International Standard 2081

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Metallic coatings — Electroplated coatings of zinc on iron or steel

Revêtements métalliques — Dépôts électrolytiques de zinc sur fer ou acier

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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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 2081 was prepared by Technical Committee ISO/TC 107, *Metallic and other non-organic coatings.*

This second edition cancels and replaces the first edition (ISO 2081-1973), of which it constitutes a technical revision.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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Metallic coatings — Electroplated coatings of zinc on iron or steel

0 Introduction

This International Standard specifies a range of electroplated coatings of zinc for the protection of iron and steel against corrosion under various service conditions.

The surface condition of the basis metal is not specified in this International Standard.

Chromate conversion coatings give additional protection against corrosion and may only be omitted at the specific request of the purchaser. The types of chromate coating which can be produced on electroplated zinc coatings are described more fully in ISO 4520. Zinc-electroplated articles to be painted may require alternative treatment such as phosphating to provide good adhesion.

Zinc-plated articles are subject to attack by certain organic materials, for example cardboard, wood or certain electrical insulating materials which emit reactive vapours. Cognizance should be taken of this fact when articles are packed, stored or transported.

It is essential that the purchaser states the classification code: merely to ask for zinc electroplating to be carried out in accordance with ISO 2081 without this information is insufficient.

1 Scope and field of application

This International Standard specifies requirements for electroplated coatings of zinc on iron or steel except for coatings applied:

a) to sheet, strip or wire in the unfabricated form;

b) to close-coiled springs;

c) for other than protective or decorative purposes.

It includes information to be supplied by the purchaser to the electroplater and requirements for heat treatment, both before and after electroplating.

The coating thickness that can be applied to threaded components may be limited by dimensional requirements, including class or fit. Attention is drawn to ISO 4042, which specifies the maximum thicknesses that can be applied to standard threads.

2 References

ISO 1461, *Metallic coatings — Hot dip galvanized coatings on fabricated ferrous products — Requirements.*

ISO 1463, *Metallic and oxide coatings — Measurement of coating thickness — Microscopical method.*

ISO 2063, *Metallic coatings — Protection of iron and steel against corrosion — Metal spraying of zinc and aluminium.*

ISO 2064, *Metallic and other non-organic coatings — Definitions and conventions concerning the measurement of thickness.*

ISO 2177, *Metallic coatings — Measurement of coating thickness — Coulometric method by anodic dissolution.*

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

ISO 4042, *Threaded components — Electroplated coatings.* [1]

ISO 4518, *Metallic coatings — Measurement of coating thickness — Profilometric method.*

ISO 4519, *Electrodeposited metallic coatings and related finishes — Sampling procedures for inspection by attributes.*

ISO 4520, *Chromate conversion coatings on electroplated zinc and cadmium coatings.*

3 Definitions

3.1 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.

(Definition taken from ISO 2064.)

3.2 local thickness: The mean of the thickness measurements, of which a specified number is made within a reference area.

(Definition taken from ISO 2064.)

1) At present at the stage of draft.

3.3 minimum local thickness: The lowest value of the local thicknesses found on the significant surface of a single article.

(Definition taken from ISO 2064.)

4 Basis metal

This International Standard does not specify requirements for the surface condition of the basis metal before electroplating with zinc, but agreement should preferably be reached between the interested parties that the surface finish of the basis metal is not too rough to prevent the appearance and/or the serviceability of the zinc coating from being satisfactory.

5 Information to be supplied to the electroplater

The following information shall be supplied to the electroplater:

a) the number of this International Standard, i.e. ISO 2081;

b) the classification code (see clause 6);

c) the significant surface indicated, for example, by drawings or by the provision of suitably marked samples;

d) the nature and surface condition and finish of the basis metal (see clause 4);

e) if appropriate, the surface appearance of the coating;

f) requirements for any heat treatment before and after electroplating (see clause 7);

g) the type of chromate or other conversion coating (see clause 9); it should be noted that chromate conversion coatings can only be omitted, or alternative conversion coatings applied, at the specific request of the purchaser;

h) sampling and inspection requirements;

i) any special requirements for, or restrictions on, preparation and electroplating (see clause 7).

