INTERNATIONAL STANDARD 1456

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Metallic coatings — Electroplated coatings of nickel plus chromium

Revêtements métalliques — Dépôts électrolytiques de nickel plus chrome

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up 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.

Prior to 1972, the results of the work of the Technical Committees were published as ISO Recommendations; these documents are now in the process of being transformed into International Standards. As part of this process, Technical Committee ISO/TC 107 has reviewed ISO Recommendation R 1456 and found it suitable for transformation. International Standard ISO 1456 therefore replaces ISO Recommendation R 1456-1970.

The Member Bodies of the following countries approved the Recommendation :

Australia	Iran	South Africa, Rep. of
Czechoslovakia	Israel	Spain
Egypt, Arab Rep. of	Italy	Sweden
Finland	Netherlands	Switzerland
France	New Zealand	Thailand
Germany	Norway	Turkey
Hungary	Poland	United Kingdom
India	Portugal	U.S.A.

No Member Body expressed disapproval of the Recommendation.

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Metallic coatings — Electroplated coatings of nickel plus chromium

0 INTRODUCTION

This International Standard covers a range of coatings of nickel plus chromium on iron and steel, zinc alloys, copper and copper alloys, for various service conditions. Coatings of copper plus nickel plus chromium on steel are covered by ISO 1457.

For both nickel and chromium deposits, the minimum thickness requirements apply only to those portions of the significant surface that can be touched by a ball 20 mm in diameter. If the design of the article is such that it cannot at all points be touched by a 20 mm ball, the minimum thickness permitted on specified areas shall be agreed between the interested parties.

Of the laboratory corrosion tests included in this International Standard, only the acetic acid salt spray test is appropriate for all coatings, the duration of the test being varied according to the service condition number. For the highest quality coatings on steel or on zinc alloys, the shorter-term CASS or the Corrodkote test may be used instead.

Acceptance or rejection of an article subjected to corrosion tests is governed by the extent of basis metal corrosion. Surface deterioration of the coating itself will occur on some types of coating, and it is recommended that the extent to which this can be tolerated should be subject to agreement between the interested parties.

It is essential that the purchaser state the basis metal and the service condition number; in addition he may also state the classification number : merely to ask for plating to be carried out in accordance with ISO 1456 without this additional information is insufficient.

1 SCOPE AND FIELD OF APPLICATION

This International Standard is applicable to electroplated coatings of nickel plus chromium on iron and steel, zinc alloys, copper and copper alloys, except for the following :

— coatings applied to machine screw threads (with tolerance);

— coatings applied to sheet, strip or wire in the unfabricated form, or to coil springs;

— coatings applied for other than protective and decorative purposes.

This International Standard does not specify the surface condition of the basis metal prior to plating; agreement on the degree of roughness which is acceptable shall be reached between the interested parties.

2 REFERENCES

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 the thickness — Microscopical examination of cross-sections.*

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

3 DEFINITION

For the purposes of this International Standard the following definition applies :

significant surface : The part of the surface which is essential to the appearance or serviceability of the article and which is to be covered, or is covered, by the coating.

When necessary the significant surface shall be the subject of agreement, and shall be indicated on drawings or by the provision of suitably marked samples.

4 MANNER OF SPECIFYING REQUIREMENTS

When ordering the plating of articles in accordance with this International Standard, the purchaser shall state, in addition to the number of the International Standard, the service condition number denoting the severity of the condition the coating is required to withstand (see 5.1). He need not, but he may if he wishes, also state the classification number of the particular coating required (see 5.2). If the service condition number is quoted and not the classification number, the supplier 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 number of the coating supplied.

5 CLASSIFICATION

5.1 Grading of service conditions

The service condition number indicates the severity of the service conditions in accordance with the following scale :

4 – exceptionally severe
3 – severe
2 – moderate
1 – mild

These designations are conventional and it is recommended that the choice of the service condition number corresponding to the use of the part to be plated should be the subject of agreement between the interested parties.

5.2 Classification of coatings

The classification number comprises :

a) the chemical symbol for the basis metal (or for the principal metal if an alloy) as follows :

- Fe for iron or steel;
- Zn for zinc alloys;
- Cu for copper or copper alloys;

b) the chemical symbol for nickel, Ni;

c) a number indicating the minimum thickness (in micrometres) of the nickel coating;

d) a letter designating the type of nickel coating as follows :

- b for nickel deposited in the fully bright condition;
- p for dull or semi-bright nickel requiring polishing to give full brightness;
- d for a double-layer or triple-layer nickel coating;

e) the chemical symbol for chromium, Cr;

f) a letter designating the type of chromium coating and its minimum thickness as follows :

- r for regular (i.e. conventional) chromium;
- f for chromium free from cracks;
- mc for micro-cracked chromium;
- mp for micro-porous chromium.

