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

*Revêtements par galvanisation à chaud sur produits finis ferreux —
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.

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.

International Standard ISO 1461 was prepared by the European Committee for Standardization (CEN) in collaboration with ISO Technical Committee TC 107, *Metallic and other inorganic coatings*, Subcommittee SC 4, *Hot dip coatings (galvanized, etc.)*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Throughout the text of this standard, read “..this European Standard...” to mean “...this International Standard...”.

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This second edition cancels and replaces the first edition (ISO 1461:1973) as well as the first edition of ISO 1459 (ISO 1459:1973), which has been technically revised.

Annexes A and B form an integral part of this International Standard. Annexes C to E are for information only.

For the purposes of this International Standard, the CEN annex regarding fulfilment of European Council Directives has been removed.

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Foreword

The text of EN ISO 1461:1999 has been prepared by Technical Committee CEN/TC 262 "Metallic and other inorganic coatings", the secretariat of which is held by BSI, in collaboration with Technical Committee ISO/TC 107 "Metallic and other inorganic coatings".

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 1999, and conflicting national standards shall be withdrawn at the latest by August 1999.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

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1 Scope

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

- a) sheet and wire that are continuously hot dip galvanized;
- b) tube and pipe that is hot dip galvanized in automatic plants;
- c) hot dip galvanized products for which specific standards exist and which may include additional requirements or requirements different from those of this European Standard.

NOTE Individual product standards can incorporate this standard for the coating by quoting its number, or may incorporate it with modifications specific to the product.

After-treatment/overcoating of hot dip galvanized articles is not covered by this standard.

2 Normative references

This Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this International/European Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

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

EN ISO 1460, *Metallic coatings — Hot dip galvanized coatings on ferrous materials — Gravimetric determination of the mass per unit area (ISO 1460:1992)*.

EN 22063, *Metallic and other inorganic coatings — Thermal spraying — Zinc, aluminium and their alloys (ISO 2063:1991)*.

EN ISO 2064, *Metallic and other inorganic coatings — Definitions and conventions concerning the measurement of thickness (ISO 2064:1980)*.

EN ISO 2178, *Non-magnetic coatings on magnetic substrates — Measurement of coating thickness — Magnetic method (ISO 2178:1982)*.

ISO 752, *Zinc ingots*.

ISO 2859-1, *Sampling procedures for inspection by attributes — Part 1: Sampling plans indexed by acceptable quality level (AQL) for lot-by-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*.

3 Term(s) and definition(s)

For the purposes of this standard, the following definitions apply together with those given in EN ISO 2064.

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 molten zinc.

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'.

3.3**coating mass**

total mass of zinc and/or zinc-iron alloys per area of surface (expressed in grams per square metre, g/m²)

3.4**coating thickness**

total thickness of zinc and/or zinc-iron alloys (expressed in micrometres, µm).

3.5**significant surface**

the 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**

the article or group of articles from a lot that is selected for testing

3.7**reference area**

the area within which a specific number of single measurements has to be made

3.8**local coating thickness**

the mean value of coating thickness obtained from the specified number of measurements within a reference area for a magnetic test or the single value from a gravimetric test

3.9**mean coating thickness**

the average value of the local thicknesses either on one large article or on all the articles in the control sample.

3.10**local coating mass**

the value of coating mass obtained from a single gravimetric test

3.11**mean coating mass**

the average value of the coating masses determined either by using a control sample selected in accordance with clause 5 using tests in accordance with EN ISO 1460 or by conversion of the mean coating thickness (see 3.9)

3.12**minimum value**

within a reference area, the lowest single measurement in a gravimetric test or the lowest mean obtained from the specified number of measurements in a magnetic test

3.13**inspection lot**

single order or single delivery load

3.14**acceptance inspection**

inspection of an inspection lot at the hot dip galvanizer's works (unless otherwise specified)

3.15**uncoated areas**

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

4 General requirements

NOTE 1 The chemical composition and the surface condition (finish or roughness) of the basis metal, the mass of the parts and the galvanizing conditions affect the appearance, the thickness, the texture and physical/mechanical properties of the coating.

This Standard does not define any requirement regarding these points, but gives some recommendations in annex C.