6 Service conditions, service life, and classification code

6.1 Effect of service conditions and service life

The thickness of zinc coating required depends upon the severity of the service conditions and on the service life required. Class Fe/Zn 5 (see 6.2) is recommended only for dry, indoor conditions. As the service conditions become more severe and/or the life required increases, coatings with greater zinc thickness shall be specified.

6.2 Classification code

The classification code comprises:

a) the chemical symbol, Fe, for the basis metal (iron or steel), followed by an oblique stroke;

b) the chemical symbol for zinc, Zn;

c) a number indicating the minimum local thickness, in micrometres, of the zinc coating;

d) if appropriate, symbols indicating the presence, and class and designation (if required), of a chromate conversion coating (see ISO 4520).

A typical example is Fe/Zn 25 c 1A where, additionally:

c refers to the chromate conversion coating;

1 is the class of the chromate conversion coating;

A is the designation of the chromate conversion coating.

6.3 Coatings appropriate to service condition and service life

Table 1 shows the coating classification code and minimum local thickness (see 9.2) of zinc after chromate treatment, if carried out, and an indication of their relationship to service conditions and to service life.

Table 1 — Coatings of zinc on iron or steel — Coating classification code, minimum local thickness, service condition and service life

Service condition or service life	Classification code	Minimum local thickness (µm)
Increasing severity of service condition or of life required	Fe/Zn 5*	5
	Fe/Zn 8*	8
	Fe/Zn 12* †	12
	Fe/Zn 25* †	25

* Followed by the appropriate symbol of ISO 4520 for the chromate conversion coating, when present. Details of any other conversion coating shall be given separately.

† It is recommended that coatings with classification codes Fe/Zn 25 and Fe/Zn 12 should receive a coloured, class 2, chromate conversion coating (see ISO 4520).

NOTES

1 In any particular environment, the protective value of a zinc coating is directly proportional to its mass per unit area (surface density). Therefore, a coating of 40 µm thickness may also be used for special purposes.

2 When very long service life is required, as for example on structural steel components, the thicker zinc coatings required are usually applied by hot-dip galvanizing (see ISO 1461) or by zinc spraying (see ISO 2063).

7 Heat treatment

7.1 General

Heat treatment as specified in 7.3 and 7.4 shall be performed on certain basis metals to reduce the risk of damage by hydrogen embrittlement. In all cases, the duration of heat treatment shall commence from the time at which the whole of each part attains the specified temperature.

Parts made from steels with maximum specified tensile strengths greater than 1 050 MPa* (corresponding hardness values approximately 34 HRC, 340 HV or 325 HB) and surface-hardened parts will require heat treatment. Preparation involving cathodic treatments in alkaline or acid solutions shall be avoided.

NOTE — The selection of electroplating solutions with high cathodic efficiencies, for example fluoroboric solutions, is recommended for steel components with tensile strengths greater than 1 450 MPa (corresponding hardness values approximately 45 HRC, 440 HV or 415 HB).

7.2 Categorization of steels

7.2.1 With the exception of surface-hardened parts (see 7.3.2 and 7.4.2), the heat-treatment conditions shall be selected on the basis of the specified maximum tensile strength. Steels shall be categorized according to specified maximum tensile strength according to table 2. If the steel specification is only in terms of minimum tensile strength, the corresponding maximum tensile strength shall be determined from table 2.

Table 2 — Categories of steels and maximum tensile strengths corresponding to specified minimum tensile strengths

Strengths in megapascals

Minimum specified tensile strength, $R_{m\ min}$	Corresponding maximum tensile strength, $R_{m\ max}$
$R_{m\ min} \leqslant 1\ 000$	$R_{m\ max} \leqslant 1\ 050$
$1\ 000 < R_{m\ min} \leqslant 1\ 400$	$1\ 050 < R_{m\ max} \leqslant 1\ 450$
$1\ 400 < R_{m\ min} \leqslant 1\ 750$	$1\ 450 < R_{m\ max} \leqslant 1\ 800$
$1\ 750 < R_{m\ min}$	$1\ 800 < R_{m\ max}$

7.2.2 If neither the maximum nor the minimum tensile strength is specified for the steel, Vickers hardness values of 340, 440, and 560 HV shall be regarded as equivalent to maximum tensile strengths of 1 050, 1 450, and 1 800 MPa, respectively, and these strengths shall be used to select the heat-treatment conditions.

