
INTERNATIONAL STANDARD



1457

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Metallic coatings — Electroplated coatings of copper plus nickel plus chromium on iron or steel

Revêtements métalliques — Dépôts électrolytiques de cuivre plus nickel plus chrome sur fer ou acier

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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 1457 and found it suitable for transformation. International Standard ISO 1457 therefore replaces ISO Recommendation R 1457-1970.

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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.

Metallic coatings — Electroplated coatings of copper plus nickel plus chromium on iron or steel

0 INTRODUCTION

This International Standard covers a range of coatings of copper plus nickel plus chromium on iron and steel for various service conditions.

For copper, 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 on 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.

The duration of the laboratory corrosion tests is varied according to the service condition number. 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 1457 without this additional information is insufficient.

1 SCOPE AND FIELD OF APPLICATION

This International Standard applies to electroplated coatings of copper plus nickel plus chromium on iron and steel, 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 should 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 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 purchaser and the supplier.

5.2 Classification of coatings

The classification number comprises :

- a) the chemical symbol, Fe, for the basis metal (iron or steel), followed by an oblique stroke;
- b) the chemical symbol for copper, Cu;
- c) a number indicating the minimum thickness (in micrometres) of the copper coating;
- d) the chemical symbol for nickel, Ni;
- e) a number indicating the minimum thickness (in micrometres) of the nickel coating;
- f) 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;
- g) the chemical symbol for chromium, Cr;
- h) 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 comprising 20 µm (minimum) copper plus 25 µm (minimum) bright nickel plus 0,3 µm (minimum) micro-cracked chromium has the classification number :

Fe/Cu20 Ni25b Cr mc

5.3 Coatings appropriate to each service condition number

Table 1 shows the coating classification numbers appropriate to each service condition number.

TABLE 1 – Coatings on iron or steel

Service condition number	Classification number
4	Fe/Cu20 Ni25b Cr mc Fe/Cu20 Ni25b Cr mp Fe/Cu20 Ni30p Cr r Fe/Cu20 Ni25p Cr mc Fe/Cu20 Ni25p Cr mp Fe/Cu20 Ni30d Cr r Fe/Cu20 Ni30d Cr f Fe/Cu20 Ni25d Cr mc Fe/Cu20 Ni25d Cr mp
3	Fe/Cu20 Ni30b Cr r Fe/Cu20 Ni20b Cr mc Fe/Cu20 Ni20b Cr mp Fe/Cu15 Ni25p Cr r Fe/Cu15 Ni20p Cr mc Fe/Cu15 Ni20p Cr mp Fe/Cu15 Ni25d Cr r Fe/Cu15 Ni25d Cr f Fe/Cu15 Ni20d Cr mc Fe/Cu15 Ni20d Cr mp
2*	Fe/Cu20 Ni10b Cr r
1*	Fe/Cu10 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 2 and 1.

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 hardness¹⁾) 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.

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

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.

6.2 Heat treatment after plating

Components subject to fatigue or sustained loading stress in service and made from severely cold-worked steels or from steels of tensile strength of 1000 N/mm² (or corresponding hardness¹⁾) 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.

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 2 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 2 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.

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 should 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 numbers following the chemical symbols Cu and Ni indicate respectively, in micrometres, the minimum thickness of the copper or brass coating and the minimum thickness of the nickel coating, measured by the method given in Annex B, at points on the significant surface agreed upon between the interested parties or at any point on the significant surface that can be touched by a ball 20 mm in diameter. These numbers shall satisfy the appropriate values in Table 1.

