SRI LANKA STANDARD 658:1984

UDC 621.357.76

CODE OF RECOMMENDED PRACTICE FOR ELECTROPLATING

SRI LANKA STANDARDS INSTITUTION

CODE OF RECOMMENDED PRACTICE FOR ELECTROPLATING (METALLIC COATINGS OR METALLIC SURFACES)

SLS 658:1984

Gr. 11

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SRI LANKA STANDARD

CODE OF RECOMMENDED PRACTICE FOR ELECTROPLATING (METALLIC COATINGS OR METALLIC SURFACES)

FOREWORD

This Sri Lanka Standard Code of Recommended Practice was authorised for adoption and publication by the Council of the Sri Lanka Standards Institution on 1984-08-17, after the draft, finalised by the Drafting Committee on Electroplating has been approved by the Mechanical Engineering Divisional Committee.

Electroplating has found wide usage in industry in view of its numerous advantages which include corrosion resistance, ease of soldering, decorative effect. To obtain a good coating of metal by electroplating, it is advisable to follow a standard procedure. Details relating to polishing and cleaning have not been included in this standard, references to which have been made at appropriate places.

All values in this standard are given in SI units.

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 CS 102. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

In the preparation of this standard, the assistance obtained from the publications of the International Organisation for Standardization and the Indian Standards Institution is gratefully acknowledged.

1 SCOPE

This standard describes plating equipment and ancillary equipment generally used and recommends proper sequences in electroplating of metallic coatings on metallic surfaces. It describes factors affecting the quality of deposits and stresses the need for safety

in the plating shop and effluent control. This standard does not cover metallic coatings on non-metallic surfaces such as plating on plastics.

2 REFERENCES

ISO 2819/1 Metallic coatings on metallic substrates - Review of method available for testing adhesion

Part 1 Electrodeposited and chemically deposited coatings

ISO 3768 Metallic coatings - Neutral Salt Spray test (NSS test)

ISO 3769 Metallic coatings - Acetic acid salt spray test (ASS test)

ISO 3770 Metallic coatings - Copper - Accelerated acetic acid salt spray test (CASS test)

ISO 3882 Metallic and other non-organic coatings - Review of methods of measurement of thickness

ISO 4541 Metallic and other non-organic coatings - corrodkote corrosion test (CORR test)

SLS 322 Code of practice for cleaning of metals prior to electroplating

SLS 450 Code of recommended practice for mechanical polishing of metals for electroplating

3 PREREQUISITES OF THE BASIS METAL

The basis metal should be free from non-conducting inclusions, such as slag and refractories; being non-conductors, these inlcusions will cause discontinuity in the coating.

4 POLISHING

The metal surface should be ground if necessary to remove imperfections, polished to a high lustre if a bright finish is desired and then conditioned suitably for electroplating. This is done by mechanical or chemical treatment, electropolishing, etc. For details of these processes, reference may be made to SLS 450.

5 CLEANING

The surface of the basis metal should be chemically clean as otherwise there may be poor adhesion of the plated material, depending upon the nature and thickness of the soil. For details, reference may be made to SLS 322.

6 PLATING EQUIPMENT

6.1 Tanks

Welded steel tanks, suitably lined inside and painted from outside are used for the majority of electroplating and pre-treatment processes. Different types of tank linings used for pre-treatment processes and electroplating solutions are given in Appendix A and Appendix B.

6.1.1 In the case of tanks with linings, the following important operations shall be carried out prior to use.

6.1.1.1 *Rubber-lined tanks*

a) When using acidic solution, fill the tank with dilute sulphuric acid (approximately 3 per cent to 5 per cent (*V/V*). Heat it for at least eight hours at a temperature ranging from 45 °C to 60 °C. The temperature chosen for heating, however, should be 3 °C in excess of normal operating temperature. Remove the acid solution and wash the tank with clean water. (See Note)

NOTE - Water shall be free from acid anions and calcium. It is preferable to use distilled or de-ionised water.

b) When using cyanide solution, fill the tank with caustic soda solution (100 g/l) and keep it for at least eight hours. If possible, keep it heated around 50 °C. Remove the solution and wash the tank with clean water, scouring the lining slightly with a fibre or bristle brush. Wash it again before putting to use.

