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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

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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This document was prepared by Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*, Subcommittee SC 4, *Hot dip coatings (galvanized, etc.),* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 262, *Metallic and other inorganic coatings,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

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This fourth edition cancels and replaces the third edition (ISO 1461:2009), which has been technically revised.

The main changes are as follows:

— definitions have been added for ‘galvanizer’, ‘after-treatment’, ‘additional coating’, ‘wet storage stain’ and ‘duplex system’ in Clause 3;

— the difficulty to remove flux residues and zinc ash when access is restricted has been recognised in 6.1;

— procedures for choice of reference areas have been clarified and additional requirements to avoid reference areas on certain small ancillary elements on a larger article have been added in 6.2.3;

— requirements for renovation of uncoated areas have been revised: the requirements for the pigment of a zinc-containing paint to conform with ISO 3549 have been removed; Annex C has been extended to include additional information on the suitability of different methods of renovation given in 6.3;

— all requirements related to coating thickness, including Table 3 and Table 4, have been placed within 6.5, including requirements linked to the size of the article in the control sample previously within 6.2.3; the lower coating thicknesses that can result in ultra-low reactive steels are recognised in new requirements for these steel types in 6.5;

— information on corrosion resistance of galvanized coatings has been updated, including the reference to ISO 9224 for longer-term corrosion resistance in Annex E.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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

1 Scope

This document specifies the general properties of hot dip galvanized coatings and test methods for hot dip galvanized coatings applied by dipping fabricated iron and steel articles (including certain castings) in a zinc melt (containing not more than 2 % of other metals). This document 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 can include additional requirements or requirements which are different from those of this document.

NOTE Individual product standards can incorporate this document for the galvanized 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.

This document does not apply to after-treatment or additional coating of hot dip galvanized articles.

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2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

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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 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 limiting quality (LQ) for isolated lot inspection*

ISO 2859-3, *Sampling procedures for inspection by attributes — Part 3: Skip-lot sampling procedures*

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

ISO 14713-2:2019, *Zinc coatings — Guidelines and recommendations for the protection against corrosion of iron and steel in structures — Part 2: Hot dip galvanizing*

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

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

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3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org

3.1
hot dip galvanizing
formation of a galvanized coating of either zinc or zinc iron alloys, or both, on fabricated iron or steel articles by dipping in a *zinc melt* (3.16)

3.2
hot dip galvanized coating
galvanized coating
coating obtained by batch *hot dip galvanizing* (3.1)

3.3
galvanizer
company or organisation that operates a plant for the *hot dip galvanizing* (3.1) of batches of fabricated iron or steel articles

3.4
galvanized coating mass
either total mass of zinc or zinc alloys per area of surface, or both

Note 1 to entry: The galvanized coating mass is expressed in grams per square metre, g/m^2.

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3.5
galvanized coating thickness
either total thickness of zinc or zinc alloys, or both

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Note 1 to entry: The thickness is expressed in micrometres, µm.

3.6
significant surface
part of the article covered or to be covered by the galvanized coating and for which the galvanized coating is essential for either serviceability or appearance, or both

3.7
control sample
article or group of articles from a lot that is selected for sampling

3.8
reference area
area within which a specific number of single measurements are made

3.9
local galvanized coating thickness
mean value of *galvanized coating thickness* (3.5) obtained from the specific number of measurements within a *reference area* (3.8) for a magnetic test or the single value from a gravimetric test

3.10
mean galvanized coating thickness
average value of the *local galvanized coating thicknesses* (3.9)

3.11
local galvanized coating mass
value of *galvanized coating mass* (3.4) obtained from a single gravimetric test

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3.12
mean galvanized coating mass
average value of the *galvanized coating masses* (3.4) determined either by using a *control sample* (3.7) or by conversion of the *mean galvanized coating thickness* (3.10)

Note 1 to entry: The control sample shall be selected in accordance with Clause 5 using tests in accordance with ISO 1460.

