

Australian Standard™

Electroplated coatings—Gold and gold alloys



This Australian Standard was prepared by Committee MT-009, Metal Finishing. It was approved on behalf of the Council of Standards Australia on 8 October 2004. This Standard was published on 29 October 2004.

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Australian Chamber of Commerce and Industry
Australian Industry Group
Australian Institute of Metal Finishing
Australian Paint Manufacturer's Federation
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STANDARDS AUSTRALIA

RECONFIRMATION

OF

AS 1901—2004

Electroplated coatings—Gold and gold alloys

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Technical Committee MT-009 has reviewed the content of this publication and in accordance with Standards Australia procedures for reconfirmation, it has been determined that the publication is still valid and does not require change.

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NOTES

Australian Standard™

Electroplated coatings—Gold and gold alloys

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PREFACE

This Standard was prepared by the Australian members of the Joint Standards Australia/Standards New Zealand Committee MT-009, Metal Finishing at the request of industry to supersede AS 1901—1993, *Electroplated coatings—Gold and gold alloys*. After consultation with stakeholders in both countries, Standards Australia and Standards New Zealand decided to develop this Standard as an Australian rather than an Australian/New Zealand Standard.

The objective of this Standard is to specify the requirements for gold electroplated coatings.

The objective of this revision is to include new plating classifications, applications, test methods and hydrogen embrittlement treatments.

In the preparation of this Standard cognisance was taken of the following Standards:

ISO

- | | |
|--------|---|
| 2064 | Metallic and other inorganic coatings—Definitions and conventions concerning the measurement of thickness |
| 3868 | Metallic and other non-organic coatings—Measurement of coating thicknesses—Fizeau multiple-beam interferometry method |
| 4523 | Metallic coatings—Electrodeposited gold and gold alloy coatings for engineering purposes |
| 4524 | Metallic coatings—Test methods for electrodeposited gold and gold alloy coatings |
| 4524-3 | Part 3: Electrographic tests for porosity |
| 4524-5 | Part 5: Adhesion tests |
| 4524-6 | Part 6: Determination of the presence of residual salts |

ASTM

- | | |
|------|---|
| B488 | Electrodeposited coating of gold for engineering uses |
|------|---|

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the appendix to which they apply. A ‘normative’ appendix is an integral part of a Standard, whereas an ‘informative’ appendix is only for information and guidance.

Statements expressed in mandatory terms in footnotes to tables are deemed to be requirements of this Standard.

CONTENTS

	<i>Page</i>
FOREWORD.....	4
1 SCOPE.....	5
2 REFERENCED DOCUMENTS.....	5
3 DEFINITIONS.....	6
4 CLASSIFICATION AND DESIGNATION.....	7
5 CONDITION OF THE SUBSTRATE.....	12
6 COATING REQUIREMENTS	13
7 SUPPLEMENTARY REQUIREMENTS.....	15
8 TEST SPECIMENS	16
9 SAMPLING	16
10 MARKING	16
11 PACKAGING	16
 APPENDICES	
A PURCHASING GUIDELINES.....	17
B MEANS OF DEMONSTRATING COMPLIANCE WITH THIS STANDARD.....	18
C APPLICATIONS FOR ELECTRODEPOSITED GOLD AND GOLD ALLOYS.....	20
D PRETREATMENT OF IRON OR STEEL TO REDUCE THE RISK OF HYDROGEN EMBRITTLEMENT	21
E POST-COATING TREATMENTS OF IRON OR STEEL TO REDUCE THE RISK OF HYDROGEN EMBRITTLEMENT	24
F GOLD ELECTROLYTES	28
G DETERMINATION OF THICKNESS—GRAVIMETRIC METHOD.....	29
H CHEMICAL ANALYSIS	31
I ADHESION TESTS FOR ELECTRODEPOSITED GOLD AND GOLD ALLOY COATINGS ON METALLIC SUBSTRATES	36
J ELECTROGRAPHIC TESTS FOR POROSITY OF ELECTRODEPOSITED GOLD AND GOLD ALLOY COATINGS.....	38
K DETERMINATION OF THE PRESENCE OF RESIDUAL SALTS FOR ELECTRODEPOSITED GOLD AND GOLD ALLOY COATINGS	42

FOREWORD

This Standard specifies a range of electrodeposited gold and gold alloy coatings for electrical, electronic and other engineering applications, as well as for decorative purposes. In this Standard engineering purposes are defined as those for which the coating has to fulfil primary non-decorative functional tasks, while decorative purposes are defined as those for which the appearance of the finished article is of prime importance. However protection against corrosion may be a requirement in both cases.