6.1.1.2 *Alloy-lead-lined tanks for chromium plating*

Clean the tank and fit the reinforced glass lining or rigid plastic lining. Fill up the tank with plating solution and heat rapidly up to 60 °C. It is important that the cold solution is not left in contact with the new lining until the above treatment is carried out.

6.2 Accessories

The following accessories are required:

a) Insulators;

b) Anode and Cathode, rods; and

c) Rod connectors.

6.3 Plating rack

A plating rack is a contrivance to suspend parts in position in an electrolyte and to conduct current through them. In its simplest form a rack may be a hook made of bare copper wire.

6.3.1 In designing a plating rack the following should be taken into consideration.

a) The rack should be such that it carries the required current;

b) It should permit holding significant surfaces such that they suitably face the anode;

c) It should be designed to avoid any uneven distribution of deposit;

d) It should have sufficient strength to hold the workpiece;

e) There should be sufficient clearance between the top of the work and solution level, and also between the bottom of the work and bottom of the tank.

The materials used for the rack and its insulation, if any, should be such as that they do not have any adverse effect on the plating owing to any reaction with the electrolyte.

6.4 Anodes

Anodes of suitable composition either of the soluble or insoluble type could be used for electroplating. Sufficient number of anodes and surface area should be used to yield optimum efficiency. Anode bags could be used in order to prevent solid particles from soluble anodes entering the plating baths, causing rough deposits. Anodes in the form of pellets, squares, balls etc are used in baskets made of titanium, propylene etc., In the case of ball anodes, wire cages are also used in place of baskets. Anodes should not touch the tank.

6.5 Barrel plating equipment

Barrel plating is widely employed for the bulk processing of small to medium sized components. Recent improvements in plant and processes have greatly increased the range of components which can be electroplated in barrels and now permit the application of heavier deposits, thus enabling specification finishes to be produced.

Barrel plating equipment may consist of multi-station units in which the plating and pre-and post-plating sections are combined in one plant, or single station unit where the plating barrel is fed from an independent and usually, manually operated cleaning line.

7 ANCILLARY EQUIPMENT

7.1 Equipment for heating

7.1.1 *Heating by steam*

This should be carried out by one of the three methods detailed below:

7.1.1.1 Steam injection

In this method live steam is directly injected. Owing to considerable dilution that may result if steam is directly injected into the solution, this method is restricted to heat water and water jackets. Each injector should be provided with a pressure reducing valve and a safety valve to restrict the steam pressure to 70 kPa.

7.1.1.2 Steam coil

Immersion of steam pipe coil in solution is the most common method employed. The type of coil to be used depends upon the type of solution. The following data should serve as a guide;

a) Plain steel coils - for alkaline or cyanide solution

b) Titanium covered coils - for acidic solutions

c) Tellurium lead coils - for sulphuric acid pickling solution, chromium plating solutions containing chloride or silicon fluoride.

7.1.1.3 Heat exchangers

Carbon block heat exchangers are now used in place of pure nickel steam coils for bright nickel plating solutions. The following too could be used:

a) Stainless steel heat exchangers - for chromic acid solution

b) Mild steel heat exchangers - for cyanide solution

c) Titanium heat exchangers - for nickel and chromium plating solution.

7.1.2 *Heating by gas*

This method makes use of a variety of gas burners and is convenient for heating small tanks.

7.1.3 *Heating by electricity*

This method of heating provides ease of control. A variety of immersion heaters are used for this purpose. Among them the hair-pin types are more commonly employed. The type of heater,

however, depends upon the solution to be heated. The following recommendations would serve as a guide.

	Solution	Type of heater
a)	Cyanide and alkaline, such as metal cleaner, tin-plating etc.,	With steel casing
b)	Weak acidic, such as for dull nickel plating	With rolled lead casing over steel or fused silica
c)	Bright nickel solution	Fused silica.

7.1.4 *Heating by outer jacket*

This may be electrically heated by screw-in type immersion heaters fitted horizontally at the inside bottom of tank. It is advantageous to heat lead-lined tanks by means of water jacket. For rubber-lined tanks this is a difficult problem, but when the amount of heat necessary is small and the time of heating is not the main factor, this method may be used.

NOTE - Where electric immersion heaters are used, it is essential they be effectively earthed to ensure safety to operators in the event of failure of insulation medium surrounding the heated elements.

