INTERNATIONAL STANDARD

ISO 15726

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Metallic and other inorganic coatings — Electrodeposited zinc alloys with nickel, cobalt or iron

Revêtements métalliques et autres revêtements inorganiques — Dépôts électrolytiques d'alliages de zinc au nickel, cobalt ou fer

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 15726 was prepared by Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*, Subcommittee SC 3, *Electrodeposited coatings and related finishes*.

Introduction

Electrodeposited zinc alloy coatings containing nickel, cobalt or iron are significantly more corrosion-resistant than electrodeposited zinc coatings of equivalent thickness. The alloy coatings are anodic to steel, but less so than pure zinc. Although originally developed for the continuous coating of steel for the fabrication of automobile body panels, zinc alloy electroplating processes have become available that are suitable for the rack and barrel electroplating of individual components.

In the case of zinc-nickel alloys, proprietary acid and alkaline electroplating processes exist that yield deposits with controlled nickel contents. Zinc-nickel coatings containing either 8 % or 12 % nickel are most widely used, and are often considered possible substitutes for cadmium coatings. Zinc-nickel alloy coatings can reportedly be applied by brush electroplating techniques.

The alloy coatings are often used in combination with chromate conversion coatings, organic sealants and other supplementary treatments to further enhance corrosion resistance, and often serve as the base for applying organic coatings. Chromate conversion coatings formulated specifically for use with zinc-cobalt and zinc-nickel alloy coatings are available for producing yellow- to bronze-coloured surfaces.

Metallic and other inorganic coatings — Electrodeposited zinc alloys with nickel, cobalt or iron

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1 Scope

This International Standard covers the requirements for electrodeposited zinc alloy coatings containing either nickel, cobalt or iron. It provides a method of designating the electrodeposited coatings, chromate conversion coatings and other supplementary treatments.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2064, *Metallic and other inorganic coatings — Definitions and conventions concerning the measurement of thickness*

ISO 2080, *Metallic and other inorganic coatings — Surface treatment, metallic and other inorganic coatings — Vocabulary*

ISO 2819, *Metallic coatings on metallic substrates — Electrodeposited and chemically deposited coatings — Review of methods available for testing adhesion*

ISO 3882, *Metallic and other inorganic coatings — Review of methods of measurement of thickness*

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 9587, *Metallic and other inorganic coatings — Pretreatment of iron or steel to reduce the risk of hydrogen embrittlement*

ISO 9588, *Metallic and other inorganic coatings — Post-coating treatments of iron or steel to reduce the risk of hydrogen embrittlement*

ISO 10308, *Metallic coatings — Review of porosity tests*

ISO 10309, *Metallic coatings — Porosity tests — Ferroxyl test*

ASTM B117, *Standard Practice for Operating Salt Spray (Fog) — Apparatus*

3 Terms and definitions

For the purpose of this document, the terms and definitions in ISO 2064, ISO 2080, ISO 9587 and ISO 9588 apply.

4 Information to be supplied by the purchaser to the electroplater

4.1 Essential information

When ordering articles to be electroplated in accordance with this International Standard, the purchaser shall provide the following information in writing, for example in the contract or purchase order, or on engineering drawings:

a) the number of this International Standard (ISO 15726) and the article designation (see Clause 5);

b) the significant surface to be electroplated, as indicated, for example, by drawings or by the provision of suitably marked samples and of any surfaces that are not to be electroplated;

c) the nature, condition and finish of the basis metal if they are likely to affect the serviceability and/or appearance of the coating;

d) position, type, dimensions and number of unavoidable defects on the surface, such as rack marks, that can be tolerated (see 6.1);

e) appearance of the zinc alloy coating, for example as-deposited or with a chemical conversion coating and/or other supplementary treatment (see Clause 5 and 6.1);

   Alternatively, samples showing the appearance shall be supplied or approved by the purchaser and used for comparison purposes (see 6.1).

f) type of chromate conversion coating or supplementary treatment (see 5.6 and Annex B);

