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Threaded components — Electroplated coatings

Composants filetés — 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.

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 4042 was prepared by Technical Committee ISO/TC 2, *Fasteners*.

Annexes A, B, C and D form an integral part of this International Standard. Annex E is for information only.

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Introduction

This International Standard covers the coating of threaded components of steel or copper alloy by electrodeposition of the more common finishes. The properties of the coatings are specified in other International Standards for the individual finishes.

With customary methods for the surface preparation and deposition of metallic coatings from aqueous solutions, there is a risk of delayed brittle failure due to hydrogen embrittlement for bolts and screws made from steel with tensile strengths above 1 000 N/mm^2 and/or hardnesses exceeding 320 HV.

The risk may be reduced significantly when surface preparation and coating operations are carefully carried out and process-controlled, including subsequent baking.

An increased risk of breaking due to hydrogen embrittlement occurs in the case of spring accessories having hardnesses exceeding 390 HV. Therefore, special measures are again necessary concerning the selection of material, heat treatment and surface treatment.

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Threaded components — Electroplated coatings

1 Scope

This International Standard specifies dimensional requirements for electroplated threaded fasteners of steel or copper alloy. It establishes a service condition classification for these fasteners and specifies coating thicknesses and hydrogen embrittlement relief for high-strength or surface-hardened fasteners.

It primarily concerns the electroplating of threaded fasteners but it may also be applied to other threaded components. For the applicability to wood screws, self-tapping screws and thread-forming screws, see clause 8.

The coatings specified in this International Standard may also be applied to non-threaded components such as washers.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 965-1 : 1980, *ISO general purpose metric screw threads — Tolerances — Part 1 : Principles and basic data.*

ISO 965-2 : 1980, *ISO general purpose metric screw threads — Tolerances — Part 2 : Limits of sizes for general purpose bolt and nut threads — Medium quality.*

ISO 965-3 : 1980, *ISO general purpose metric screw threads — Tolerances — Part 3 : Deviations for constructional threads.*

ISO 1456 : 1988, *Metallic coatings — Electrodeposited coatings of nickel plus chromium and of copper plus nickel plus chromium.*

ISO 1458 : 1988, *Metallic coating — Electrodeposited coatings of nickel.*

ISO 1502 : 1978, *ISO general purpose metric screw threads — Gauging.*

ISO 2064 : 1980, *Metallic and other non-organic coatings — Definitions and conventions concerning the measurement of thickness.*

ISO 2081 : 1986, *Metallic coatings — Electroplated coatings of zinc on iron or steel.*

ISO 2082 : 1986, *Metallic coatings — Electroplated coatings of cadmium on iron or steel.*

ISO 4519 : 1980, *Electrodeposited metallic coatings and related finishes — Sampling and procedures for inspection by attributes.*

ISO 4520 : 1981, *Chromate conversion coatings on electroplated zinc and cadmium coatings.*

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 2064 (in particular, the definitions of significant surface, measuring area, local thickness and minimum local thickness), together with the following, apply.

3.1 average thickness of deposit : The coating thickness which would result if the whole of the deposit were evenly distributed over the entire surface of the electroplated article.

3.2 batch : A quantity of identical components either plated together at one time in a particular barrel, or consigned under cover of one delivery note.

3.3 group : Ten or more items selected at random from a batch.

3.4 batch average thickness : The mean of the average thicknesses of the coating on all the components of a batch.

3.5 baking : The process of hydrogen embrittlement relief by low temperature heat treatment (see annex A).

4 Dimensional requirements and gauging

4.1 Dimensional requirements before electroplating

Threaded components supplied for electroplating, except thread rolling screws and certain types of tapping screws, shall comply with the relevant International Standards before coating, except where screw threads are specifically manufactured to allow the application of thicker coatings than are possible on normal threads (see annex C).

Coating thicknesses are based on the tolerances for metric ISO threads according to ISO 965 having the following tolerance positions:

g, f and e for external threads;

H and G for internal threads.

The tolerance positions apply prior to application of the electroplated coating.

4.2 Dimensional requirements after electroplating

After coating, ISO metric screw threads shall be gauged according to ISO 1502 with a GO-gauge of tolerance position h for external threads and H for internal threads.

Other product dimensions apply only before coating.

