D.T.D.903D

Ministry of Defence
Defence Procurement Agency, ADRP2
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Bristol
BS34 8JH

OBSOLESCENCE NOTICE

All DTD specifications were declared obsolescent from 1st April 1999. All DTD 900 series approvals also lapsed at that time. The standards will no longer be updated but will be retained as obsolescent documents to provide for the servicing of existing equipment.

Further Guidance

The aim in declaring the specifications obsolescent is to recognise that the documents are not being updated and thus should be used with care by both purchaser and supplier. For example, a specification could contain valid technical information but may also contain type approval clauses that contradict procurement policy and/or use materials that do not comply with environmental legislation. The obsolescent specification can still be used as a basis for a purchase provided that the supplier and purchaser agree suitable changes to the specification within the purchase order/contract.

For the DTD 900 system, each specification has provided an MoD approved material and process. For these items, the declaration of obsolescence will constitute the termination of both the extant MoD approval and the continuing MoD assessment that had underpinned those approvals. Again, the technical content of the document remains valid and can be used by both purchaser and supplier as a basis for a contract but an acceptable (to the parties) approval/assessment procedure would be required.

MINISTRY OF TECHNOLOGY

D.T.D. 903D

(Superseding D.T.D. 903C)
March, 1966
Reprinted May, 1968

Process Specification
ZINC PLATING

NOTE 1. Where allowed by the design document, zinc plating is the normal alternative to cadmium plating for protecting close-tolerance parts against corrosion. It is particularly useful for reducing or avoiding bi-metallic corrosion and is suitable for service at temperatures up to 350°C.

NOTE 2. Zinc is liable to rapid attack in humid atmospheres and, like cadmium and some other metals, by vapours emanating from certain woods, varnishes, plastics and other organic materials, particularly in poorly ventilated or humid conditions (see Defence Guide DG-3).

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1. Scope

1.1 This specification covers the requirements for zinc plating of carbon steel and low alloy steel parts for protection against corrosion. Parts made of steel of minimum specified tensile strength exceeding 90 tonf/in^2 or of equivalent hardness (see Clause 3.3) are subject to the special limitations and requirements of D.T.D. 934. The specification also covers the requirements for zinc plating of copper-base materials and corrosion-resisting steels for the reduction of contact corrosion of less noble metallic materials.

1.2 Zinc plating shall not be used on parts which are liable to be subjected to temperatures in excess of 350°C (660°F).

2. Related specifications

Reference is made in this specification to the following:

B.S.622,	'Cyanides for electroplating'
B.S.2656,	'Zinc anodes, zinc cyanide and zinc oxide for eleotroplating'
DEF-130,	'Chromate passivation of cadmium and zinc surfaces'
D.T.D.901,	'Cleaning and preparation of metal surfaces'
D.T.D.934,	'The treatment and protection of very high strength steels'

3. General

3.1 The treatments required for steel parts before and after plating depend partly on:

(a) the type of steel, i.e. carbon, low alloy, or corrosion resisting

(b) the tensile strength (or hardness) of the steel

(c) the presence of surface-hardened areas

(d) the need or otherwise for stress-relieving heat treatment.

3.2 If no minimum tensile strength is specified for the steel, the treatments shall be based on the minimum specified hardness. for the purpose of this specification, steels having hardness values of 300 HV or 295 HB and 430 HV or 405 HB shall be regarded as having tensile strengths of 65 and 90 tonf/in^2 respectively.

3.3 The Design Authority or main contractor shall give the plater instructions regarding the treatments to be applied under Clauses 4, 6 and 7 or, alternatively, the information necessary to enable the plater to select appropriate treatments under these clauses.

4. Pre-treatment

4.1 *Steels, carbon and low alloy.* Stress-relieving heat treatment (if required) and preparation for plating shall be carried out in accordance with D.T.D. 901.

4.2 *Steels, corrosion-resisting.* These shall be cleaned and prepared as described in D.T.D.901.