   Chromate conversion coatings shall only be omitted, and alternative conversion coatings and/or other supplementary treatments (see Table 3) or conformal coatings, such as lacquers, applied over the chromate coating, at the specific request of the purchaser.

g) requirements for minimum thickness, additional portions of surfaces where the minimum thickness requirements apply, adhesion test and corrosion testing and its performance rating (see 6.2, 6.3, 6.6 and Annex B);

h) the tensile strength of the parts and the requirements for stress- and embrittlement-relief heat treatments before and/or after electrodeposition (see 6.7 and 6.8);

i) method of porosity testing (see Annex A), and the number and location of acceptable pores (see 6.4);

j) sampling methods, acceptance levels or any other inspection requirements, if different from those given (see Clause 7);

k) any other relevant information.

4.2 Additional information

The following additional information, as relevant, shall also be provided:

a) any cleaning precautions to be followed (see Note in 6.1);

b) any special pre- and/or post-plating treatments (see Note in 6.1).

5 Designation

5.1 General

The article designation shall appear on engineering drawings, in the purchase order, in the contract or in the detailed product specification. The designation specifies the basis material, the requirements for stress relief before electroplating, the nominal composition and thickness of the zinc alloy coating, the type of chromate or other conversion coatings and other supplementary treatments, and the type of heat treatment to reduce susceptibility to hydrogen embrittlement.

5.2 Designation specification

The designation shall comprise the following, in the order given:

a) the term “Electrodeposited coating”;

b) the number of this International Standard, ISO 15726;

c) a hyphen;

d) the chemical symbol of the basis metal;

e) a solidus (/);

f) if relevant, any SR designation (see 5.4);

g) the chemical symbol for the metal or alloy or coating, its composition in parentheses, and its thickness, in micrometres (see 5.5), separated by solidi (/) for each stage in the coating sequence in the order of application, if more than one;

h) a solidus (/);

i) if appropriate, codes indicating the type of any supplementary coating (see 5.6), followed by a solidus (/);

j) if appropriate, codes designating any supplementary treatments (see 5.6);

k) ER designation (see 5.7).

5.3 Basis metal

The basis metal shall be designated by its chemical symbol, or its principal constituent, if an alloy. For example: Fe for iron and steel; Zn for zinc alloys; Cu for copper and copper alloys; and Al for aluminium and aluminium alloys.

The specific alloy may be identified by its standard designation (for example its UNS number or its national or regional equivalent) placed between the symbols < >, for example Fe<G434000> (see Reference [19]).

NOTE Electrodeposited zinc alloys with nickel, cobalt or iron are most often applied to steel, but can be electrodeposited on other basis metals.

5.4 Stress-relief heat treatment prior to electroplating

Stress-relief heat treatment prior to coating may be required for some basis materials. Brackets shall be placed around the letters SR, the temperature, in Celsius, and the time, in hours. The temperature shall be in parentheses after the letters SR; for example [SR(210)1].

5.5 Type and thickness of zinc alloy coating

The electrodeposited zinc alloy coating shall be designated by the chemical symbols given in Table 1 followed by a number in parentheses giving the composition of the alloy coating within 0,5 % mass fraction (w), followed by a number giving the minimum local thickness of the coating, in micrometres. For example, ZnNi(12)5 designates a zinc alloy coating containing 12 % nickel that is 5 µm thick.

Table 2 gives typical thickness values specified for zinc alloy coatings deposited on steel, as guidance.

Table 1 — Symbols for electrodeposited zinc alloys with nickel, cobalt or iron

Type of alloy coating	Symbol	Typical composition w %	Composition range w %
Zinc-nickel	ZnNi	12 nickel, balance zinc 8 nickel, balance zinc	6 to 18 nickel, balance zinc
Zinc-cobalt	ZnCo	1,0 cobalt, balance zinc	0,3 to 1,2 cobalt, balance zinc
Zinc-iron	ZnFe	0,5 iron, balance zinc	0,3 to 1,0 iron, balance zinc

Table 2 — Typical minimum local thickness of zinc alloy coatings on steel

Thickness µm		
ZnNi	**ZnCo**	**ZnFe**
5	6	6
8	12	12
10	18	18

NOTE Proprietary acid and alkaline processes exist from which zinc-nickel alloy coatings containing 8 % and 12 % mass fraction nickel can be electrodeposited. Suppliers of proprietary processes provide information on how to control the nickel content of the coating [see 4.1 k)].

