Chapter 1-6

ELECTROPLATING (OR ELECTRODEPOSITION) FOR PROTECTIVE SURFACE TREATMENTS

CONTENTS

LETHAL WARNINGS ...

(1) CYANIDE SOLUTIONS ARE DEADLY POISONOUS, AND MUST NEVER BE SUCKED BY MOUTH INTO A PIPETTE. COLLECT SOLUTION FROM PLATING BATH IN A SMALL BEAKER AND TRANSFER TO A BURETTE. RUN OUT REQUIRED VOLUME FROM THE BURETTE.

(2) THE HEATING OF CYANIDE SOLUTION WITH STRONG ACID DRIVES OFF HYDROGEN CYANIDE GAS, WHICH IS DEADLY POISONOUS. THE OPERATION MUST ONLY BE CARRIED OUT IN A PROPERLY VENTILATED FUME CHAMBER.

(3) FOR THE FIRST-AID TREATMENT OF CYANIDE POISONING SEE PARA. 42 OF THIS CHAPTER.

Introduction

1 Electroplating consists of depositing one metal on another by electrolytic action on passing a current through a cell, providing:

1.1 Corrosion resistance

1.2 Wear-resistance.

1.3 A low coefficient of friction.

2 The articles to be plated form the cathode, and are connected to the negative pole of the supply, the plating metal acting as the anode. A low voltage direct current is passed through the liquid electrolyte, (generally an aqueous solution of a salt of the metal being deposited) with additives to increase conductivity, act as stabilisers and modify the deposit texture.

3 The anodes, in most cases, provide the metal ions to replace those removed from the electrolyte and deposited on the workpiece.

4 The quantity of electricity (current x time) required to deposit the equivalent weight in grammes of any metal, is 26.8 Ah, and is known as a 'faraday'.

5 Table 1 details the metal deposition rate (assuming 100 per cent efficiency) in grammes/Ah.

TABLE 1 ELECTROPLATING DEPOSITION DATA

Metal	Valency	Chemical Equivalent	Deposit
Cadmium	2	56.20	2.10
Chromium	6	8.67	0.323
Chromium	3	17.35	0.646
Chromium	2	26.00	0.97
Cobalt	2	29.47	1.10
Copper Cuprous	1	63.54	2.371
Copper Cupric	2	31.77	1.19
Gold Aurous	1	196.97	7.36
Gold Auric	3	65.70	2.45
Iron	2	27.92	1.042
	3	18.61	0.695
Lead	2	103.60	3.865
Nickel	2	29.35	1.095
Platinum	2	97.50	3.642
	4	48.80	1.821
Silver	1	107.87	4.025
Tin	2	59.35	2.214
	4	29.70	1.107
Zinc	2	32.67	1.22

6 Dependent on the material, and process treatment specified for the component, all parts are to be thoroughly cleaned immediately prior to the protective treatment as laid down in DEF 162.

7 Table 2 details the relevant BS specifications and methods for particular coatings.

TABLE 2 B.S. COATING SPECIFICATIONS

B.S. No.	Coating
1706	Cadmium and Zinc on Iron and Steel
4641	Chromium for Engineering purposes
4292	Gold and Gold alloy
4758	Nickel for engineering purposes
2816	Silver for engineering purposes
1224	Nickel and chromium
1872	Tin
3597	65/35 Tin-Nickel alloy

8 The following processes are prohibited (per DEF 162) for steels with a tensile strength in excess of 142 kg/mm^2 (90 ton/in^2).

8.1 Copper plating may introduce irreversible hydrogen embrittlement affects with reduced fatigue properties.

8.2 Galvanising - may adversely affect the properties of the part(s).

8.3 Sherardizing- may adversely affect the properties of the part(s).

8.4 Tin-zinc alloy plating - due to the danger of inter-granular penetration of this alloy into the steel, occurring at temperatures below its melting point 200°C (329°F) during the 190 - 200°C (375 - 392°F) baking treatment required to remove embrittlement.