4.3 *Steel parts locally chromium plated.* Parts which are to be chromium plated locally and then heated in the range 440-480°C (825-895°F) as described in D.T.D. 916, shall be given these treatments before zinc plating.

4.4 *Copper-base materials.* These shall be prepared for plating in accordance with D.T.D.901.

5. Plating

5.1 *Electrolyte.*

5.1.1 Zinc is usually deposited from a cyanide electrolyte. Examples of suitable conventional cyanide electrolytes for vat and barrel plating, with guidance in making up and operation, are given in Appendix I for information.

NOTE. Where freedom from hydrogen embrittlement is a primary consideration the use of other electrolytes, e.g., modified cyanide, sulphate or fluoborate, may be advantageous. Some of these electrolytes, however, have a lower throwing power than the normal cyanide electrolyte. Addition agents such as are used to improve the properties or appearance of the coating may accentuate hydrogen absorption by steel during plating.

5.1.2 For the plating of parts such as springs, a flexible type of coating is required and the electrolyte used for this purpose should be of the type given in Appendix I and free from addition agents.

5.1.3 Any zinc cyanide or zinc oxide used for making up or maintaining the electrolyte shall conform to the requirements of B.S.2656. Any potassium cyanide or sodium cyanide used shall conform to the requirements of B.S.622 and the supplier or user of these or any other salts employed shall certify them as free from mercury. Care shall be taken to avoid contamination of the electrolyte with mercury.

5.2 *Anodes.* Zinc anodes shall conform to the requirements of B.S.2656.

6. Treatment after plating

6.1 *Washing procedure.* Parts shall be washed in clean running water immediately after plating. Unless specifically prohibited by the Design Authority or unless the parts are to be immediately passivated (see Clause 6.2) without drying, they shall then be dipped in an aqueous solution containing about 5 per cent (8 oz/gal) of chromic acid free from other acids, maintained at a temperature of not less than 60°C (140°F). for 15 to 30 seconds. They shall then be washed in clean running water, finally in warm water, and dried.

6.2 *Chromate passivation.*

6.2.1 Parts shall normally be chromate passivated. The passivation shall conform to DEF-130. Passivation may only be omitted at the specific request of the Design Authority or when the parts are to be etch primed within eight hours of plating.

6.2.2 Parts not required to be heated for removal of embrittlement (see Clause 7) shall be passivated immediately after plating and washing, without intermediate drying. Other steel parts shall be heated for removal of embrittlement and then, if necessary, cleaned as described in DEF- 130 before chromate passivation.

NOTE. In order to avoid staining it may be found desirable in some districts to use demineralised water in washing or chromate dip operations.

7. Removal of embrittlement

7.1 All plated steel parts of minimum specified tensile strength of 65 tonf / in^2 or greater (or of equivalent hardness) shall be heated as described below as soon as is practicable but not more than 16 hours after plating. This treatment shall also be applied to parts of this tensile strength after any stripping, except that the minimum time of heating of stripped parts may be reduced to not less than half of that specified for plated parts. Parts of minimum specified tensile strength exceeding 90 tonf/in^2 shall not be replated without the consent of the Design Authority.

7.2 Plated parts, other than those with carburised areas (see Clause 7.3), or certain bolts (see Clause 7.4). made of steel of minimum specified tensile strength of 65 tonf/in^2 or greater, up to and including 90 tonf/in^2, shall be heated at a temperature within the range 190°C to 230°C (375°F to 445°F) for not less than 4 hours. Parts of minimum specified tensile strength exceeding 90 tonf/in^2, shall be heated in accordance with the requirements of D.T.D.934.

7.3 Plated steel parts having carburised areas which would suffer an unacceptable reduction in hardness by treatment as in Clause 7.2 shall be heated at not less than 130°C (265°F) for not less than 6 hours.