5.6 Chromate conversion coatings and other supplementary treatments

The type of chromate conversion coating (see ISO 4520) and other supplementary treatments shall be designated by the symbols given in Table 3.

Chemical conversion coatings that do not contain hexavalent chromium, such as trivalent chromium, or are chromium-free are commercially available. All forms of chromate conversion coatings, alternative conversion coatings or substitutes, with the exception of phosphate coatings, that may be used shall meet the corrosion requirements given in this International Standard. Conversion coatings containing trivalent chromium are available for all codes. However, the surface appearance of these substitutes may be different from those produced with hexavalent chromium-conversion coatings. The tables in this International Standard reflect the requirements and products that have been used and accepted universally in practice over several decades by producers, purchasers and users in the metal finishing industry [see 4.1 f)].

Table 3 — Symbols for chromate conversion coatings and other supplementary treatments

Symbol	Description
A	Clear or transparent (blue-bright)
C	Iridescent yellow
F	Black
T2	Organic sealants applied over A, C or F

NOTE Chromate conversion coatings specifically formulated for use with zinc-cobalt and zinc-nickel alloy coatings have been developed to achieve yellow- to bronze-coloured surface finishes.

5.7 Hydrogen-embrittlement-relief heat treatment after electroplating

Heat treatment requirements, after electroplating, to reduce the susceptibility of high-strength steels to hydrogen embrittlement may be required in certain applications. Brackets shall be placed around the letters ER, the temperature, in Celsius, and the time, in hours. The temperature shall be in parentheses after the letters ER; for example [ER(200)12].

When heat treatment for stress-relief or hydrogen-embrittlement-relief purposes is specified, the requirements shall appear in the designation as shown in Example 3 in 5.8.

5.8 Examples of coating designations

EXAMPLE 1 A coating 8 µm thick containing 10 % nickel, balance zinc, on steel (Fe), with a supplementary chromate conversion coating that is iridescent yellow (C) has the following designation:

Electrodeposited coating ISO 15726 - Fe/ZnNi(10)8/C

EXAMPLE 2 A coating 5 µm thick containing 8 % nickel, balance zinc, on steel, with a supplementary chromate conversion coating that is colourless (blue bright) and that has received a subsequent organic sealant has the following designation:

Electrodeposited coating ISO 15726 - Fe/ZnNi(8)5/A/T2

EXAMPLE 3 A coating on high-strength steel that is stress-relieved at 190 °C for 1 h before electroplating with a coating 5 µm thick containing 1,0 % cobalt, balance zinc, with a supplementary chromate conversion coating that is black (F), and that is heat-treated at 200 °C for 6 h after coating to minimize the risk of hydrogen embrittlement has the following designation:

Electrodeposited coating ISO 15726 - Fe/[SR(190)1]/ZnCo(1)5/F/[ER(200)6]

6 Requirements

6.1 Appearance

The coating on the significant surfaces of the product shall be smooth and free of visual defects such as blisters, pits, roughness, cracks, flaking, burned deposits, and non-coated areas. The boundaries of electroplating that cover only a portion of the surface shall, after finishing as indicated in the drawings, be free of beads, nodules, jagged edges and other detrimental irregularities. Imperfections and surface conditions of the basis metal (scratches, pores, roll marks, inclusions) that persist in the finish despite the observance of good metal finishing practices shall not be cause for rejection.

Approved samples of artefacts shall be used for comparison purposes to control the final appearance of the coating [see 4.1 c)].

