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Metallic coatings — Electrodeposited coatings of nickel

Revêtements métalliques — Dépôts électrolytiques de nickel

Reference number
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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 1458 was prepared by Technical Committee ISO/TC 107, *Metallic and other inorganic coatings.*

This second edition cancels and replaces the first edition (ISO 1458 : 1974), 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 — Electrodeposited coatings of nickel

1 Scope and field of application

1.1 This International Standard specifies requirements for nickel electrodeposited coatings that are applied to iron and steel, to zinc alloys, to copper or copper alloys, and to aluminium and aluminium alloys to provide an attractive appearance and corrosion resistance. Several classes of coatings are provided that differ in thickness and guidance is given in selecting the coating class appropriate to the service conditions to which the coated product will be exposed.

1.2 The nickel coatings without chromium topcoats that are specified in this International Standard are suitable for applications in which tarnishing is prevented by rubbing or handling in service, or by the use of topcoats other than chromium. They are also suitable for those applications where tarnishing is of no importance.

NOTE — Similar coatings that provide an attractive appearance and corrosion resistance, and that do not tarnish in service are specified in ISO 1456. Coatings of nickel used for engineering purposes are covered by ISO 4526.

1.3 This International Standard does not specify the surface condition required by the basis metal prior to the coating process.

1.4 This International Standard is not applicable to coatings on sheet strip or wire in the unfabricated form nor to threaded fasteners or coil springs.

2 References

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

ISO 1462, *Metallic coatings — Coatings other than those anodic to the basis metal — Accelerated corrosion tests — Method for the evaluation of the results.*

ISO 1463, *Metal and oxide coatings — Measurement of thickness by microscopical examination of cross-sections.*

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

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

ISO 2361, *Electrodeposited nickel coatings on magnetic and non-magnetic substrates — Measurement of coating thickness — Magnetic method.*

ISO 2819-1, *Metallic coatings on metallic substrates — Review of methods available for testing adhesion — Part 1 : Electrodeposited and chemically deposited coatings.*

ISO 2859, *Sampling procedures and tables for inspection by attributes.*

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

ISO 3769, *Metallic coatings — Acetic acid-salt spray test (ASS test).*

ISO 3770, *Metallic coatings — Copper-accelerated acetic salt spray test (CASS test).*

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

ISO 4526, *Metallic coatings — Electroplated coatings of nickel for engineering purposes.*

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 2064 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 :

4.1.1 The number of this International Standard.

4.1.2 The basis metal and either the service condition number (see 5.1) denoting the severity of the conditions to be withstood by the coated article or the classification code (see 5.2) of the particular coating required.

If the basis metal and the service condition number are quoted and not the classification code, the electroplater is free to supply any of the classes of coating corresponding to the service condition number, but he shall inform the purchaser of the classification code of the coating which he has selected.

4.1.3 The finish required, for example, bright, dull, or satin (see 7.2). Alternatively, samples showing the required finish or range of finish shall be supplied or approved by the purchaser.

4.1.4 Significant surfaces to be indicated on drawings of the parts, or by the provision of suitably marked specimens.

4.1.5 The corrosion test to be used (see 7.4).

4.1.6 The type of adhesion test to be used (see 7.3), if any.

4.1.7 The extent to which defects are able to be tolerated on non-significant surfaces (see 7.1).

4.1.8 The positions on the significant surface for rack or contact marks, where such marks are unavoidable (see 7.1).

4.1.9 Sampling methods and acceptance levels (see clause 8).

4.2 Additional information

The following additional information may be provided by the purchaser, when appropriate :

4.2.1 The tensile strength of the steel and any requirement for heat treatment either before or after electroplating (see clause 6).

4.2.2 Thickness requirements on those areas that cannot be touched by a ball 20 mm in diameter (see 7.2.1).

4.2.3 Whether or not a copper undercoat is required [see 5.2 b)].

5 Classification

5.1 Service condition number

The service condition number is used by the purchaser to specify the degree of protection required, as related to the severity of the conditions to which a product is to be subjected, in accordance with the following scale :

3 — Severe

2 — Moderate

1 — Mild

0 — Exceptionally mild

Typical service conditions for which the various service condition numbers are appropriate are listed in annex E.

