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Hot dip galvanized coatings on fabricated iron and steel articles — Specifications and test methods

Revêtements par galvanisation à chaud sur produits finis en fonte et en acier — Spécifications et méthodes d'essai

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 1461 was prepared by Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*, Subcommittee SC 4, *Hot dip coatings (galvanized, etc.)*.

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This third edition cancels and replaces the second edition (ISO 1461:1999), which has been technically revised. This revision reflects the experience gained in the use of ISO 1461 and includes a simplification of procedures and presentation.

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Significant changes to the text include the following:

— further refining of the scope of application of the standard to exclude woven or welded mesh products that are continuously galvanized;

— adding a definition for weld seepage in Clause 3;

— adding references to the availability of secondary zinc supply;

— adding explanatory notes on coating finish;

— simplifying requirements for sampling and testing;

— adding references for the use of alternative renovation materials and for methods of adhesion testing;

— moving much informative information on the influence of the basis metal on the hot dip galvanized coatings produced and designed for galvanizing into the guidance document ISO 14713-2 [8].

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Hot dip galvanized coatings on fabricated iron and steel articles — Specifications and test methods

1 Scope

This International Standard specifies the general properties of coatings and test methods for coatings applied by dipping fabricated iron and steel articles (including certain castings) in a zinc melt (containing not more than 2 % of other metals). It does not apply to the following:

a) sheet, wire and woven or welded mesh products that are continuously hot dip galvanized;

b) tube and pipe that are hot dip galvanized in automatic plants;

c) hot dip galvanized products (e.g. fasteners) for which specific standards exist and which might include additional requirements or requirements which are different from those of this International Standard.

NOTE Individual product standards can incorporate this International Standard for the coating by quoting its number, or can incorporate it with modifications specific to the product. Different requirements can also be made for galvanized coatings on products intended to meet specific regulatory requirements.

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After-treatment/over-coating of hot dip galvanized articles is not covered by this International Standard.

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2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 752, *Zinc ingots*

ISO 1460, *Metallic coatings — Hot dip galvanized coatings on ferrous materials — Gravimetric determination of the mass per unit area*

ISO 2064, *Metallic and other inorganic coatings — Definitions and conventions concerning the measurement of thickness*

ISO 2178, *Non-magnetic coatings on magnetic substrates — Measurement of coating thickness — Magnetic method*

ISO 2808, *Paints and varnishes — Determination of film thickness*

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*

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ISO 3549, *Zinc dust pigments for paints — Specifications and test methods*

ISO 3882, *Metallic and other inorganic coatings — Review of methods of measurement of thickness*

ISO 10474, *Steel and steel products — Inspection documents*

EN 1179, *Zinc and zinc alloys — Primary zinc*

EN 13283, *Zinc and zinc alloys — Secondary zinc*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2064 and the following apply.

3.1
hot dip galvanizing
formation of a coating of zinc and/or zinc iron alloys on iron and steel products by dipping prepared steel or cast iron in a zinc melt

3.2
hot dip galvanized coating
coating obtained by hot dip galvanizing

NOTE The term "hot dip galvanized coating" is subsequently referred to as the "coating".

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3.3
coating mass
total mass of zinc and/or zinc alloys per area of surface

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NOTE The coating mass is expressed in grams per square metre, g/m^2.

3.4
coating thickness
total thickness of zinc and/or zinc alloys

NOTE The thickness is expressed in micrometres, µm.

3.5
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

3.6
control sample
article or group of articles from a lot that is selected for sampling

3.7
reference area
area within which a specific number of single measurements are made

3.8
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

3.9
mean coating thickness
average value of the local thicknesses

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3.10
local coating mass
value of coating mass obtained from a single gravimetric test

3.11
mean coating mass
average value of the coatings masses determined either by using a control sample selected in accordance with Clause 5 using tests in accordance with ISO 1460 or by conversion of the **mean coating thickness** (3.9)

3.12
minimum value of the coating thickness
lowest single measurement in a gravimetric test or lowest mean obtained from the specified number of measurements in a magnetic test within a reference area

3.13
inspection lot
single order or single delivery load

3.14
acceptance inspection
inspection of an inspection lot at the hot dip galvanization works, unless otherwise specified

3.15
uncoated area
areas on the iron or steel articles that do not react with the molten zinc

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3.16
zinc melt
molten mass containing primarily zinc

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3.17
weld seepage
emission of previously retained pretreatment solutions from narrow spaces between two closely contacting surfaces that have been subject to intermittent welding or from very small cavities (pinholes) in the welds of a galvanized article

4 General requirements

4.1 General

This International Standard sets out requirements for the contents of the zinc melt used to apply a galvanized coating to articles (see 4.2). The chemical composition and the surface condition (finish and roughness) of the basis metal, the mass of the parts and the galvanizing conditions may affect the appearance, thickness, texture and physical/mechanical properties of the coating. This International Standard does not define any requirements regarding these points. Guidance on these parameters can be found in ISO 14713-2 [8].

