# भारतीय मानक ब्यूरो

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# Draft Indian Standard RECOMMENDED PRACTICE FOR SILVER PLATING FOR GENERAL ENGINEERING PURPOSES

(First Revision)

ICS 25.220.40

Corrosion Protection and Finishes	Last date for receipt of comments is
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#### FOREWORD

(Formal clause of the foreword will be added later)

This standard was first published in 1970.

This code is intended as a guide to electroplaters to obtain electro- deposited coatings of silver for general engineering purposes. However, any alternative process may be used provided the coating obtained by the method satisfies the requirements specified in the relevant Indian Standard on silver plating.

This revision has been brought out to bring the standard in the latest style and format of the Indian Standards. In addition to this, modifications have been made Major modifications compared to previous edition are as follows:

- a) References clause has been added.
- b) Requirements for stress relief before plating and heat treatment after plating have been modified. (*see* **3.1**)

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

# Draft Indian Standard

# RECOMMENDED PRACTICE FOR SILVER PLATING FOR GENERAL ENGINEERING PURPOSES

(First Revision)

#### **1 SCOPE**

**1.1** This standard provides important guidelines for obtaining good quality electrodeposited silver coatings on copper and copper alloys, steels, and aluminium and aluminium alloys, for general engineering purposes.

#### **2 REFERENCES**

The following standards contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	Title	
IS 1959 : 1994	Silver anodes for electroplating — Specification (second revision)	
IS 1985 (Part 1) : 1980	Recommended practice for preparation of iron and steel for electroplating: Part 1 high carbon steel (First Revision)	
IS 1985 (Part 2) : 1980	Recommended practice for preparation of iron and steel for electroplating: Part 2 low carbon steel (First Revision)	
IS 1985 (Part 3) : 1980	Recommended practice for preparation of iron and steel for electroplating: Part 3 iron castings (First Revision)	
IS 2450 : 1963	Recommended practice for plating on aluminium and its alloys	

#### **3 HEAT TREATMENT**

#### 3.1 Steel

When required by the purchaser, heat treatment as described below should be performed on certain steels for reducing the susceptibility or degree of susceptibility to hydrogen embrittlement or degradation that may arise in electroplating, autocatalytic plating, porcelain enameling, chemical conversion coating, and phosphating and the associated pre-treatment processes. This specification is applicable to those steels whose properties are not affected adversely by baking at 190 to 230 °C or higher.

3.1.1 Stress Relief Before Plating

- a) For high-strength steels, the following conditions apply. Stress relief treatment is not essential for steels of actual tensile strength below 1 000 MPa. The conditions given in Table 1 are applied for steels of actual tensile strength above 1000 MPa. The heat treatment shall be conducted before the commencement of any preparations or cleaning treatments using processes liable to cause embrittlement such as cathodic electro cleaning or acid pickling.
- b) Suitable combinations of a shorter time at appropriate higher temperatures may be used if they have been shown not to be detrimental. For tempered steels, items shall not be heated above a temperature that shall be at least 50 °C below the tempering temperature.
- c) If stress relief is given after shot peening or other cold working processes to introduce beneficial compressive stresses, the temperature shall not exceed 230 °C.
- d) Items having surface-hardened areas that would suffer an unacceptable reduction in hardness by treatment in accordance with Table 1 shall be heat-treated at a lower temperature, but not below 130 °C, for a minimum period of 8 h. This treatment is applicable for items made of steel with actual tensile strengths below 1 400 MPa.

<mark>SI No.</mark>	Tensile Strength of Steel MPa	<mark>Temperature</mark> °C	<mark>Time, hour</mark> Min
<mark>(1)</mark>	(2)	<mark>(3)</mark>	(4)
i)	Over 1800	200-230 190-220	<mark>24</mark>
ii)	1401-1800	200-230	<mark>18</mark>
iii)	1450-1800	<mark>190-220</mark>	<mark>18</mark>
iv)	1034 or greater	<mark>177-205</mark>	<mark>3</mark>
v)	1000-1400	<mark>200-230</mark>	<mark>3</mark>
vi)	1050-1450	<mark>190-200</mark>	1
vii)	Surface Hardened parts $\leq 1400$	<b>130-160</b>	8

# Table 1 Stress Relief Requirements for High Strength Steels Before Plating (Clause 3.1.1)

#### 3.1.2 Heat Treatment After Plating

- a) The heat treatment shall commence as soon as possible, preferably within 1 hour but not later than 3 hour after plating and before commencement of any grinding or other mechanical operation.
- b) For high-strength steels, the conditions given in Table 2 may be applied. For steels of actual tensile strength below 1 000 MPa, heat treatment after plating is not essential.
- c) Electroplated steel items having surface-hardened areas and through hardened or bearing steels, which would suffer an unacceptable reduction in hardness by treatment

in accordance with Table 2 shall be heat treated at a lower temperature, but not below 130 °C.

