

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

The European Standard EN ISO 1461:1999 has the status of a
British Standard

ICS 25.220.40

National foreword

This British Standard is the English language version of EN ISO 1461:1999. It supersedes BS 729:1971 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee STI/34, Hot dip galvanized coatings, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

Cross-references

Attention is drawn to the fact that CEN and CENELEC standards normally include an annex which lists normative references to international publications with their corresponding European publications. The British Standards which implement these international or European publications may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN ISO title page, pages 2 to 11 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Amendments issued since publication

Amd. No.	Date	Comments

This British Standard, having been prepared under the direction of the Sector Committee for Materials and Chemicals, was published under the authority of the Standards Committee and comes into effect on 15 March 1999

© BSI 09-1999

ISBN 0 580 32024 3

Contents

	Page
National foreword	Inside front cover
Foreword	2
Text of EN ISO 1461	3

ICS 25.220.40

Descriptors: Metal coatings, dip coating, hot dip galvanizing, steel products, metal products, specific area, materials specifications

English version

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

(ISO 1461:1999)

Revêtements par galvanisation à chaud sur produits finis ferreux — Spécifications et méthodes d'essai
(ISO 1461:1999)

Durch Feuerverzinken auf Stahl aufgebrachte Zinküberzüge (Stückverzinken) — Anforderungen und Prüfung
(ISO 1461:1999)

This European Standard was approved by CEN on 8 November 1998.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

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.

Contents

	Page
Foreword	2
1 Scope	3
2 Normative references	3
3 Term(s) and definition(s)	3
4 General requirements	4
4.1 Hot dip galvanizing bath	4
4.2 Information to be supplied by the purchaser	4
4.3 Safety	4
5 Sampling	4
6 Coating properties	4
6.1 Appearance	4
6.2 Thickness	5
6.2.1 General	5
6.2.2 Test methods	5
6.2.3 Reference areas	5
6.3 Renovation	6
6.4 Adhesion	7
6.5 Acceptance criteria	7
7 Certificate of compliance	7
Annex A (normative) Information to be supplied by the purchaser to the hot dip galvanizer	8
Annex B (normative) Safety and process requirements	8
Annex C (informative) Properties of the articles to be coated that affect the results of hot dip galvanizing	8
Annex D (informative) Determination of thickness	10
Annex E (informative) Bibliography	11
Table 1 — Control sample size related to lot size	4
Table 2 — Coating minimum thicknesses on samples that are not centrifuged	6
Table 3 — Coating minimum thicknesses on samples that are centrifuged	6
Table D.1 — Coating minimum masses (related to thicknesses) on samples that are not centrifuged	11
Table D.2 — Coating minimum masses (related to thicknesses) on samples that are centrifuged	11

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

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 ($7,2 \text{ g/cm}^3$).

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 m^2 ("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 $10\,000 \text{ mm}^2$ and up to 2 m^2 (inclusive): On each article in the control sample, there shall be at least one reference area.
- c) For articles with significant surface area between $1\,000 \text{ mm}^2$ and $10\,000 \text{ mm}^2$ (inclusive): On each article in the control sample, there shall be one reference area.
- d) For articles with less than $1\,000 \text{ mm}^2$ significant surface area: Enough articles shall be grouped together to provide at least $1\,000 \text{ mm}^2$ 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 $10\,000 \text{ mm}^2 = 100 \text{ cm}^2$
 $1\,000 \text{ mm}^2 = 10 \text{ cm}^2$
 2 m^2 is typically $200 \text{ cm} \times 100 \text{ cm}$; $10\,000 \text{ mm}^2$ is typically $10 \text{ cm} \times 10 \text{ cm}$; $1\,000 \text{ mm}^2$ is typically $10 \text{ cm} \times 1 \text{ cm}$

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 Table 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 Table 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 Table 2 and Table 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).

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

Article and its thickness	Local coating thickness (minimum) ^a µm	Mean coating thickness (minimum) ^b 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.		

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.

6.3 Renovation

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 Table 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 Table 2 and Table 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).

Annex A (normative) Information to be supplied by the purchaser to the hot dip galvanizer

A.1 Essential information

The number of this standard, i.e. EN ISO 1461, shall be supplied by the purchaser to the hot dip galvanizer.

A.2 Additional information

The following information may be required for particular purposes and, if so, shall be supplied or specified, as applicable, by the purchaser.

The galvanizer shall on request provide any relevant information available to him including the method of renovation of uncoated areas.