NOTE 2 EN ISO 14713 gives guidance on the selection of hot dip galvanized coatings for iron and steel. EN ISO 12944-5 includes information on paint coatings over hot dip galvanized steel coatings.

4.1 Hot dip galvanizing bath

The hot dip galvanizing bath shall primarily contain molten zinc. The total of impurities (other than iron and tin) in the molten zinc shall not exceed 1,5 % by mass, the said impurities being those defined in ISO 752 or EN 1179. (See also annex C.)

4.2 Information to be supplied by the purchaser

The information listed in annex A shall be supplied by the purchaser.

4.3 Safety

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

5 Sampling

A control sample for thickness testing shall be taken randomly from each inspection lot (see 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

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Number of articles in the 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

Acceptance inspection shall be undertaken before the products leave the hot dip galvanizer's custody, unless otherwise specified at the time of ordering by the purchaser.

6 Coating properties

6.1 Appearance

At acceptance inspection, the significant surface(s) of all the hot dip galvanized article(s), when examined by normal corrected vision, shall be free from nodules, blisters (i.e., raised areas without solid metal beneath), roughness and sharp points (if they can cause injury) and uncoated areas.

NOTE 1 'Roughness' and 'smoothness' are relative terms and the roughness of coatings on articles galvanized after fabrication differs from mechanically wiped products, such as galvanized sheet and wire.

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

NOTE 2 It is not possible to establish a definition of appearance and finish covering all requirements in practice.

Flux residues shall not be permitted. Lumps and zinc ash shall not be permitted where they may affect the intended use of the hot dip galvanized article or its corrosion resistance requirement.

Articles that fail visual inspection shall be renovated in accordance with 6.3 or 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 and C.1.4) if required.

6.2 Thickness

6.2.1 General

Coatings applied by hot dip galvanizing are designed to protect the iron and steel products against corrosion (see annex C). The length of time of corrosion protection by such coatings (whether light or dark grey) is approximately proportional to the coating thickness. For extremely aggressive conditions and/or an exceptionally long service life, thicker coatings than those specified here may be required.

The specification of these thicker coatings shall be subject to agreement between the galvanizer and the purchaser concerning the means of implementation (e.g. grit blasting, steel chemical composition).

6.2.2 Test methods

In case of dispute regarding the test method, the method of calculating the coating thickness shall be by determination of the mean mass of hot dip galvanized coating per unit area using the gravimetric method in accordance with EN ISO 1460 and the nominal density of the coating (7,2 g/cm³).

Where less than 10 articles are involved, the purchaser shall not have to accept the gravimetric test if that would involve destruction of articles and unacceptable remedial costs to the purchaser.

NOTE Tests (see annex D) are preferably by the magnetic method (EN ISO 2178) or the gravimetric method (possible alternative methods, e.g., electromagnetic method (ISO 2808), coulometric or microscopic cross-section are given in annex D).

The EN ISO 2178 method is most appropriate within works and for routine quality control. Because the area over which each measurement is made in this method is very small, individual figures may be lower than the values for the local or mean coating thickness. If a sufficient number of measurements are made within a reference area, effectively the same local thickness will be determined by magnetic as by 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 shape and size 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 each end and at 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 follows.

- a) For articles with significant surface area greater than 2 m² ("large articles"): At least three reference areas shall be taken on each article in the control sample. On 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 given in table 2 or table 3.
- b) For articles with significant surface area over 10 000 mm² and up to 2 m² (inclusive): On each article in the control sample, there shall be at least one reference area.
- c) For articles with significant surface area between 1 000 mm² and 10 000 mm² (inclusive): On each article in the control sample, there shall be one reference area.

- d) For articles with less than 1 00 mm² significant surface area: Enough articles shall be grouped together to provide at least 1 000 mm² surface for an individual reference area. The number of reference areas shall be as given in the last column of table 1. Hence, the total number of articles tested equals the number of articles required to provide one reference area multiplied by the appropriate number from the last 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 shall be used.