<mark>SI No.</mark>	<b>Tensile Strength of Steel</b>	<b>Temperature</b>	Time, <i>Min</i>
	MPa	°C	hour
<mark>(1)</mark>	<mark>(2)</mark>	<mark>(3)</mark>	<mark>(4)</mark>
i)	1000-1100	190-220	8
ii)	1101-1200	190-220	10
iii)	1201-1300	190-220	12
iv)	1301-1400	190-220	<mark>14</mark>
v)	1401-1500	190-220	<mark>16</mark>
vi)	1501-1600	190-220	18
vii)	1601-1700	190-220	20
viii)	1701-1800	190-220	22
ix)	Over 1800	<u>190-220</u>	<mark>24</mark>

# Table 2 Stress Relief Requirements for High Strength Steels After Plating (Clause 3.1.2)

# **3.2 Aluminium**

After finish-plating or at an intermediate stage approved by the purchaser, articles made from aluminium alloys shall be heated in air to promote adhesion of the coating. The temperatures shall not exceed any elevated temperature originally employed and the articles shall be heated gradually to the required temperature as follows:

- a) *Non-heat-Treatable Alloys* Such alloys shall be heated within the range 130 to 200°C for not less than 1 hour and not more than 3 hours; and
- b) *Heat-Treatable Alloys* These alloys shall be heated within the range 150 to 170 °C for not less than 2 hours and not more than 3 hours.

# **4 PRE-TREATMENT**

**4.1** Pre-treatment may consist of degreasing with a suitable solvent followed by electrolytic cleaning in a hot alkaline cleaning solution except in the case of steels with a tensile-strength in excess of 145 kgf/mm<sup>2</sup> which shall only be cleaned by mechanical means, such as wet and dry abrasives.

NOTE — For details of pre-treatment procedures, reference may be made to IS 1985 (Part 1), IS 1985 (Part 2), IS 1985 (Part 3) and IS 2450.

**4.1.1** The elapsed time between the end of the cleaning process and the beginning of the plating process should be kept to a minimum, otherwise the adhesion and brightness of subsequently electrodeposited coatings may be affected.

## **5 ANODES**

**5.1** Silver anodes used for plating shall conform to IS 1959. The anode's area should be at least equal to, but preferably twice that of the area being plated. To prevent nodular plating, it is usual for the anodes to be bagged or diaphragmed.

**5.2** The minimum silver content of the coating shall, if required, be specified by the purchaser as a percentage by mass to one decimal place and included at the appropriate place in the classification number.

**5.3** The lead content of the silver deposit shall be not more than 0.02 percent.

### **6 UNDERPLATES AND STRIKES**

**6.1** Most of the base metals which are customarily plated with silver will displace silver from the plating bath. This would give rise to poor adhesion hence the components should be given an initial strike in a solution having a lower silver and a higher free cyanide content than a conventional silver bath.

**6.1.1** For thin coatings on copper and copper alloys, for example up to  $0.8 \mu m$ , a very thin underplate of copper (of the order  $0.1 \mu m$ ) is beneficial in providing adhesion. An underplate of copper to be applied on ferrous metals shall be from a cyanide and not a sulphate type solution. In cases where an under plate of copper is not permitted on steel components, a double silver strike (2 to 3 times the first strike) is recommended.

**6.1.2** Aluminium and its alloys should be prepared by the zincate process followed by copper plating in a cyanide bath to deposit an under plate. For details, reference should be made to IS 2450.

**6.1.3** With non-ferrous metals and alloys, such as copper and brass, only a single strike is required. Passivation will occur if articles are allowed to remain exposed to the air for prolonged periods during processing but this effect may be removed by brief immersion in a solution consisting of equal parts of water and concentrated hydrochloric acid (sp gr 1.16).

**6.1.4** The composition and operating conditions of a conventional strike solution are as follows:

Silver	1.5 to 5 g/l
Potassium cyanide	60 to 70 g/l
Temperature	22 to 27°C
Current density	1.5 to 2.5 A/dm <sup>2</sup>
Voltage	4 to 6 volts
Time	15 to 20 seconds

Table 3 Requirements for Undercoats         (Clause 6.1.5)         All dimensions in micrometer			
<mark>SI No</mark>	<b>Base materials</b>	<b>Undercoats</b>	Minimum thickness of undercoats
<mark>(1)</mark>	<mark>(2)</mark>	<mark>(3)</mark>	<mark>(4)</mark>
i)	Copper	None	-
ii)	Copper Alloy( notably free cutting brass containing lead )	Copper or nickel may be required	To be agreed between supplier and purchaser
iii)	Ferrous materials ( other than austenitic stainless steel )	Nickel or copper + nickel	10 or 10 ( Cu) + 5 ( Ni )
iv)	Austenitic stainless steel	An acid nickel strike (Woods bath) normally required	Thin coating to promote adhesion of the silver coating
v)	Zinc and zinc alloys	Copper + Nickel	8(Cu) + 10(Ni)
vi)	Aluminium and aluminium alloy	Nickel (see NOTE)	To be agreed
vii)	Other basis materials and basis metal with soldered joints	Nickel or copper may be required to meet functional or other requirements of this standard	To be agreed
NOTE – An initial copper plating may be employed under the nickel coating.			