5.2 Coating classification code

The coating classification code comprises the following :

a) The chemical symbol for the basis metal (or for the principal metal if an alloy) followed by a stroke, as follows :

— Fe/ for iron or steel;

— Zn/ for zinc alloys;

— Cu/ for copper or copper alloys;

— Al/ for aluminium or aluminium alloys.

b) The chemical symbol for copper (Cu), if copper or brass containing more than 50 % copper is used as an undercoat.

c) A number indicating the minimum local thickness, in micrometres, of the copper coating where applicable.

d) The chemical symbol for nickel (Ni).

e) A number indicating the minimum local thickness of the nickel coating in micrometres.

f) A letter designating the type of nickel coating (see 7.2.3.2).

Example of a complete classification code : A coating on steel comprising 20 µm copper (minimum) plus 30 µm bright nickel (minimum) has the classification code

Fe/Cu20 Ni30b

NOTE — The minimum thickness requirements apply only to those portions of the significant surface that can be touched by a ball 20 mm in diameter unless otherwise specified by the purchaser (see 7.2.1).

5.3 Coatings appropriate to each service condition number

Tables 2 to 5 show, for various basis metals, the coating classification codes appropriate for each service condition number.

6 Heat treatment of steel

NOTE — Work is at present being undertaken that may further refine the contents of this clause.

If the purchaser specifies that heat treatment is necessary (see 4.2.1) before and/or after electroplating, it shall be carried out in accordance with the appropriate recommendations given in annex A.

7 Coating requirements

7.1 Appearance

Over the significant surface, there shall be no clearly visible plating defects such as blisters, pits, roughness, cracks, unplated areas, stains or discolorations. The extent to which

defects may occur on non-significant surfaces shall be specified by the purchaser. Where rack marks on the significant surface are unavoidable, their position on the surface shall be specified by the purchaser.

7.2 Thickness and type of coatings

7.2.1 General

For a specified service and condition number, thickness and type of coatings shall correspond to the classification codes given in tables 2 to 5. The minimum allowable thickness for the metal coatings shall be required on any point on the significant surface that can be touched by a ball 20 mm in diameter and the purchaser may also specify that other points shall meet those thickness requirements. Test methods for determining coating thickness are specified in 9.1.

7.2.2 Thickness of copper coatings

For copper plus nickel coatings, the minimum thickness for copper is indicated in the notes to tables 2 to 5.

NOTE — All the nickel coatings given in table 3 are applied over an undercoat of copper having a thickness of 8 µm [see 5.2 b)]. However, for articles of complex shape, the minimum thickness of copper on the significant surface may need to be increased to 10 µm or 12 µm in order to achieve adequate coverage on low-current areas outside the significant surface.

7.2.3 Thickness and type of nickel coatings

7.2.3.1 Thickness of nickel coating

The total minimum thickness of nickel shall be that designated by the classification code (see 5.2).

7.2.3.2 Type of nickel coating

The type of nickel coating shall be designated by the following symbols :

b for nickel deposited in the fully bright condition;

p for dull or semi-bright nickel which has been mechanically polished;

s for dull, satin, or semi-bright nickel which shall not have been mechanically polished;

d for double or triple-layer coatings; the requirements for such coatings are given in table 1.

NOTES

1 The test method for the determination of specific elongation is specified in annex C.

2 The sulfur contents are specified in order to indicate the type of nickel plating solution that is to be used. No simple method exists for determining the sulfur content of a nickel deposit on a coated article.

However, an accurate determination is possible on a specially prepared test specimen using either of the methods specified in annex D.

3 It will usually be possible to identify the type and to determine the ratios of thicknesses of nickel layers by microscopical examination of a polished and etched section of an article prepared in accordance with ISO 1463.

7.3 Adhesion

The coating shall be sufficiently adherent to the basis metal, and the separate layers of a multilayer coating shall be sufficiently adherent to each other, to pass the appropriate test specified in 9.2.