NOTE 1 10 000 mm² = 100 cm²
 1 000 mm² = 10 cm²
 2 m² is typically 200 cm x 100 cm; 10 000 mm² is typically 10 cm x 10 cm; 1 000 mm² is typically 10 cm x 1 cm

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

When the zinc coating thickness is determined by the magnetic method in accordance with EN 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 1 000 mm², 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, which should be at least 1 000 mm², 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 2 and 3, 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 (EN 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 C.1.3).

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Table 2 — Coating minimum thicknesses on samples that are not centrifuged

Article and its thickness	Local coating thickness (minimum) ^a	Mean coating thickness (minimum) ^b
	µm	µm
Steel ≥ 6 mm	70	85
Steel ≥ 3 mm to < 6 mm	55	70
Steel ≥ 1,5 mm to < 3 mm	45	55
Steel < 1,5 mm	35	45
Castings ≥ 6 mm	70	80
Castings < 6 mm	60	70
^a See 3.8.		
^b See 3.9.		

NOTE 2 Table 2 is for general use; individual product standards may include different requirements including different categories of thickness. A requirement for thicker coatings or additional requirements can be added without otherwise affecting conformity to this standard.

The local coating thickness in table 2 shall only be determined in relation to reference areas selected in accordance with 6.2.3.

Table 3 — Coating minimum thicknesses on samples that are centrifuged

Article and its thickness	Local coating thickness (minimum) ^a µm	Mean coating thickness (minimum) ^b µm
Article with threads:		
≥ 20 mm diameter	45	55
≥ 6 mm to < 20 mm diameter	35	45
< 6 mm diameter	20	25
Other articles (including castings):		
≥ 3 mm	45	55
< 3 mm	35	45
^a See 3.8. ^b See 3.9.		

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NOTE 3 Table 3 is for general use; fastener coating standards and individual product standards may have different requirements; see also annex A.2, g).

The local coating thickness in table 3 shall only be determined in relation to reference areas selected in accordance with 6.2.3.
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6.3 Renovation

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The total uncoated areas for renovation by the galvanizer shall not exceed 0,5 % of the total surface area of a component. Each uncoated area for renovation shall not exceed 10 cm². If uncoated areas are larger, the article containing such areas shall be regalvanized unless otherwise agreed between the purchaser and the galvanizer.

Renovation shall be by zinc thermal spraying (EN 22063 is relevant) or by a suitable zinc rich paint within the practical limits of such systems. The use of a zinc alloy stick (see annex C.5) is also possible. The purchaser or end-user shall be advised by the galvanizer of the method of renovation.

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

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

The coating thickness on the renovated areas shall be a minimum of 30 µm more than the local coating thickness requirement in table 2 or 3 for the relevant hot dip galvanized coating unless the purchaser advises the galvanizer otherwise e.g. when the galvanized surface is to be overcoated and the thickness for renovated areas is to be the same as for the hot dip galvanized coating. The coating on the renovated areas shall be capable of giving sacrificial protection to the steel to which it is applied.

NOTE See also C.5 for advice on repair of damaged areas.

6.4 Adhesion

No suitable ISO Standards currently exist for testing the adhesion of hot dip galvanized coatings on fabricated iron and steel articles. See also C.6.

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

Should it be necessary to test the adhesion, e.g. in the case of workpieces that are to be subjected 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.

A cross-hatch test will give some guidance on the mechanical properties of the coating but in some cases may be more demanding than the application requires. Other impingement tests and cutting tests may also be developed for hot dip galvanized coatings and will be further considered for possible eventual issue as a separate document.

6.5 Acceptance criteria

When tested in accordance with 6.2.2 for the appropriate number of reference areas given in 6.2.3, the coating thickness shall be not less than the values given in table 2 or table 3 as appropriate. Except in the case of dispute, the non-destructive test shall be used unless the purchaser specifically accepts that his articles may be cut for mass loss determinations. Where articles include a number of different thicknesses of steel, each thickness range shall be regarded as a separate article and the relevant values in tables 2 and 3, as appropriate, shall apply.

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, the articles that do not conform to the requirements shall either be discarded or the purchaser may authorize them to be regalvanized.

7 Certificate of compliance

When required, the hot dip galvanizer shall provide a certificate of compliance with the requirements of this standard (ISO 10474 is relevant).

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