International Standard 2179

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Electroplated coatings of tin-nickel alloy — Specification and test methods

Dépôts électrolytiques d'alliage étain-nickel — Spécifications et méthodes d'essai

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Foreword

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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 2179 was prepared by Technical Committee ISO/TC 107, *Metallic and other non-organic coatings.*

This second edition cancels and replaces the first edition (ISO 2179-1972), 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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Electroplated coatings of tin-nickel alloy — Specification and test methods

0 Introduction

This International Standard specifies requirements for electroplated coatings of the intermetallic compound SnNi of the approximate composition 65 % (m/m) tin and 35 % (m/m) nickel. Such coatings are generally recognized as being hard, wear-resistant and corrosion resistant.

The coatings are intended for use on both ferrous and non-ferrous basis metals and also on printed circuit boards. A classification scheme is included by which the nature of the basis metal and undercoat, if any, and the coating thickness can be defined.

Annex B gives additional information as guidance to the user.

It is essential that the purchaser should state the information itemized in 4.1 and, if appropriate, 4.2. Specifying ISO 2179 without this information is insufficient.

1 Scope and field of application

This International Standard specifies requirements for electroplated coatings of the intermetallic compound SnNi, with a composition of approximately 65 % (m/m) tin and 35 % (m/m) nickel.

It does not apply to

a) threaded components;

b) coatings on sheet, strip or wire in the unfabricated form, or on articles made from them;

c) coatings on coil springs;

d) electroplating of steels with tensile strength greater than 1 000 MPa[1] (or of corresponding hardness), because such steels are subject to hydrogen embrittlement (see 8.2).

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, *Metallic and oxide coatings — Measurement of coating thickness — Microscopical method.*

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

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

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

ISO 2859, *Sampling procedures and tables for inspection by attributes.*[2]

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

ISO 3543, *Metallic and non-metallic coatings — Measurements of thickness — Beta backscatter method.*

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

ISO 6988, *Metallic and other non-organic coatings — Sulfur dioxide test with general condensation of moisture.*

3 Definition

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

(Definition taken from ISO 2064.)

1) 1 MPa = 1 N/mm²

2) At present at the stage of draft.

4 Information to be supplied by the purchaser to the electroplater

4.1 Essential information

The following information shall be supplied by the purchaser to the electroplater:

a) the number of this International Standard;

b) the nature of the basis material (see clause 5);

c) the service condition number (see 7.1) or the classification code of the coating required (see 7.2);

d) the significant surface of the article to be electroplated indicated, for example, by drawings or by the provision of suitably marked samples;

e) the sampling procedure to be adopted (see clause 6);

f) the positions where unavoidable contact marks and other defects are acceptable (see 10.1);

g) the method of adhesion testing to be used (see 10.3).

4.2 Additional information

The following additional information may be required and, if so, shall be specified by the purchaser:

a) any heat treatment required (see clause 8);

b) any requirements for porosity testing (see 10.4);

c) any special requirements for undercoats (see clause 9);

d) a sample showing the required finish (see 10.1);

e) any special pretreatment required;

f) any special packaging requirements for plated components.

5 Basis material

This International Standard specifies no requirements for the condition, finish or surface roughness of the basis material prior to electroplating (see B.2.1).

6 Sampling

Sampling procedures are specified in ISO 2859 and ISO 4519.

The method of sampling and acceptance levels shall be agreed between purchaser and supplier.

7 Classification

7.1 Service condition number

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

4: exceptionally severe — for example service outdoors in severe corrosive conditions

3: severe — for example service outdoors in typical temperate conditions

2: moderate — for example service indoors with some condensation

1: mild — for example service indoors in dry atmospheres.

NOTE — See 10.2, which gives guidance on the relation between service condition number and minimum thickness.

When specifying the service condition number or coating classification code, it should be noted that tin-nickel alloy is brittle and liable to damage by impact. See also annex B.

7.2 Coating classification code

The coating classification code shall consist of three parts, the first two of which shall be separated by an oblique stroke, as follows:

a/b c

where

a indicates the chemical symbol for the basis metal (or for the main constituent if an alloy);

b indicates the chemical symbol for the undercoat metal (or for the main constituent if an alloy) followed by a figure for its minimum thickness, in micrometres, and is omitted if no undercoat is required [see 4.2 c)];

c indicates the chemical symbol, SnNi, followed by a figure for its minimum coating thickness, in micrometres.

An example is

Fe/Cu 2,5 SnNi 10

which represents an iron or steel basis metal, with a 2,5 µm copper undercoat, tin-nickel electroplated to a thickness of 10 µm.

8 Heat treatment of steel

8.1 Stress relief before electroplating

Severely cold-worked steel parts shall be stress relieved before electroplating by heating for 1 h at 190 to 220 °C.