No distinction is made between gold and gold alloy coatings in this Standard; however gold coatings are required to be at least 99% pure, whereas gold alloy coatings are specified to have a minimum gold content of 58.5%. In the case of multi-layered gold alloy coatings, at least 58.5% of gold in each layer is required.

Gold coatings complying with the requirements of this Standard are used for their corrosion and tarnish resistance, solderability, wear resistance, bondability, low and stable electrical contact resistance, and infra-red reflectivity.

Attention is drawn to the fact that coatings, produced from cyanide-free electrolytes based on complex sulfide ions, and coatings with hardnesses lower than 90 HKN 25, produced from cyanide electrolytes, show a pronounced tendency to cold weld or gall. The use of such deposits on both surfaces forming mating connections or sliding contacts should therefore be avoided. Gold coatings containing lower than 99.0% by mass of gold can cause electrical resistance problems in high-reliability, low-electrical-impedance and voltage-static contacts.

STANDARDS AUSTRALIA

Australian Standard Electroplated coatings—Gold and gold alloys

1 SCOPE

This Standard specifies requirements for electrodeposited coatings including composition (single-layer or multi-layer) for gold and its alloys for electrical, electronic and other engineering applications, as well as for decorative purposes, on metallic and non-metallic materials.

In the case of double-layer and multi-layer coatings, the thickness requirements apply to the total gold or gold alloy coating, but the requirements for gold content apply to each layer.

Appendix A sets out information to be supplied by the purchaser to the electroplater.

NOTES:

- 1 Appendix B shows a means of demonstrating compliance to this Standard.
- 2 Appendix C lists a number of applications for electrodeposited gold coatings.
- 3 Appendix F discusses electrolytes and associated factors which affect electrodeposited gold and gold alloy coatings.

2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

1199	Sampling procedures for inspection by attributes
1199.0	Part 0: Introduction to the ISO 2859 attribute sampling system
1199.1	Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection
1627	Metal finishing—Preparation and pretreatment of surfaces
1627.1	Part 1: Removal of oil, grease and related contamination
2331	Methods of test for metallic and related coatings
2331.1.1	Method 1.1: Local thickness tests—Micrographic examination of cross-sections
2331.1.2	Method 1.2: Local thickness tests—Coulometric method
2331.1.5	Method 1.5: Local thickness tests—Beta-backscatter method
2331.1.6	Method 1.6: Local thickness tests—Taper section method
2331.4.5	Method 4.5: Physical tests—Electroplated plastics—Thermal cycling tests
2400	Packaging
2400.6	Part 6: Paper and paperboard
2400.21	Part 21: Packaging of dangerous goods
2483	Metal finishing—Recommended sampling plans for the inspection and testing of coatings (ISO 4519:1980, MOD)
4108	Metal finishing—Glossary of terms used in electroplating and related processes
4291	Mechanical properties of fasteners made of carbon steel and alloy steel
4291.1	Part 1: Bolts, screws and studs

AS/NZS ISO	
9001	Quality management system—Requirements
9004	Quality management system—Guidelines for performance improvements
HB18	Guidelines for third-party certification and accreditation
HB18.28	Guide 28: General rules for a model third-party certification scheme for products
ISO	
3497	Metallic coatings—Measurement of coating thickness—X-ray spectrometric methods
4516	Metallic and other inorganic coatings—Vickers and Knoop microhardness tests
4518	Metallic coatings—Measurement of coating thickness—Profilometric method
12686	Metallic and other inorganic coatings—Automated controlled shot-peening of metallic articles prior to nickel, autocatalytic nickel or chromium plating or as a final finish
ASTM	
E1004	Standard practice for determining electrical conductivity using the electromagnetic (Eddy-Current) method.

3 DEFINITIONS

For the purpose of this Standard, the definitions given in AS 4108 and those below apply.

3.1 Double-layer gold or gold alloy coating

A gold or gold alloy coating of two contiguous layers of different gold content.

3.2 Finished state

The condition of an item after coating and any subsequent treatment.

3.3 Gold or gold alloy coating

An electrodeposited coating of gold or gold alloy, having a gold content of not lower than 58.5% (*m/m*).

3.4 Multi-layer gold or gold alloy coating

A gold or gold alloy coating consisting of more than two contiguous layers of differing gold content.