ELECTROPLATING METALS

9 Brief details of the metals and alloys commonly electroplated, together with typical applications and processes, are given in the following paragraphs.

Aluminium

10 At normal temperatures it is necessary to use a non-aqueous electrolyte, taking special precautions to exclude moisture. Aluminium may be deposited electrophoretically as an adherent powder layer.

Cadmium

WARNING ...

THE INSTRUCTIONS GIVEN IN AP.100B-01 ORDER 1703 AND ITS ANNEX A MUST BE FULLY COMPLIED WITH.

11 Chiefly used for its anti-corrosion qualities on metallic parts, ease of soldering, resistance to alkalis and low contact potential in relation to aluminium.

12 Care must be exercised in the choice of electrolyte, since the proportions of the constituents of the normal cyanide electrolyte may induce hydrogen embrittlement. Acid electrolytes, based on fluorborate or perchlorate, and certain organic electrolytes, cause less embrittlement, but may have rather poor 'throwing power'. Proprietary cynanide electrolytes with oxidizing agents, e.g. nitrate and pertitanate, also cause less embrittlement.

13 The electrolytes used, are to be maintained at a high level of purity to reduce embrittlement, and are not to contain brightening agents.

14 The usual thickness of deposit is 8 to 12 µm. On completion of plating, parts are to be baked prior to passivation as laid down in DEF162.

15 Where possible, parts should be cadmium coated by the vacuum-deposition method, since it does not cause hydrogen embrittlement. Procedures ensuring good adhesion are to be used.

Chromium

16 Hard chromium plating to DEF160, is applied to working parts which may be subject to fatigue as well as sustained load. It is also used where hard wear-resistant surfaces are required, e.g. tools, gauges, moulds and certain moving parts e.g. hydraulic rams.

17 Depending upon the application, the thickness of plating will vary from 5 µm to 0.25 mm (0.0098 in). The normal plating solution is based on chromic acid with sulphate as a catalyst, i.e. $CrO_3 : H_2SO_4 = 100.1$.

18 Black chromium, when used in conjunction with satin nickel, produces an effective coating for solar collectors.

19 Mechanical preparation by shot-peening improves the fatigue and sustained load properties. The baking treatment of plated parts differs for the peened and unpeened condition.

Gold

20 Gold plating, to DTD938, is mainly for use on electronic components, e.g. sliding contacts and connectors as an anti-corrosive, thus ensuring consistently low contact potentials.

21 Such plating may be of pure gold or contain alloying constituents, e.g. nickel, cobalt, silver, copper or cadmium, in order to increase or improve hardness, wear-resistance and electrical conductivity.

22 There are three main solutions used, viz:

22.1 Alkaline gold.

22.2 Acid gold.

22.3 Alkaline sulphite gold.

23 The normal thickness of the deposit is 5 μm. Parts to be gold plated must initially be plated with nickel or silver, followed by anodic electrolytic cleaning.

24 On completion of gold plating, the parts are to be baked in accordance with DEF162.

Nickel

25 Nickel or heavy plating, (to DTD919/905 respectively), used in conjunction with chromium, produces a combination of decorative finish with resistance to corrosion, wear and heat.

26 The majority of nickel plating solutions are of the Watts type i.e., nickel sulphate with chloride, which promotes anodic corrosion, and boric acid as a buffer preventing large changes in pH. values at the cathode face.

27 Various organic additions are introduced to produce a deposit with the required properties.

28 Nickel sulphamate solutions are also used, particularly where low-stress deposits are required, using current densities as high as 50 A/dm^2.

29 Two main forms of nickel plating are obtained, viz:

29.1 Duplex nickel, for maximum resistance to corrosion, where nickel is applied in two layers.

29.2 Satin nickel, used where a low-reflective and non-glare finish is required. It may also act as a base for subsequent black-chromium plating.

30 Dull plating solutions are normally used at 25 to 40°C at 1 to 3 A/dm^2; bright solutions at 50 to 60°C at 4 to 8 A/dm^2.

