HOT DIP GALVANIZERS ASSOCIATION SOUTHERN AFRICA

Code of Practice for the Performance Requirements for Coating Systems

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

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HDGASA 02 – Rev 1:2014

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CONTENTS

INTRODUCTION

This Code of Practice is intended for paint manufacturers and specifiers and covers requirements for paint systems intended for application to hot dip galvanized steel (sheet or structural), but excluding colour coated coil. Paint systems complying with this Code of Practice, when applied to galvanized surfaces in accordance with the recommendation of the HDGASA 01 rev 1:2014, "The Surface Preparation and Application of Organic Coatings to Hot Dip Galvanized Steel (sheet and section) excluding In-line Colour Coating coil", can be anticipated to provide cost-effective, long-term protection when used within the appropriate environment.

To avoid misleading information all generic names e.g. vinyl, chlorinated rubber, epoxies etc. have been avoided as paints with the same generic name, but manufactured by different paint manufacturers do not necessarily have the same characteristics, properties and performance. It is important that the various paint coats comprising the paint system used, should be sourced from one manufacturer.

On request, paint manufacturers should provide documentary evidence of compliance with HDGASA 01 rev 1:2014 for all paints, which they recommend.

1. SCOPE

1.1. The Code of Practice covers duplex coating systems exposed to the following environmental conditions. Refer to ISO 9223:2012 for atmospheric **corrosivity categories.**

* **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.

1.2. The Code of Practice excludes in-line continuous colour coating processes.

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 Codes 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. REQUIREMENTS FOR DUPLEX SYSTEMS

This Code of Practice covers duplex coating systems exposed to the following environmental conditions. Refer to ISO 9223:2012 for atmospheric **corrosivity categories.**

* **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.

3.1. Physical and Chemical Requirements

3.1.1. Systems shall comply with the relevant values for each test and corresponding environment given in Table 1 on page 14.

3.1.2. *Number of Coats*
The number of coats in the system shall be as recommended by the manufacturer of the system.

The following is given as a guide:

Mild Environment	One colour coding coat
Industrial Environment	Two Coats
Marine Environment	Two or Three coats depending on the severity of the environment
Mining	Two or Three coats depending on the severity of the environment
Immersed Pipes	Two or Three coats depending on film build of each coat

3.2.3 Dry Film Thickness

Coatings shall be applied within the dry film thickness range recommended by the manufacturer. Dry film thickness is dependent on the solids content by volume and the flow characteristics of the coating materials.

The following is given as a guide, but subject to the manufactures recommendations:

Mild Environment	20 – 40 microns
Industrial Environment	40 – 90 microns
Marine Environment	80 – 160 microns
Mining	90 – 180 microns
Immersed Pipes	150 – 250 microns

3.2.4 Visual Assessment

The coating shall be applied by the method(s) stated by the manufacturer. Applied coatings shall have a uniform glossy, semi-glossy, semi-matt or matt finish as specified by the purchaser. The dry film shall be free from runs, wrinkles, sags, orange peel effect, “fish eyes”, excessive brush marks or other visible defects.

3.2.5 Time Interval Between Coats

The time interval between coats shall be as specified by the manufacturer in his data sheets for the material to be used.

NOTE:
In some case, especially with two-component materials, there is frequently a time window within which subsequent coats must be applied.
This time window is dependent upon ambient temperature, the higher the temperature, the shorter the window.

In multi-coat systems, coats subsequent to the first shall be applied not sooner than the minimum nor longer than the maximum over coating time specified by the manufacturer for the prevailing ambient temperature.

3.2.6 Pot Life

Two component materials have a limited useable life after the two components have been mixed.

Pot Life is dependent upon temperature (the higher the temperature the shorter the pot life) and upon the volume mixed (the larger the volume the shorter the pot life).

NOTE:
Some materials, such as two-pack etch primers and water dispersed epoxies, do not give a simple visual indication of expired pot life.