- a) The composition and any properties of the basis metal (see Annex C) that may affect hot dip galvanizing;
- b) an identification of significant surfaces, for example by drawings or by the provision of suitably marked samples;
- c) a drawing or other means of identifying where surface unevenness, for example round drops or contact marks, will make the coated article unacceptable for its intended purpose; the purchaser shall discuss with the galvanizer the way to deal with such problems;
- d) a sample or other means of showing the required finish;
- e) any special pretreatment requirements;
- f) any special thickness of coating (see 6.2.1, notes 2 and 3 to 6.2.3 and Annex C);
- g) the need for, or the acceptability of, a centrifuged coating that is to meet the requirements of Table 3 instead of Table 2;
- h) any after-treatments or overcoating to be given to the galvanized coating (see 6.3, C.4 and C.5);
- i) inspection arrangements (see clause 5);
- j) whether a certificate of compliance is required in accordance with ISO 10474.

Annex B (normative) Safety and process requirements

In the absence of national safety and health regulations covering venting and draining of cavities, the purchaser shall provide means for handling the work and holes or other means for venting and draining enclosed cavities or give consent for the galvanizer to provide such vents and drains. These are essential for both safety and process reasons.

WARNING It is essential to avoid enclosed cavities as these can cause explosions during hot dip galvanizing.

NOTE Further information on venting and draining is given in EN ISO 14713.

Annex C (informative) Properties of the articles to be coated that affect the results of hot dip galvanizing

C.1 Basis metal

C.1.1 Composition

Unalloyed carbon steel, low-alloy steels and grey and malleable cast iron are in general suitable for hot dip galvanizing. Where other ferrous metals are to be galvanized, adequate information or samples should be provided by the purchaser for the galvanizer to decide whether these steels can be satisfactorily galvanized. Sulfur-containing free-cutting steels are normally unsuitable.

C.1.2 Surface condition

The surface of the basis metal should be clean before dipping into the molten zinc. Pickling in acid is the recommended method of cleaning the surface. Excessive pickling should be avoided. Surface contaminants that cannot be removed by pickling, e.g. carbon films (such as rolling oil residues), oil, grease, paint, welding slag and similar impurities should be removed prior to pickling. The responsibility for removal of such impurities should be agreed between the galvanizer and the purchaser.

Castings should be as free as possible from surface porosity and shrinkage holes and should be cleaned by grit blasting, electrolytic pickling or by other methods specially suitable for castings.

C.1.3 The influence of steel surface roughness on the hot dip galvanized coating thickness

The surface roughness of the steel surface has an influence on the thickness and the structure of the coating. The effect of surface unevenness of the basis metal generally remains visible after galvanizing.

A rough steel surface as obtained by grit blasting, coarse grinding, etc., prior to pickling gives a thicker coating than a surface that is obtained by pickling alone.

Flame-cutting changes the steel composition and structure in the flame-cut zone, so that the coating thicknesses given in 6.2, and Table 2 and Table 3, are more difficult to obtain. In order to obtain these coating thicknesses reliably, flame cut surfaces should be ground off by the fabricator.

C.1.4 The influence of reactive elements in the basis metal on the zinc coating thickness and appearance

Most steels can be satisfactorily hot dip galvanized. However, several reactive elements in the steel can affect hot dip galvanizing, for example, silicon (Si) and phosphorus (P). The steel surface composition has an influence on the thickness and appearance of the zinc coating. At certain composition levels, silicon and phosphorus can give uneven, bright and/or dull dark grey coatings, which may be brittle and thick. French Standard NF A35-503:1994 gives some guidance on behaviour and on steels possibly suitable for hot dip galvanizing but research on the influence of specific elements in the steels is still in progress (see also EN ISO 14713).

C.1.5 Stresses in the basis metal

Some stresses in the basis metal will be relieved during the hot dip galvanizing process and this may cause deformation of the coated article.

Steel articles that are cold worked (e.g. bent) may become embrittled, depending on the type of steel and the degree of cold work. As hot dip galvanizing is a form of heat treatment, it may accelerate the onset of strain age embrittlement if the steel is already susceptible. To avoid risk of embrittlement, a steel which is not susceptible to strain age-hardening can be used. If a steel is thought to be susceptible to strain age embrittlement, avoid severe cold work if possible. If severe cold work cannot be avoided, stress should be relieved by heat-treatment before pickling and hot dip galvanizing.

NOTE Susceptibility to strain age-hardening and the consequent risk of embrittlement is principally caused by the nitrogen content of the steel, which, in turn, is largely dependent on the steelmaking process. As a general guide, the problem does not occur in modern steelmaking practice. Aluminium-killed steels are the least susceptible to strain age-hardening.