Electrodeposited finishes generally perform better when the substrate over which they are applied is smooth and free from deep scratches, torn metal, pores, inclusions and other defects. It is recommended that the specifications that cover the unfinished product provide limits for these defects. A metal finisher can often remove defects through special treatments such as grinding, polishing, abrasive blasting, and special chemical treatments. However, these are not normal treatment steps [see 4.2 a) and 4.2 b)].

NOTE Zinc alloy coatings are commonly used in automotive applications where subsequent forming, bending and crimping operations are commonly performed. These operations will necessarily detract from the performance of coatings. Some cracking of coatings may be unavoidable.

Flaking of the coating after the operations described in the Note above shall be cause for rejection.

6.2 Thickness

The coating thickness specified in the article designation shall be the minimum local thickness. The minimum local thickness of an electrodeposited coating shall be measured at any point on the significant surface that can be touched by a ball of 20 mm in diameter, unless otherwise specified.

The minimum local thickness of the zinc alloy coatings shall be measured by one of the methods given in A.1.

NOTE Variations in the minimum local thickness from point to point on an article, and from article to article in a production lot, are intrinsic to electroplating. If all the articles in a production lot are to meet minimum local thickness requirements, the average coating thickness of the entire production lot will be greater than the specified minimum.

6.3 Adhesion

The coating shall withstand normal handling and storage conditions without chipping, flaking, or other coating damage, and shall conform to the minimum requirements given in A.2.

It is the responsibility of the electroplater to ensure that the method for surface preparation used prior to electroplating results in a surface capable of meeting the requirements of this subclause [see 4.1 c)].

6.4 Porosity

The porosity shall be measured by one of the methods in A.3. The specific test method to be used, and the number and location of acceptable pores, shall be specified by the purchaser.

6.5 Composition of coating

The composition of the coating shall be verified by atomic absorption spectrophotometry (AA), inductively coupled plasma (ICP), directly coupled plasma (DCP), or any other method with a measurement uncertainty of less than 10 % determined on standard reference materials.

6.6 Corrosion performance in neutral salt spray

Corrosion performance of the coated parts shall be evaluated by exposure to neutral salt spray testing in accordance with ASTM B117. Annex B gives the minimum number of hours during which the coating should withstand corrosion after continuous exposure to neutral salt spray. The requirements for corrosion performance shall be specified by the purchaser [see 4.1 g)].

The time to zinc alloy coating corrosion given in Table B.1 is for rack-processed parts. For parts processed in barrels, the time to zinc alloy coating corrosion will be less.

NOTE The duration and results of artificial atmosphere corrosion tests may bear little relationship to the service life of the coated article and, therefore, the results obtained are not to be regarded as a direct guide to the corrosion resistance of the tested coatings in all environments where these coatings may be used.

6.7 Stress-relief heat treatments

Steel parts that have an ultimate tensile strength equal to or greater than 1 000 MPa (31 HRc) and that contain tensile stresses caused by machining, grinding, straightening, or cold-forming operations shall be given a stress-relief heat treatment prior to cleaning and metal deposition, according to the procedures and classes of ISO 9587 [see 4.1 h)], unless otherwise specified by the purchaser.

Steels with oxide or scale shall be cleaned before application of the coatings. For high-strength steels, non-electrolytic alkaline and anodic alkaline cleaners, as well as mechanical cleaning procedures, are preferred to avoid the risk of producing hydrogen embrittlement during cleaning operations. The possibility of overheating should be considered in the case of mechanical cleaning of high-strength steel with a tensile strength greater than 1 400 MPa.

6.8 Hydrogen-embrittlement-relief heat treatments

Steel parts having an ultimate tensile strength equal to or greater than 1 000 MPa (31 HRC), as well as surface-hardened parts, shall receive hydrogen-embrittlement-relief heat treatment according to the procedures and classes of ISO 9588, unless otherwise specified by the purchaser [see 4.1 h)].

Electroplated springs or other parts subject to flexure shall not be flexed before the hydrogen-embrittlement-relief heat treatment is carried out.