4.2 Hot dip galvanizing bath

The hot dip galvanizing bath shall primarily contain molten zinc. The total of the other elements (as identified in ISO 752, EN 1179 or EN 13283, excluding tin and iron) in the molten zinc shall not exceed 1,5 % by mass.

4.3 Information to be supplied by the purchaser

The information listed in Annex A (Clauses A.1 and A.2) shall be supplied by the purchaser.

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4.4 Safety

Venting and draining shall be provided for in accordance with Annex B.

5 Acceptance inspection and sampling

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

If the customer requires this, a control sample for thickness testing shall be taken randomly from each inspection lot (3.13) selected for testing. 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

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6 Coating properties

6.1 Appearance

At acceptance inspection, the significant surface(s) of all the hot dip galvanized article(s), when first examined by normal or corrected vision from a distance of not less than 1 m, shall be free from nodules, blisters (i.e. raised areas without solid metal beneath), roughness and sharp points (if either can cause injury) and uncoated areas.

The primary purpose of the galvanized coating is to protect the underlying iron or steelwork against corrosion. Considerations related to aesthetics or decorative features should be secondary. Where these secondary features are also of importance, it is highly recommended that the galvanizer and customer agree upon the standard of finish that is achievable on the iron or steelwork (in total or in part), given the range of materials used to form the article. This is of particular importance where the required standard of finish is beyond that set out in this subclause. It should be noted that “roughness” and “smoothness” are relative terms and the roughness of coatings on articles galvanized after fabrication differs from that of mechanically wiped products, such as galvanized sheet, tube and wire. In practice, it is not possible to establish a definition of appearance and finish covering all requirements.

The occurrence of darker or lighter areas (e.g. cellular pattern or dark grey areas) or some surface unevenness shall not be a cause for rejection. The development of wet storage staining, primarily basic zinc oxide (formed during storage in humid conditions after hot dip galvanizing), shall not be a cause for rejection, providing the coating thickness remains above the specified minimum value.

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NOTE In certain circumstances, for example, where the galvanized article is to receive a further treatment or application of additional coatings, the purchaser might ask the galvanizer

a) not to quench the article, and/or

b) to take measures to prevent the formation of corrosion products on the surface of the galvanized coating during storage and transport.

Flux residues shall not be permitted. Lumps and zinc ash shall not be permitted where they might affect the intended use of the hot dip galvanized article or its corrosion resistance requirement (see ISO 14713-1 [7] for corrosion protection performance data).

Aesthetic effects (e.g. weld seepage) resulting from the use of intermittent welds around overlapping surfaces in the fabrication should not be a cause for rejection. Use of this type of welding pattern often results from consideration of health and safety issues. Further guidance is given in ISO 14713-2 [8].

Articles that fail visual inspection shall be renovated in accordance with 6.3. Otherwise, the articles shall be regalvanized and resubmitted for inspection.

When particular requirements exist (for example, when the galvanized coating is to be painted), a sample shall be produced [see A.2 f)] at the purchaser's request.

6.2 Thickness

6.2.1 General

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Coatings applied by hot dip galvanizing are designed to protect the iron and steel products against corrosion (see Annex E). The length of time of corrosion protection by such coatings is approximately proportional to the coating thickness (see ISO 14713-1 [7]).

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6.2.2 Test methods

In case of dispute regarding the test method, the method of calculating the coating thickness shall be by the determination of the mean mass of hot dip galvanized coating per unit area using the gravimetric method in accordance with ISO 1460, and the nominal density of the coating, 7,2 g/cm^3, shall be used for calculation purposes. Where less than 10 articles are involved, the purchaser shall not have to accept the gravimetric test if that would involve the destruction of articles and unacceptable remedial costs to the purchaser.

Tests (see Annex D) are most commonly carried out by one of the magnetic methods given in ISO 2808 and ISO 2178 (also specified in ISO 3882). Instruments for magnetic methods measure either the magnetic attraction between a permanent magnet and the base metal, as influenced by the presence of the coating, or the reluctance of the magnetic flux path passing through the coating and the base metal. Alternative methods include the gravimetric and the microscopic cross-section methods (see Annex D).