7.4 Corrosion resistance

Coated articles shall be sufficiently corrosion-resistant and pore-free to pass the appropriate test specified in 9.3 for the particular service condition number. The performance rating shall be determined in accordance with ISO 1462. The minimum acceptance rating, after testing in accordance with 9.3, shall be a rating of 9.

8 Sampling

The method of sampling shall be selected from the procedures specified in ISO 2859 or ISO 4519. The acceptance levels shall be specified by the purchaser.

9 Methods of test

9.1 Thickness

The thickness of a coating and of its component layers shall be measured at any part of the significant surface that can be touched by a ball 20 mm in diameter. The coulometric method specified in ISO 2177 may be used to measure the total thickness of nickel, the thickness of the copper and the thickness of an alloy undercoat, if its composition is known.

Table 1 — Requirements for double- or triple-layer nickel coatings

Layer (type of nickel coating)	Specific elongation % (see note 1)	Sulfur content % (*m*/*m*) (see note 2)	Thickness, as a percentage of total nickel thickness (see note 3)	
			Double-layer	Triple-layer
Bottom (s)	> 8	< 0,005	> 60	> 50
Middle (high-sulfur) (b)	—	> 0,15	—	10
Top (b)	—	> 0,04 and < 0,15	< 40	< 40

The microscopical method specified in ISO 1463 may be used to measure the thickness of each nickel layer where the minimum thickness is 10 µm, and of a copper or copper alloy layer, when present (see 7.2).

NOTE — The thickness of the individual nickel layers in double-layer and triple-layer coatings, as well as the electrochemical relationships between the individual layers, can also be measured by the STEP test[1]. Because this test can be used on production parts, it is being evaluated intensively and being incorporated in company and national standards. The optimum value of the potential difference between bright and semi-bright nickel layers to assure good corrosion performance is still a matter of controversy, but one company has specified that it shall be not less than 125 mV. It is recommended that users of this International Standard become familiar with this test and begin using it, because it has the potential of greatly improving the quality of electroplated production parts.

The magnetic method specified in ISO 2361 may be used to measure the total thickness of b, d, s or p nickel on zinc alloys and copper alloys, and on ferrous materials, if an appropriate calibration can be made. Other methods may be used if it can be demonstrated that the uncertainty of the measurement is less than 10 %.

In cases of dispute, the coulometric method shall be used for measuring the thickness of nickel coatings of thickness less than 10 µm and the microscope method shall be used for measuring those of thickness greater than 10 µm.

9.2 Adhesion

Adhesion of the coating shall be tested by either the file test or the thermal shock test specified in ISO 2819. There shall not be any detachment of the coating from the substrate, or any separation between layers of the coating.

9.3 Corrosion resistance

Nickel coatings without chromium topcoats are not widely used and, as a result, there is limited information about their performance in accelerated tests and in actual service.

Coated articles shall be subjected to one of the corrosion tests specified in annex B for the particular service condition number. The particular test to be used shall be specified by the purchaser. The duration of each corrosion test has not been established experimentally and the times suggested in annex B are provided for guidance. In order to assure that the coatings render a useful service, the duration of the corrosion test shall be approved by the purchaser, taking into account the requirements of the particular application and its intended service.

The corrosion tests are specified in ISO 3769 and ISO 3770 and provide a means of controlling the continuity and quality of the coating. However, the duration of these tests bears little relationship to the service life of the finished article, especially in connection with the nickel coatings covered in this International Standard.

After the articles have been subjected to the appropriate corrosion test, they shall be examined and rated in accordance with ISO 1462 (see 7.4).

9.4 Ductility

The ductility shall be such that the elongation will be not less than stated in 7.2.3.2 for nickel when tested by the method specified in annex C.

Table 2 — Nickel coatings on steel (or iron)

Service condition number	Classification code[1)]
3	Fe/Ni30b
2	Fe/Ni20b
1	Fe/Ni10b
0	Fe/Ni5b

1) s nickel may be substituted for b nickel in each classification number. p or d nickel may be substituted for b nickel in service condition numbers 3, 2 and 1.