The effectiveness of the hydrogen-embrittlement-relief treatement shall be determined in accordance with ISO 10587 for testing threaded articles for residual hydrogen-relief heat treatement and with ISO 15724 for measuring the relative, diffusible hydrogen concentration in steels, unless otherwise specified by the purchaser.

7 Sampling

Sampling plans are described in ISO 4519 and shall be used as a basis for agreement [see 4.1 j)].

Annex A
(normative)

Thickness, adhesion and porosity tests

A.1 Thickness tests

Thickness of electrodeposits shall be determined using an appropriate method from those listed in ISO 3882. Examples of these methods are ISO 1463, ISO 2177, ISO 2178, ISO 3497, ISO 3543, ISO 3868, ISO 4518 and ISO 9220. Other thickness measurements may be used if it can be demonstrated that the measurement uncertainty is less than 10 %.

A.2 Adhesion test

Adhesion shall be determined using one or more of the methods described in ISO 2819. Any flaking or peeling shall constitute failure.

A.3 Porosity tests

Porosity in the coating on iron or steel shall be determined using the ferroxyl test described in ISO 10309. Porosity on other basis metals shall be determined using a suitable method as described in ISO 10308.

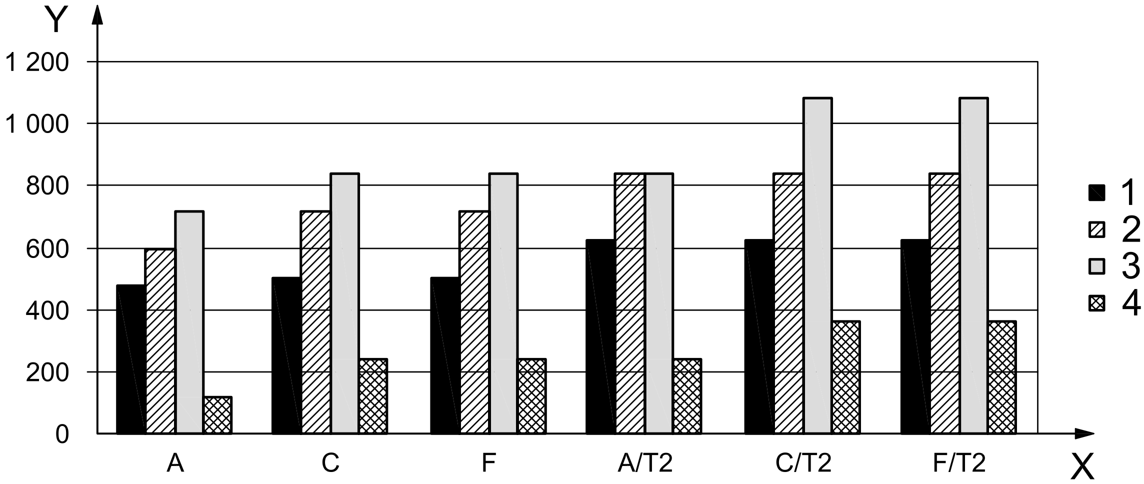
Annex B
(normative)

Corrosion performance of zinc alloy coatings with chromate conversion and other supplementary treatments on steel in neutral salt spray

The corrosion performance of zinc alloy coatings with chromate or other conversion coatings and other supplementary treatments shall be evaluated by means of the neutral salt spray (NSS) test described in ASTM B117. Table B.1 gives the minimum number of hours of continuous exposure that a properly applied coating should withstand. The data in the table have been compiled from the references given in the Bibliography and are plotted in Figures B.1, B.2 and B.3. (see also 5.6).