The applicability of the recommended coatings to ISO metric threads is limited by the fundamental deviation of the threads concerned and, hence, by the pitch and tolerance positions. The coating shall not cause the zero line to be exceeded in the case of external threads; nor shall it fall below in the case of internal threads. This means that for an internal thread of tolerance position H, a measurable coating thickness can only be applied to the threads if the tolerance zone is not taken up to the zero line.

5 Quality of coating

The electroplated coating shall comply with the provisions of the International Standard for the coating concerned in respect of appearance, adhesion, ductility, corrosion resistance, etc.

6 Hydrogen embrittlement relief

Threaded fasteners made from steel, heat-treated to property class 10.9 and greater, case-hardened fasteners, and fasteners with captive washers made from hardened steel shall be baked after electroplating but before any chromating treatement for at least the requisite time and temperature specified in annex A.

However, complete elimination of hydrogen embrittlement cannot be guaranteed. If complete freedom from embrittlement is required, then a different coating method shall be used.

7 Protective value and service condition number

The protective value and service life of an electroplated coating depends to a considerable extent on its thickness. In addition to greater coating thickness, a chromate conversion treatment can be specified for increased corrosion protection on zinc and cadmium coatings.

For the purposes of this International Standard, degrees of severity of service conditions are defined as follows.

Very mild (0): Exposure to indoor atmosphere and not subject to condensation, wear or abrasion. Example: product with temporary protective coatings.

Mild (1): Exposure to indoor atmosphere with rare condensation and subject to minimum wear or abrasion. Examples: buttons, wire goods.

Moderate (2): Exposure mostly to dry indoor atmospheres but subject to occasional condensation, wear, or abrasion. Examples: tools, zippers, drawer handles, machine parts.

Severe (3): Exposure to condensation, perspiration, infrequent wetting by rain, and cleaners. Examples: tubular furniture, insect screens, window fittings, builder's hardware, washing-machine parts, bicycle parts.

Very severe (4): Exposure to harsh conditions, or subject to frequent exposure to moisture, cleaners, and saline solutions, plus likely damage by denting, scratching, or abrasive wear. Examples: plumbing fixtures, electric pylon hardware.

Guidance on deposit thickness (classification code) for electroplating on threaded components to withstand service conditions 0 to 4 is given in table 1.

Table 1 — Appropriate classification codes

Service condition number	Classification code			
	Cadmium[1] ISO 2082	Zinc ISO 2081	Nickel ISO 1458	Nickel + chromium and copper + nickel + chromium ISO 1456
0	Fe/Cd 3	Fe/Zn 3	Cu/Ni 3b Fe/Ni 5b	
1	Fe/Cd 5[2]	Fe/Zn 5[2]	Cu/Ni 5b Fe/Ni 10b	Cu/Ni 5b Cr r Fe/Ni 10b Cr r Fe/Cu 10 Ni 5b Cr r
2	Fe/Cd 8[2]	Fe/Zn 8[2]	Cu/Ni 10b Fe/Ni 20b	Cu/Ni 10b Cr r Fe/Ni 20b Cr r Fe/Cu 20 Ni 10b Cr r
3	Fe/Cd 12[2]	Fe/Zn 12[2]	Cu/Ni 20b Fe/Ni 30b	Cu/Ni 20b Cr r Fe/Ni 30b Cr r
4	Fe/Cd 25[2]	Fe/Zn 25[2]	[3]	[3]

1) The use of cadmium is restricted in certain countries.

2) Followed by the appropriate symbol of ISO 4520 for chromate conversion treatment.

3) See ISO 1456 and ISO 1458 for details of deposit thicknesses of nickel and chromium for service condition No. 4.

NOTE — When corrosion protection systems as specified in this table are used, attention shall be paid to the fact that, in view of the basis Fe, the coatings Cd and Zn act as an anode (cathodic protection) and the coatings Ni and Ni + Cr act as a cathode (anodic protection). The corrosion effects to be expected when the protective coating is damaged will vary accordingly. For this reason, it is not recommended to compare or exchange coatings of the two groups.

Electroplated coatings applicable to threaded fasteners to meet service condition No. 4, and in many cases also No. 3, are not applicable to standard screw threads unless special procedures are adopted (see annex C).