3.5 Reference area

The area within which a specified number of single measurements are required to be made.

3.6 Significant surface

The surface, specified in a product specification or by the purchaser, on which the coating is required to comply with all specified requirements, including appearance. In most cases, the significant surface will be evident to the electroplater but at times, because of the complex nature of items or specific service requirements, the purchaser may require specific parts of the surface to be treated as part of the significant surface. In such cases, the purchaser should provide suitably marked drawings or suitably marked specimens.

3.7 Strike (flash)

An electrodeposition process of short duration, used to apply a thin coating of gold to the basis metal or to an undercoat, to assist the adhesion of subsequent electrodeposited coatings and to limit contamination of the electrolyte by the substrate metal.

3.8 Undercoating

A metallic coating layer between the basis metal or substrate and the topmost metallic coating. The thickness of an underplating is usually greater than 1 μm , in contrast to a strike or flash, which is thinner.

4 CLASSIFICATION AND DESIGNATION

4.1 General

Gold and gold alloy coatings are designated in accordance with the basis metal, the undercoat metal or metals, the purity of the coating, the minimum local thickness requirements and hardness. For the elements composing the designation and their sequential order, see Clause 4.8.

4.2 Classification of coatings

The coating shall be specified by a combination of the following requirements:

(a) *Type*

Type, characterizing minimum purity in accordance with Clause 4.3.

(b) *Code*

Code, designation Knoop hardness in accordance with Clause 4.4.

(c) *Thickness*

Thickness, in micrometres, in accordance with Clause 4.6.

4.3 Purity

4.3.1 Purity

The purity of gold shall be designated in three types as specified in Table 4.1.

TABLE 4.1
PURITY DESIGNATION

Type	Mass percentage gold, minimum, excluding potassium, carbon and nitrogen
I	99.7
II	99.0
III	99.9

NOTE: Gold purity of 99.7% is defined as no more than 0.3% of total deposited metallic impurities, excluding potassium and sodium. Likewise, 99.9% purity is recognized to mean no more than 0.1% of total deposited metal impurities, excluding potassium and sodium. Almost all gold electrodeposits will contain potassium, carbon and nitrogen that are occluded or precipitated in the deposit. In the case of Type I gold, the occluded potassium has been shown to improve durability and is desirable for that reason.

4.3.2 Purity calculation

Gold purity is calculated by subtraction of the sum of all non-gold metals in mass percent, excluding potassium and sodium, from 100 percent. The presence of elements carbon, nitrogen, hydrogen, sodium and potassium contained in the electrodeposit is not included in the calculation.

4.4 Hardness values

Hardness values shall be specified as shown in Table 4.2.

NOTE: If a value for hardness is specified, the hardness of the coating should be determined by one of the methods specified in ISO 4516.

TABLE 4.2
HARDNESS

Code	Knoop hardness range
A	90 HK25 maximum
B	91-129 HK25
C	130-200 HK25
D	>200 HK25

4.5 Relationship between purity and hardness

The relationship between purity and hardness is shown in Table 4.3.

TABLE 4.3
RELATIONSHIP BETWEEN PURITY AND HARDNESS

Type*	Code*
I	A, B and C
II	B, C and D
III	A

* See Tables 4.1 and 4.2.

4.6 Gold and gold alloy coating thickness

Gold coatings are classified by thickness and the preferred range for general engineering and decorative applications is given in Table 4.4. Any other coating thickness may be called up by specifying the required minimum local thickness in micrometres or specified by the mass of gold per unit area (coating mass) in milligrams per square centimetre. Unless otherwise specified, the density of gold is assumed to be 19.3 g/cm³ for Type III and 17.5 g/cm³ for Type I and Type II.

NOTES:

- 1 The density of Type III gold coatings is less than or equal to 19.3 g/cm³, but not less than 18.5 g/cm³.
- 2 When significant surfaces are involved on which the specified thickness of deposit cannot readily be controlled, such as threads, holes, deep recesses, bases of angles, and similar areas, the purchaser and the supplier should recognize the necessity for either thicker deposits on the more accessible surfaces or for special racking. Special racks may involve the use of conforming, auxiliary, bipolar electrodes, or non-conducting shields

TABLE 4.4
LOCAL THICKNESS REQUIREMENTS FOR GOLD
AND GOLD ALLOY COATINGS

Coating thickness classification	Minimum local thickness*
	μm
Au 0.25	0.25
Au 0.50	0.50
Au 0.75	0.75
Au 1.00	1.00
Au 1.25	1.25
Au 2.00	2.00
Au 2.50	2.50
Au 5.00	5.00
Au 10.00	10.00
Au 20.00	20.00

* Where a thickness testing method is selected that provides average coating thickness, the minimum required values shown in Table 4.4 may be increased by 20 percent.