Table B.1 — Time to basis metal corrosion and corrosion of typical zinc alloy coatings on steel in neutral salt spray

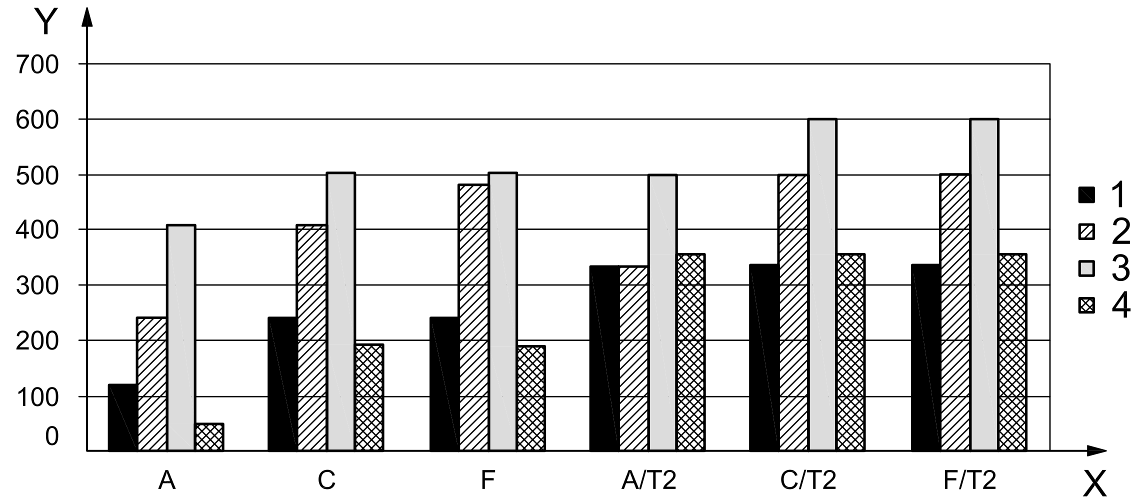
Symbols for conversion coating/supplementary treatment	Minimum time to basis metal corrosion (red rust) h			Minimum time to zinc alloy coating corrosion (white corrosion) h
	ZnNi (12 % Ni) alloy coating thickness			**Rack-electrodeposited parts**
	5 µm	8 µm	10 µm	
A	480	600	720	120
C	504	720	840	240
F	504	720	840	240
A/T2	624	840	840	240
C/T2	624	840	1 080	360
F/T2	624	840	1 080	360
	ZnCo (1 % Co) alloy coating thickness			**Rack-electrodeposited parts**
	6 µm	12 µm	18 µm	
A	120	240	408	48
C	240	408	504	192
F	240	480	504	192
A/T2	336	336	504	350
C/T2	336	504	600	360
F/T2	336	504	600	360
	ZnFe (1 % Fe) alloy coating thickness			**Rack-electrodeposited parts**
	6 µm	12 µm	18 µm	
A	480	552	696	216
F	696	744	792	312



Key

X designation of supplementary treatments
Y NSS, h
1 5 µm, basis metal corrosion
2 8 µm, basis metal corrosion
3 10 µm, basis metal corrosion
4 alloy corrosion product

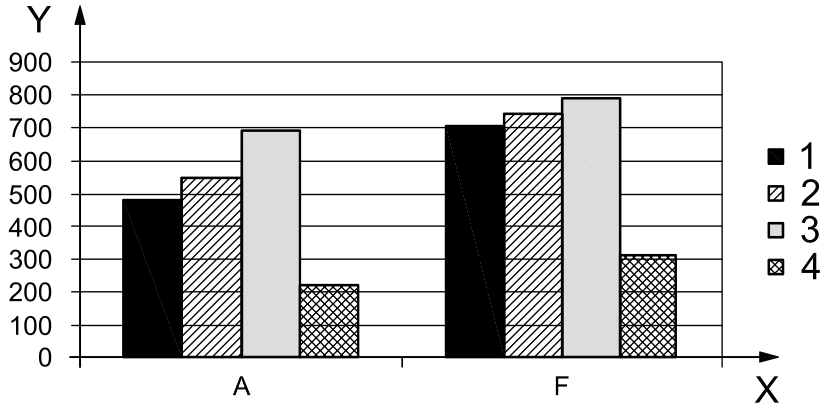
Figure B.1 — Corrosion performance of zinc-nickel alloy coatings (12 % Ni) in neutral salt spray



Key

X designation of supplementary treatments
Y NSS, h
1 6 µm, basis metal corrosion
2 12 µm, basis metal corrosion
3 18 µm, basis metal corrosion
4 alloy corrosion product