7.2 Equipment for filtration

Filtration of plating solutions is essential if roughness or porosity due to inclusion of suspended matter in the plated deposit is to be avoided. Agitated solutions and those operated at high current density should be continuously filtered. Such baths therefore need to be filtered with filtering units. For other solutions, filtration at regular intervals may serve the purpose. A portable filtration unit on wheels is very convenient for intermittent filtration work. The use of a simple filtration unit for different types of solution should be avoided. Intake and discharge points should be located properly to provide complete turn-over of the solution. When using a diaphragm in a plating tank, the suction line of the pump should be connected so that solution from both compartments are drawn in, and the filtrate should be returned to the cathode side of the diaphragm. A pressure gauge should be fitted to the line to determine when to clean the filter.

7.2.1 *Choosing a filtration unit*

The following should be taken into consideration when choosing a filtration unit.

a) Suitability of the materials of construction of the unit including pump and connections for the solution treated;

b) Filtration rate; and

c) Size of particles retained by the filter.

7.2.2 *Types of filters*

a) Gravity filters;

b) Pressure filters; and

c) Vacuum filters.

Gravity filters are suitable for slow filtration rates, while the other two types are suitable for faster filtration rates.

7.2.3 *Filter media and filter aids*

The filter medium and filter aid (if used) should suit the solution treated at normal working temperature and effectively retain even smaller size particles.

7.3 **Electrical equipment**

How voltage direct current required for electroplating can be obtained by generating d.c. or converting a.c. by use of rectifiers. For some small scale work storage batteries may be used.

7.3.1 *d.c. generators*

Various output capacities available are included in Appendix C.

7.3.2 *Rectifiers*

Many types of rectifiers such as silicon, metallic selenium, germinium, and mercury arc are available. Oil immersed metallic rectifiers were extensively used in the past, silicon rectifiers are now popular because of their size and power efficiency.

The following rectifier units are suitable:

a) Single - phase sets operating from 230 volts, nominal, 50 hertz; and

b) Three - phase sets operating from 400 volts nominal, 50 hertz.

NOTE - Single - phase rectifier sets are unsuitable for chromium plating unless the output is smoothened to the desired level. For a majority of plating processes 7.5 volt units are quite suitable. However, a set having a maximum output of 16 volts would be advantageous. It is preferable to have continuously variable voltage regulator.

7.3.3 *Electrical control*

For proper control of voltage and current at the tank a voltmeter, an ammeter and a resistance panel should be incorporated.

8 PLATING PROCESSES

Two types of plating processes are generally used based on the size, shape and quantity of the article.

8.1 Process for racked parts

The treatment cycle for plating should be chosen with care keeping in view the nature of the basis metal and that of the electro-deposit for achieving the properties desired such as corrosion resistance, mechanical properties and lustre. Three typical cycles are given in Appendix D and Appendix E.

8.2 Process for parts in bulk

Components in bulk, suitable for treatment in barrels, should be plated in barrels, manually operated or fully automatic. Care should be taken in selecting parts to be plated in barrel so that owing to their shape and size they do not lock together. The chief facility of barrel is that racking of small articles required in tank plating is avoided. A typical example of treatment cycle for barrel plating is given in Appendix F.

9 CONTROL AND QUALITY OF DEPOSIT

9.1 Electrical control

The electrical current and voltage should be controlled within the established values to maintain the properties of the deposit.

9.2 Bath control

In general, plating baths are aqueous solutions containing various chemicals and compounds of the metals being plated.

In operation the solution may get contaminated and the composition would change with use.

9.2.1 The working temperature, agitation, filtration, pH and other operating conditions of the solution should be carefully controlled within the established values to maintain the properties of the deposit.

9.2.2 All solutions should be subjected to regular analytical control including determination of the concentration of metal ions, added materials and injurious impurities.

9.2.3 Organic contamination and other types of impurities can be removed by addition of activated carbon followed by filtration in a suitable filter. In place of activated carbon, a larger quantity of good quality carbon may be used.

9.2.4 Chemical purification should be frequently done to remove certain types of impurities from the plating bath. It should not

be carried out in the plating tank itself, but in a separate purification tank. Some examples of chemical purification are;

a) Addition of zinc dust to zinc baths to precipitate nobler metals.

b) High pH precipitation of heavy metals from nickel bath carried out at elevated temperature. (pH is usually raised to a value between 5.6 to 5.8) followed by filtration.