4.7 Undercoatings

4.7.1 General

Undercoats may be necessary on any basis material for the following reasons:

- (a) To improve corrosion resistance.
- (b) To improve adhesion.
- (c) To improve diffusion.
- (d) To prevent contamination of the electrolyte.
- (e) To improve solderability and its retention of solder.
- (f) To reduce surface roughness.
- (g) To reduce porosity.

Typical undercoatings used are copper, nickel, palladium, tin-nickel alloys and combinations of these metals.

The thickness requirements for undercoats shall be as in Table 4.5 and shall be minimum values. For arduous conditions of service, greater thickness may be required and shall be specified by the purchaser. Other undercoats to be used for special purposes shall also be specified by the purchaser.

NOTE: To promote good adhesion it may be necessary to deposit a gold strike immediately prior to the main gold deposition.

4.7.2 Silver undercoat

Silver shall not be used as an undercoat unless specified by the purchaser.

4.7.3 Copper alloy undercoats

Copper alloys containing beryllium, lead, tellurium or zinc shall be precoated to prevent poor adhesion. If copper or nickel undercoatings are used, they shall have a nominal thickness of at least 1.2 μm .

NOTE: Thickness of the undercoating should be consistent with end-use requirements. With cyanide-sensitive copper alloys, such as those containing beryllium or tellurium, an acid strike is recommended.

4.7.4 *Gold or gold alloy coatings on aluminium, steel and zinc*

Gold or gold alloy coatings on aluminium, steel, zinc and other metals normally require an undercoat, such as copper or nickel, of sufficient thickness to impart adequate corrosion protection to the basis metal.

4.7.5 *Undercoats for elevated temperatures*

To minimize diffusion, a nickel undercoat with a thickness of at least 1.25 µm shall be applied before depositing any of these gold finishes on copper and copper alloy parts that may be subjected to elevated temperatures. The thickness of the undercoating shall be consistent with end-use requirements.

4.7.6 *Gold strike*

See Clause 3.7.

4.7.7 *Nickel undercoat*

The application of nickel undercoats is used for a number of reasons; some of these are as follows:

(a) *Diffusion barrier*

To inhibit diffusion of copper from the basis metal (and of zinc from brass) to the surface of the precious metal plating and also to inhibit interdiffusion between the basis metal and the gold top (for example, silver and copper), which might produce a weak alloy or intermetallic compound at the interface.

(b) *Levelling layer*

To produce a smoother surface than the basis metal in order to ensure a lower porosity gold top plate (for example, levelling nickel over a rough substrate).

(c) *Pore corrosion inhibitor*

Nickel undercoats for gold topcoats form passive oxides at the base of pores in humid air, provided the environment does not contain significant amounts of acidic pollutants (such as SO₂ or HCl).

(d) *Tarnish creepage inhibitor for gold*

Non-copper basis metals will inhibit creepage of copper tarnish films over the gold where the tarnish originates from pores and bare copper edges.

(e) *Load-bearing underlayer for contacting surfaces*

A hard nickel underplate can serve as a load-bearing foundation for the gold topcoat to prevent cracking of hard golds and reduce the wear of the precious metal during sliding of the contacting surfaces.

TABLE 4.5
REQUIREMENTS FOR UNDERCOATS

Substrate metallic surface	Undercoats	Minimum thickness of undercoats μm
Copper	None	—
Copper alloys containing lead or beryllium, tellurium, tin or zinc.	Nickel *	1.25
	Copper †	1.25
	Tin-nickel alloy ‡	1.25
Ferrous metals (other than austenitic stainless steel)	Nickel *	10
	Copper plus	10
	nickel *	5
Austenitic stainless steel†	Either an acid nickel strike Wood's bath or an acid gold strike will normally be required‡	5
Zinc and zinc alloys	Copper plus	8
	nickel *	10
Aluminium and aluminium alloys	Nickel*§	20
Other metallic substrate surfaces and metallic substrate surfaces with solder joints	Nickel or copper may be required to meet functional or other requirements of this Standard*	To be agreed between the purchaser and supplier

* Low stress nickel undercoats should normally be used.