The test methods given in ISO 2808 and ISO 2178 (also reviewed in ISO 3882) are most appropriate within works and for routine quality control. Because the area on which each measurement is made in these methods is very small, individual figures may be lower than the values for the local or mean coating thickness. If a sufficient number of measurements is made within a reference area, effectively the same local thickness will be determined by magnetic as well as gravimetric methods.

6.2.3 Reference areas

The number and position of reference areas and their sizes for the magnetic or gravimetric 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 or mass per unit area, as applicable. On a long article in the control sample, the reference areas shall be cut 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.

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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	$> 2\ m^2$	$\geqslant 3$
b	$> 100\ cm^2$ to $\leqslant 2\ m^2$	$\geqslant 1$
c	$> 10\ cm^2$ to $\leqslant 100\ cm^2$	1
d	$\leqslant 10\ cm^2$	1 on each of N articles
NOTE $2\ m^2 = 200\ cm \times 100\ cm$; $100\ cm^2 = 10\ cm \times 10\ cm$.		

For articles in category a in Table 2, with a significant surface area greater than 2 m^2 ("large" articles) for each article (taken separately) in the control sample, the mean coating thickness within the reference areas shall be equal to or greater than the mean coating thickness values in Table 3 or Table 4.

In categories b, c and d in Table 2, the average coating thickness on each reference area shall be equal to or greater than the "local coating thickness" values given in Tables 3 or 4, as appropriate. The average coating thickness on all reference areas in a sample shall be equal to or greater than the "mean coating thickness" values given in Tables 3 or 4, as appropriate.

For category d in Table 2 only, N is the sufficient number of articles to provide a minimum of 10 cm^2 of significant surface 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). Alternatively, sampling procedures selected from ISO 2859-1, ISO 2859-2 or ISO 2859-3 shall be used.

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When the zinc coating thickness is determined by the magnetic method in accordance with ISO 2178, the reference areas shall be within, and representative of, those that would have been chosen for the gravimetric method.

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.

Within each reference area of 10 cm^2, a minimum of five magnetic test readings shall be taken on coated areas. If any of the individual readings is lower than the values in Tables 3 or 4, 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. The mean coating thickness for all reference areas shall be calculated in a similar way for the magnetic test as for the gravimetric test (see ISO 1460).

Thickness measurements shall not be taken on cut surfaces or areas less than 10 mm from edges, flame-cut surfaces or corners (see ISO 14713-2 [8]).

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

Article and its thickness	Local coating thickness (minimum)[a] µm	Local coating mass (minimum)[b] g/m²	Mean coating thickness (minimum)[c] µm	Mean coating mass (minimum)[b] g/m²
Steel > 6 mm	70	505	85	610
Steel > 3 mm to ⩽ 6 mm	55	395	70	505
Steel ⩾ 1,5 mm to ⩽ 3 mm	45	325	55	395
Steel < 1,5 mm	35	250	45	325
Castings ⩾ 6 mm	70	505	80	575
Castings < 6 mm	60	430	70	505

NOTE This table is for general use: individual product standards may include different requirements including different categories of thickness. Local coating mass and mean coating mass requirements are set out in this table for reference in such cases of dispute.

[a] See 3.8.

[b] Equivalent coating mass using a nominal coating density of 7,2 g/cm³ (see Annex D).

[c] See 3.9.

The local coating thickness in Table 3 shall only be determined in relation to reference areas selected in accordance with 6.2.3. In cases of dispute, the results of gravimetric tests (coating mass) take precedence over the results of coating thickness tests.

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

Article and its thickness	Local coating thickness (minimum)[a] µm	Local coating mass (minimum)[b] g/m²	Mean coating thickness (minimum)[c] µm	Mean coating mass (minimum)[b] g/m²
Articles with threads:				
> 6 mm diameter	40	285	50	360
⩽ 6 mm diameter	20	145	25	180
Other articles (including castings):				
⩾ 3 mm	45	325	55	395
< 3 mm	35	250	45	325

NOTE This table is for general use: fastener coating standards and individual product standards may have different requirements: see also A.2.h). Local coating mass and mean coating mass requirements are set out in this table for reference in such cases of dispute.

[a] See 3.8.

[b] Equivalent coating mass using a nominal coating density of 7,2 g/cm³ (see Annex D).

[c] See 3.9.

The local coating thickness in Table 4 shall only be determined in relation to reference areas selected in accordance with 6.2.3. In cases of dispute, the results of gravimetric tests (coating mass) take precedence over the results of coating thickness tests.

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