3.13
inspection lot
single order or single delivery load

3.14
acceptance inspection
inspection of an *inspection lot* (3.13) at the *hot dip galvanizing* (3.1) plant, unless otherwise specified

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

3.16
zinc melt
molten mass containing primarily zinc

3.17
weld seepage
emission of previously retained pre-treatment 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

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3.18
after-treatment
immediate application of chemical or other treatments with temporary effects such as inhibition of *wet storage stain* (3.20) or to enhance appearance of galvanized articles

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3.19
additional coating
application of coating layers, such as liquid paints or powder coating, after galvanizing as part of a *duplex system* (3.21)

3.20
wet storage stain
surface stain resulting from the formation of zinc corrosion products (usually zinc hydroxide and zinc oxide) when freshly galvanized steel is stored or transported in moist or humid conditions

3.21
duplex system
hot dip galvanized coating (3.2) with an additional liquid paint or powder coating

4 General requirements

4.1 General

This document 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 can affect the appearance, thickness, texture, and physical and mechanical properties of the galvanized coating. This document does not specify any requirements regarding these points. Guidance on these parameters can be found in ISO 14713-2.

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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 Clauses A.1 and A.2 shall be supplied by the purchaser.

4.4 Safety

Venting and draining shall be provided 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 galvanizer's custody, unless otherwise specified at the time of ordering by the purchaser. Acceptance inspection involves assessment of the appearance of the surface of the galvanized article and testing of the galvanized coating thickness. Adhesion tests are normally not carried out and are only tested by agreement (see 6.4).

If the purchaser requests it, a control sample for thickness testing shall be taken randomly from each inspection lot selected for testing. Unless otherwise agreed, the minimum number of articles from each inspection lot that forms the control sample shall be in accordance with Table 1.

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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 Galvanized coating properties

6.1 Appearance

At acceptance inspection, the visible 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 blisters (i.e. raised areas without solid metal beneath), roughness and sharp points (if that roughness or sharp point can cause injury) and uncoated areas. It shall be recognised that "roughness" is a relative term and the roughness of galvanized coatings on articles galvanized after fabrication differs from that of mechanically-wiped products, such as hot dip coated sheet (e.g. see EN 10143[14] or EN 10346[19]), tube (e.g. see EN 10240[17]) and wire (e.g. see EN 10244-2[18]).

The primary purpose of the galvanized coating is to protect the iron or steel articles 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 purchaser agree upon the standard of finish that is achievable on the articles (in total or in part), given the range of materials used to form the article (see ISO 14713-2). This is of particular importance where the required standard

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of finish is beyond that set out in this subclause. 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 (e.g. 'orange peel') shall not be a cause for rejection (see 4.1). The development of wet storage stain shall not be a cause for rejection, providing the galvanized coating thickness remains above the specified minimum value of the galvanized coating thickness (see 6.5).

NOTE 1 In certain circumstances, for example, where the galvanized article will receive a further treatment or application of additional coatings, the purchaser can ask the galvanizer either:

a) not to quench the article or apply an after-treatment,

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

c) both.

Flux residues and zinc ash shall be removed where they can affect the intended use of the hot dip galvanized article, or its corrosion resistance requirement, unless access is restricted, for example, inside hollow sections.

Aesthetic effects (e.g. weld seepage resulting from the use of intermittent welds around overlapping surfaces in the fabrication) shall not be a cause for rejection.

NOTE 2 Use of this intermittent of welding often results from consideration of health and safety issues during galvanizing (see Annex B). Further guidance is given in ISO 14713-2.

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

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

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6.2 Thickness

6.2.1 General

Galvanized coatings are designed to protect iron and steel articles against corrosion (see Annex E). The duration of corrosion protection that is provided by a galvanized coating is approximately proportional to the coating thickness (see ISO 14713-1[11]).

6.2.2 Test methods

Tests (see Annex D) are most commonly carried out by one of the magnetic methods given in ISO 2178 and ISO 2808[3] (also reviewed in ISO 3882[5]). Instruments for magnetic methods measure either the magnetic attraction between a permanent magnet and the base metal, as influenced by the presence of the galvanized coating, or the reluctance of the magnetic flux path passing through the galvanized 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 2178 are most appropriate within works and for routine quality control. As the area on which each measurement is made in these methods is very small, the single measurement values can be lower than the values for the local or mean galvanized coating thickness. If a sufficient number of measurements is made within a reference area, effectively the same local thickness is determined by magnetic or gravimetric methods.