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TABLE 2 – Tests appropriate for each service condition number

Service condition number	Duration (in hours) of corrosion test		
	CASS (see Annex F)	Corrodokote (see Annex G)	Acetic salt (see Annex H)
4	24	2 × 16	144
3	16	16	96
2	—	—	24
1	—	—	8

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 coatings

7.2.1 Nickel coating¹⁾

7.2.1.1 DULL OR SEMI-BRIGHT COATING (P NICKEL)

- Sulphur content : 0,005 % maximum²⁾.
- 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 % maximum²⁾;
- 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, section 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/cm² when determined by the method given in Annex L, section L.2. The pores shall be invisible to the unaided eye.
- Minimum thickness : 0,3 μm

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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 contracting parties.

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/mm ²	mm	hours
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	Requires experimental determination

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ANNEX B

**DETERMINATION OF THICKNESS OF NICKEL AND COPPER OR BRASS
MICROSCOPICAL 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 described 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.

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ANNEX D

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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.

ANNEX F

CASS TEST

(Copper accelerated acetic salt spray test)

F.1 SPRAYING LIQUID

Dissolve 50 ± 5 g of sodium chloride¹⁾ (NaCl) and $0,26 \pm 0,02$ g of cupric chloride (CuCl_2) in water containing less than 100 p.p.m. of total solids or having a conductivity of less than 0,002 S/m and dilute to 1 l.

Add glacial acetic acid (CH_3COOH) to adjust the pH to $3,2 \pm 0,1$.

F.2 TEST CONDITIONS

Operating temperature inside cabinet : 50 ± 1 °C.

Spray collection rate : $1,5 \pm 0,5$ ml/h over 8 000 mm² horizontal area, averaged over at least 16 h.

Collected spray : solution containing 50 ± 10 g of sodium chloride per litre and having a pH of $3,2 \pm 0,1$.

F.3 SUGGESTED APPARATUS

A fog cabinet or room shall be made of or lined with a material resistant to the corrosive medium employed in this test (glass, rubber or certain plastics materials are suitable) and shall be provided with specimen supports meeting the same requirements.

Provision shall be made for a supply of clean air of controlled pressure and humidity, one or more spray nozzles, and means for heating the apparatus and maintaining the test temperature.

Baffles inside the cabinet shall prevent direct impingement of the spray on the specimens. The use of adjustable baffles will be found of assistance in obtaining a uniform collection rate throughout the cabinet.

The air used to provide the spray shall first be humidified by passing it through a saturator tower containing water²⁾ thermostatically maintained at the correct temperature. The temperature of the water in this tower will need to be several degrees higher than the test temperature, but shall

be adjusted according to the pressure used and the type of nozzle, so that both the collection rate and the concentration of collected fog are kept within the specified limits. It is desirable to maintain the level of the water in the saturator tower at a set height, and this is most conveniently done by an automatic level control.

It is also important to maintain a constant head between the nozzles and the test solution in the supply tank. If this cannot be done manually throughout the cycle, an automatic level control shall be fitted.

F.4 PROCEDURE

Immediately before testing, clean the specimens with a slurry of light magnesium oxide on a swab; rinse the specimens in clean running water so that they are free from water breaks.

Place the specimens in the heated cabinet so that as far as possible their significant surfaces are at an angle of 15 to 30° to the vertical. Do not allow test solution from one specimen to drip onto any other. Place at least two collector vessels in the zone where the specimens are located, but take care that only fog, and no liquid falling from specimens or parts of the cabinet and its fittings, is collected.

Restore the cabinet and saturator tower to the required temperature and commence the test. Do not recirculate the spraying liquid.

After the test is completed, rinse the specimens in clean, running water to remove any deposits of salt, and dry. For each specimen make an assessment of the frequency of corrosion spots, based on the number of spots showing evidence of basis metal corrosion.

To examine any deterioration in appearance, swab the surface using a mild abrasive to remove all corrosion products, rinse in clean water, and dry.

1) In a dry condition the sodium chloride (NaCl) shall contain not more than 0,1 % of sodium iodide (NaI) and not more than 0,3 % of total impurities.

2) The water used shall contain less than 100 p.p.m. of solids, or have a conductivity of less than 0,002 S/m.