4. SURFACE PREPARATION AND APPLICATION OF SYSTEMS

Surface preparation and application shall be carried out in accordance with the Code of Practice for the Surface Preparation and Application of Duplex Systems – HDGASA 01-rev 1:2014.

5. PROPERTIES OF APPLIED SYSTEMS

The properties of the applied systems shall meet the relevant requirements given in section 3 of this Code of Practice.

6. METHODS OF TEST

6.1 Preparation of Test Panels

6.1.1. Structural Steel

Test panels shall be cut from steel plate 6mm in thickness and containing 0,2 – 0,3% silicon, which has been hot dip galvanized in accordance with SANS 121 (ISO 1461:2009).. The hot dip galvanized steel plate shall be quenched in clean potable water and shall not be passivated.

Test panels 300mm by 100mm, shall be cut from the plate preferably by guillotine or band saw. Alternatively, panels may be cut by angle grinder or by laser but they shall not be flame cut.

All angles shall be ground to a radius of not less than 2mm prior to hot dip galvanizing.

Newly hot dip galvanized panels shall be stored in a clean, dry environment and shall be separated from each other by at least 2mm to prevent the formation of white rust.

6.1.2. Sheet Steel

Use test plates of newly galvanized steel sheet – 150 x 75 x 0,6mm, complying with SANS / ISO 3575 Grade Z275.

6.1.3. Cleaning

Immediately prior to use, panels shall be cleaned by brushing vigorously with the manufacturer's solvent detergent cleaner for galvanized iron, alternatively, with medium duty solvent detergent, which shall remain on the surface for 5 – 10 minutes.

After this period, the test panels shall be thoroughly washed with clean potable water until all degreaser and residues have been removed. Finally, the panels shall be dried with a clean, lint-free cloth.

Test panels shall be water-break free. If not, the cleaning process shall be repeated until a water-break free surface is obtained.

Test panels, which have been cleaned, shall not be touched with bare hands.

Operators shall wear clean lint-free gloves in all subsequent operations until completion of the coated test panel.

6.2. Application of Coating Material

6.2.1. Coating material for test shall be supplied in the manufacturer's containers, clearly marked with the following:

(a) Manufacturer's name.
(b) Product brand name and reference number or code.
(c) Date of manufacture.
(d) Abbreviated instructions for use, which shall include mixing ratio(s) of multi-component materials by mass and by volume, minimum and maximum temperature for application and method of application.

6.2.2. Samples for test will normally be applied by brush or doctor blade, the former being the preferred method.

6.2.3. Coating material shall be mixed and applied to the relevant test panels cleaned as described in 6.1.3. The spreading rate or wet film thickness shall be in accordance with the manufacturer's instructions. After drying, the dry film thickness of the coating shall be measured by a non-destructive electro-magnetic thickness gauge (minimum 5 readings per panel). All readings shall be within the dry film thickness range recommended by the manufacturer.

In multi-coat systems, test panels shall be exposed in well-ventilated conditions at a temperature of 20±5ºC and between coats shall be in accordance with the manufacturer's instructions. Completed system shall be allowed 7 days curing time before testing.

6.3. X-Cut Adhesion Test

6.3.1. X-Cut Adhesion – Structural Steel Only

Prepare test panels in accordance with 6.1.1, 6.1.3 and 6.2.3. Use SABS Method 159. Rate the result in accordance with Table 1 of this method.

6.3.2. X-Cut Adhesion – Sheet Steel Only

Prepare the test panels in accordance with 6.1.2, 6.1.3 and 6.2.3. Use SABS Method 159. Rate the result in accordance with Table 1 of this method.

6.4. Tensile Pull-Off Test – Structural Steel Only

Prepare the test panels in accordance with 6.1.1, 6.1.3 and 6.2.3.

Use SABS Method 776, except that a hydraulic adhesion tester shall be used in preference to a mechanical tester.

