Advisory *Note*

GEN 37/1

Testing Coating Thickness of Hot Dip Galvanizing: Statistical Sampling – Magnetic Method

December 2013

Introduction

The means by which compliance with AS/NZS 4680[1] can be demonstrated includes statistical sampling, product certification and the supplier's quality system. The details for these methods are outlined in Appendix B of the Standard, although users should note that the requirements are 'informative' only. Galvanizers will generally conduct coating thickness tests on a regular basis for confirmation of their process capability and ensure they are complying with the Standard. These routine tests allow the galvanizer to offer a certificate of compliance with the articles they hot dip galvanize.

The detailed statistical testing method described in this Advisory Note is used for the purpose of issuing a test certificate. The testing method uses the non-destructive magnetic method, as outlined in AS 2331.1.3[2]. Typically, this is carried out using a calibrated hand-held instrument (e.g. Elcometer 456). Other statistical methods to determine compliance to AS/NZS 4680 generally involve destructive testing (e.g. gravimetric method), which will add cost and time. The statistical sampling section (Clause B2) of AS/NZS 4680 is reproduced below.

> *B2 STATISTICAL SAMPLING*
>
> *Statistical sampling is a procedure which enables decisions to be made about the quality of batches of items after inspecting or testing only a portion of those items. This procedure will only be valid if the sampling plan has been determined on a statistical basis and the following requirements are met:*
>
> *The sample needs to be drawn randomly from a population of product of known history. The history needs to enable verification that the product was made from known materials at essentially the same time, by essentially the same processes and under essentially the same system of control.*
>
> *For each different situation, a suitable sampling plan needs to be defined. A sampling plan for one manufacturer of given capability and product throughput may not be relevant to another manufacturer producing the same items.*
>
> *In order for statistical sampling to be meaningful to the customer, the manufacturer or supplier needs to demonstrate how the above conditions have been satisfied. Sampling and the establishment of a sampling plan should be carried out in accordance with AS 1199.1, guidance to which is given in AS 1199.0.*

[1] AS/NZS 4680, Hot-dip galvanized (zinc) coatings on fabricated ferrous articles
[2] AS 2331.1.3, Methods of test for metallic and related coatings - Local thickness tests – Magnetic method

Discussion

Clause B2 recommends statistical sampling to a procedure carried out in accordance with the AS 1199[3] series. This standard is identical to the ISO 2859 series[4] and the processes required by the various sections of ISO 2859 have been developed into a statistical sampling procedure detailed in the International Standard for batch hot dip galvanizing (ISO 1461[5]). The procedure from ISO 1461 is reproduced in this Advisory Note to allow consistent statistical sampling methods to be used throughout the hot dip galvanizing industry. A form for recording results from an inspection performed as described in this Advisory Note can be found at the end.

Definitions

acceptance inspection	→	inspection of an inspection lot at the hot dip galvanization works, unless otherwise specified
certificate of compliance	→	a document with a producer's written assurance that the supplied goods meet the required specification
coating thickness (µm)	→	total thickness of zinc and/or zinc alloys (in microns)
control sample	→	article or group of articles from a lot that is selected for sampling
inspection lot	→	single order or single delivery load (or daily throughput for process compliance checks)
local coating thickness	→	mean value of coating thickness obtained from the specific number of measurements within a reference area for a magnetic test or the single value from a gravimetric test
mean coating thickness	→	average value of the local thicknesses
minimum value of the coating thickness	→	lowest mean obtained from the specified number of measurements in a magnetic test within a reference area
reference area	→	area within which a specific number of single measurements are made
significant surface	→	part of the article covered or to be covered by the coating and for which the coating is essential for serviceability and/or appearance
test certificate	→	a certificate to show the supplied goods have passed a specified test

[3] AS 1199.0, Sampling procedures for inspection by attributes - Introduction to the ISO 2859 attribute sampling system
[4] ISO 2859-1, Sampling procedures for inspection by attributes — Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection
ISO 2859-2, Sampling procedures for inspection by attributes — Part 2: Sampling plans indexed by limited quality (LQ) for isolated lot inspection
ISO 2859-3, Sampling procedures for inspection by attributes — Part 3: Skip-lot sampling procedures
[5] ISO 1461, Hot dip galvanized coatings on fabricated iron and steel articles — Specifications and test methods

Acceptance inspection and sampling

An acceptance inspection undertaken by, or on behalf of, the purchaser shall be undertaken before the products leave the hot dip galvanizers custody, unless otherwise specified at the time of ordering by the purchaser. An acceptance inspection involves assessment of the appearance of the coated product and testing of the zinc coating thickness. Adhesion tests are not normally carried out and are only tested by agreement.

A control sample for thickness testing shall be taken randomly from each **inspection lot** selected for testing. The random selection method should ensure there is no bias, whether positive or negative, which would skew the coating thickness measurement. For example, articles selected should not all be from an area on a rack/jig which has spent more time in the molten zinc due to immersion procedures, as their mean coating thickness will generally be thicker. The minimum number of articles from each inspection lot that forms the control sample shall be in accordance with **Table 1**.