Example of complete classification number : A coating on steel comprising 40 μm (minimum) bright nickel plus 0,3 μm (minimum) micro-cracked chromium has the classification number :

Fe/Ni40b Cr mc

5.3 Coatings appropriate to each service condition number

Tables 1 to 3 show, for the various basis metals, the coating classification numbers appropriate for each service condition number.

TABLE 1 – Coatings on iron or steel

Service condition number	Classification number
4	Fe/Ni40b Cr mc Fe/Ni40b Cr mp Fe/Ni40p Cr r Fe/Ni30p Cr mc Fe/Ni30p Cr mp Fe/Ni40d Cr r Fe/Ni40d Cr f Fe/Ni30d Cr mc Fe/Ni30d Cr mp
3	Fe/Ni40b Cr r Fe/Ni30b Cr mc Fe/Ni30b Cr mp Fe/Ni30p Cr r Fe/Ni25p Cr mc Fe/Ni25p Cr mp Fe/Ni30d Cr r Fe/Ni30d Cr f Fe/Ni25d Cr mc Fe/Ni25d Cr mp
2*	Fe/Ni20b Cr r
1*	Fe/Ni10b Cr r

* p or d nickel may be substituted for b nickel and f, mc or mp chromium may be substituted for r chromium for service condition numbers 2 and 1.

TABLE 2 — **Coatings on zinc alloy**

Service condition number	Classification number
4	Zn/Cu Ni35b Cr f Zn/Cu Ni35b Cr mc Zn/Cu Ni35b Cr mp Zn/Cu Ni35p Cr r Zn/Cu Ni35p Cr f Zn/Cu Ni25p Cr mc Zn/Cu Ni25p Cr mp Zn/Cu Ni35d Cr r Zn/Cu Ni35d Cr f Zn/Cu Ni25d Cr mc Zn/Cu Ni25d Cr mp
3	Zn/Cu Ni35b Cr r Zn/Cu Ni25b Cr f Zn/Cu Ni25b Cr mc Zn/Cu Ni25b Cr mp Zn/Cu Ni25p Cr r Zn/Cu Ni25p Cr f Zn/Cu Ni20p Cr mc Zn/Cu Ni20p Cr mp Zn/Cu Ni25d Cr r Zn/Cu Ni25d Cr f Zn/Cu Ni20d Cr mc Zn/Cu Ni20d Cr mp
2*	Zn/Cu Ni15b Cr r
1*	Zn/Cu Ni8b Cr r

* p or d nickel may be substituted for b nickel and f, mc or mp chromium may be substituted for r chromium for service condition numbers 2 and 1.

Tables 1 and 2 :

All these coatings shall be applied over an undercoat of copper or brass (at least 50 % copper) having a minimum thickness of 8 μm, but for articles of complex shape the minimum thickness on the significant surface may need to be increased to 10 or 12 μm in order to achieve adequate coverage. The method for determining the thickness of the undercoat is given in Annex B.

TABLE 3 — **Coatings on copper or copper alloy**

Service condition number	Classification number
4	Cu/Ni25b Cr mc Cu/Ni25b Cr mp Cu/Ni30p Cr r Cu/Ni25p Cr mc Cu/Ni25p Cr mp Cu/Ni30d Cr r Cu/Ni30d Cr f Cu/Ni25d Cr mc Cu/Ni25d Cr mp
3*	Cu/Ni20b Cr r
2*	Cu/Ni10b Cr r
1*)**)	Cu/Ni5b Cr r

* p or d nickel may be substituted for b nickel and f, mc or mp chromium may be substituted for r chromium for service condition numbers 3, 2 and 1.

** When the coating is applied for anti-tarnish purposes only, the minimum thickness of nickel may be reduced to 3 μm by agreement between the interested parties.

6 HEAT TREATMENT OF STEEL

When required by the purchaser, heat treatment as described below shall be performed on certain steels to reduce the risk of damage by hydrogen embrittlement.

6.1 Stress relief before plating

Severely cold-worked steel parts or parts made from steel of tensile strength of 1 000 N/mm² (or corresponding hardness[1]) or greater, which have been ground or subjected to severe machining after tempering, shall normally be stress relieved. As a guide, they may be maintained, preferably, at the highest temperature within the limit imposed by the tempering temperature for 30 min, or maintained at a temperature of 190 to 210 °C for not less than 1 h.