The electrodeposits used to provide protective coatings, namely zinc, cadmium, nickel and chromium, vary in the manner in which they corrode and in the degree of protection they provide in any particular corrosive environment, so the choice of a particular coating for a protective application should be guided whenever possible by experience.

8 Applicability to wood screws, self-tapping screws and thread-forming screws

All recommended coatings may be applied to screws that cut or form their own threads. The maximum value for batch average thickness given in table 2 may be ignored unless otherwise specified (see annex A).

9 Specification of coating thickness

The local and batch average thicknesses corresponding to the nominal coating thicknesses recommended in the relevant International Standards for electroplating are given in table 2.

Table 2 — Nominal coating thicknesses

Thicknesses in micrometres

Nominal coating thickness[1)]	Effective coating thickness		
	Minimum local thickness	Batch average thickness	
		min.	max.
3	3	3	5
5	5	4	6
8	8	7	10
10	10	9	12
12	12	11	15
15	15	14	18
20	20	18	23
25	25	23	28
30	30	27	35

1) See annex C.

In order to reduce the risk of interference on assembly of threads with electroplated coatings, the nominal coating thickness shall not exceed one-quarter of the fundamental deviation of the thread. These values are specified in table 3.

The effective coating thicknesses measured according to one of the methods specified in clause 10 shall comply with the values specified in table 2.

In the case of batch average thickness measurement and if the threaded parts have nominal lengths $l > 5d$, smaller nominal thicknesses as specified in table 2 shall be applied. See table 3.

Table 3 — Upper limits of nominal coating thickness

Pitch P	Nominal thread diameter[1)] d	Internal thread: Tolerance position G: Fundamental deviation	Internal thread: Tolerance position G: Nominal coating thickness max.	External thread: Tolerance position g: Fundamental deviation	g: Nominal coating thickness max.[2)] All nominal lengths	g: Nominal coating thickness max.[3)] Nominal length, l: $l \leq 5d$	g: [3)] $5d < l \leq 10d$	g: [3)] $10d < l \leq 15d$	Tolerance position f: Fundamental deviation	f: Nominal coating thickness max.[2)] All nominal lengths	f: [3)] $l \leq 5d$	f: [3)] $5d < l \leq 10d$	f: [3)] $10d < l \leq 15d$	Tolerance position e: Fundamental deviation	e: Nominal coating thickness max.[2)] All nominal lengths	e: [3)] $l \leq 5d$	e: [3)] $5d < l \leq 10d$	e: [3)] $10d < l \leq 15d$
	mm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm
0,2		+17	3	−17	3	3	3	3										
0,25	1; 1,2	+18	3	−18	3	3	3	3										
0,3	1,4	+18	3	−18	3	3	3	3										
0,35	1,6(1,8)	+19	3	−19	3	3	3	3	−34	8	8	5	5					
0,4	2	+19	3	−19	3	3	3	3	−34	8	8	5	5					
0,45	2,5(2,2)	+20	5	−20	5	5	3	3	−35	8	8	5	5					
0,5	3	+20	5	−20	5	5	3	3	−36	8	8	5	5	−50	12	12	10	8
0,6	3,5	+21	5	−21	5	5	3	3	−36	8	8	5	5	−53	12	12	10	8
0,7	4	+22	5	−22	5	5	3	3	−38	8	8	5	5	−56	12	12	10	8
0,75	4,5	+22	5	−22	5	5	3	3	−38	8	8	5	5	−56	12	12	10	8
0,8	5	+24	5	−24	5	5	3	3	−38	8	8	5	5	−60	15	15	12	10
1	6(7)	+26	5	−26	5	5	3	3	−40	10	10	8	5	−60	15	15	12	10
1,25	8	+28	5	−28	5	5	5	3	−42	10	10	8	5	−63	15	15	12	10
1,5	10	+32	8	−32	8	8	5	5	−45	10	10	8	5	−67	15	15	12	10
1,75	12	+34	8	−34	8	8	5	5	−48	12	12	8	8	−71	15	15	12	10
2	16(14)	+38	8	−38	8	8	5	5	−52	12	12	10	8	−71	15	15	12	10
2,5	20(18; 22)	+42	10	−42	10	10	8	5	−58	12	12	10	8	−80	20	20	15	12
3	24(27)	+48	12	−48	12	12	8	8	−63	15	15	12	10	−85	20	20	15	12
3,5	30(33)	+53	12	−53	12	12	10	8	−70	15	15	12	10	−90	20	20	15	15
4	36(39)	+60	15	−60	15	15	12	10	−75	15	15	15	12	−95	20	20	15	15
4,5	42(45)	+63	15	−63	15	15	12	10	−80	20	20	15	12	−100	25	25	20	15
5	48(52)	+71	15	−71	15	15	12	10	−85	20	20	15	12	−106	25	25	20	15
5,5	56(60)	+75	15	−75	15	15	15	12	−90	20	20	15	15	−112	25	25	20	15
6	64	+80	20	−80	20	20	15	12	−95	20	20	15	15	−118	25	25	20	15