2) A copper undercoat may be used. If the minimum thickness of copper is 20 µm, then for service condition number 3, the minimum thickness of nickel can be reduced by 5 µm below the value stated in the table. When a copper undercoat is used for service condition numbers 0, 1 and 2, no reduction in minimum nickel thickness shall be made.

Table 3 — Nickel coatings on zinc alloys

Service condition number	Classification code[1)]
3	Zn/Cu Ni25b
2	Zn/Cu Ni15b
1	Zn/Cu Ni10b
0	Zn/Cu Ni5b

1) s nickel may be substituted for b nickel in each classification number. p or d nickel may be substituted for b nickel in service condition numbers 3, 2 and 1.

2) If the minimum thickness of copper is increased to 15 µm, then for service condition 3 it is permissible to reduce the minimum thickness of nickel by 5 µm below the value stated in the table. No reduction in the minimum thickness of nickel is made for other service conditions when additional copper is used.

Table 4 — Nickel coatings on copper and copper alloys

Service condition number	Classification code[1)]
3	Cu/Ni20b
2	Cu/Ni10b
1	Cu/Ni5b
0	Cu/Ni3b

1) s nickel may be substituted for b nickel for each service condition. p or d nickel may be substituted for b nickel in service condition numbers 3 and 2.

Table 5 — Nickel coatings on aluminium and aluminium alloys

Service condition number	Classification code[1)]
3	Al/Ni30b
2	Al/Ni20b
1	Al/Ni10b

1) p, d, or s nickel may be substituted for b nickel for each service condition number.

10 Bibliography

[1] HARBULAK, E. P., Simultaneous Thickness and Electrochemical Potential Determination of Individual Layers in Multilayer Nickel Deposits, *Plating and Surface Finishing, 67 (February)*, **49** (1980).

Annex A

Recommendations for heat treatment of steel

(This annex forms an integral part of the Standard.)

Heat treatment is normally necessary for some steels to reduce the risk of damage by hydrogen embrittlement and can comprise

a) stress relief before electroplating;

b) heat treatment after electroplating.

Recommendations for such treatment are summarized in table 6.

Table 6 — Recommendations for heat treatment of steels

	Before electroplating	After electroplating		
Steel components normally requiring heat treatment	Components that have been severely cold-worked or that are made from steel of tensile strength of 1 000 MPa (or corresponding hardness[1]) or greater, that have been ground or subjected to severe machining after tempering.	Components that are made from severely cold-worked steels or from steels of tensile strength of 1 000 MPa (or corresponding hardness[1]) and that are subject to fatigue or sustained loading stress in service.		
Heat treatment **a) General recommendations**	30 min at the highest temperature within the limit imposed by the tempering temperature **but not higher than 50 °C below the tempering temperature** or 1 h minimum at a temperature of between 190 and 210 °C	**Tensile strength** MPa	**Maximum thickness of component** mm	**Minimum period at 190 to 210 °C** h
		> 1 000 and ⩽ 1 150	< 12	2
			12 to 25	4
			> 25	8
		> 1 150 and ⩽ 1 400	< 12	4
			12 to 25	12
			> 25	24
				NOTE — Heating to commence within 16 h of plating.
b) Restrictions	Steels that have been carburized, flame- or induction-hardened shall be heated at a lower temperature for a longer period, e.g. more than 1 h at a temperature of 170 °C.	If the components have been surface-hardened, they shall be heated at a lower temperature for a longer period, provided that these conditions have been shown to be effective for a particular component and are acceptable to the purchaser.		

1) 30 HRC, 295 HV, 280 HB (approximate values).

Annex B

Guidance on corrosion testing of nickel coatings

(This annex forms an integral part of the Standard.)

Service condition number	Duration (in hours) of corrosion test[1)]	
	CASS test (ISO 3770)	Acetic acid salt spray test (ISO 3769)
3	16	96
2	8	24
1	4	8

1) The duration of each corrosion test has not been established experimentally and the times indicated are provided as a guidance only (see 9.3).

NOTE — There are no corrosion test requirements for service condition 0.