
Fasteners — Electroplated coating systems

Fixations — Systèmes de revêtements électrolytiques

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 2, *Fasteners*, Subcommittee SC 14, *Surface coatings*.

This third edition cancels and replaces the second edition (ISO 4042:1999), which has been technically revised. The main changes compared to the previous edition are as follows:

- application to all fasteners, including self-tapping and thread forming screws, washers, rivets, clips, etc.;
- focus on coatings designed for corrosion protection of fasteners;
- application to electroplated coating systems with or without additional layers (conversion coating, sealant, top coat, lubricant);
- specification of minimum corrosion resistance (white corrosion and red rust);
- inclusion of up-to-date knowledge about hydrogen embrittlement and prevention measures;
- definitions specified in ISO 1891-2;
- concerning corrosion tests, inclusion of sulfur dioxide test (Kesternich) and calibration of neutral salt spray test;
- inclusion of gaugeability and assemblability requirements;
- for thickness determination, addition of adequate test methods and deletion of the batch average thickness;
- new designation system for all coating systems;
- specification for mechanical and physical properties and related test methods;
- information about design aspects and assembly of coated fasteners;

- information for coating thickness and thread clearance for ISO metric screw threads;
- information about evaluation of cabinet corrosivity for the neutral salt spray test.

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Introduction

This document was completely revised to take into account new developments related to hexavalent chromium free passivations, application of sealants and top coats, requirements for functional properties as well as results of research work to minimize the risk of hydrogen embrittlement.

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Fasteners — Electroplated coating systems

1 Scope

This document specifies requirements for electroplated coatings and coating systems on steel fasteners. The requirements related to dimensional properties also apply to fasteners made of copper or copper alloys.

It also specifies requirements and gives recommendations to minimize the risk of hydrogen embrittlement; see [4.4](#) and [Annex B](#).

It mainly applies to zinc and zinc alloy coating systems (zinc, zinc-nickel, zinc-iron) and cadmium, primarily intended for corrosion protection and other functional properties:

- with or without conversion coating;
- with or without sealant;
- with or without top coat;
- with or without lubricant (integral lubricant and/or subsequently added lubricant).

Specifications for other electroplated coatings and coating systems (tin, tin-zinc, copper-tin, copper-silver, copper, silver, copper-zinc, nickel, nickel-chromium, copper-nickel, copper-nickel-chromium) are included in this document only for dimensional requirements related to fasteners with ISO metric threads.

This document applies to bolts, screws, studs and nuts with ISO metric thread, to fasteners with non-ISO metric thread, and to non-threaded fasteners such as washers, pins, clips and rivets.

Information for design and assembly of coated fasteners is given in [Annex A](#).

This document does not specify requirements for properties such as weldability or paintability.

NOTE Other International Standards specify differing electroplating processes. For electroplating of fasteners, the requirements of this document apply, unless otherwise agreed.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 1456, *Metallic and other inorganic coatings — Electrodeposited coatings of nickel, nickel plus chromium, copper plus nickel and of copper plus nickel plus chromium*

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

ISO 1502, *ISO general-purpose metric screw threads — Gauges and gauging*

ISO 1891-2, *Fasteners — Terminology — Part 2: Vocabulary and definitions for coatings*

ISO 2081, *Metallic and other inorganic coatings — Electroplated coatings of zinc with supplementary treatments on iron or steel*

ISO 2082, *Metallic and other inorganic coatings — Electroplated coatings of cadmium with supplementary treatments on iron or steel*

ISO 2093, *Electroplated coatings of tin — Specification and test methods*

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 3231, *Paints and varnishes — Determination of resistance to humid atmospheres containing sulfur dioxide*

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

ISO 3613:2010, *Metallic and other inorganic coatings — Chromate conversion coatings on zinc, cadmium, aluminium-zinc alloys and zinc-aluminium alloys — Test methods*

ISO 4521, *Metallic and other inorganic coatings — Electrodeposited silver and silver alloy coatings for engineering purposes — Specification and test methods*

ISO 6988, *Metallic and other non organic coatings — Sulfur dioxide test with general condensation of moisture*

ISO 8991, *Designation system for fasteners*

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

ISO 15330, *Fasteners — Preloading test for the detection of hydrogen embrittlement — Parallel bearing surface method*

ISO 15726, *Metallic and other inorganic coatings — Electrodeposited zinc alloys with nickel, cobalt or iron*

ISO 16047, *Fasteners — Torque/clamp force testing*

ISO 16228, *Fasteners — Types of inspection documents*

ISO 19598, *Metallic coatings — Electroplated coatings of zinc and zinc alloys on iron or steel with supplementary Cr(VI)-free treatment*

ISO 21968, *Non-magnetic metallic coatings on metallic and non-metallic basis materials — Measurement of coating thickness — Phase-sensitive eddy-current method*

ASME B18.6.3, *Machine Screws, Tapping Screws, and Metallic Drive Screws (Inch Series)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1891-2 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1 reference panel

reference material that is to be exposed to check the corrosivity level of the test cabinet used for fastener testing

4 General characteristics of the coating

4.1 Coating metals or alloys and main purposes

Electroplated coating systems for steel fasteners are primarily applied for corrosion protection and functional properties, such as torque/clamp force relationship.

