as described in 4 above.

7 TREATMENT OF CREVICES

Crevices in overlapped joints such as between mating surfaces of bolted connections and similar narrow gaps should be sealed with a suitable sealant such as silicon, polyurethane, polysulphide or oleoresinous sealant depending on the degree of movement anticipated.

APPENDIX 1

DUPLEX SYSTEM

Duplex systems (hot dip galvanizing plus a suitable paint system) provide synergy by virtue of the fact that the durability of the combined hot dip galvanized substrate and top organic coating system is greater than the sum of the separate durability's of the two forms of corrosion control.

Synergistic effect can be estimated mathematically as follows:

Duplex Life = factor x (zinc life + paint life)

Table 1 - Synergistic protection provided by the combined use of a zinc coating and a paint coating. (Refer Jan van Eijnsbergen and Porter)

Environment	Synergistic effect increase factor
Industrial and Marine	1,8 to ,2,0
Seawater (immersion)	1,5 to 1,6
Non-aggressive climate	2,0 to 2,7

The synergy factors vary from 1,5 in the extreme corrosive environments to 2,7 in less-aggressive environments. In a highly aggressive environment (ISO 9223:2012 C4, C5 and CX corrosivity categories) hot dip galvanizing on its own tends to become marginal in terms of service life. Duplex systems have been shown to provide a significant service life extension. On the bases of the synergistic effect increase factor of 1.5, table 4 has been developed.

Table 2 - Estimated Service Life for Duplex system (zinc plus paint) complying with SANS 121 (ISO 1461:2009) and subjected to atmospheric environmental classified in terms of ISO 9223:2012

Corrosivity Category	Service life in years for Duplex Coated Steel				
	Units	**Hot Dip Galvanizing** r_{corr}	**85µm mean coating thickness for steel > 6 mm (years) ****	**Estimated service life of a 2 coat paint system 270 to 300µm (years)**	**Estimated service life of a Duplex system 355 to 385µm (years)****
C 1	µm/a	$r_{corr} \leq 0.1$	> 80	15	Required for aesthetics only
C 2	µm/a	$0.1 < r_{corr} \leq 0.7$	> 80	15	Required for aesthetics only
C 3	µm/a	$0.7 < r_{corr} \leq 2.1$	40 to > 80	12	Required for aesthetics only
C 4	µm/a	$2.1 < r_{corr} \leq 4.2$	20 to ≤ 40	10	(20+10) x 1.5 = 45
C 5	µm/a	$4.2 < r_{corr} \leq 8.4$	10 to ≤ 20	8	(10 + 8) x 1.5 = 27
CX	µm/a	$8.4 < r_{corr} \leq 25$	3.4 to ≤ 10	6	(3.4 + 6) x 1.5 = 14

** Assumes the worst case in terms of HDG figures used in calculating Duplex service life.

APPENDIX 2

APPLICABLE STANDARDs & ASSOCIATION INFORMATION SHEETS

Reference is made to the latest issue of the following standards and methods of test:

SANS 14713-1 & 2	Protection against corrosion of iron and steel in structures – Zinc and aluminium coatings – Guidelines.
SANS/ISO 12944-5:2007	Paints and varnishes – Corrosion protection of steel structures by protective paint systems Part 5: Protective paint system.
SANS 121 (ISO 1461:2009)	Hot dip galvanized coatings on fabricated iron and steel articles – Code of Practices and test methods.
SANS 32 (EN10240:1997)	Code of Practice for hot dip galvanized coatings applied in automatic plants
ISO 9223:2012	Corrosion of metals and alloys - Corrosivity of Atmospheres – Classification, determination and estimation
SANS 3575	Continuous hot dip zinc coated carbon steel sheet of commercial, lock forming and drawing grades.
SANS 4998	Continuous hot dip zinc coated carbon steel sheet of commercial, structural grades.
INFO. SHEET No. 8	Corrosion of Zinc – Corrosivity of atmospheres
INFO. SHEET No. 9	Surface Preparation of Hot Dip Galvanized Steel to accept a Paint coating system - Referred to as Sweep Blast Cleaning
INFO. SHEET No. 12	Hot dip galvanizing & duplex coat repair procedure.

APPENDIX 3

RECOMMENDED QUALITY CONTROL PROCEDURES

Quality control in duplex coating should be carried out at the following stages:

Before commencing work, to check removal of sharp edges, weld spatter, slivers and similar mechanical interference with the application of organic coatings.

After cleaning, when the surface must be tested to ensure that it is “water-break” free.

During and after each coat of paint to ensure that the paint is uniformly applied to the correct wet film or dry film thickness as appropriate, in accordance with the manufacturer’s recommendations.

Gloss finish, uniformity of surface, absence of craters, fish eyes, blisters, runs, sags and other visible defects represent sub-standard quality.

Total coating dry film thickness, determined by an electromagnetic gauge calibrated on a similar hot dip galvanized but unpainted surface. Alternatively, the gauge may be calibrated on smooth polished steel plate, and then the thickness of the hot dip galvanizing (without paint) can be measured. The mean of at least 10 hot dip galvanized thickness readings is then deducted from total layer thickness over steel to obtain the average thickness of paint.

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This Code of Practice has been prepared for the use of manufacturers, contractors, engineers and others involved in the design or application of Duplex Systems. It has been compiled from work carried out by a co-ordinating committee drawn from industry. While recognising that each system must be designed and applied to meet particular circumstances, the committee assumes no responsibility or liability of any kind, in connection with this Code of Practice or its use by any person or organisation and makes no representation or warranties of any kind hereby.

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