9.2.5 Electrolytic purification (Continuous or intermittent) is another process that is being used to remove dissolved metallic contaminations. A current ranging from 0.6 kA/m^2 to 10.0 kA/m^2 with corrugated cathodes is usually being used. Batch dummying may also be used to remove heavy contamination using live large surface area cathodes. Circulation of solution is recommended.

10 TESTS

For controlling the quality of deposits, regular testing is necessary. Some important tests are mentioned below.

10.1 Thickness test

There are several destructive and non-destructive methods available for the determination of thickness of electro deposits. Gravimetric methods where the coating thickness is determined by chemical stripping are accurate and simple. Non destructive methods such as magnetic and eddy current methods offer quick results, but are less accurate than the chemical stripping methods. They could be used for quality control work. ISO 3882 could be referred for further details.

10.2 Adhesion test

There are several methods available for testing adhesion. However the simple method available gives qualitative results. For thin deposits ball burnishing test is recommended and for thick coating chisel test could be used. ISO 2819/1 could be referred for further details.

10.3 Corrosion test

There are several methods such as neutral salt spray test, acetic acid salt spray test, copper-accelerated acetic acid salt spray test and corrodkote test used to determine the corrosion resistance properties of the electro deposits. Depending mostly on the time available for the tests a suitable test method could be employed. The above tests are described in the following standards : ISO 3768; ISO 3769; ISO 3770; and ISO 4541.

11 DESIGN OF ARTICLE

Besides the fabrication and function of an article, its design plays a vital role in the requirements of finishing processes. Design should preferably avoid deep recesses, concavities that cannot be touched by a ball of 25 mm diameter, sharp edges and blind holes, close overlapping cavities and tubular stems where solutions may be trapped. If some of these requirements cannot be fully met in the design of the article, and the ability of a bath to deposit metals into deep recessed areas or holes is limited, special techniques are required where a certain thickness of deposit is essential.

12 CHARACTERISTICS AND USES OF DEPOSITS

Broad recommendations on characteristics and uses of some metallic coatings are listed in Appendix G.

13 SAFETY IN THE PLATING SHOP

Some chemicals used in the electroplating industry are either highly corrosive or poisonous. Therefore the risks involved with accidents are high. Also, the effects of the toxic fumes evolved during certain operations on the workmen are serious. Another hazard is faulty electrical connections. When planning an electroplating shop due consideration shall be given to the above hazards to avoid unwarranted incidents. The following points shall serve as a guide;

13.1 Equipment shall not be crowded into an insufficient space and the building and the equipment shall be regularly maintained.

13.2 All electrical equipment shall be earthed properly and it shall be possible to isolate each equipment.

13.3 Building design shall be such that the natural draught carries away as much as possible, fumes produced, in case of failure of exhaust ventilation apparatus.

13.4 Fume hoods with exhausters and chimney shall be fitted above tanks in which toxic fumes are evolved.

13.5 Workmen who have open wounds shall not be permitted to handle solutions containing cyanides and other highly poisonous chemicals.

13.6 When handling concentrated chemicals or solutions, appropriate devices shall be used and the correct procedure shall be followed in preparing solutions.

13.7 Chemicals shall be stored in a separate room and the containers shall be kept properly closed.

13.8 Suitable safety equipment such as respirators, goggles, gloves, aprons and boots, in good condition, shall be worn when necessary.

14 EFFLUENT CONTROL

The effluent from the plant should be treated to render it harmless before it is discharged.

APPENDIX A

STEEL TANK LININGS FOR PRE-TREATMENT PROCESSES

PROCESS (1)	PLAIN STEEL (2)	LEAD LINED (3)	RUBBER LINED (4)	PLASTIC LINED (5)	ENAMELLED IRON (6)	STONE WARE (7)	STAINLESS STEEL (8)
i) Alkaline cleaners	R	U	U	U	U	U	U
ii) Cyanide cold cleaners	R	U	S	S	S	S	U
iii) Acid dips:							
a) Dilute sulphuric acid	U	R	R	S	S	S	U
b) Dilute hydrochloric acid	U	U	R	R	S	S	U
c) Dilute hydrofluoric acid	U	U	R	R	U	U	U
d) Sulphuric acid	U	R	U	U	S	U	U
e) *Aquafortis bright dip	U	U	U	R	S	R	R
f) Chromic sulphuric acid	U	S	U	S+	S	R	R

R = Recommended, S = Suitable, U = Unsuitable.