In case of dispute regarding the test method, the method of calculating the galvanized coating thickness shall be by the determination of the mean mass of galvanized coating per unit area using the gravimetric method in accordance with ISO 1460 and the nominal density of 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

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the gravimetric test if that would involve the destruction of articles and unacceptable remedial costs to the purchaser.

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 galvanized coating thickness or mass per unit area, as applicable. Unless otherwise agreed, the reference areas shall be chosen by the galvanizer. The minimum size of a reference area shall be 10 cm^2. On a long article in the control sample, the reference areas shall be chosen at the approximate centre; approximately 100 mm from the edges and approximately 100 mm from each end.

Unless otherwise agreed, reference areas shall not be chosen from ancillary elements, when they are significantly smaller than the main elements of a larger article.

NOTE 1 Ancillary elements can be thinner, or less reactive during galvanizing and include, for example, stiffeners, end plates and brackets.

Therefore, thickness measurements are not taken on these ancillary elements.

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.		

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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.

When more than five articles have to be taken to make up a reference area of minimum 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, a minimum of five magnetic test measurements shall be taken. If any of those single measurement values is lower than the "local galvanized coating thickness" values in Table 3 or Table 4, this is not relevant, as only the average value over the whole of each reference area is required. The mean galvanized 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).

NOTE 2 Flame-cutting, laser-cutting and plasma-cutting changes the steel composition and structure in the zone on and around the cut surface, so that the minimum coating thickness can be more difficult to obtain and the coating formed can exhibit decreased cohesion or adhesion.

In order to obtain the required coating thicknesses more reliably and to ensure adequate cohesion or adhesion of the coating, flame-cut, laser-cut and plasma-cut surfaces should have been ground off and

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sharp edges should have been removed during fabrication and prior to delivery to the galvanizer. See also Clause A.2, b) and ISO 14713-2:2019, 6.6.1.

When the galvanized 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.

6.3 Renovation

The total uncoated areas for renovation by the galvanizer shall not exceed 0,5 % of the total surface area of the article. Each uncoated area for renovation shall not exceed 10 cm^2. If uncoated areas are larger, the article containing such areas shall be re-galvanized, unless otherwise agreed between the purchaser and the galvanizer.

Renovation shall be by either:

— a suitable zinc-containing paint with a zinc dust pigment;

— a suitable zinc-containing paint with a lamellar zinc pigment;

— a suitable zinc paste product or zinc alloy stick;

— thermal zinc spraying (see ISO 2063-2[2]), within the practical limits of such systems;

The repair coating on the renovated areas shall be capable of giving sacrificial protection to the steel to which it is applied.

The treatment shall include the removal of any scale, cleaning and any necessary pre-treatment to ensure adhesion.

Where the purchaser advises a special requirement (e.g. a paint coating shall be applied subsequently), the proposed renovation procedure shall be advised in advance to the purchaser by the galvanizer.

Where the article is intended for reinforcement of concrete, the purchaser and the galvanizer may agree to a repair coating that is especially suited to such applications and may differ from the methods listed above.

The repair coating thickness on the renovated areas shall have a minimum average thickness of 100 µm unless otherwise agreed because, for example, a different thickness for renovated areas is more compatible with a different surrounding galvanized coating thickness on the article; or when the galvanized surface is to receive an additional coating and the thickness for renovated areas shall be the same as for the galvanized coating.

NOTE See also Annex C for further advice on renovation of uncoated areas.

6.4 Adhesion

No suitable International Standards currently exist for testing the adhesion of galvanized coatings on fabricated iron and steel articles.

Adhesion between zinc and basis metal does not generally need to be tested as adequate bonding is characteristic of the galvanizing process and the galvanized article should be able to withstand, without peeling or flaking, handling consistent with the nature and thickness of the galvanized coating and the normal use of the article. In general, thicker galvanized coatings require more careful handling than thinner galvanized coatings. Bending or forming after galvanizing are not considered to be normal handling.

Where adhesion tests are required by the purchaser, any such test should be agreed by the galvanizer and the purchaser prior to the work being galvanized. Should it be necessary to test the adhesion, for example, in the case of articles that are subject to high mechanical stresses, any test shall only be on significant surfaces, i.e. in areas in which good adhesion is important for the proposed application.

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