Some steels which have been carburized, flame-hardened or induction-hardened and subsequently ground would be impaired by the treatment given before as guidance and shall instead be stress relieved at a lower temperature, for example at 170 °C for not less than 1 h.

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

6.2 Heat treatment after plating

Components subject to fatigue or sustained loading stresses in service and made from severely cold-worked steels or from steels of tensile strength of 1 000 N/mm² (or corresponding hardness[1]) or greater, shall be heat treated after plating. Guidance is given in Annex A.

Where the heat treatment temperatures would be harmful, as for example to certain surface-hardened articles, it may be necessary to apply a lower temperature for a longer time.

7 REQUIRED CHARACTERISTICS

7.1 General requirements

7.1.1 *Appearance*

Over the significant surface, the plated article shall be free from clearly visible plating defects such as blisters, pits, roughness, cracks or unplated areas, and shall not be stained or discoloured. The extent to which blisters can be tolerated on non-significant surfaces shall be the subject of agreement between the interested parties. On articles where a contact mark is inevitable, its position shall also be the subject of agreement between the interested parties.

The article shall be clean and free from damage. The purchaser shall state the appearance required, for example bright, dull or satin. Alternatively, a sample showing the required finish shall be supplied or approved by the purchaser.

7.1.2 *Thickness*

The number following the chemical symbol Ni indicates, in micrometres, the minimum thickness of the nickel coating, measured by the method given in Annex B, at points on the significant surface agreed between the interested parties or at any point on the significant surface that can be touched by a ball 20 mm in diameter. This number shall satisfy the appropriate value in Table 1, Table 2 or Table 3.

The thickness of the chromium coating shall be measured by the method given in Annex C at points on the significant surface agreed between the interested parties or at any point on the significant surface that can be touched by a ball 20 mm in diameter.

If the design of the article is such that it cannot at all points be touched by a 20 mm ball, the minimum thickness permitted on specified areas shall be agreed between the interested parties.

7.1.3 *Adhesion*

Adhesion of the coating shall be tested by one of the methods specified in Annexes D and E. The coating shall continue to adhere to the basis metal when subjected to the test selected.

7.1.4 *Corrosion resistance*

Coated articles shall be subjected for the stated time to one of the corrosion tests shown in Table 4, appropriate for the particular service condition number. The tests are described in detail in Annexes F, G and H.

The corrosion tests indicated in Table 4 are a means of controlling the continuity and quality of the coatings and the duration of the tests does not necessarily have a fixed relationship with the service life of the finished article.

TABLE 4 — **Tests appropriate for each service condition number**

Basis metal	Service condition	Duration (in hours) of corrosion test		
		CASS (see Annex F)	Corrodkote (see Annex G)	Acetic salt (see Annex H)
Steel	4	24	2 × 16	144
	3	16	16	96
	2	—	—	24
	1	—	—	8
Zinc alloy	4	24	2 × 16	144
	3	16	16	96
	2	—	—	24
	1	—	—	8
Copper or copper alloy	4	16	—	96
	3	—	—	24
	2	—	—	8
	1	—	—	—

NOTE — It will be noticed that the duration of tests is less when the basis metal is copper or copper alloy than when it is iron or steel or zinc alloy. This is necessary since, for the same service condition number, the nickel deposits on copper and copper alloy are thinner than those on iron or steel or zinc alloy. The use of these thinner and less corrosion-resistant coatings is justified by the slower corrosion of copper and copper alloys when the coatings are penetrated. The duration of the corrosion tests is not, therefore, to be understood as a direct indication of overall performance in service.

After the article has been subjected to the treatment described in the relevant test method (see Annex F, G or H) it shall be examined by the procedure described in Annex J to determine whether it passes or fails the test.

Surface deterioration of the coating itself is expected to occur during tests on some types of coating. The extent to which surface deterioration can be tolerated shall be subject to agreement between the interested parties.

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

7.2 Particular requirements for various types of coating

7.2.1 *Nickel coating*[1)]

7.2.1.1 DULL OR SEMI-BRIGHT COATING (p NICKEL)

– Sulphur content : 0,005 % maximum[2)].

– Elongation : 8 % minimum when tested by the method given in Annex K.

7.2.1.2 DOUBLE-LAYER OR TRIPLE-LAYER COATING (d NICKEL)

a) Bottom layer

– Sulphur content : 0,005 % maximum[2)].

– Elongation : 8 % minimum when tested by the method given in Annex K.