* *This is a mixture containing nitric acid and sulphuric acid*

\+ *Certain plastics are suitable.*

NOTE - There are new polymers which may be categorised under rubbers and plastics that have necessary properties such as pH, thermal and chemical stability and they may be suitable for electroplating bath linings. The reader is advised to consult manufacturers of these new materials for their suitability.

APPENDIX B

TANK LININGS FOR ELECTROPLATING SOLUTIONS

	PROCESS (1)	PLAIN STEEL (2)	LEAD LINED (3)	RUBBER LINED (4)	PALSTIC LINED (5)	ENAMELLED IRON (6)	STONE WARE (7)	STAINLESS STEEL (8)
i)	Dull nickel	U	R*	R+	S	S	S	U
ii)	Bright nickel	U	U	R+	S	S	S	U
iii)	Chromium	U	R++	U	S	S	U	U
iv)	Copper							
	a) Cyanide	R*	U	S	S	S	S	U
	b) Bright	R*	U	S**	S	S	S	U
	c) Acid	U	R*	R+	S	S	S	U
v)	Brass	R	U	S	S	S	S	U
vi)	Silver	S*	R*	S	S	S	S	U
vii)	Gold	U	U	U	U	R	U	R***
viii)	Cadmium	R	U	R	S	S	S	U
ix)	Zinc							
	a) Cyanide	R	U	R	S	S	S	U
	b) Acid	U	R	R	S	S	S	U
x)	Tin							
	a) Alkaline	R	U	S	U	S	U	U
	b) Acid	U	R*	R	S	S	S	U
xi)	Lead	U	U	R	S	S	S	U

R = Recommended, S = Suitable, U = Unsuitable.

* *With preferably, a loose inner lining of reinforced glass or plastic sheets*
** *Special quality rubber pre-treated with hot dilute acid.*
*** *Stainless steels of widely differing composition are available. It is therefore, important when ordering stainless steel tanks that the process be specified.*
\+ *Special quality rubber pre-treated with hot dilute acid.*
++ *Special alloy lead with loose inner lining of reinforced glass or plastic sheets.*

NOTE - There are new polymers which may be categorised under rubbers and plastics that have necessary properties such as pH, thermal and chemical stability and they may be suitable for electroplating bath linings. The reader is advised to consult manufacturers of these new materials for their suitability.