The properties of some steels which have been carburized, flame-hardened or induction-hardened and subsequently ground would be impaired by this treatment and shall instead be stress relieved at a lower temperature, for example at 130 to 150 °C for not less than 5 h.

8.2 Hydrogen embrittlement relief after electroplating

Because diffusion of hydrogen through tin-nickel coatings is very slow, heat treatment for hydrogen embrittlement relief after electroplating is impractical.

9 Requirements for undercoats

Undercoats may be necessary on certain basis materials for the following reasons:

a) to ensure adhesion (see B.2.2 and B.2.3);

b) to improve protection against corrosion.

Care should be taken to select an undercoat or undercoat system that will not confer undesirable properties such as embrittlement of the basis material or finished article. For example the use of highly stressed nickel should be avoided.

For use in service conditions 2, 3 or 4, an undercoat of copper, nickel, bronze or tin of minimum local thickness 8 µm is essential on steel, iron and iron alloys, in addition to the specified coating thickness of tin-nickel alloy (see 10.2).

If undercoats are specified, their nature and minimum local thickness shall be specified by the purchaser (see clause B.2).

The thickness of the undercoat or undercoats shall be measured by the method specified in A.1.1.

10 Requirements for coatings

10.1 Appearance

When examined by the unaided eye or corrected vision the significant surfaces of the electroplated article shall be free from any visible defects such as blisters, pits, roughness, cracks or unelectroplated areas and shall not be stained or discoloured.

The acceptability and positions of unavoidable contact marks and defects on non-significant surfaces shall be specified by the purchaser.

If necessary, a sample showing the required finish shall be supplied or approved by the purchaser.

10.2 Thickness

Tin-nickel coatings are classified by thickness and for each service condition (see 7.1), minimum values are specified in the table (see also clause B.1).

Table — Coating thickness

Service condition number	(Partial) classification code	Minimum thickness
		µm
4	SnNi 25	25
3	SnNi 15	15
2	SnNi 10	10
1	SnNi 5	5

NOTES

1 For certain engineering applications, tin-nickel is used solely for its wear-resistant properties and in such cases, where corrosion protection is of secondary importance, thinner coatings than those given in the table may be used (see clause B.1).

2 In very exceptional circumstances thicker coatings (for example 45 µm) than those specified in the table may be required (see clause B.1).

The thickness of the coating shall be measured over a reference area (see ISO 2064) by the appropriate method given in annex A on any part of the significant surface that can be touched with a 20 mm diameter ball. In the case of articles having a significant surface area of 100 mm^2 or greater, the minimum thickness shall be regarded as the minimum value of local thickness. In the case of articles having a significant surface area of less than 100 mm^2, the minimum thickness shall be regarded as the minimum value of average thickness.

In the case of printed circuit boards with electroplated-through holes, the requirements shall also apply to the surfaces within the holes, and not only to the areas that can be touched with a 20 mm diameter ball (see A.0.2.4).

In the case of dispute, the referee methods are given in A.0.2.

10.3 Adhesion

CAUTION — This test may have an adverse effect on the mechanical properties of the article tested. Accordingly, the thermal shock test piece shall not be used for other tests.

If specified by the purchaser, adhesion shall be tested by the thermal shock test method described in ISO 2819 using a heating period of 1 h. The specimen shall be deemed to have failed if there is evidence of the coating showing signs of detachment.

10.4 Porosity

If specified by the purchaser, coatings having a minimum thickness of 10 µm or greater shall be subjected to the test specified in ISO 6988, and the results of the test shall be evaluated in accordance with ISO 1462 and a rating number obtained. The specimen shall be deemed to have failed if

a) the coating thickness is 25 µm or more and the rating number is less than 9;

b) the coating thickness is between 10 and 25 µm and the rating number is less than that specified by the purchaser.

Annex A

Determination of coating thickness

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

A.0 Introductory notes

A.0.1 Routine methods

All the methods given in this annex are those which are considered to have an adequate accuracy when properly used with samples suitable for the particular method. The method chosen for routine test purposes shall be one which is expected to yield the most reliable results considering such factors as coating thickness, shape of component, size of component, coating composition, basis material, etc.

Other test methods may be used if it can be demonstrated that they are as good as or better than the methods given in this annex for the particular application.

A.0.2 Referee methods

A.0.2.1 General

In cases of dispute, the methods designated for referee purposes shall be in accordance with A.0.2.2. to A.0.2.4.

A.0.2.2 Local thickness greater than 9 µm

Use the microscopical method specified in A.1.1.

A.0.2.3 Local thickness less than 9 µm

Use the coulometric method specified in A.1.4 if the coating surface is sufficiently smooth and flat so that there is no leakage of the electrolyte at the cell-probe and if the substrate is copper, copper-base alloy, nickel, or steel; otherwise use the microscopical method specified in A.1.1.