In addition, other functional properties or decorative properties can be specified; see [Annex A](#).

[Table 1](#) shows commonly used electroplated coatings in relation with their main purposes and references to related ISO standards, which give additional general information not covered by this document, e.g. for designation. Some of the International Standards listed in [Table 1](#) specify differing electroplating processes. For the purpose of fasteners, the requirements of this document apply.

Table 1 — Electroplated coatings in accordance with their main purposes and related ISO standards

Coating metal(s)		Nature	Main purpose of the coating for fasteners	ISO standard
Symbol	Element			
Zn	Zinc	Metal	P/D/F	ISO 2081, ISO 19598
ZnNi	Zinc-nickel	Alloy	P/D/F	ISO 15726, ISO 19598
ZnFe	Zinc-iron	Alloy	P/D/F	ISO 15726, ISO 19598
Cd	Cadmium ^a	Metal	P/F	ISO 2082
Ni	Nickel	Metal	D/F	ISO 1456
Ni+Cr	Nickel-chromium	Multi-layer	D	ISO 1456
Cu+Ni	Copper-nickel	Multi-layer	D	ISO 1456
Cu+Ni+Cr	Copper-nickel-chromium	Multi-layer	D	ISO 1456
CuZn	Brass	Alloy	D	—
CuSn	Copper-tin (bronze)	Alloy	F	—
Cu	Copper	Metal	F/D	—
Ag	Silver	Metal	F/D	ISO 4521
CuAg	Copper-silver	Alloy	F	—
Sn	Tin	Metal	F	ISO 2093
SnZn	Tin-zinc	Metal	F/P	—

P corrosion protection

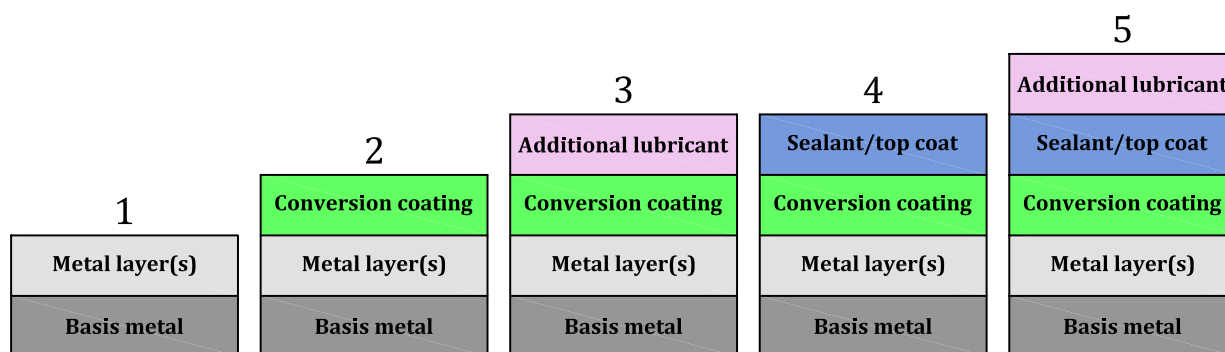
F functional properties

D decorative properties (colour, aspect)

^a Cadmium is restricted or prohibited for many applications (remaining cadmium users are predominantly military and aerospace industries).

4.2 Build-up of basic electroplated coating systems

[Figure 1](#) shows basic electroplated coating systems.

**Key**

- 1 only metal layer(s)
- 2 metal layer(s) + conversion coating
- 3 metal layer(s) + conversion coating + additional lubricant
- 4 metal layer(s) + conversion coating + sealant/top coat
- 5 metal layer(s) + conversion coating + sealant/top coat + additional lubricant

Figure 1 — Basic electroplated coating systems (schematic)

A conversion coating increases corrosion protection on zinc, zinc alloys and cadmium coatings. It may be a passivation (chromium VI free) or a chromatisation (chromium VI containing). The conversion coating can also provide better adhesion for additional layer(s) and/or additional colour/paint.

An additional sealant/top coat (with or without integral lubricant) may be chosen to increase corrosion resistance and to achieve other specific properties (e.g. torque/clamp force properties, resistance to chemicals, mechanical resistance, aspect, colour, thermal stability, increased electrical resistance, UV radiation resistance). The selection of the nature of a sealant or top coat should be based on desired additional properties.

An additional lubricant may be applied to adjust or amend the torque/clamp force relationship.

4.3 Coating systems and coating processes

The type and geometry of the fasteners should be considered when selecting a coating system and the related coating process (see [Annex A](#)) as well as hydrogen embrittlement considerations (see [Annex B](#)).