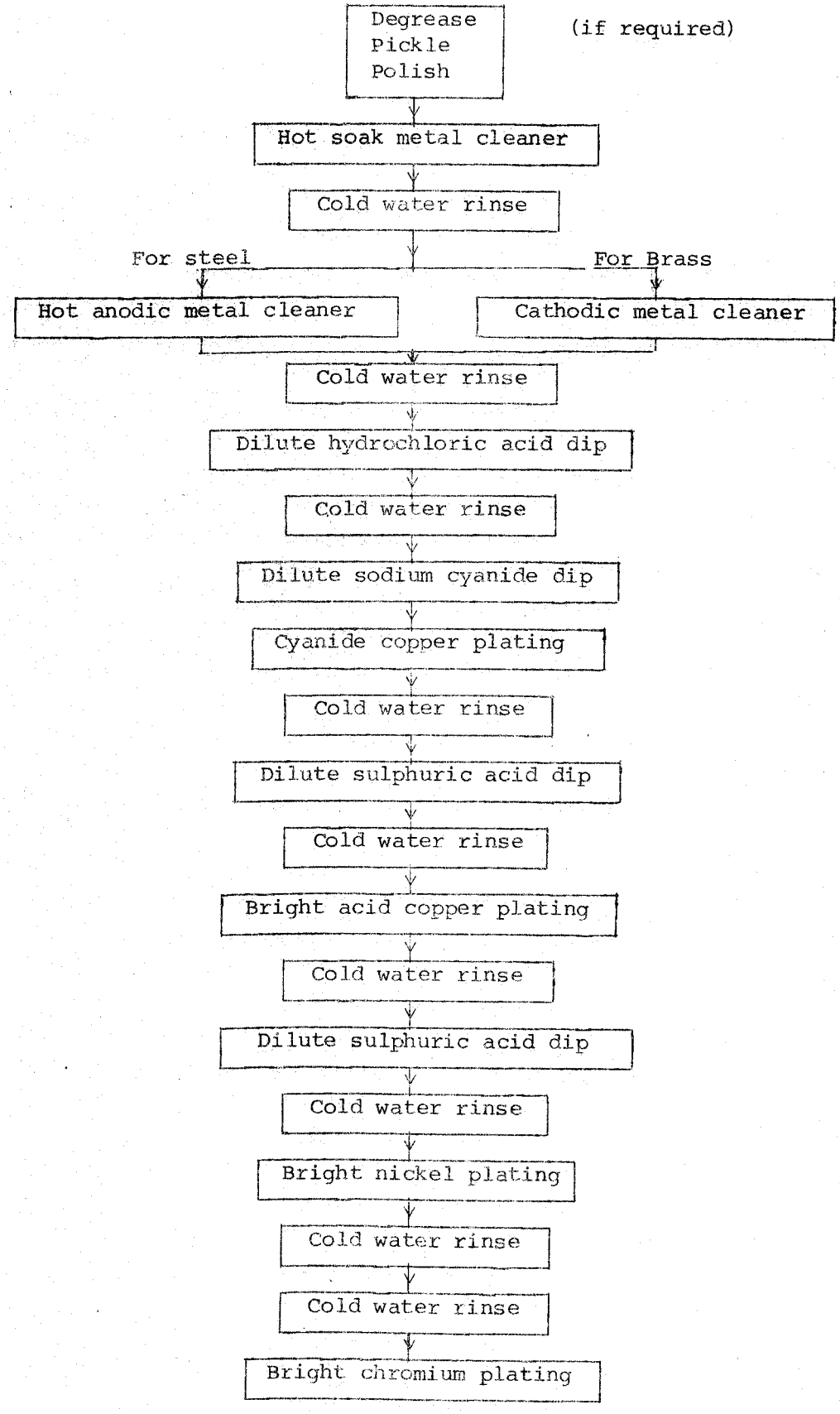
APPENDIX C

OUTPUT DETAILS OF GENERATORS

OUTPUT CURRENT	OUTPUT VOLTAGE	NOMINAL SPEED	APPROXIMATE POWER INPUT REQUIRED
Amperes (A)	Volts (V)	(rev/m)	(kW)
15	06	1 850	0.19
15	10	2 100	0.10
30	06	2 800	0.37
30	06	1 850	0.37
30	08	2 200	0.47
30	10	2 400	0.56
50	06	2 800	0.56
50	06	1 450	0.56
50	08	1 750	0.65
50	10	2 200	0.93
100	06	1 450	1.12
100	08	1 700	1.31
100	10	1 850	1.68
150	06	1 200	1.49
150	08	1 350	1.86
150	10	1 450	2.24
250	06	1 200	2.24
250	08	1 350	2.98
250	10	1 450	3.73
500	06	1 450	4.47
500	08	1 450	5.59
500	06	960	4.47
500	08	960	5.97
500	10	1 200	6.71
750	06	850	5.97
750	08	1 960	8.20
750	10	960	9.70
1 000	06	720	7.83
1 000	08	960	10.10
1 000	10	960	13.05
1 500	06	720	11.19
1 500	08	960	14.91
1 500	10	960	18.64
2 000	06	720	14.91
2 000	08	720	20.13
2 000	10	960	23.86
3 000	06	575	22.37
3 000	08	575	29.83
3 000	10	720	37.29
4 000	06	360	37.29
5 000	08	485	49.96
5 000	10	485	63.39