NOTE — For the coulometric measurement of undercoats, it is essential to remove the tin-nickel first. This can be accomplished by the coulometric dissolution of the tin-nickel coating.

A.0.2.4 Thickness of tin-nickel in electroplated-through holes of circuit boards

Use the microscopical method specified in A.1.1. The microsection shall be parallel to the axis of the hole.

A.1 Measurement of local thickness

A.1.1 Microscopical method

Use the method specified in ISO 1463, with the overplating procedure. For deposits in excess of 9 µm it is recommended that the thickness of the overplate be of a similar thickness to that of the tin-nickel to be measured.

This method as stated has an accuracy of ±0,8 µm or, for thicknesses greater than 25 µm, to within 5 %.

A.1.2 Beta backscatter method

Use the method specified in ISO 3543, which requires the equipment and its operation to be such that the coating thickness can be determined to within 10 % of its true value; this accuracy is dependent on the mass per unit area of the coating and the effective atomic number of the basis material and any variations in the alloy composition.

A.1.3 X-ray spectrometric method

Use the method specified in ISO 3497, which requires the instrument, its calibration and its operation to be such that the coating thickness can be determined to within 10 % of its true value.

A.1.4 Coulometric method

Use the method specified in ISO 2177. This method is stated to be normally accurate to within 10 %.

When this method is used as a referee test, the density of the tin-nickel alloy shall be taken as 8,828 g/cm^3 and the composition shall be taken as 35,0 % (m/m) Ni and 65,0 % (m/m) Sn for computation of the electrochemical equivalent unless direct measurements are made of the density and composition.

A.2 Measurement of average thickness

There is no generally applicable gravimetric method and therefore use the average of a number of local thickness determinations to obtain the average thickness (see ISO 2064).

Annex B

Guidance notes

(This annex does not form part of the Standard.)

These notes are intended to draw the attention of the user to

a) certain properties of the tin-nickel alloy which, if not understood, may lead to inappropriate use of the coating;

b) properties and preparation of the substrate;

c) electroplating practice.

B.1 Properties of the coating

Electroplated tin-nickel alloy is a single-phase, metastable compound corresponding approximately to the formula SnNi. Although the alloy does not melt below 800 °C, phase transformation occurs at elevated temperatures but deposits with a suitable undercoat are considered to have a maximum safe working temperature of about 300 °C. The coating is hard (about 750 HV), inherently brittle and it is inadvisable to carry out fabrication involving deformation after electroplating, nor, where appearance is important, should the coating be applied to parts subject to deformation or vibration in service. Because of the brittle nature of the alloy the use of coatings thicker than 25 µm is not generally recommended. The brightness of the as-electroplated tin-nickel alloy is related to that of the basis material but tends to decrease with increasing thickness (see also B.2.1).

On exposure to air, tin-nickel alloy readily forms a passive oxide film that provides excellent resistance to corrosion except in certain strongly acid environments. The coating is more "noble" than most common metals and basis metal exposed at pores may therefore be subjected to a more intense local corrosive attack. For this reason, low porosity of the coating is the most important requirement if corrosion resistance is required and then coatings thicker than those specified in the table (for example 45 µm) may be necessary.

For some applications, for example when tin-nickel is used because of its low coefficient of friction or for its high wear resistance, the presence of porosity may not be significant and may even be advantageous if oil retention is required.

Unlike tin coatings, tin-nickel alloy is not subject to either whisker growth or allotropic change. However, it should be noted that undesirably highly stressed coatings may be deposited by an incorrectly operated process.

The classification number is based on coating thickness which is some guide to the expected porosity, although it should be remembered that parameters other than coating thickness can also affect porosity.

B.2 Properties and preparation of the basis material

B.2.1 Surface condition

The surface condition of the coating will depend partly on the surface condition of the basis material.

B.2.2 "Difficult" basis materials

Some basis materials, for example phosphor-bronze, beryllium-copper and nickel-iron alloys, especially when rolled or drawn, are difficult to prepare chemically clean because of the nature of the surface oxide film. In such cases, an undercoat of copper of approximately 2,5 µm may be advantageous.

B.2.3 Aluminium, magnesium and zinc alloys

These alloys are readily attacked by dilute acids and/or alkalis and therefore special pretreatments, including the deposition of relatively thick (10 to 25 µm) undercoats of copper, bronze or nickel, are necessary before the article can be electroplated with tin-nickel alloy.

B.3 Electroplating practice

B.3.1 Coating thickness requirements

It should be noted that the deposit thicknesses specified in this International Standard are minimum local and *not* average thicknesses. The average thickness required to give a minimum local thickness on the significant surfaces will depend upon the geometry both of the article being electroplated and of the electroplating bath with regard to the positions of the electrodes. It should also be borne in mind that, with barrel electroplating (especially of small parts), the variation in coating thickness conforms to a normal (gaussian) distribution.