Rhodium

31 Rhodium plating to DTD931, is used to prevent the tarnishing of silver, silver-plated or nickel plated parts.

32 Prior to rhodium plating, such parts must be cleaned using an anodic electrolyte.

33 On completion of rhodium plating, the parts are to be baked in accordance with DTD162.

Silver

34 Silver plating, to DTD919, is widely used in bearing surfaces, electrical contacts, electronic components, and reflectors.

35 For most applications, the electrolyte solution consists of silver/potassium cyanide, with additives which may be varied.

36 Following silver plating, the parts are to be baked in accordance with DEF162.

Tin plating

37 Whilst permitted, this process is not recommended for steels with a tensile strength in excess of 142 kg/mm^2 (90 tons/in^2) due to the danger of inter-granular penetration of the tin into the steel. This occurs at temperatures below the melting point of tin, 232°C (350°F) during the baking treatment required to remove embrittlement.

38 If the process is used, organic agents are not to be added to the electrolyte.

39 Parts which have been tin-plated are to be baked in accordance with DEF-162; attention is particularly drawn in Section 5, para. 11(d) of this Defence Specification.

Zinc plating

40 Zinc plating to DTD903, is a widely used anti-corrosive treatment for steel parts; employing bright zinc plating followed by bright passivation, presenting a similar finished appearance to bright chromium plate.

41 For general purposes, it is usual to employ an alkaline cynanide solution. However, care must be exercised in the choice of electrolyte, since the normal cyanide solution may induce hydrogen embrittlement. Similar precautions to those detailed in para. 12 are to be taken.

WARNINGS ...

(1) CYANIDE SOLUTIONS ARE DEADLY POISONOUS AND MUST NEVER BE SUCKED BY MOUTH INTO A PIPETTE.

(2) CYANIDE SOLUTIONS ARE HARMFUL TO THE SKIN BY ABSORPTION. RUBBER BOOTS, APRONS AND GLOVES ARE TO BE WORN BY OPERATORS WHEN ENGAGED IN CYANIDING PROCESSES.

FIRST AID IN CASE OF CYANIDE POISONING

Symptoms

42 The early symptoms of cyanide poisoning are:

42.1 Headache.

42.2 Drumming in the ears.

42.3 Irritation of the throat.

42.4 Palpitations (increased heart rate).

42.5 Disorder of vision.

Immediate action

43 If cyanide poisoning is suspected:

43.1 Administer, by mouth, 0.142 litres (1/4 pint) of the cyanide antidote. (para. 44).

43.2 Summon medical assistance.

44 The antidote for cyanide poisoning is comprised of:

44.1 Solution A

158 grams of ferrous sulphate ($FeSO_4 7H_2O$) in one litre of water.

44.2 Solution B

60 grams anhydrous sodium carbonate (NA_2CO_3) in one litre of water.

45 Make up to antidote by mixing equal parts of solution A and B to make a dose of 0.142 litres (1/4 pint).

46 The antidote is to be held ready in made-up doses which are immediately available (not under lock and key) in all plating shops and laboratories where cyanides, or cyanide solutions, are held.

Secondary action

47 Secondary action is to be taken as follows:

47.1 Commence artificial respiration immediately (following para. 43.2), using the mouth-to-nose method, since paralysis of the respiratory centres may occur within two or three minutes.

47.2 Stimulate the heart and apply heart massage as needed.

47.3 Remove any cyanide-contaminated clothing.

47.4 Keep the casualty warm.

48 General instructions on safety precautions, including the recognition of symptoms and the treatment of other forms of poisoning, are given in AP 119A-0203-1, Sect. 1, Chap. 6.

49 Non-cyanide bright zinc plating solutions, based on acid, alkaline or neutral compounds are tending to replace the cyanides in view of their lower toxicity.

50 The thickness of plating varies from 12 µm to 0.25 mm, dependent upon the degree of protection required, deposited at a current density of 1 to 10 A/dm^2, and followed by chromate passivation.