Results shall be expressed in Mega Pascal's (MPa)

If any one result differs from the mean by more than 10% of the mean value, it shall be ignored and the mean of the other two results shall be taken as the Adhesion Value.

If no two results agree to within 10% of the mean, the tests shall be repeated unless all results are above minimum value specified, when the result shall be expressed as greater than the specified values in Table 1(1.c).

6.5. V-Cut Adhesion Test – Structural Steel Only

Prepare test panels in accordance with 6.1.1, 6.1.3 and 6.2.3.

With a sharp knife, cut two lines at approximately 30º to each other such that the incisions cross with not less than 35mm length of incision on each line on the same side as the crossing point. From the crossing point, try to life the coating away from the substrate with the sharp point of the knife. If the coating can be lifted, lever and lift until no further de-bonding.

Measure the length de-bonding from the point of intersection to the incisions.

6.6. Impact Resistance Test – Structural Steel Only

Prepare test panels in accordance with 6.1.1, 6.1.3 and 6.2.3. Use SABS Method 146, except that:

(a) The mass-piece or tup shall have a mass of 1,25kg, a length of 260mm and diameter of 25mm. The ball shall have a diameter of 16mm.

The mass shall be measured accurately to 1g.

(b) The coated test panel shall be replaced with the painted side uppermost and shall be firmly clamped to the baseplate.
Impact energy (Joules) = mass of tup (kilogram) x height (metres) x 9,81

6.7. Weather Resistance (Q.U.V.) Test

NOTE: These tests can only be done on sheet steel test panels by virtue of limitations of the test equipment. The test results are equally applicable to structural steel.

Prepare test panels in accordance with 6.1.2, 6.1.3 and 6.2.3.

Prepare two test panels for each system to be tested. After curing, retain one panel for reference.

Expose the second panel in a Q.U.V. cabinet, operated in accordance with ASTM G-53, using a cycle of 4th U.V. exposure at 60ºC, followed by 4h condensation at 50ºC, for a total test period of 500h.

Evaluate the panel for the following properties:

A – gloss retention
B – colour retention
C – chalking
D – checking
E – cracking
F – adhesion by 6.3.2

Evaluate each property by comparison with the reference sample using the scale 10 = no change or no defect; 0 = drastic change.

Calculate the overall assessment as:
A + B + C + 2D + 2E + 3F

6.8. Salt Fog Resistance Test – Structural Steel Only

Prepare four test panels in accordance with 6.1.1, 6.1.3 and 6.2.3 retain two panels.

Cut a cross into the coating using a broken hacksaw blade to give a 1mm wide cut exposing the galvanizing substrate. The length of each cut shall be approximately

60mm and the cuts shall intersect at their centres at an angle of 30º. The cross so formed shall have its centre at approximately 40mm from the bottom of the test panel.

Test two panels in accordance with SABS Method 155 for a total of 500h.

After washing and drying immediately evaluate the test panels for the following:

(a) Blistering, in accordance with ASTM D-714.
(b) Under corrosion creep from the cross at the bottom on the panel, measured in mm from the edge of the initial cut.
(c) Allow the test panels to dry for 24h then measure adhesion in accordance with 6.5. If this is satisfactory, measure adhesion in accordance with 6.4 and compare with similar measurements on unexposed panels.

6.9. **Acid Water Resistance Test – Structural Steel Only**

Prepare three test panels in accordance with 6.1.1, 6.1.3 and 6.2.3. Retain one as a reference.

On the other two cut cross as described in 6.8.

Prepare a solution buffered to pH 4,5 as follows:
Dissolve 255,3g of potassium hydrogen phthalate in approximately 2*l* of distilled or de-ionised water. Add 111ml of 10% sodium hydroxide solution and stir thoroughly. Make the total volume up to 25*l* with distilled water.

Measure the pH with an electrometric pH meter and adjust if necessary to give a pH value of 4,5 ± 0,1.

