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ELECTROPLATED COATINGS OF NICKEL PLUS CHROMIUM

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BRIEF HISTORY

The ISO Recommendation R 1456, *Electroplated coatings of nickel plus chromium,* was drawn up by Technical Committee ISO/TC 107, *Metallic and other non-organic coatings,* the Secretariat of which is held by the Ente Nazionale Italiano di Unificazione (UNI).

Work on this question led to the adoption of Draft ISO Recommendation No. 1456 which was circulated to all the ISO Member Bodies for enquiry in May 1968. It was approved, subject to a few modifications of an editorial nature, by the following Member Bodies :

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

No Member Body opposed the approval of the Draft.

This Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in April 1970, to accept it as an ISO RECOMMENDATION.

FOREWORD

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

In this ISO Recommendation the surface condition of the basis metal prior to plating is not specified and agreement should be reached between the plater and the purchaser regarding the degree of roughness of the basis metal that is acceptable.

The purchaser should specify the service condition number denoting the severity of the conditions the coating is to withstand. It is not necessary to state the classification number of the coating, defined in terms of the nature, thickness and properties of the deposits it comprises, but the purchaser may include this if he wishes.

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 should be agreed between the purchaser and the supplier.

Of the laboratory corrosion tests included in this ISO Recommendation, 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 supplier and purchaser.

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 RECOMMENDATION R 1456 WITHOUT THIS ADDITIONAL INFORMATION IS INSUFFICIENT.

ISO Recommendation R 1456 April 1970

ELECTROPLATED COATINGS OF NICKEL PLUS CHROMIUM

1. SCOPE

This ISO Recommendation defines the characteristic properties as well as the classification and the symbols of electroplated coatings of nickel plus chromium on steel (or iron), zinc alloys, copper and copper alloys. Furthermore it describes, in annexes, the test methods for these coatings.

2. FIELD OF APPLICATION

This ISO Recommendation applies to electroplated coatings defined in section 1, *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.

3. DEFINITION

For the purposes of this ISO Recommendation 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 by the coating.

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

4. APPEARANCE

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

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

5. HEAT TREATMENT FOR STEEL

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

5.1 Stress relief before plating

5.1.1 Severely cold-worked steel parts, or parts made from steel of tensile strength of about 1000 MN/m^2 (100 kgf/mm^2) or greater which have been ground or subjected to severe machining after tempering, should 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 minutes, or maintained at 190 to 210 °C for not less than 1 hour.

5.1.2 Some steels which have been carburized, flame-hardened or induction-hardened and subsequently ground would be impaired by the treatment given as guidance in clause 5.1.1, and should instead be stress relieved at a lower temperature, for example at 170 °C for not less than 1 hour.

5.2 Heat treatment after plating

5.2.1 Components subject to fatigue or sustained loading stresses in service and made from severely cold-worked steels or from steels of tensile strength of about 1000 MN/m^2 (100 kgf/mm^2) or greater should be heat treated after plating. Guidance is given in Annex L.

5.2.2 Where the proposed temperature of heat treatment would be harmful, as for some surface-hardened parts, a lower temperature for a longer time may be required.

6. COATING REQUIREMENTS

6.1 Manner of specifying requirements

When ordering the plating of articles in accordance with this ISO Recommendation, the purchaser should state, in addition to the number of the ISO Recommendation, the basis metal and the service condition number denoting the severity of the conditions the coatings are required to withstand (see clause 6.2). He need not, but he may, if he wishes, also state the classification number of the particular coating required (see clause 6.3). 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 should inform the purchaser of the classification number of the coating supplied.

6.2 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

6.3 Classification of coatings

The classification number comprises the following elements :

- the chemical symbol for the basis metal (or for the principal metal in the case of an alloy), followed by an oblique stroke;
- the chemical symbol for nickel, Ni;
- a number indicating the minimum thickness (in micrometres) of the nickel coating;
- a letter designating the type of nickel deposit;
- the chemical symbol for chromium, Cr;
- a letter designating the type of chromium deposit and its minimum thickness.

6.3.1 *Basis metal.* The following chemical symbols are used :

Fe for steel (or iron);

Zn for zinc alloy;

Cu for copper or copper alloy.

6.3.2 *Nickel deposit.* The number following the chemical symbol Ni indicates, in micrometres, the minimum thickness of the nickel deposit, measured by the method given in Annex B, at points on the significant surface agreed between the purchaser and the supplier or at any point on the significant surface that can be touched by a ball 20 mm in diameter.

The type of nickel * is designated by the following symbols :

b – for nickel deposited in the fully bright condition;

p – for dull or semi-bright nickel requiring polishing to give full brightness, containing less than 0.005 % sulphur ** and having an elongation greater than 8 % when tested by the method given in Annex A;

d – for a double-layer or triple-layer nickel coating, of which the bottom layer contains less than 0.005 % sulphur ** and has an elongation greater than 8 % when tested by the method given in Annex A and the top layer contains more than 0.04 % sulphur **; the thickness of the bottom layer in double-layer coatings should be not less than 60 % of the total nickel thickness and in triple-layer coatings should be not less than 50 % of the total nickel thickness, the thickness of the top layer in either case being not less than 20 % of the total nickel thickness. If there are three layers, the intermediate layer should contain more sulphur than the top layer and should not exceed 10 % of the total nickel thickness.

6.3.3 *Chromium deposit.* The thickness of the chromium deposit should be measured by the method given in Annex C at points on the significant surface agreed between the purchaser and the supplier or at any point on the significant surface that can be touched by a ball 20 mm in diameter.

The type of chromium is designated by the following symbols placed after the chemical symbol Cr :

r – for regular (i.e. conventional) chromium, having a minimum thickness of 0.3 μm;

f – for chromium free from cracks, when checked by the method given in Annex D, section D.2 (except for cracks extending from the edges of the article to 25 % of the width of the article or 10 mm whichever is the lesser) and having a minimum thickness of 0.8 μm;

m – for micro-cracked chromium, having 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 D, and having a minimum thickness of 0.3 μm. (With some processes a substantially greater thickness, about 0.8 μm, will be required to achieve the necessary crack pattern.)

Exemple 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 m

* 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 B.

** 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.

6.4 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 steel (or iron)**

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

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

TABLE 2 – **Coatings on zinc alloy**

All these coatings should 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.

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

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

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

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

* p or d nickel and f or m chromium may be substituted for b nickel and 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 purchaser and the supplier.

6.5 Adhesion

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

6.6 Corrosion resistance

Coated articles should 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 G, H and J.

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 number	Duration (in hours) of corrosion test		
		CASS (see Annex G)	Corrodkote (see Annex H)	Acetic salt (see Annex J)
Steel	4	24	2 X 16	144
	3	16	16	96
	2	–	–	24
	1	–	–	8
Zinc alloy	4	24	2 X 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 steel (or iron) 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 steel (or iron) 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, as given in Annex G, H or J, it should be examined by the procedure described in Annex K 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 should be subject to agreement between the supplier and the purchaser.