7.4 Plated bolts of less than ½ inch nominal diameter, made of steel of minimum specified tensile strength of 65 tonf/in^2 or greater, up to and including 75 tonf/in^2, which have been thread rolled and rolled under the head after final heat treatment, shall be heated at a temperature within the range 190° to 230°C (375° to 446°F) for not less than 2 hours.

8. Inspection

8.1 *Visual.* Before chromate passivation (Clause 6.2) or chromate dipping (Clause 6.1) the coating shall be smooth and bluish white (matt or bright) and of uniform appearance. The coating shall be free from “burns” or blisters and shall appear to be adherent and continuous. The part or parts shall not have developed any defect as a result of the plating process.

8.2 *Selection of test samples.*

8.2.1 *Parts plated by the vat process.* The inspector shall select a sample, normally comprising at least two parts, to represent each vat load. Where a continuous form of vat plating is in operation, i.e. one involving movement of the parts through the bath by means of a conveyor system, a representative sample shall be taken at intervals of not more than one hour. Each part in the sample shall be tested for adhesion and thickness, the tests being carried out in this order. The mean of the local thickness or the average thickness for each part shall not be less than that specified in Table 1. The maximum difference between the coating thickness of the parts (mean local thickness or average thickness as appropriate) shall not exeeed 50 per cent of the thickness specified in Table 1.

8.2.2 *Parts plated by the barrel process.*

(i) From each group of more than one hundred parts of the same size and shape plated together, the inspector shall select a sample, normally comprising ten or more parts, for adhesion and thickness tests. The number of parts selected shall be such that significant weighing errors are avoided.

(ii) From each group of not more than one hundred parts of the same size and shape plated together, the inspector shall select a sample, normally comprising two or more parts, for adhesion and thickness tests. The number of parts selected shall be such that significant weighing errors are avoided.

8.2.3 *Parts plated in small numbers.* In exceptional circumstances, e.g., the vat plating of single large parts or the barrel plating of small numbers of parts, the sampling procedures specified in Clauses 8.2.1 and 8.2.2 may be modified at the discretion of the Inspecting Authority. In suitable instances coupon samples may be used, due consideration being given to their shape, size, material and, if applicable, position in the vat. The treatment of the coupon samples shall be suitably representative of that applied to the parts being plated.

8.3 *Thickness of coating.*

8.3.1 *General.*

(i) The thickness of zinc coating shall be reasonably uniform and when measured as described in Clause 8.3.2 or 8.3.3 shall comply with the minimum requirement shown in Table 1. Wherever practicable the local thickness test (Clause 8.3.2) shall be used.

(ii) For certain parts, where it is necessary to conform to the tolerance requirements of mating parts or where inter-changeability considerations apply, e.g., mating screw threads, it may be necessary to impose an upper limit on the thickness of deposit. In such instances the maximum thickness requirement shall be stated on the order. Alternatively, the plater shall be supplied with a drawing containing this information.

8.3.2 *Local thickness.* The local thickness of zinc shall be determined by the B.N.F. Jet Test before passivation or after removal of the passivation film (see DEF-130), or by micro-sectioning or any other local test method approved by the Inspecting Authority for the parts concerned.

The points selected for test shall be not less than ¼ inch from an edge and the tests on any one part shall normally be not less than four in number. Wherever practicable the tests shall be made at points which are widely separated and which would be expected to be comparatively thinly coated, but normally the points selected shall each be capable of being touched by a sphere of 1 inch diameter. When the full specification thickness of coating is required on shielded areas, this shall be stated on the drawing or order and the test procedure shall be suitably modified.

The local thickness requirements of Table 1 shall normally apply to parts plated by the vat process except that, at the discretion of the inspector, an average thickness test may be used for parts unsuitable for local thickness test or which, by virtue of their size, shape or the method of plating (e.g., where auxiliary anodes are used) would be expected to be reasonably uniformly coated.

8.3.3 *Average thickness.* The average thickness shall be determined by the stripping-and-weighing method described in Appendix III or by any method approved by the Inspecting Authority. The average thickness requirements of Table 1 shall normally apply to parts plated by the barrel process.

