
INTERNATIONAL STANDARD 2093

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Metallic coatings — Electroplated coatings of tin

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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, International Standard ISO 2093 replaces ISO Recommendation R 2093-1971 drawn up by Technical Committee ISO/TC 107, *Metallic and other non-organic coatings*.

The Member Bodies of the following countries approved the Recommendation :

Australia	India	Spain
Chile	Israel	Sweden
Czechoslovakia	Italy	Switzerland
Egypt, Arab Rep. of	Netherlands	Thailand
France	New Zealand	United Kingdom
Germany	Portugal	U.S.S.R.
Greece	Romania	
Hungary	South Africa, Rep. of	

No Member body expressed disapproval of the Recommendation.

Metallic coatings — Electroplated coatings of tin

0 INTRODUCTION

This International Standard covers a range of coatings of tin applied by electro-deposition to fabricated articles of ferrous and some non-ferrous metals to protect them against corrosion and to facilitate soldering.

The minimum thickness requirements apply only to those portions of the significant surface that can be touched by a ball 20 mm in diameter.

Attention is drawn to the possibility of interdiffusion between tin coatings and copper alloys, slow at room temperature and more rapid at elevated temperatures. This may lead to darkening and impairment of solderability of thin coatings after long storage. With such thin coatings, provision is made for the use of an undercoat to act as a diffusion barrier but users should consider the use of a thicker coating when solderability has to be maintained over a period of years.

When tin coatings are used with the primary purpose of restraining galvanic corrosion between two dissimilar metals, it will usually be sufficient to choose the class appropriate to the conditions of service for a coating on the less noble metal.

It is essential that the purchaser state either the basis metal and the service condition number, or the classification number : merely to ask for plating to be carried out in accordance with ISO 2093 without this number is insufficient.

1 SCOPE AND FIELD OF APPLICATION

This International Standard applies to electroplated coatings of not less than 99,5 % of tin on steel (or iron), and copper or copper alloys. It also applies to coatings brightened by fusion after electrodeposition, the process being known as flow-brightening (or flow-melting). It does not apply to

- coatings applied to machine screw threads (with tolerance);
- coatings applied to sheet, strip or wire in the unfabricated form, or to coil springs.

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 thickness by microscopical examination of cross-sections.*

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 CLASSIFICATION

4.1 Grading of service conditions

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

4 — exceptionally severe (such as contact with food or water where a complete cover of tin has to be maintained against corrosion and abrasion)

3 — severe

2 — moderate

1 — mild (including applications where solderability is the main requirement)

The letter "f" shall be added after service condition number 1 when a flow-brightened coating is to be indicated.

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.

4.2 Classification of coatings

The classification number comprises :

- the chemical symbol for the basis metal (or for the principal metal if an alloy) as given below, followed by an oblique stroke :
- Fe for steel (or iron);
- Cu for copper or copper alloy;
- the chemical symbol for tin, Sn;
- a number indicating the minimum thickness (in micrometres) of the tin coating;
- (where appropriate) the letter "f", indicating that the coating has been flow-brightened.

4.3 Coatings appropriate to each service condition number

Tables 1 and 2 show, for the various basis metals, the coating classification number and minimum thickness appropriate for each service condition number.

5 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.

It is recommended that steels of tensile strength above 1 500 N/mm² (or corresponding hardness¹⁾) should not be electroplated with zinc by conventional methods. It should also be noted that steels of tensile strength above 1 000 N/mm² (or corresponding hardness²⁾) will require heat treatment to minimize this risk.

5.1 Stress relief before plating

Severely cold-worked steel parts or parts made from steel of tensile strength of 1 000 N/mm² (or corresponding hardness²⁾) 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 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 should instead be stress relieved at a lower temperature; for example, at 170 °C for not less than 1 h.

5.2 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 hardness²⁾) 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.

TABLE 1 – Coatings of tin on steel (or iron)

Service condition number	Classification number	Minimum thickness μm
4	Fe/Sn 30	30
3	Fe/Sn 20	20
2	Fe/Sn 12	12
1	Fe/Sn 4	4
1f	Fe/Sn 4f	4*

* The local thickness shall not exceed 8 μm. The use of an undercoat of copper, bronze or nickel is advantageous but the thickness of tin shall not be reduced if an undercoat is used.