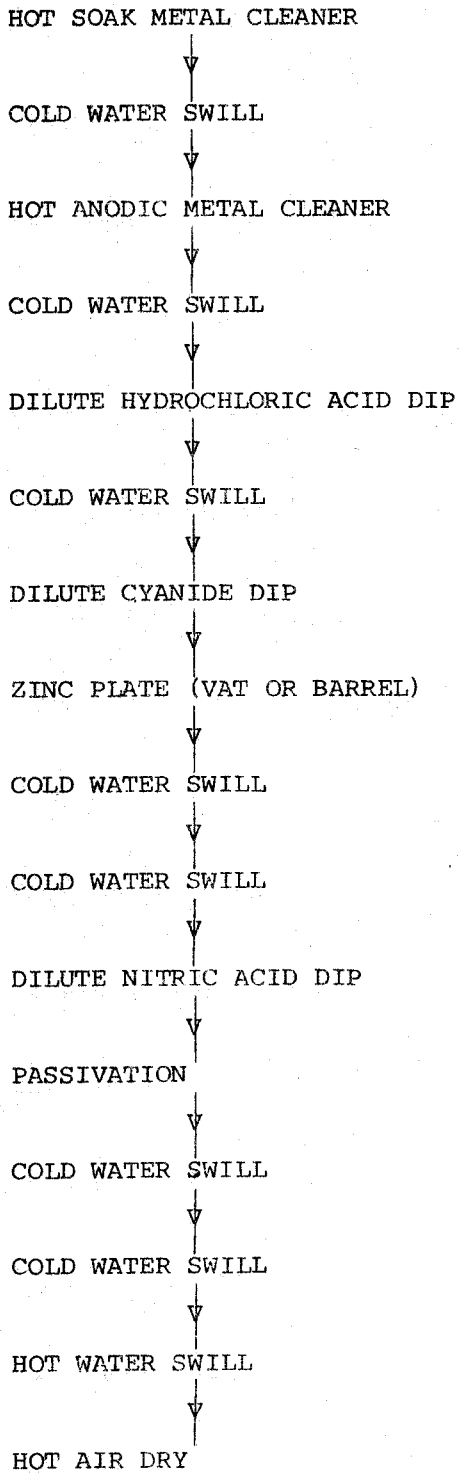
APPENDIX D

TYPICAL CYCLE FOR CHROMIUM PLATING ON STEEL AND CHROMIUM PLATING ON BRASS



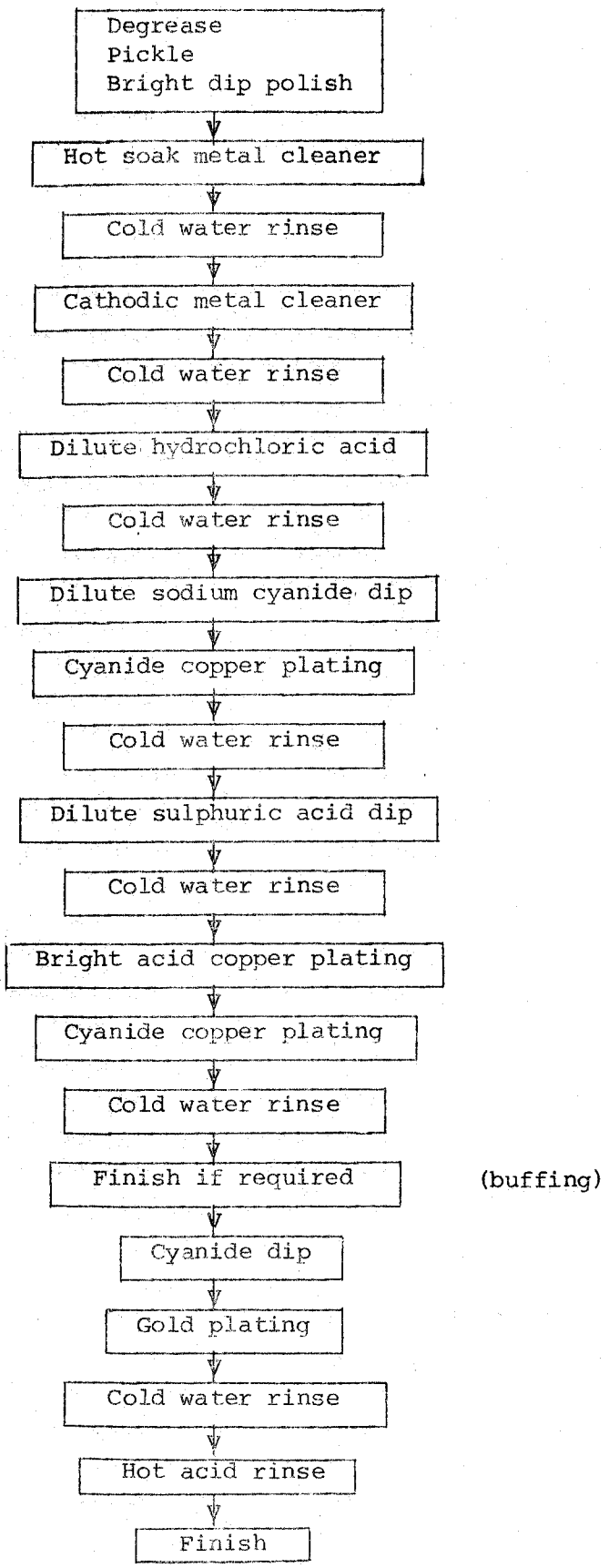
APPENDIX E

TYPICAL CYCLE FOR BRIGHT ZINC PLATING AND PASSIVATION



APPENDIX F

TYPICAL CYCLE FOR GOLD PLATING ON BRASS



APPENDIX G

CHARACTERISTICS AND USES OF DEPOSITS

COATING METALS	CHARACTERISTICS	SOME IMPORTANT USES
Cadmium	Protects steel, better solderability than zinc, greater resistance to alkalis, toxic, white and more lustrous than zinc. Relatively expensive, thinner coating will suffice.	Protection of ferrous metals, specially against humid conditions and marine atmosphere. As an alkali resistant coating, to reduce bimetallic corrosions and as finish on light equipment.
Chromium	Highly tarnish resitant, bright hard and wear resistant, low frictional properties.	Decorative plating, flash chromium to give non-tarnishing properties to an underlying nickel deposit. Heavier deposits for building up worn-out engineering parts, and for claiming accidentally over-machined parts. As bearing surfaces, for other low frictional properties. Also as protective coating to resist chemical attack.
Cobalt	Expensive, reflective, hard	Used on printing plates, reflectors and also with some bright nickel.
Copper	Ductile and conductive, basis metal to many electrodeposits.	As an undercoat for nickel/chromium plating. In electroforming, as protection during selective casehardening. For bronze finishes on steel and other metals.
Gold	Pleasing colour, non tarnishing and corrosion resistant even at higher temperatures, good conductor, resists chemical attack.	Used on ornamental and decorative works, electrical contacts of low resistance for example, printed circuits.

COATING METALS	CHARACTERISTICS	SOME IMPORTANT USES
Iridium	Soft, white, high-melting, and corrosion resistant	Used on silverware and decorative consumer items. For lead/iridium alloy plating on heavy duty bearings specifically for aero-engine bearings.