The electroplating process shall be under control, in accordance with a recognized standard and/or a specification by agreement with the customer.

4.4 Internal hydrogen embrittlement

4.4.1 General

If the three following conditions are concurrently present for fasteners:

- with high tensile strength or hardness or which have been case-hardened and tempered or cold worked to high hardness,
- which are under tensile stress, and
- which have absorbed hydrogen,

there is a risk of Internal Hydrogen Embrittlement (IHE).

The susceptibility to IHE increases with increasing hardness of the fastener material. Appropriate measures for prevention of IHE for quenched and tempered fasteners depending on hardness are

specified in [Table 2](#). For fasteners in accordance with ISO 898-1, ISO 898-2 and ISO 898-3, Tables 3, 4 and 5 apply.

Table 2 — Measures related to IHE for quenched and tempered fasteners with regard to hardness

360 HV		390 HV
A	B	C
No supplemental process verification or product testing with regard to IHE AND No baking necessary	Supplemental process verification and/or product testing with regard to IHE OR Baking (at the choice of the fastener manufacturer)	Supplemental process verification and/or product tests with regard to IHE AND Baking (baking temperature and duration shall be specified)
See 4.4.2	See 4.4.3 and B.6	See 4.4.4 and B.6

4.4.2 Fasteners with hardness below 360 HV

When electroplating fasteners with specified maximum hardness below 360 HV (A in [Tables 2, 3, 4](#) and [5](#)), no supplemental process verification with regard to IHE and no baking are necessary.

4.4.3 Fasteners with hardness equal to and above 360 HV and up to 390 HV

When electroplating fasteners with specified maximum hardness equal to and above 360 HV and up to and including 390 HV (B in [Tables 2, 3, 4](#) and [5](#)), baking is not required provided supplemental process verification and/or product testing with regard to IHE have been performed. However, the purchaser is free to require baking generally.

For fasteners in this specified hardness range, electroplating does not pose a risk of IHE. In case of a failure in a product test, it cannot be assumed that baking the parts would have prevented such failure: the metallurgical and physical conditions of the fastener material should be investigated for non-conformances. For more information, see [B.4](#).

4.4.4 Fasteners with hardness above 390 HV

When electroplating fasteners with specified maximum hardness above 390 HV (C in [Tables 2, 3](#) and [5](#)), baking is required; see [B.4](#) for minimum recommended baking temperature and duration.

The following exemptions apply:

- for fasteners which are not specified to be under tensile stress by design or standard (e.g. set screws in accordance with ISO 898-5), baking is not required (see [B.2](#)),
- induction hardened ends (e.g. for thread forming screws) shall not be considered for determining measures related to IHE in relation to [Table 2](#), because they are normally not subjected to tensile stress provided that the end protrudes through the mating thread.

For alkaline zinc-nickel electroplatings (and nickel content from 12 % to 16 %), it is possible to avoid baking because of low risk of IHE (see [B.3](#)). The decision not to carry out baking shall be based on testing (see [B.6](#)) and be agreed between the supplier and the purchaser.

NOTE For acid zinc-nickel electroplatings, studies have shown similar benefits as for alkaline zinc-nickel electroplating, however more data is necessary with regard to baking avoidance.

4.4.5 Fasteners in accordance with ISO 898-1, ISO 898-2 and ISO 898-3

For fasteners in accordance with ISO 898-1, ISO 898-2 and ISO 898-3, [Tables 3, 4](#) and [5](#) apply.

Table 3 — Measures related to IHE for fasteners in accordance with ISO 898-1

	Property class		
	≤ 9.8	10.9	12.9 and <u>12.9</u>
Bolts, screws, studs in accordance with ISO 898-1			
Measures related to IHE	A	B	C
	No supplemental process verification or product testing with regard to IHE AND No baking necessary	Supplemental process verification and/or product testing with regard to IHE OR Baking	Supplemental process verification and/or product testing with regard to IHE AND Baking ^a
	—	At the choice of the fastener manufacturer	Baking temperature and duration shall be specified (see also B.4)
	See 4.4.2	See 4.4.3 and B.6	See 4.4.4 and B.6
^a For alkaline zinc-nickel electroplatings (and nickel content from 12 % to 16 %), the decision not to carry out baking shall be based on testing (see B.6) and be agreed between the supplier and the purchaser.			

Table 4 — Measures related to IHE for nuts in accordance with ISO 898-2

	Property class	
	≤ 12	
Nuts in accordance with ISO 898-2	Nuts with specified maximum hardness < 360 HV	Nuts with specified maximum hardness ≥ 360 HV ^a
Measures related to IHE	A	B
	No supplemental process verification AND No baking necessary	Supplemental process verification with regard to IHE OR Baking
	—	At the choice of the fastener manufacturer
	See 4.4.2	See 4.4.3
^a Only: — for regular nuts (style 1) with fine pitch thread, property class 10, and — for high nuts (style 2) with fine pitch thread, property class 12, and diameters above 16 mm.		