1) Information for coarse pitch threads is given for convenience only. The determining characteristic is the thread pitch.

2) Maximum values of nominal coating thickness if local thickness measurement is agreed.

3) Maximum values of nominal coating thickness if batch average thickness measurement is agreed.

NOTE — The additional deviations that can be applied to threads specially manufactured to accommodate thick coatings are given in table C.1.

10 Measurement of coating thickness

10.1 Local thickness

The local thickness shall be not less than the minimum local thickness specified in table 2, and shall be measured using one of the methods specified in the International Standard for the coating being applied. Thicknesses on fasteners shall only be measured on the test surfaces shown in figure 1.

10.2 Batch average thickness

Batch average thickness shall be measured by the method described in annex B. Exceeding the maximum batch average thickness shall not cause rejection if the coated thread is accepted by an appropriate GO-gauge (H or h).

10.3 Agreement on test method

Unless otherwise specified, local thickness shall be measured.

NOTE — Most screws and bolts are electroplated in bulk in barrels and as a consequence the greatest coating thickness is always at both extremities of the components. This effect is increased the longer the screw or bolt is in relation to its diameter and tends to reduce the pitch size that can accept the specified coating thickness.

11 Sampling for thickness tests

Sampling for thickness measurement shall be carried out in accordance with the requirements of ISO 4519.

12 Ordering requirements for electroplating

When ordering threaded components to be electroplated in accordance with this International Standard, the following information shall be supplied to the electroplater :

a) The International Standard for the desired coating and the coating designation (or service condition number).

b) The requirement, if any, for stress-relieving before electroplating, in which case the stress-relieving conditions shall be specified.

c) The requirement, if any, for de-embrittlement baking, stating either the tensile strength of the steel or the baking time.

d) Preference, if any, for batch average thickness measurement (see clause 10).

e) Any requirement for selective electroplating or reduction of thread dimensions.

13 Designation

Fasteners shall be specified according to the appropriate product standards. The code system given in annex D covers the specification of surface treatments which shall be added to the product designation.

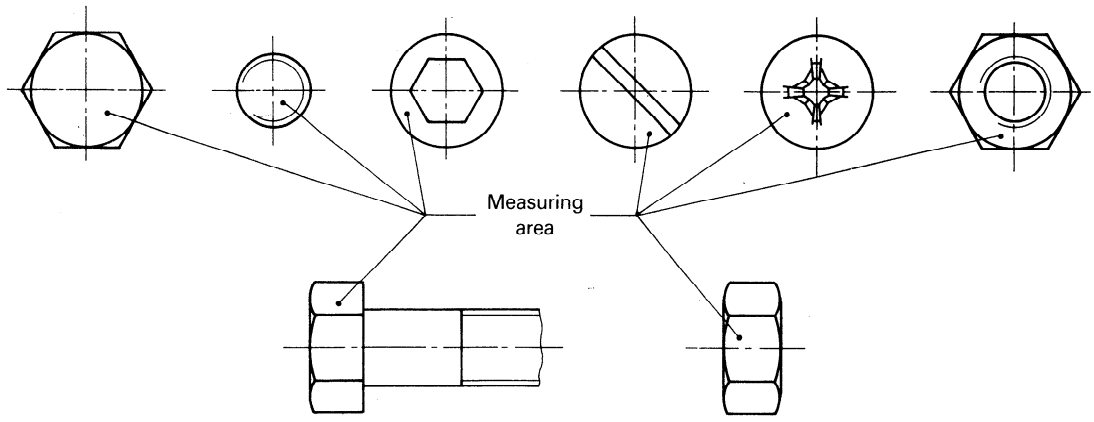

Figure 1 — Measuring area for local coating thickness measurement on fasteners

Annex A
(normative)

Hydrogen embrittlement relief after electroplating

This annex gives specifications additional to clause 6.