Heat treated or cold worked steels may be tempered by the heat in the hot dip galvanizing bath and lose some of any increased strength obtained by heat treatment or cold working.

Hardened and/or high tensile steels may contain internal stresses of such a magnitude that pickling and hot dip galvanizing may increase the risk of cracking of the steel in the hot dip galvanizing bath. The risk of cracking may be reduced by stress relieving before pickling and hot dip galvanizing, but specialist advice should be sought when hot dip galvanizing such steels.

Structural steels are not normally embrittled by the absorption of hydrogen during pickling, and hydrogen remaining (if any) does not in general affect structural steels. With structural steels, absorbed hydrogen is discharged during hot dip galvanizing. If steels are harder than approximately 34 HRC, 340 HV or 325 HB (see ISO 4964), care is necessary to minimize hydrogen absorption during surface preparation.

Where experience shows that specific steels, pretreatments, thermal and mechanical treatments, pickling and hot dip galvanizing procedures have been satisfactory, the information serves as an indication that an embrittlement problem is not to be expected for the same combination of steels, pretreatments, thermal and mechanical treatments and galvanizing procedures.

C.1.6 Large objects or thick steels

Longer handling times are needed in the galvanizing bath for large articles and this, as well as the metallurgical properties of thick steels due to normal manufacturing methods, may cause thick coatings to form.

C.1.7 Hot dip galvanizing practice

Very small amounts of alloying elements may be added to the galvanizing bath (subject to the requirements of 4.1) as part of the processing technique of galvanizers, notably to reduce the adverse effects of silicon and phosphorus (see C.1.4) or to modify the surface appearance of the galvanized coating. Such possible additions do not affect the general quality or long-term corrosion resistance of the galvanized coating or the mechanical properties of the galvanized product and are not required to be standardized.

C.2 Design

C.2.1 General

The design of the articles to be hot dip galvanized should be appropriate for the process of hot dip galvanizing. The purchaser should seek the advice of the hot dip galvanizer before designing or making a product that is subsequently to be hot dip galvanized, as it may be necessary to adapt the construction of the article for the hot dip galvanizing process (see Annex B).

C.2.2 Dimensional tolerances on mating threads

There are two different ways to make allowances — either by undercutting the male thread or by overcutting the female thread. For fasteners, see the relevant fastener documents. In general, allowances should be made on mating threads to accommodate the thickness of the coating. There are no coating requirements for internal threads which are threaded or re-threaded after hot dip galvanizing.

The coating thicknesses given for threaded components relate to components that require centrifuging immediately after galvanizing to ensure clean threads.

NOTE 1 The coating on external screw threads galvanically protects the internal threads in an assembly. Therefore, no zinc coating is required on the internal threads.

NOTE 2 The coated threads should have strength adequate to meet the design requirement.

C.2.3 Effect of process heat

Materials that will be adversely affected by the heat of the hot dip galvanizing bath should not be hot dip galvanized.

C.3 The hot dip galvanizing bath

Where there is a special requirement, levels of additions or impurities in the bath or in the coating may be specified by the purchaser.

In particular, where boilers (i.e., tanks and cylinders) are hot dip galvanized and specified for use with hot dip galvanized tubes in potable water systems, the purchaser may require that their coating conforms to the same compositional requirements as for tube in EN 10240.

C.4 After-treatment

Normally articles should not be stacked together while hot or wet. Small articles dipped in bulk in baskets or on jigs may be centrifuged immediately after withdrawal from the zinc to remove any surplus metal [see A.2, g)].

To retard the possible formation of wet storage stain on the surface, articles that are not to be painted can be given a suitable surface treatment after hot dip galvanizing.

If the articles are to be painted or powder coated after galvanizing, the purchaser should inform the galvanizer before the article is galvanized.

C.5 Renovation of uncoated or damaged areas

Where the hot dip galvanizer is advised that an overcoating is to be specified, the purchaser should be informed that repair of damaged areas is permitted and informed about the proposed methods and materials used for repair of uncoated or damaged areas. Purchasers and applicators of subsequent coatings should assure themselves that such a subsequent coating system is compatible with the methods and materials used.

6.3 covers the thickness of coating required by the renovation procedure at acceptance inspection. The same techniques are used for on-site repairs to damaged areas. The size of areas acceptable for treatment should be similar to those acceptable for uncoated areas.

C.6 Adhesion testing

Any proposed test should be agreed and related to the likely constraints in service.