TABLE 2 – Coatings of tin on copper or copper alloy

Service condition number	Classification number	Minimum thickness μm
4	Cu/Sn 30	30
3	Cu/Sn 15	15
2	Cu/Sn 8	8
1	Cu/Sn 4	4*
1f	Cu/Sn 4f	4**

* For brass basis metal, an undercoat of 2 μm of copper, bronze or nickel shall be used.

** The local thickness shall not exceed 8 μm.

For brass basis metal, an undercoat of 2 μm of copper, bronze, or nickel shall be used.

1) 45 HRC, 440 HV, 415 HB (approximate values).

2) 30 HRC, 295 HV, 280 HB (approximate values).

6 REQUIRED CHARACTERISTICS

6.1 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 plated surface shall be of a smooth texture and free from nodules. Flow-brightened coatings shall be free from de-wetted areas. If necessary, a sample showing the required finish shall be supplied or approved by the purchaser.

6.2 Thickness

The number following the chemical symbol Sn indicates, in micrometres, the minimum thickness of the tin coating which shall satisfy the appropriate value in Table 1 or Table 2.

In the case of articles having a significant surface area of 100 mm² or greater, this minimum thickness shall be regarded as the minimum value of local thickness measured by the method given in ISO 1463, particular attention being given to the requirements for over coating, 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.¹⁾

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.

In the case of articles having a significant surface area less than 100 mm², this minimum thickness shall be regarded as the minimum value of average thickness measured by the method given in Annex B.

6.3 Adhesion

The coating shall continue to adhere to the basis metal when subjected to the test given in Annex C.

6.4 Porosity

Coatings having a local thickness of 12 µm and greater on articles of steel (or iron) shall be subjected to the porosity test given in Annex D, and the results evaluated according to the procedure described in that Annex.

6.5 Solderability

When specified by the purchaser, coatings shall be tested for solderability by the method given in Annex E. The tin coating is considered to be solderable if, after testing, it shows a uniform coating of solder that is visibly free from discontinuities or breaks (for example "de-wetting" uncoated or black areas). When specified by the purchaser, coatings on copper or copper alloy shall be subjected before testing to the preliminary artificial ageing treatment described in Annex E.

NOTE — The object of this preliminary treatment is to demonstrate whether articles may be expected to retain their solderability during long periods of storage.

6.6 Manner of specifying requirements

When ordering articles to be plated in accordance with this International Standard, the purchaser shall state, in addition to the number of the International Standard, either the classification number of the particular coating required (see 4.2) or the basis metal and the service condition number denoting the severity of the conditions it is required to withstand (see 4.1).

7 SAMPLING

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

1) Other methods of thickness determination may be suitable for control purposes but are not mentioned in this International Standard.

ANNEX A

GUIDANCE ON HEAT TREATMENT OF STEEL PARTS AFTER PLATING

TABLE 3 – Times and temperature for heat treatment

Tensile strength	Maximum sectional thickness of part	Minimum period at 190 to 210 °C
N/mm ²	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 Heating to commence within 16 h of plating
	Over 40	Requires experimental determination

ANNEX B

DETERMINATION OF AVERAGE THICKNESS

B.1 STRIPPING SOLUTION

Dissolve 20 g of antimony trioxide in 1 000 ml of cold hydrochloric acid ($d = 1,16$ to $1,18$).

B.2 PROCEDURE

Carefully clean a plated part of known area, free it from grease by means of a suitable solvent treatment, thoroughly dry it and weigh it to an accuracy of 1 part in 10 000. Sufficient area of sample shall be taken to give a loss in mass on stripping of at least 0,2 g of tin.

Immerse it totally in the stripping solution and turn it over so that the solution has free access to all surfaces. A fresh portion of the stripping solution shall be used in each test; at least 100 ml of the solution shall be used to remove 1 g of tin.

Allow the sample to remain in the solution for a period of 1 min after gas evolution has ceased.

Remove the part, wash it immediately in running water, mop it with a wet soft cloth or cotton wool swab to remove the black powdery deposit of antimony, dry it and re-weigh.

B.3 CALCULATION

Thickness of tin coating, in micrometres, is given by the formula :

$$\frac{137 \times 10^3 (m_1 - m_2)}{A}$$

where

m_1 is the original mass of the sample, in grams;

m_2 is the final mass of the sample, in grams;

A is the area of coating, in square millimetres.

NOTE — The above calculation assumes a density of $7,30 \text{ g/cm}^3$ for tin.

