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English version

# Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods (ISO 1461 : 1999)

Revétements par galvanization á chaud finis ferreux – Spécifications et méthods d'essai (ISO 1461:1999)

Durch Feuerverzinken auf Stahl aufgebrachte Zinküberzuge (Stuckverzinken) – Anforderungen und Prüfung (ISO 1461:1999)

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

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This European Standard exists in three official versions (English, French and German). A version in any other language may be made translation under the responsibility of a CEN member into its own language and notifi3ed to the Central Secretariat has the same status as the official versions.

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**EUROPÄISCHES KOMITT FÜR NORMUNG**

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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of an identical text or by endorsement at the latest stage by August 1999 and conflicting national standards shall be withdrawn at the latest by August 1999.

According to 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, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and United Kingdom.

## 1 Scope

This standard specifies the general properties of and methods of test for coatings applied by the 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 which are 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 modification specific to the product.

After-treatment/over-coating 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 revision 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 of attributes – Part 1: Sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection.

ISO 2859-3 Sampling procedure for inspection by attributes – Part 3: Skip-lot sampling procedures.

## 3 Term(s) and definition(s)

For the purposes of this standard, the following definitions apply together with those given in EN ISO 1064.

**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 irons 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 as grams per square metre, $g/m^2$)

**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 sampling

**3.7**
**reference area**
the area within which a specific number of single measurements have to be made

**3.8**
**local coating thickness**
the 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**
the average value of the local thicknesses either on one large article or on all 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 galvanizers works (unless otherwise specified)

**3.15**
**uncoated area**
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 and roughness) of the basis metal, the mass of the parts and the galvanizing conditions affect the appearance, the thickness, texture and physical/mechanical properties of the coating.

This Standard does not define any requirements 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 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 galvanizers 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 galvanize 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 area (e.g. cellular pattern or dark grey areas) or some surface unevenness shall not be cause for rejection: also wet storage stain (white or dark corrosion product – 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 grey0 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 and steel composition).

#### 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 EN ISO 1460 and the nominal density of the coating (7.2 g/cm$^3$). 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.

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 of 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, affectively the same local thickness will be determined by magnetic 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 each end and the approximate centre and shall comprise the whole cross-section of the article.

The number of reference areas, dependent upon the size of the individual articles in the control sample, shall be as follows;

a) For articles with significant surface area greater than 2m$^2$ (‘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 area shall be equal or greater than the mean coating thickness values in Table 2 or Table 3.
b) For articles with significant surface area over 10,000 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 mm$^2$ and 10,000 mm$^2$ (inclusive): On each article in the control sample there shall be one reference area.
d) For articles with less than 1,000 mm$^2$ significant surface area: Enough articles shall be grouped together to provide at least 1,000 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 10,000 $mm^2$ = 100 $cm^2$
1,000 $mm^2$ = 10 $cm^2$
2 $m^2$ is typically 200cm x 100 cm : 10,000 $mm^2$ is typically 10 cm x 10 cm: 1,000 $mm^2$ 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 $mm^2$, 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, which should be at least 1,000 $mm^2$, a minimum of five magnetic test readings shall be taken 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 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 thickness 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 < 6mm | 55 | 70 |
| Steel ≥ 1.5 mm to < 3 mm | 45 | 55 |
| Steel < 1.5 mm | 35 | 45 |
| Castings ≥ 6 mm | 70 | 80 |
| Castings < 6mm | 60 | 70 |
| [a] See 3.8<br>[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 of 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 thickness on samples that are centrifuged**

| Article and its thickness | Local coating thickness (minimum)[a] µm | Mean coating thickness (minimum)[b] µm |
|---|---|---|
| **Articles 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<br>[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 inn 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 the 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 thermal zinc 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 is to be applied subsequently, the proposed renovation procedure shall be advised in advance to the purchaser by the galvanizer.

The treatment shall include the 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 work pieces that are to be 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.

A crosshatch 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).

# 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 indication 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 acceptability of, a centrifuged coating that is to meet the requirements of Table 3 instead of Table 2;
h) Any after-treatments or over-coating to be given to the galvanized coating (see 6.3, C.4 and C.5);
i) Inspection arrangements (see clause 5);
j) Where 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 for handling of 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.

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 steels, 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. Sulphur-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 contamination 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 of removing 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 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 basting, course 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 thickness given in 6.2, and tables 2 and 3, are more difficult to obtain. In order to obtain these coating thicknesses more 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 A 35 503: 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 steel

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

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 work cannot be avoided, stress should be relieved by heat-treatment prior to 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 steel making process. As a general guide, the problem does not occur in modern steel making practice. Aluminium-killed steels arte 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 the 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 affects 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 of 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 under-cutting the male thread or by over-cutting the female thread. For fasteners, see the relevant fasteners 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 thickness given for threaded components relates 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 on assembly. Therefore, no zinc coating is required on internal threads.

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

### C.2.3 The affect 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 coatings 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 dipping in bulk in baskets or on jigs may 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 galvanizer is advised that an over coating 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 constraint 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).

## 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 g/cm$^3$). The approximate coating masses corresponding to the thicknesses given in Tables 2 and 3are given in Table D.1 and D.2.

**Table D.1 – Coating minimum masses (related to thickness) 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 |
| < 3mm | 250 | 35 | 325 | 45 |

[a] See note 3 to 6.2.3.
[b] See 3.10.
[c] See 3.11.

## Annex E
(informative)

## Bibliography

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