Immerse the two scribed panels in acid water for a test period of 500h. Remove the panels, wash thoroughly with distilled water, dry with absorbent paper then evaluate the test panels for the following:

(a) Blistering, in accordance with ASTM D-714.
(b) Under corrosion creep from the cross at the bottom of the panel measured in mm from the edge of the initial cut.
(c) Allow the test panel to dry for 24h, then measure adhesion loss in 5mm or less.
(d) Determine adhesion in accordance with 6.4 and express the difference as a percentage of the adhesion of the system on table 1.

Table 1

Property	Type 1 Mild	Type 2 Industrial	Type 3 Marine	Type 4 Mining	Type 5 Immersion	Test Method Section
Adhesion					10	
(a) X-cut min – structural steel	8	8	8	8	-	6.3.1
(b) X-cut min – sheet steel	8	8	8	8	10	6.3.2
(c) Tensile pull-off MPa min – structural steel	5,0 -	5,0 -	5,0 -	6,0 -	10	6.4 6.5
(d) V-cut, mm max – structural steel						
Impact Resistance Joules, min value for no cracking or loss of adhesion	12	12	12	12	10	6.6
Weather Resistance (QUV) overall evaluation min.	70	70	70	70	-	6.7
Salt Fog Resistance						
(a) Blistering max.	-	4MD	4M	4F	-	6.8
(b) Under corrosion creep, mm max.	-	2	1,5	1,0	-	6.8
(c) Loss of adhesion % of original max.	-`	20	20	20	-	6.8
Acid Water (pH 4,5) Resistance						
(a) Blistering, max.	-	-	-	Nil	Nil	6.9
(b) Undercreep.mm max.	-	-	-	20	20	6.9
(c) Loss of Adhesion % of original max.	-	-	-	20	20	6.9

APPENDIX A

APPLICABLE STANDARDS

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

ASTM G-53	Recommended practice for operating light-and-water exposure apparatus (fluorescent UV – condensation type) for exposure of non-metallic materials.
ASTM D-714	Standard method of evaluating degree of blistering of paints.
SANS 121 (ISO 1461:2012)	Hot dip galvanized coatings on fabricated iron and steel articles – Code of Practices and test methods.
SANS / ISO 3575	Continuous hot dip zinc coated carbon steel sheet of commercial, lock forming and drawing grades.
SABS 1344	Medium duty solvent detergent.
SABS Method 146	Resistance to impact of paint films.
SABS Method 155	Resistance to salt fog of paint films.
SABS Method 159	Adhesion of paint and varnish films (cross cut test).
SABS Method 776	Adhesion of coatings (direct pull-off method).

APPENDIX B

NOTES TO PURCHASERS

B1 The purchaser must specify the environment to which the duplex coated surface will be exposed. In the case of pipes, both internal (cargo) and external (in soil, backfill, exposed to air, underground) conditions should be stated. If the pipeline is to be joined by welding, the hot dip galvanized layer should be ground off for not less than 20mm on each side of the weld and both inside and outside the pipe. (Alternatively a mask may be used prior to hot dip galvanizing, in order to prevent coating formation at the area to be cleaned). After welding, the welds and adjacent area should be blast cleaned then zinc flame sprayed or coated with at least two coats of 2-component epoxy zinc rich primer before application of the Duplex Coating.

B2 Systems tested to the requirements of this Code of Practice may be expected to give excellent performance in service. However, the most important aspect of the duplex coating is in the surface preparation of the zinc prior to application of the paint system. Purchasers are therefore strongly advised to consult the Code of Practice for Surface Preparation and Application of Organic Coatings (HDGSA01 Rev 1:2014) published by the Hot Dip Galvanizers Association South Africa and to specify that its recommendations shall be followed by the contractor applying the system.

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Steel (Sheet and Section) excluding In-line
Coil Coating (Duplex Systems)

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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