ANNEX C

QUENCHING TEST FOR ADHESION

Heat a plated article for 1 h in an oven at a temperature of $185 \pm 10^\circ\text{C}$.

Then quench the article in water at room temperature, withdraw it and examine the coating for blistering and other signs of poor adhesion.

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

ANNEX D

SULPHUR DIOXIDE POROSITY TEST

D.1 PRINCIPLE

Exposure to a moist atmosphere containing a low concentration of sulphur dioxide causes no corrosion of tin but causes spots of corrosion product to appear at discontinuities in the coating.

If the sulphur dioxide concentration in the atmosphere is too high, the corrosion product formed is too fluid to permit easy observation of pore sites. The method given here, which depends on the production of sulphur dioxide from the reaction between sodium thiosulphate and sulphuric acid within the test chamber, ensures suitable conditions for the development of immobile corrosion products at discontinuities.

D.2 APPARATUS

D.2.1 Test cabinet, consisting of a chamber fitted with a lid or door, and preferably made of glass or a transparent plastics material.

The size shall be sufficient to accommodate the test specimens with their lowest part at least 75 mm above the surface of a solution occupying at least one-fiftieth of the total capacity.

The closure of the vessel and other joints shall be gas-tight but need not be capable of resisting pressure. A glass plate makes an adequate joint on the lubricated ground edges of a glass tank.

The cabinet shall be of uniform cross-section and the solution placed in it shall cover the base completely.

D.2.2 Glass or plastics stand inside the cabinet to support the specimens under test.

The significant surfaces may be inclined at any angle but it may be desirable to choose the same inclination for similar articles.

D.3 CORROSIVE MEDIUM

The corrosive medium shall be moist air containing sulphur dioxide. Such a medium is obtained in a closed chamber above a solution occupying one-fiftieth of the capacity of the chamber. It can be prepared by adding 1 part by volume of 0,1 N sulphuric acid to 4 parts of a solution containing 10 g of sodium thiosulphate crystals in 1 l of water.

D.4 TEMPERATURE OF TEST

The test shall be conducted at 20 ± 5 °C taking precautions against rapid temperature fluctuation in the course of the test.

D.5 PROCEDURE

Before the test, clean the specimens with an organic solvent (for example trichloroethylene), wipe with a lint-free cloth and allow to attain room temperature.

Introduce into the test cabinet a volume of aqueous sodium thiosulphate solution equal to one-fiftieth of the volume of the cabinet. Suspend the test specimens above this solution on non-metallic supports with the surfaces of the specimens not less than 25 mm apart, nor less than 25 mm from any wall of the cabinet and not less than 75 mm from the surface of the sodium thiosulphate solution.

Add to the solution thiosulphate solution a volume of 0,1 N sulphuric acid equal to a quarter of the volume of the thiosulphate solution and seal the cabinet, keeping it shielded from draughts or other causes of rapid temperature fall. The addition of the sulphuric acid may be made before the test specimens are placed in position provided that the cabinet is closed within 5 min of the addition of the acid.

Leave the specimens in the closed cabinet for 24 h. After removing the specimens from the corrosive atmosphere, allow them to dry without wiping or cleaning in any way and then examine them.

D.6 EVALUATION

Examine each specimen for spots or cracks at which the coating is penetrated, with resulting corrosion of the basis metal. If, on any specimen, any spot or crack has an area greater than 2,5 mm², the specimen fails the test.

Evaluate the results of the test on each specimen in accordance with ISO 1462. A specimen that has a rating number less than the appropriate value given in Table 4 fails the test.

TABLE 4 – Rating numbers

Classification number	Rating number
Fe/Sn 30	10
Fe/Sn 20	6
Fe/Sn 12	4

If a specimen with a significant surface area greater than 50 000 mm² is being tested, in addition find the 50 mm X 50 mm area showing the greatest number of corrosion spots. Count the number (*M*) of 5 mm squares in this area that are occupied by corrosion spots. If, for the actual rating number obtained, *M* is equal to or greater than the value given in Table 5 below for the appropriate classification number, then the specimen fails the test.

TABLE 5 – Maximum permissible values of *M*

Actual rating number	<i>M</i>	
	Fe/Sn 20	Fe/Sn 12
9	40	60
8	30	50
7	20	40
6	10	30
5	—	20
4	—	10