7.3 Stress relief before electroplating

7.3.1 The conditions given in table 3 are recommended, except for surface-hardened parts, if the purchaser requires the parts to be stress relieved before electroplating, although different conditions, namely suitable combinations of shorter periods at appropriate higher temperatures, may be used if they have been shown to be effective. The heat treatment shall be carried out before the commencement of any preparation or cleaning treatment using aqueous solutions.

Table 3 — Heat-treatment conditions for stress relief before electroplating (excluding surface-hardened parts)

Maximum specified tensile strength, $R_{m\ max}$	Temperature	Time
MPa	°C	h
$R_{m\ max} \leqslant 1\ 050$	None required	—
$1\ 050 < R_{m\ max} \leqslant 1\ 450$	190 to 220	1
$1\ 450 < R_{m\ max} \leqslant 1\ 800$	190 to 220	18
$1\ 800 < R_{m\ max}$	190 to 220	24

7.3.2 Surface-hardened parts shall be heat treated at 130 to 150 °C for not less than 5 h or for shorter periods at higher temperatures if the resulting loss of surface hardness of the substrate is acceptable.

7.3.3 If stress relief is given after shot peening or other cold working processes, the temperature shall not exceed 220 °C.

7.4 Hydrogen embrittlement relief after electroplating

7.4.1 The treatment given in table 4 shall be used, except for surface-hardened parts, and shall be carried out as soon as possible and in any case not later than 4 h after electroplating and before any chromate treatment.

7.4.2 Surface-hardened parts shall be heat treated at 190 to 220 °C for not less than 2 h but otherwise as in 7.4.1.

7.4.3 Other temperatures and durations may be specified and used if they have been shown to be effective for the particular part, and are acceptable to the purchaser. However, parts shall not be heat treated above their tempering temperature.

Table 4 — Heat-treatment conditions for hydrogen embrittlement relief after electroplating (excluding surface-hardened parts)

Maximum specified tensile strength, $R_{m\ max}$	Temperature	Time
MPa	°C	h
$R_{m\ max} \leqslant 1\ 050$	None required	—
$1\ 050 < R_{m\ max} \leqslant 1\ 450$	190 to 220	8
$1\ 450 < R_{m\ max} \leqslant 1\ 800$	190 to 220	18
$1\ 800 < R_{m\ max}$	190 to 220	24

8 Sampling

A random sample of the size required by ISO 4519 shall be selected from the inspection lot. The articles in the sample shall be inspected for conformance to the requirements of this specification and the lot shall be classified as conforming or not conforming to each requirement according to the criteria of the sampling plans in ISO 4519.

9 Coating requirements

9.1 Appearance

Over the significant surface, the electroplated article shall be free from clearly visible plating defects such as blisters, pits, roughness, cracks or unplated areas other than those arising from defects in the basis metal. On articles where a contact mark is unavoidable, its position shall be the subject of agreement between the interested parties.

The articles shall be clean and free from damage. Unless the purchaser specifies otherwise, the zinc coating shall be bright. If necessary, a sample showing the required finish shall be supplied or approved by the purchaser.

* 1 MPa = 1 N/mm²

9.2 Thickness of zinc coating

9.2.1 Minimum local thickness

The minimum local thickness requirement of the zinc coating, as indicated by the classification code (see table 1), or which is otherwise designated, shall apply to those portions of the significant surface that can be touched with a ball 20 mm in diameter. The minimum local thickness requirement shall also apply to additional portions of the significant surface if specified by the purchaser.

9.2.2 Thickness of coating on small articles

In the case of articles having a significant surface area less than 100 mm^2, the minimum local thickness shall be deemed to be the minimum value of the average thickness determined by the method specified in 10.1.2.

9.3 Adhesion

The coating shall continue to adhere to the basis metal when subjected to the test specified in 10.2.

9.4 Application of conversion coatings

Conversion coatings, particularly chromate coatings, enhance the corrosion resistance of electrodeposited zinc coatings, and chromate conversion coatings may only be omitted, or replaced by other conversion coatings, at the specific request of the purchaser. The types of chromate coating which can be produced on electrodeposited zinc coatings are described more fully in ISO 4520 (see also 6.3).

