
**Metallic and other inorganic coatings —
Electrodeposited silver and silver alloy
coatings for engineering purposes —
Specification and test methods**

*Revêtements métalliques et autres revêtements inorganiques — Dépôts
électrolytiques d'argent et d'alliages d'argent pour applications
industrielles — Spécifications et méthodes d'essai*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established 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. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 4521 was prepared by Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*, Subcommittee SC 3, *Electrodeposited coatings and related finishes*.

This second edition cancels and replaces the first edition (ISO 4521:1985), and also ISO 4522-1:1985, ISO 4522-2:1985 and ISO 4522-3:1988, which have been technically revised.

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Introduction

Electrodeposited silver and silver alloy coatings are often specified for their extremely good electrical conductivity, but corrosion protection is often an additional requirement for electrical, electronic and other applications. In many conditions of service, sulfide films may form on the coatings, increasing the contact resistance at the silver electroplated mating surface and making them unsuitable for use in low-voltage electronic circuits. Sulfide films are not especially detrimental to other electronic applications where higher voltage and higher contact pressures are used, because the films are not completely insulating.

Because the appearance and serviceability of electroplated silver coatings depend on the condition of the basis material, agreement should be reached between interested parties that the surface finish and roughness of the basis material are satisfactory for electroplating.

Electroplated silver coatings have been used as bearing surfaces for many decades and are particularly useful where the load-bearing surfaces are not well lubricated.

Electroplated silver coatings have largely replaced electroplated gold coatings on metallic lead frames, the devices that support the majority of silicon chips.

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Metallic and other inorganic coatings — Electrodeposited silver and silver alloy coatings for engineering purposes — Specification and test methods

WARNING — This International Standard may not be compliant with some countries' health and safety legislations and calls for the use of substances and/or procedures that may be injurious to health if adequate safety measures are not taken. This International Standard does not address any health hazards, safety or environmental matters and legislations associated with its use. It is the responsibility of the user of this International Standard to establish appropriate health, safety and environmentally acceptable practices, and take suitable actions to comply with any national and international regulations. Compliance with this International Standard does not, in itself, confer immunity from legal obligations.

1 Scope

This International Standard specifies requirements for electroplated silver and silver alloy coatings for electrical, electronic and other engineering applications, including test methods. Engineering applications are defined as those in which the coating essentially serves a non-decorative purpose.

Although this International Standard does not specify the condition, finish or surface roughness of the basis material prior to electroplating, the appearance and serviceability of electroplated silver and silver alloy coatings depend on the condition of the basis material. It is essential that the purchaser specifies the surface finish and roughness of the basis material in order to conform to the product requirements.

This International Standard does not apply to coatings on screw threads or to coatings on sheet, strip or wire in the non-fabricated form.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1463, *Metallic and oxide coatings — Measurement of coating thickness — Microscopical method*

ISO 2064, *Metallic and other inorganic coatings — Definitions and conventions concerning the measurement of thickness*

ISO 2080, *Metallic and other inorganic coatings — Surface treatment, metallic and other inorganic coatings — Vocabulary*

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

ISO 2178, *Non-magnetic coatings on magnetic substrates — Measurement of coating thickness — Magnetic method*

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

ISO 4521:2008(E)

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

ISO 3868, *Metallic and other non-organic coatings — Measurement of coating thicknesses — Fizeau multiple-beam interferometry method*

ISO 4516, *Metallic and other inorganic coatings — Vickers and Knoop microhardness tests*

ISO 4518, *Metallic coatings — Measurement of coating thickness — Profilometric method*

ISO 4519:1980, *Electrodeposited metallic coatings and related finishes — Sampling procedures for inspection by attributes*

ISO 4538, *Metallic coatings — Thioacetamide corrosion test (TAA test)*

ISO 9587, *Metallic and other inorganic coatings — Pretreatment of iron or steel to reduce the risk of hydrogen embrittlement*

ISO 9588, *Metallic and other inorganic coatings — Post-coating treatments of iron and steel to reduce the risk of hydrogen embrittlement*

ISO 10111, *Metallic and other inorganic coatings — Measurement of mass per unit area — Review of gravimetric and chemical analysis methods*