Table 1 — Control sample size related to lot size

Number of articles in lot	Minimum number of articles in the control sample
1 to 3	All
4 to 500	3
501 to 1,200	5
1,201 to 3,200	8
3,201 to 10,000	13
> 10,000	20

Reference areas

The number and position of reference areas and their sizes for the magnetic test shall be chosen with regard to the shapes and sizes of the article(s) in order to obtain a result as representative as possible of mean coating thickness. On a long article in the control sample, the reference areas shall be approximately 100 mm from the edges and 100 mm from each end and the approximate centre, and shall comprise the whole cross-section of the article.

The number of reference areas, dependent upon the size of the individual articles in the control sample, shall be as identified in **Table 2**.

Table 2 — Required number of reference areas for testing

Category	Size of significant surface area	Number of reference areas to be taken per article
a	> 2 m^2	≥ 3
b	> 100 cm^2 to ≤ 2 m^2	≥ 1
c	> 10 cm^2 to ≤ 100 cm^2	1
d	≤ 10 cm^2	1 on each of N articles

NOTE 2 m^2 = 200 cm × 100 cm; 100 cm^2 = 10 cm × 10 cm.

For articles in ***Category a*** of **Table 2** which have a significant surface area greater than 2 m^2 ("large" articles, e.g. structural steel fabrications), the mean coating thickness within the reference areas shall be equal to or greater than the appropriate mean coating thickness values in **Table 3** for each article in the control sample. In this case AS/NZS 4680 Clause 9.2 says the local coating thickness shall be the average of 10 determinations performed randomly over an area of 20 cm^2 (the reference area) and the mean coating thickness shall be taken from three separate reference areas (i.e. the mean of 30 determinations).

In ***Categories b, c and d*** of **Table 2**, the average coating thickness on each reference area shall be equal to or greater than the "local coating thickness" values given in **Table 3**. The average of the coating thicknesses on all reference areas in a sample shall be equal to or greater than the "mean coating thickness" values given in **Table 3**.

For ***Category d*** of **Table 2** only, N is the sufficient number of articles able to provide a minimum of 10 cm^2 of significant surface area for an individual reference area. The total number of articles tested equals the number of articles required to provide one reference area, N, multiplied by the appropriate number from the second column of **Table 1** related to the size of the lot (or the total number of articles galvanized if that is less). When more than five articles have to be taken to make up a reference area of at least 10 cm^2, 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. For more detail on the gravimetric test, refer to AS/NZS 4680. Within each reference area of 10 cm^2, a minimum of five magnetic test readings shall be taken on coated areas.

If any individual reading is lower than the values in **Table 3**, this is allowable, as long as the mean value for each reference area is equal to or greater than the applicable local thickness given in the table and the mean value of the local coating thicknesses are equal to or greater than the applicable mean coating thickness.

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

Table 3 — Minimum coating thickness and mass on samples that are not centrifuged

Steel thickness	Local coating thickness minimum (µm)	Mean coating thickness minimum (µm)
> 6 mm	70	85
> 3 mm to ≤ 6 mm	55	70
≥ 1.5 mm to ≤ 3 mm	45	55
< 1.5 mm	35	45
NOTE This table is for general use: individual product standards may include different requirements including different categories of thickness.		

The local coating thickness in **Table 3** shall only be determined in relation to reference areas selected in accordance with **Table 2**.

Table 4 — Minimum coating thickness and mass on samples that are centrifuged

Steel thickness	Local coating thickness minimum (µm)	Mean coating thickness minimum (µm)
≥ 8 mm	40	55
< 8 mm	25	35

Acceptance criteria

When tested in accordance with AS/NZS 4680 for the appropriate number of reference areas given in **Table 2**, the coating thickness shall be not less than the values given in **Table 3**. Where a hot dip galvanized article includes a number of different sections joined together, each section shall be regarded as a separate article and the relevant values in **Table 3**, shall apply. However, for contiguous hot-rolled sections (e.g. I-beams) where 2 or more thicknesses are integral to the section, it is considered satisfactory to measure only one thickness to confirm compliance to the Standard, so long as the reference area requirement is met.

If the thickness of coating on a control sample does not conform to these requirements, twice the original number of articles (or all the articles if that is the lesser number) shall be taken from the lot and tested. If this larger control sample passes, the whole inspection lot shall be accepted. If the larger control sample does not pass, either the articles that do not conform to the requirements shall be discarded or the purchaser may authorize them to be regalvanized.

Certificate of compliance

When required, the hot dip galvanizer shall provide a certificate of compliance to the requirements of AS/NZS 4680. Additionally, if the galvanizer is so registered, the purchaser may request a certificate that the work has been carried out according to AS/NZS 4680 by a galvanizer registered to an appropriate quality assurance scheme, such as ISO 9001.

Example 1:

An order comprises **24** off 150x100x6.0 RHS sections to AS/NZS 1163, each 0.5 metres in length (wall thickness *6.0mm*, total external surface area per length = *0.237m²*), to be hot dip galvanized to AS/NZS 4680.