Iron	Hard, poor corrosion resistant	Building up worn-out parts, limited application in electroforming.
Lead	Resistant to acid fumes and liquids. Soft. Applied in thick deposit.	Little commercial use. Used in bearing surfaces.
Nickel	Decorative, corrosion resistant hard, chemical resistant	Widest use in decorative field with a top coat of chromium. Heavier deposit used for building up worn-out parts, widely used in electroforming. Also a protective coating to resist chemical attack.
Platinum	Expensive, tarnish and corrosion resistant. High reflectivity.	Used for ornamental purposes and in radio valves.
Rhodium	Expensive, tarnish and corrosion resistant, hard wear resistant, good conductor. High reflectivity.	Surfacing of electrical contacts, frequently of the sliding or wiping type, for example, slip rings and brushes, selector switches and commutator plating. In jewellery, reflectors of projectors and search lights, some applications in electroforming.
Silver	Soft, ductile, lustrous best conductor of heat and electricity. Fatigue resistant low elastic modulus, non-toxic.	Ornamental; decorative for tableware; surgical parts, electrical contacts, reflectors, heavy deposition on bearings for heavy loads like aircraft bearings.

COATING METALS	CHARACTERISTICS	SOME IMPORTANT USES
Tin	Fairly tarnish and corrosion resistant, easily solderable non-toxic resistant to food stuffs.	Manufacture of tinned steel sheets for canning industry and other purposes. Protection to copper utensils, refrigerator trays, etc. As a cheap decorative coating in certain applications.
Zinc	Protects steel, cheaper than cadmium	Protection of ferrous metal especially against industrial and rural atmospheres.

SRI LANKA STANDARDS INSTITUTION

The Sri Lanka Standards Institution (SLSI) is the National Standards Organization of Sri Lanka established under the Sri Lanka Standards Institution Act No. 6 of 1984 which repealed and replaced the Bureau of Ceylon Standards Act No. 38 of 1964. The Institution functions under the Ministry of Science & Technology.

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