Annex D (informative) Determination of thickness

D.1 General

The most general non-destructive method of determining thickness is the magnetic method (see 6.2 and EN ISO 2178). Other methods may however be used (see, for example, ISO 2808, the electromagnetic method).

Destructive methods include the determination of mass per area by the gravimetric method converted to thickness (microns) by dividing the grams per square metre figure by 7,2 (see D.3), the coulometric method (see EN ISO 2177), and the microscopic cross-section method (see D.2).

Careful study should be made of the definitions in clause 3; in particular, the relationship between local and mean thickness should be given when the magnetic method is used and the results are compared with those from the gravimetric test of EN ISO 1460 used in cases of dispute.

D.2 Microscopic cross-section method

The microscopic cross-section method (see EN ISO 1463) may also be used. However, it is inappropriate for routine use on large or expensive articles as it is a destructive method and relates only to a single line. It gives a simple visual picture of the line examined.

D.3 Calculation of thickness from mass per area (reference method)

The EN ISO 1460 method gives the coating mass per unit area expressed in grams per square metre. This can be converted to local thickness (microns) by dividing by the nominal density of the coating ($7,2 \text{ g/cm}^3$). The approximate coating masses corresponding to the thicknesses given in Table 2 and Table 3 are given in Table D.1 and Table D.2.

Table D.1 — Coating minimum masses (related to thicknesses) on samples that are not centrifuged^a

Article and its thickness	Local coating (minimum) ^b		Mean coating (minimum) ^c	
	g/m ²	µm	g/m ²	µm
Steel ≥ 6 mm	505	70	610	85
Steel ≥ 3 mm to < 6 mm	395	55	505	70
Steel ≥ 1,5 mm to < 3 mm	325	45	395	55
Steel < 1,5 mm	250	35	325	45
Castings ≥ 6 mm	505	70	575	80
Castings < 6 mm	430	60	505	70

^a See note 2 to 6.2.3.
^b See 3.10.
^c See 3.11.

Table D.2 — Coating minimum masses (related to thicknesses) on samples that are centrifuged^a

Article and its thickness	Local coating (minimum) ^b		Mean coating (minimum) ^c	
	g/m ²	µm	g/m ²	µm
Articles with threads:				
≥ 20 mm diameter	325	45	395	55
≥ 6 mm to < 20 mm diameter	250	35	325	45
< 6 mm diameter	145	20	180	25
Other articles (including castings):				
≥ 3 mm	325	45	395	55
< 3 mm	250	35	325	45

^a See note 3 to 6.2.3.
^b See 3.10.
^c See 3.11.

Annex E (informative) Bibliography

EN ISO 1463:1994, *Metallic and oxide coatings — Measurement of coating thickness — Microscopical method (ISO 1463:1982)*.

EN ISO 2177:1994, *Metallic coatings — Measurement of coating thickness — Coulometric method by anodic dissolution (ISO 2177:1985)*.

ISO 2808:1997, *Paints and varnishes — Determination of film thickness*.

ISO 4964:1984, *Steel — Hardness conversions*.

EN ISO 12944-4, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 4: Types of surface and surface preparation (ISO 12944-4:1998)*.

EN ISO 12944-5, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 5: Protective paint systems (ISO 12944-5:1998)*.

EN ISO 14713, *Protection against corrosion of iron and steel in structures — Zinc and aluminium coatings — Guidelines (ISO 14713:1999)*.

EN 10240, *Internal and/or external protective coatings for steel tubes — Specification for hot dip galvanized coatings applied in automatic plants*.

NF A35-503:1994, *Iron and steel — Steel for hot dip galvanizing*.

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: 020 8996 9000. Fax: 020 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: 020 8996 9001. Fax: 020 8996 7001.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: 020 8996 7111. Fax: 020 8996 7048.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: 020 8996 7002. Fax: 020 8996 7001.

Copyright

Copyright subsists in all BSI publications. BSI also holds the copyright, in the UK, of the publications of the international standardization bodies. Except as permitted under the Copyright, Designs and Patents Act 1988 no extract may be reproduced, stored in a retrieval system or transmitted in any form or by any means – electronic, photocopying, recording or otherwise – without prior written permission from BSI.

This does not preclude the free use, in the course of implementing the standard, of necessary details such as symbols, and size, type or grade designations. If these details are to be used for any other purpose than implementation then the prior written permission of BSI must be obtained.

If permission is granted, the terms may include royalty payments or a licensing agreement. Details and advice can be obtained from the Copyright Manager. Tel: 020 8996 7070.