– Minimum thickness : 60 % of the total nickel thickness in double-layer coating; 50 % of the total nickel thickness in triple-layer coating.

b) Top layer

– Sulphur content : more than 0,04 %[2)].

– Minimum thickness : 20 % of the total nickel thickness.

c) Intermediate layer (in case of triple-layer coatings)

– Sulphur content : more than the sulphur content of the top layer

– Maximum thickness : 10 % of the total nickel thickness.

7.2.2 *Chromium coating*

7.2.2.1 REGULAR (CONVENTIONAL) CHROMIUM (Cr r)

– Minimum thickness : 0,3 μm

7.2.2.2 CHROMIUM FREE FROM CRACKS (Cr f)

– Free from cracks when tested by the method given in Annex L, clause L.2 (except for cracks extending from the edges of the articles to 25 % of the width of the article or 10 mm whichever is the lesser).

– Minimum thickness : 0,8 μm.

7.2.2.3 MICRO-CRACKED CHROMIUM (Cr mc)

– Crack pattern showing more than 250 cracks per centimetre in any direction, forming a closed network over the whole of the significant surface, when determined by one of the methods given in Annex L.

– Minimum thickness : 0,3 μm. With some processes a substantially greater thickness about 0,8 μm, will be required to achieve the necessary crack-pattern.

7.2.2.4 MICRO-POROUS CHROMIUM (Cr mp)[3)]

– Number of pores : at least 10 000/cm^2 when determined by the method given in Annex L, clause L.2. The pores shall be invisible to the unaided eye.

– Minimum thickness : 0,3 μm

There may be some loss of lustre after a period of service in the case of mp chromium deposits which could be unacceptable in some applications. This tendency can be reduced by increasing the chromium deposit thickness in every case where micro-porous chromium is specified in Tables 1 to 3. The modified designation to be used in such cases in place of Cr mp is as follows :

Cr mp 0,5

The figure refers to the minimum thickness of chromium in micrometres.

8 SAMPLING

The method of sampling shall be agreed between the interested parties.

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1) It will usually be possible to identify the type of nickel by microscopical examination of a polished and etched section of an article prepared according to Annex K.

2) The sulphur 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 sulphur content of a nickel deposit on a coated article. An accurate determination is possible on a specially prepared test specimen.

3) This is commonly achieved by depositing chromium over a special thin nickel layer which contains inert non-conducting particles and is applied on top of normal b, p and d nickel.

ANNEX A

GUIDANCE ON HEAT TREATMENT OF STEEL PARTS AFTER PLATING

Tensile strength	Maximum sectional thickness of part	Minimum period at 190 to 210 °C
N/mm²	mm	h
1 000 to 1 150	Less than 12	2
	12 to 25	4
	Over 25	8
1 150 to 1 400	Less than 12	4
	12 to 25	12
	25 to 40	24
	Over 40	Heating to commence within 16 h of plating Requires experimental determination

ANNEX B

DETERMINATION OF THICKNESS OF NICKEL AND COPPER OR BRASS MICROSCOPIC METHOD

Use the method described in ISO 1463.

If etching is necessary, the following etchants are suitable :

1) equal parts by volume of nitric acid (ρ 1,42 g/ml) and glacial acetic acid;

2) equal parts by volume of solutions of sodium cyanide (100 g/l) and sodium or ammonium persulphate (100 g/l).

WARNING : Toxic fumes are evolved when solutions of these chemicals are mixed.

ANNEX C

DETERMINATION OF CHROMIUM THICKNESS
COULOMETRIC METHOD

Use the method specified in ISO 2177, using electrolyte B4 as test solution.

The thickness, in micrometres, of the chromium coating is given by the following formula (assuming 100 % current efficiency) :

$$s = 0{,}126 \frac{Q}{A}$$

where

Q is the quantity of electricity consumed, in coulombs;

A is the area tested, in square centimetres.

ANNEX D

FILE TEST FOR ADHESION

Saw off a piece of a plated article, hold it in a vice and apply a coarse file to the cut edge in such a manner as to try to raise the deposit. File in the direction from the basis metal to the coating at an angle of approximately 45° to the coated surface.

ANNEX E

QUENCHING TEST FOR ADHESION

Heat a plated article for 1 h in an oven at a temperature appropriate to the basis metal as given below, with a tolerance of ± 10 °C :

– steel	300 °C
– zinc alloy	150 °C
– copper or copper alloy	250 °C

Then quench the article in water at room temperature.

CAUTION. This may have an adverse effect on the mechanical properties of the article tested.