ISO 10289, *Methods for corrosion testing of metallic and other inorganic coatings on metallic substrates — Rating of test specimens and manufactured articles subjected to corrosion tests*

ISO 10308, *Metallic coatings — Review of porosity tests*

ISO 10587, *Metallic and other inorganic coatings — Test for residual embrittlement in both metallic-coated and uncoated externally-threaded articles and rods — Inclined wedge method*

ISO 12687, *Metallic coatings — Porosity tests — Humid sulfur (flowers of sulfur) test*

ISO 14647, *Metallic coatings — Determination of porosity in gold coatings on metal substrates — Nitric acid vapour test*

ISO 15724, *Metallic and other inorganic coatings — Electrochemical measurement of diffusible hydrogen in steels — Barnacle electrode method*

IEC 60068-2-20, *Basic environmental testing procedures — Part 2: Tests. Test T: Soldering*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2064 and ISO 2080 apply.

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 in writing, for example, in the purchase order or contract, or on engineering drawings:

- a) the number of this International Standard (ISO 4521) and the designation (see Clause 5);
- b) the significant surface indicated, for example, on drawings or by the provision of suitably marked samples;

- c) the nature, condition and finish of the basis metal, if they are likely to affect the serviceability and/or the appearance of the coating;
- d) the position on the surface of unavoidable defects, such as rack marks (see 6.2);
- e) the finish required, for example, bright, dull or another type, preferably accompanied by approved samples of the finish (see 6.2);
- f) the requirements for thickness, accelerated corrosion and adhesion testing (see 6.3, 6.5 and 6.9);
- g) the tensile strength of parts and the requirements for heat treatment before and/or after electrodeposition (see 6.7 and 6.8);
- h) sampling methods, acceptance levels or any other inspection requirements if different from those specified in ISO 4519:1980, Clause 7.

4.2 Additional information

If the following additional information is required, it shall be specified by the purchaser in writing, for example, in the contract, purchase order or on the drawing with the definition.

- a) the minimum silver content of the coating, details of any alloying elements, the methods of determining the minimum silver content (see 6.6) and presence of residual salts (see 6.16);
- b) any cleaning precautions to be followed;
- c) any special requirements for undercoats (see 6.15 and Annex A);
- d) any requirements for an anti-tarnish treatment, the type of treatment and the test method to be applied (see 6.17);
- e) the method of porosity testing to be applied, and the number and location of acceptable pores (see 6.4);
- f) the electrical properties of the coating and the methods of test to be used (see 6.10);
- g) the microhardness of the coating and the test method to be used (see 6.11);
- h) requirements for solderability and the test method to be used (see 6.12);
- i) any requirements for wear resistance and the test method to be used (see 6.13);
- j) the ductility of the coating and the method of test to be used (see 6.14);
- k) any requirements for freedom from contamination of the finished articles (see 6.16);
- l) the density of the silver coating, if the thickness method requires a density correction (see Annex B).

5 Designation

5.1 General

The designation shall appear on engineering drawings, in the purchase order, the contract or in the detailed product specification. The designation specifies, in the following order, the basis material, stress-relief requirements, the type and thickness of undercoats, if present; the thickness of the silver coating, heat treatment requirements after electroplating, and the type of conversion coating and/or supplementary treatment.

5.2 Designation specifications

The designation shall comprise the following:

- a) the term, Electrodeposited coating;
- b) the number of this International Standard, ISO 4521;
- c) a hyphen;
- d) the chemical symbol of the basis material followed by its standard designation (see 5.3);
- e) a solidus (/);
- f) if appropriate, the chemical symbol for an undercoat metal followed by a solidus and by a number giving the thickness of the undercoat, in micrometres (see 6.15 and Annex A);
- g) a solidus(/);
- h) the chemical symbol for silver, Ag, followed by a number in parentheses giving the minimum mass fraction of silver in the coating, expressed as a percent to one decimal place;
- i) a number indicating the minimum local thickness, in micrometres, of the silver coating.