A.1 Components made from steel quenched and tempered to tensile strengths $R_m \geqslant 1\,000$ N/mm^2 including property class 10.9 and above and/or hardnesses exceeding 320 HV will require baking after electroplating, to minimize the risk of hydrogen embrittlement.

For screws and bolts made from steels quenched and tempered to tensile strengths $R_m > 1\,450$ N/mm^2 and/or to hardnesses exceeding 450 HV, special pretreatments avoiding the use of acid are necessary; only high-efficiency type electroplating solutions should be used. In these circumstances the baking times shall be determined by experiment. There are therefore no baking times given in tables for screws and bolts with tensile strengths above grade 12.9.

The baking process shall be carried out as soon as possible and not later than 4 h after electroplating in accordance with table A.1. The duration of baking applies from when the parts have reached the minimum temperature.

Table A.1 — Baking times

Components	Minimum baking times at 180 °C to 230 °C
	h
Bolts and screws of strength grade 10.9	4
Bolts and screws of strength grade 12.9	6
Assemblies with spring washers, hardness range 390 HV to 500 HV	8
Assemblies with spring washers, hardness range 500 HV to 600 HV	12
Case hardened screws (tapping screws)	2
Thread-forming screws	6

NOTE — Other conditions of duration and temperature may be specified and used if they have been shown to be effective for a part, but the baking temperature should not exceed the tempering temperature. Some types of steel are more susceptible to hydrogen embrittlement than others and the baking conditions in the table may be inadequate in some circumstances. It is therefore advisable to determine the de-embrittlement conditions for critical parts by experiment.

A.2 Products requiring coating thicknesses of 5 µm or greater and hydrogen embrittlement relief treatment may be electroplated in two stages with an intermediate hydrogen embrittlement relief operation.

Annex B
(normative)

Determination of group and batch average thicknesses

B.1 Determination for cadmium and zinc

B.1.1 Procedure

Degrease the group of components in an organic solvent, dry thoroughly and weigh to an accuracy of 1 in 10 000; then totally immerse the components in the requisite stripping solution and turn them over to allow free access to all surfaces. After the effervescence has ceased, remove the samples, wash immediately in running water, and wipe with a soft cloth to remove any loose deposits. Immerse in clean acetone, remove, dry thoroughly and reweigh.

B.1.2 Reagents

A stripping solution consists of

— hydrochloric acid (1,16 g/ml $\leqslant \varrho \leqslant$ 1,18 g/ml) : 800 ml

— distilled water : 200 ml

— antimony trioxide : 20 g

B.1.3 Calculations

B.1.3.1 Calculate the group average thickness of coating, in micrometres, using the following formula :

$$\text{Thickness} = \frac{K(m_0 - m_1)}{A}$$

where

K is a factor dependent on the density of the deposit metal;

m_0 is the original mass, in grams, of the group;

m_1 is the final mass, in grams, of the group;

A is the total area, in square centimetres, of the group of components.

B.1.3.2 Values of K are as follows :

— for cadmium, K = 1 160, assuming a mass density of 8,6 g/cm^3 for cadmium;

— for zinc, K = 1 410, assuming a mass density of 7,1 g/cm^3 for zinc.

B.1.3.3 Calculate the sample average thickness from the following ratio :

$$\text{Batch average thickness} = \frac{\text{Sum of all relevant group average thicknesses}}{\text{Number of groups}}$$

B.2 Determination for nickel and nickel with chromium

B.2.1 Procedure

Degrease the group of components in an organic solvent, dry thoroughly and weigh to an accuracy of 1 in 10 000.

If the group of components has been chromium-plated, remove the chromium by immersing and stirring them in stripping solution A, which dissolves the chromium in less than 2 min, after which time there should be no appreciable gassing. The components should be removed without delay and rinsed in water, prior to stripping the nickel by the method given in either B.2.1.1 or B.2.1.2.