† If a gold-electroplated austenitic stainless steel is intended for use in a chloride environment, a nickel undercoat is necessary and its thickness should be specified.

‡ A Wood's bath consists of a solution of 240 g of nickel chloride hexahydrate ($\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$) and 85 mL of 36% (m/m) hydrochloric acid per litre. The parts are made anodic for not more than 2 min and then cathodic for 6 min, using depolarised nickel electrodes, without anode bags, at room temperature and a current density of 300 A/m^2 . If current reversal is not feasible, the anodic treatment may be replaced by immersion in the solution, without current flow, for 15 min.

§ An initial copper coating may be employed under the nickel coating but the thickness of the nickel coating should not be reduced. If required the thickness of any undercoat shall be determined by AS 2331.1.1, AS 2331.1.2 or AS 2331.1.6.

4.8 Designation

The designation for gold and gold alloy coatings for decorative purposes shall consist of the percentage of gold (m/m) and coating thickness (in μm), see Clause 10.

The designation for gold and gold alloy coatings for engineering application is composed of the following elements:

- (a) The chemical symbol for the basis metal or principal metal, if an alloy Fe/
- (b) Where applicable, the chemical symbol(s) for the undercoat metal(s)..... Ni/
- (c) A number indicating the percentage purity of gold in the coating, by mass 99
NOTE: For the purity of gold coating designation see Table 4.1.
- (d) The chemical symbol for gold Au
- (e) A number indicating the minimum thickness of the gold or gold alloy coating on the significant surfaces, in micrometres 5

Examples of a complete designation code are:

- (i) A gold coating of 98 percent purity on steel, having a minimum thickness of 5 µm, using a nickel undercoat is designated Fe/Ni/98 Au 5.
- (ii) A gold alloy coating containing 90 percent gold, having a minimum thickness of 2 µm, on a zinc alloy, using an undercoat of nickel on copper is designated Zn/Cu/Ni/90 Au 2.
- (iii) A gold alloy coating containing 75 percent gold, having a minimum thickness of 0.5 µm, on a copper alloy is designated Cu/75 Au 0.5.
- (iv) A double layer coating of gold alloy, the first coating having a minimum thickness of 30 µm of 67 percent gold content and the second, 10 µm of 98 percent gold content on a copper alloy is designated Cu/67 Au 30 + 98 Au 10.

NOTE: The density of gold alloy coatings can vary, it may be desirable to specify the minimum mass of the coating per unit area, in addition to the minimum thickness of the coating.

5 CONDITION OF THE SUBSTRATE

5.1 Process requirements

The metallic substrate shall be subjected to such cleaning procedures as are necessary to ensure a surface satisfactory for subsequent electroplating (see AS 1627.1).

Materials used for cleaning shall have no damaging effects on the substrate metallic surface resulting in pits, intergranular attack, stress corrosion cracking, hydrogen embrittlement, discoloration or staining.

Instruction for the preparation of non-metallic substrates, such as plastic materials, for gold or gold alloy plating should be agreed upon between the supplier and the purchaser.

5.2 Preplating treatment

5.2.1 General

Electroplating shall be applied after all basis metal heat treatment and mechanical operations, such as forming, machining, and joining of the article, have been completed.

Heat treatment shall be performed on basis metals for stress relief in order to reduce the risk of hydrogen embrittlement in accordance with Appendix D, see Table D1.

Parts made from iron or steel with actual tensile strengths greater than or equal to 1000 MPa (with corresponding hardness values of 300 HV, 303 HB or 31 HRC) and surface-hardened parts shall require heat treatment unless class SR-O is specified, see Appendix D.

5.2.2 Preplating treatment for electrical contacts

Where electroplated materials are to be used for electrical contacts, cleaning alone may not properly prepare the surface for gold or gold alloy electroplating. If the basis metal is scratched or rough, it may be necessary to level the surface by processes such as electropolishing, chemical polishing, or the application of a self-levelling nickel or copper undercoating before gold electroplating. However, the use of these undercoatings requires the approval of the purchaser.

5.3 Post-plating treatment

Heat treatment shall be performed on coated metals in order to reduce the risk of hydrogen embrittlement, (see Appendix E).

The heat treatment shall commence as soon as possible, preferably within one hour but not later than three hours after electroplating and before commencement of any grinding or other mechanical processes.