5.3 Designation of the basis material

The basis material shall be designated by its chemical symbol, or its principal constituent if it is an alloy. For example:

- a) Fe for iron or steel;
- b) Zn for zinc alloys; <https://standards.iteh.ai/catalog/standards/sist/2c09f906-2d8c-4158-b36f-17103bf19b60/iso-4521-2008>
- c) Cu for copper and copper alloys;
- d) Al for aluminium and aluminium alloys.

For plateable plastics materials, the letters PL shall be used. and for non-metallic materials, the letters NM shall be used.

It is recommended that the specific material be designated by its standard designation; for example, by its UNS number or the local national equivalent, in parentheses, following the chemical symbol for the basis material. For example, Fe(G43400) is the UNS designation of a high-strength steel (see References. [2] to [8] in the Bibliography).

5.4 Designation of heat treatment requirements

The heat-treatment requirements shall be designated as follows:

- a) the letters SR for stress-relief heat treatment prior to electroplating, and/or the letters ER for hydrogen-embrittlement-relief heat treatment after electroplating;
- b) in parentheses, the minimum temperature, in degrees Celsius (°C);
- c) the duration of the heat treatment, in hours (h).

For example, SR(210)1 designates stress-relief heat treatment at 210 °C for 1 h.

When heat treatment prior to or after electrodeposition is specified, the requirements shall be included in the designation as shown in the examples (see 5.5).

5.5 Examples of designations

A silver coating (Ag) with a minimum thickness of 20 µm on brass (Cu) shall have the following designation:

Electrodeposited coating ISO 4521 - Cu/Ag(98,8)20

A silver alloy coating containing 98,9 % silver, Ag (98,9), with a minimum thickness of 10 µm on steel (Fe) with a nickel undercoat (Ni) of unspecified thickness shall have the following designation:

Electrodeposited coating ISO 4521 – Fe/Ni/Ag(98,9)10

A silver alloy coating on steel containing 99,8 % silver [Ag(99,8)] with a minimum thickness of 10 µm with a nickel undercoat (Ni) that is 5 µm thick shall have the following designation:

Electrodeposited coating ISO 4521 – Fe/Ni5/Ag(99,8)10

A silver coating with a minimum thickness of 15 µm (Ag15) deposited over a copper undercoat that is 5 µm thick (Cu5) on steel that has an ultimate tensile strength of 1 200 MPa heat treated prior to electroplating for stress relief at 200 °C for 3 h, SR(200)3, and after electroplating to reduce the risk of hydrogen embrittlement at 190 °C for at least 12 h, ER(190)12, shall have the following designation:

Electrodeposited coating ISO 4521 – Fe/SR(200)3/Cu5/Ag(98,8)15/ER(190)12

The designation describes the heat treatment and electroplating steps in the order that they are performed. The standard designation of the basis material shall be placed in parentheses immediately after the chemical symbol for steel, Fe, in the above example. It is especially important to know the standard designation of a metal or alloy that is difficult to prepare for electroplating and that is susceptible to hydrogen embrittlement.

6 Requirements

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6.1 General

The test procedures specified in 6.2, 6.3, 6.7, 6.8, 6.9 and 6.11 for electroplated silver and silver alloy coatings are to be performed in the absence of any anti-tarnish treatment. The tests specified in 6.6 and 6.10 shall be carried out after the anti-tarnish treatment.

Mercury compounds shall not be used in the pretreatment of basis materials.

6.2 Appearance

Over the significant surface, the electroplated article shall be free from clearly visible defects, such as blisters, pits, roughness, cracks or uncoated areas other than those that arise from defects in the basis material. The electroplated article shall be free from extraneous soil and mechanical damage. On articles where a contact mark is unavoidable, its position shall be specified by the purchaser [see 4.1 d)].

In the case of selectively electroplated articles, the amount of stain at the boundary between the areas of the article that have been electroplated with silver and those that are not electroplated with silver shall be agreed between the parties concerned [see 4.1 e)].

Silver and silver alloy coatings that are to be subsequently machined shall be free from excessive nodulation and treeing at edges, and from other imperfections detrimental to subsequent fabrication.

If required, a preliminary sample with the required finish shall be supplied or approved by the purchaser [see 4.1 e)].