Table 1 requires **three** of the section be tested – this is the **control sample**.

Table 2 requires that there be at least **one** reference area tested for each sample. *Note: There should be a minimum of **five** readings per **10cm²** of reference area.*

The *average measured coating thicknesses* in ***each reference area*** should be equal to or greater than the appropriate **"local coating thickness"** value in Table 3. **AND**

The *average measured coating thickness* of ***all reference areas*** on a sample should be equal to or greater than the appropriate **"mean coating thickness"** values in Table 3.

Example 2:

An order comprises **6** off 3 metre lengths of 250UB37.3 to AS 3679.1 (flange thickness *10.9mm*, web thickness *6.4mm*, total external surface area per length = *3.21m²*), to be hot dip galvanized to AS/NZS 4680.

Table 1 requires **three** of the section be tested – this is the **control sample**.

Table 2 requires that there be at least **three** reference area tested for each sample. Each **reference area** should be **20cm²**. This means that the number of readings taken on each sample article is 3 * 10 = 30.

The *average measured coating thickness* of ***all reference areas*** on a sample should be equal to or greater than the appropriate **"mean coating thickness"** values in Table 3.

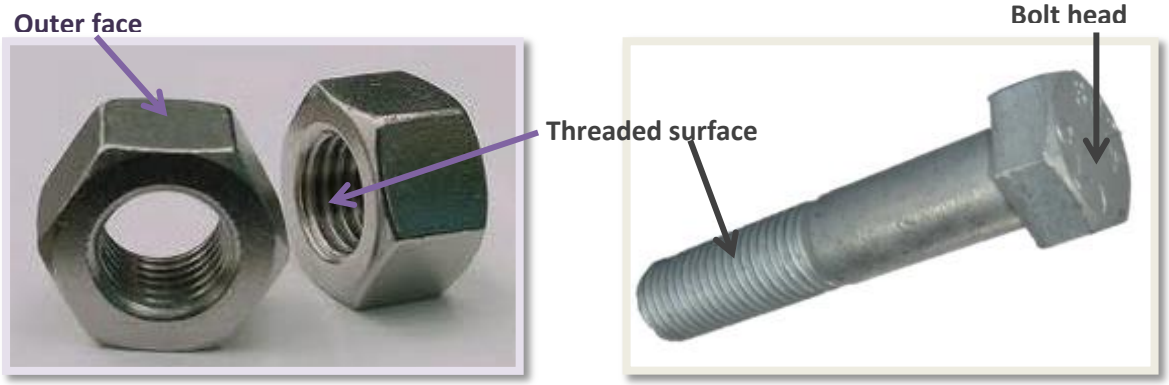
Example 3:

An order comprises **100** off M18 hex nuts to AS 1112, to be hot dip galvanized using centrifuging to AS/NZS 4680.

Table 1 requires **three** samples to be tested, which will be the **control sample**.

Table 2 requires that there be **one** *reference area* of **10cm^2** for *each sample*. If one article's surface area is less than 10cm^2 then 2 or more articles can be used to make up a single sample until their *combined surface area is at least 10cm^2*.

Note: *There should be a minimum of* ***five*** *readings per* ***10cm^2*** *of reference area.* This means that the minimum number of readings taken for the control sample is 3 * 5 = 15. All reading should be taken on a ***flat surface***. For example, this would generally refer to the *head of a bolt* and the *outer face of a hex nut*. Magnetic measurements ***should not*** be taken on a ***threaded surface***.



The *average measured coating thicknesses* in ***each reference area*** should be equal to or greater than the appropriate **"local coating thickness"** value in Table 4. **AND**

The *average measured coating thickness* of ***all reference areas*** on a sample should be equal to or greater than the appropriate **"mean coating thickness"** values in Table 4.

AS/NZS 4680 Galvanized Coating Thickness Inspection Results

galvanizers ASSOCIATION OF AUSTRALIA

Date	Gauge & Calibration Date/no.	Customer Order No:	Part No:	Description & Steel Thickness	Local coating thickness in reference area			Average coating thickness
					End	Middle	End	

NOTE: Measurements are to be taken a minimum of 10mm in from edges. Local coating thicknesses should be an average of 10 readings in a 20cm^2 area

Number of articles in lot	Minimum number of articles in the control sample
1 to 3	All
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1,201 to 3,200	8
3,201 to 10,000	13
> 10,000	20

Category	Size of significant surface area	Number of reference areas to be taken per article
a	> 2 m^2	≥ 3
b	> 100 cm^2 to ≤ 2 m^2	≥ 1
c	> 10 cm^2 to ≤ 100 cm^2	1
d	≤ 10 cm^2	1 on each of N articles

REQUIREMENTS FOR COATING THICKNESS AND MASS FOR ARTICLES THAT ARE NOT CENTRIFUGED			
Article Thickness (mm)	(Minimum) Local coating thickness (µm)	(Minimum) Average coating thickness (µm)	(Minimum) Average coating mass (g/m^2)
1.5 or less	35	45	320
Over 1.5 to 3	45	55	390
Over 3 to 6	55	70	500
Over 6	70	85	600