Figure B.2 — Corrosion performance of zinc-cobalt alloy coatings (1 % Co) in neutral salt spray



Key

X designation of chromate conversion coating

Y NSS, h

1 6 µm, basis metal corrosion

2 12 µm, basis metal corrosion

3 18 µm, basis metal corrosion

4 alloy corrosion product

Figure B.3 — Corrosion performance of zinc-iron alloy coatings (1 % Fe) in neutral salt spray

Bibliography

[1] ISO 1463, *Metallic and oxide coatings — Measurement of coating thickness — Microscopical method*

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

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

[4] ISO 3497, *Metallic coatings — Measurement of coating thickness — X-ray spectrometric methods*

[5] ISO 3543, *Metallic and non-metallic coatings — Measurement of thickness — Beta backscatter method*

[6] ISO 3613, *Chromate conversion coatings on zinc, cadmium, aluminium-zinc alloys and zinc-aluminium alloys — Test methods*

[7] ISO 3868, *Metallic and other non-organic coatings — Measurement of coating thicknesses — Fizeau multiple-beam interferometry method*

[8] ISO 4520, *Chromate conversion coatings on electroplated zinc and cadmium coatings*

[9] ISO 9220, *Metallic coatings — Measurement of coating thickness — Scanning electron microscope method*

[10] ISO 9227, *Corrosion tests in artificial atmospheres — Salt spray tests*

[11] ISO 10111, *Metallic and other inorganic coatings — Measurement of mass per unit area — Review of gravimetric and chemical analysis methods*

[12] ISO 10587, *Metallic and other inorganic coatings — Tests for residual embrittlement in both metallic-coated and uncoated externally-threaded articles and rods — Inclined wedge method*

[13] ISO 15724, *Metallic and other inorganic coatings — Electrochemical measurement of diffusible hydrogen in steels — Barnacle electrode method*

[14] ISO 27830, *Metallic and other inorganic coatings — Guidelines for specifying metallic and inorganic coatings*

[15] ISO 27831-1, *Metallic and other inorganic coatings — Cleaning and preparation of metal surfaces — Part 1: Ferrous metals and alloys*

[16] ISO 27831-2, *Metallic and other inorganic coatings — Cleaning and preparation of metal surfaces — Part 2: Non-ferrous metals and alloys*

[17] ASTM B840:1999, *Standard Specification for Electrodeposited Coatings for Zinc Cobalt Alloy Deposits*

[18] ASTM B841:1999, *Standard Specification for Electrodeposited Coatings for Zinc Nickel Alloy Deposits*

[19] ASTM B842:1999, *Standard Specification for Electrodeposited Coatings for Zinc Iron Alloy Deposits*

[20] ASTM E 527, *Standard Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)*

[21] DIN 50692:1998, *Galvanische Überzüge — Chromatierte Zinklegierungsüberzüge auf Eisenwerkstoffen* (Electrodeposited coatings — Chromated zinc alloy coatings on iron materials)

[22] BALDWIN, K.R., ROBINSON, M.J. and SMITH, C.J.E. The Corrosion Resistance of Electrodeposited Zinc-Nickel Alloy Coatings. *Corrosion Science*, **35(8)**, 1993, p. 1267

[23] HALL, D.E., Electrodeposited Zinc-Nickel Alloy Coatings — A Review. *Plating and Surface Finishing*, **70(11)**, 1983, p. 59

[24] WATSON, S.A. *Zinc-nickel alloy electroplated steel coil for use by the automotive industry*. NiDI Review Series No. 13 001, Nickel Development Institute, Toronto, Ontario, Canada, 1988

[25] ZAKI, N. Zinc-Nickel Alloy Plating, *Metal Finishing*, **76(6)**, 1989, p. 57

[26] RAY, G.P. *Thickness testing of electroplated and related coatings*, 2nd edn., 1993, Electrochemical Publications Ltd, Isle of Man, UK, ISBN 0 901150 27 4

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