10 Test methods

10.1 Thickness

10.1.1 Measurement of local thickness

Methods which are suitable for the measurement of many zinc coatings on steel are specified in ISO 1463, ISO 2177, ISO 2178 and ISO 4518.

In case of dispute, use the method specified in ISO 2177, except for articles having a significant surface of less than 100 mm^2, when the method specified in 10.1.2 shall be used.

If the coatings are rough or matt, the microscopical (ISO 1463) and profilometric (ISO 4518) methods may give unreliable results, and magnetic methods may give measurements which are somewhat greater than those obtained on smooth coatings of the same mass per unit area.

NOTE — Prior to the use of the method specified in ISO 2177, it is necessary to remove the chromate or other conversion coating using a very mild abrasive, for example a paste of levigated alumina. In the case of heavy conversion coatings, the results will, therefore, be slightly low.

10.1.2 Measurement of thickness on small articles

10.1.2.1 Procedure

In the case of articles having a significant surface of less than 100 mm^2, take a sufficient number of articles to give a mass of coating of not less than 100 mg. If the article is of complex shape, an area shall be agreed between the interested parties. Weigh the articles, to the nearest milligram, and strip off the zinc coating at room temperature using one of the solutions specified in 10.1.2.2.

When testing for referee purposes, use either solution a) or solution b).

WARNING — The stripping solutions have hazards associated with them and the precautions given in 10.1.2.2 should be carefully observed.

Rinse the articles in running water, if necessary brushing to remove any loose dark deposit [of antimony when using solutions a) or b)] from the surface, dry carefully and reweigh, noting the loss in mass. Calculate the thickness, d, in micrometres, of the zinc coating from the equation

$$d = \frac{m \times 10^3}{A\varrho}$$

where

m is the loss in mass, in milligrams;

A is the area, in square millimetres, of the surface under examination;

ϱ is the density, in grams per cubic centimetre, of the zinc coating, normally 7.1.

10.1.2.2 Examples of suitable stripping solutions

WARNING — Antimony trioxide (Sb_2O_3) dissolved in hydrochloric acid and antimony trichloride ($SbCl_3$) are poisonous. Avoid contact with the skin.

Stibine (SbH_3), which is a very poisonous gas, may be released during the stripping process when using either solution a) or b), and stringent precautions should be taken to avoid breathing it. Carry out the stripping process in a fume cupboard.

Formaldehyde solution is toxic, irritant and causes burns. Avoid breathing the vapour. Avoid contact with the skin and eyes.

Solution a)

Antimony trioxide (Sb_2O_3)	20g
Hydrochloric acid ($\varrho \geqslant 1{,}16$ g/ml)	800 ml
Water	200 ml

Solution b)

Antimony trichloride ($SbCl_3$)	32 g
Hydrochloric acid ($\varrho \geqslant 1{,}16$ g/ml)	800 ml
Water	200 ml

Dissolve the antimony trioxide or, alternatively, the antimony trichloride in the hydrochloric acid and dilute with the water.

Stripping solutions a) and b) are satisfactory as long as the articles are removed from the solution as soon as the zinc coating has completely dissolved, i.e. once the vigorous chemical action has ceased. However, they may attack the basis iron or steel if the articles are left in the solution for any considerable time after the stripping has been completed.

Solution c)

Formaldehyde [30 % (m/m) solution]	10 ml
Hydrochloric acid ($\varrho \geqslant 1{,}16$ g/ml)	500 ml
Water	500 ml

Solution d)

Ammonium nitrate (NH_4NO_3)	300 g/l

Solution e)

Hydrochloric acid ($\varrho = 1{,}19$ g/ml)	500 ml
Propin-2-ol-1 (C_3H_4O)	1 g
Water	500 ml

10.2 Burnishing test for adhesion

Rub an area of not more than 6 cm^2 of the plated surface rapidly and firmly with a smooth metal implement for 15 s.

The pressure shall be sufficient to burnish the coating at every stroke, but not so great as to cut the deposit. Poor adhesion will be shown by the appearance of a loose blister which grows as rubbing is continued. If, in addition, the quality of the deposit is poor, the blister may crack and the plating will peel away from the basis metal.

More than one area may be tested if desired.

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