#### 6.1.5 The minimum thickness requirements for undercoats are as given in Table 3.

#### 7 MASKING

**7.1** Areas which are to be kept free from plating may be protected by the use of suitable masking materials, for example chlorinated rubber paints or wax. Where the article is to be immersed in molten wax, the areas to be plated may be protected by painting with a mixture of chalk and glycerine which permits easy stripping of unwanted wax.

## **8 MATERIAL OF CONSTRUCTION**

**8.1** Articles used in the process of applying electrodeposited coatings of silver may be constructed from the following materials:

Anode racks, hangers and hooks may be made of stainless steel or titanium. Plating tanks should be constructed of stainless steel, rubber-lined mild steel or alkali-resistant plastics. Stainless steel tanks should have panels of solid rigid plastic placed along the bottom and sides to prevent silver from depositing due to bipolar effects.

## 9 ELECTROLYTE

# 9.1 Composition

Usually electrolytes are aqueous solutions of silver and alkali cyanides, the proportions of which are varied according to usage. Normally the silver content varies within the range of 15 to 50 g/l and the free cyanide 15 to 150 g/l. For high speed plating or heavy deposition, the silver content may be as high as 150 g/l with a correspondingly high free cyanide content. Barrel-plating of silver is also extensively carried out using an electrolyte composition similar to that given for the conventional electrolyte in Table 4. For this purpose, there should also be a high free cyanide content to increase anode solubility by reducing anode polarization characteristics.

**9.1.1** Addition agents, such as ammonium thiosulphate and carbon disulphide are frequently used for brightness and grain refinement. Proprietary materials are also available for this purpose and should be used in accordance with the suppliers' instructions.

**9.1.2** Plating materials should be of the highest purity obtainable and free from sulphur. Only distilled or demineralized water should be used in making up the electrolyte.

### 9.2 Operation

### 9.1.1 *Temperature*

Plating from the conventional bath described above is normally carried out at room temperature but the temperature may be increased for special requirements. It is important that the temperature should not fall too low in cold weather as this is a source of inferior deposits.

SI No.	Item	Electrolyte Composition	High Speed Bath
(1)	(2)	(3)	(4)
i)	Silver cyanide	38 g/l	75-150 g/l
ii)	Potassium cyanide	75 g/l	120-200 g/1
iii)	Potassium carbonate	15 g/l, Min	15 g/l, Min
iv)	Potassium hydroxide	-	3 g/l
v)	Metallic silver	35 g/l	60-105 g/l
vi)	Free cyanide	55 g/l	75-120 g/l
vii)	Operating temperature	22-30°C*	40-50°C
viii)	Current density	0.5-1.5 A/dm <sup>2</sup>	5-10 A/dm <sup>2</sup>

# Table 4 Conventional Electrolyte Composition and Operating Details (Clause 9.1)

## 9.2.2 Agitation

Although still baths may be employed, mild agitation prevents the formation of burnt deposits due to local depletion of the electrolyte. With the use of higher current densities rapid agitation is essential and may be obtained by a combination of cathode movement or rotation or by pumping the electrolyte past the cathode surface.

**9.2.3** Constant replenishment of metal salts is not necessary when soluble anodes are used. A reduction of the silver content of the electrolyte may result from continuous working with low anode areas.

**9.2.4** The best results will be obtained if the composition of the electrolyte is maintained at the optimum levels for silver and cyanide by regular chemical analyses. This type of control should also be applied to strike solutions, particularly as a means of preventing the accumulation of impurities which could then be carried over into the plating bath.

**9.2.5** Carbonates may begin to have an adverse effect at concentrations in excess of 90 g/l. Removal of excess carbonate can be carried out by using barium cyanide but attention is drawn to the fact that this treatment leads to an increase in the cyanide content of the electrolyte. Alternatively, removal with calcium nitrate may be employed; 50 g of calcium nitrate crystals [Ca (NO<sub>3</sub>)<sub>2</sub>.4H<sub>2</sub>O] will remove 30 g of potassium carbonate.

**9.2.6** Filtration, at least intermittent but preferably continuous, is recommended. Although a plating solution may operate for long periods without trouble, eventually the accumulation of impurities will result in the production of inferior coatings. Purification of the solution may be undertaken using activated carbon (*see* Note 2) at the rate of 4 g/l of electrolyte.

The carbon is stirred through the solution (which should be held in a separate tank from that normally used for plating) for about 30 minutes after which the solution is filtered and returned to the plating tank.

#### NOTES

1 When it becomes necessary to prepare a fresh solution of electrolyte the silver in the spent solution should be removed by adding zinc dust until there is an excess present and all the silver salts have been precipitated. The clear solution is then syphoned off, the precipitate washed from soluble cyanides and stored in plastics containers.

2 Carbon treatment will also remove any organic additives from the electrolyte; and adjustment of these will have to be made based upon laboratory tests or upon the quality of work after the treatment.