8.4 *Adhesion.* When the shape and size of the part permits, a small area of the plated surface, selected at the discretion of the inspector, shall be rubbed rapidly and firmly with a suitable tool for about 15 seconds and visually inspected when there shall be no indication of the deposit becoming blistered or otherwise detached from the basis metal. The pressure applied shall be sufficient to burnish the coating at each stroke but not to cut the deposit.

NOTE. A suitable tool is a steel rod of ¼ inch diameter with a smooth hemispherical end or a copper disc, e.g., a coin, used edgewise and broadside.

8.5 *Freedom from mercury.* Tests for mercury in the deposit shall be made periodically at the discretion of the Inspecting Authority. Mercury shall not be detectable when the deposit is tested by the method given in Appendix II or by any other method approved by the Inspecting Authority.

TABLE 1

Thickness requirements

	Local thickness, in, minimum	Average thickness,* in, minimum
1. Normal requirements		
(i) Steels, carbon and low alloy	0·0004	0·0006
(ii) Copper-base materials and corrosion-resisting steels	0·0003	0·0005
2. Mating threaded parts not exceeding 0·75 in dia.†		
Screws, bolts and nuts of nominal major thread diameter:		
(i) up to and including 0·126 in	—	0·00015
(ii) 0·127 in to 0·249 in inclusive	—	0·00020
(iii) 0·250 in to 0·375 in inclusive	—	0·00025
(iv) 0·376 in to 0·75 in inclusive	—	0·00030
3. Washers		
(i) up to and including 0·126 in nominal bore	—	0·00020
(ii) exceeding 0·126 in nominal bore	—	0·00030
4. Rivets, taper pins, split cotters, self-tapping screws and woodscrews	—	0·00030

* For barrel-plated parts average thickness is normally based on the whole sample, but for vat-plated parts, is normally based on individual parts.

† Thickness requirements for threaded parts are dictated by dimensional tolerance limits. Such thicknesses will not necessarily provide adequate protection against corrosion.

APPENDIX I

Composition, preparation and operation of suitable cyanide electrolytes

1. Composition

(a) A normal cyanide electrolyte should contain in solution zinc, sodium cyanide and sodium hydroxide. While considerable variation in the concentration of these constituents is permissible for satisfactory working, their relative concentrations should preferably be maintained in accordance with the following ratio:

Zinc: total cyanide (calculated as sodium cyanide): sodium hydroxide (caustic soda)
= 1 : 2.25-2.5: 1.5-1.75 for matt zinc coatings
or 1 : 2.5-3.0: 1.5-2.0 for bright zinc coatings.

(b) The following example of a satisfactory range of electrolyte composition is given for guidance:

	Minimum	*Maximum*
Zinc (as metal)	4.0 oz/gal (25g/l)	8.0 oz/gal (50g/l)
Total cyanide (as sodium cyanide)	9.0 oz/gal (56g/l)	18.0 oz/gal (112g/l)
Total sodium hydroxide	6.5 oz/gal (40g/l)	13.0 oz/gal (80g/l)

The ratio of the constituents in this example is 1: 2.25: 1.6. For any intermediate strength of electrolyte the amount of each constituent should be varied so as to maintain the recommended ratio. Electrolytes near the maximum concentration are recommended for barrel operation.

2. Preparation

Electrolytes having approximately the composition given above may be prepared, using zinc cyanide or zinc oxide to provide the metal content, from the following formulae:

		Minimum	*Maximum*
Zinc cyanide	(to B.S.2656)	7.25 oz/gal (45g/l)	14.5 oz/gal (90g/l)
Sodium cyanide	(to B.S.622)	3.0 oz/gal (19g/l)	6.0 oz/gal 38g/l)
Sodium hydroxide		6.5 oz/gal (40g/l)	13.0 oz/gal (80g/l)
		or	
Zinc oxide	(to B.S.2656)	5.0 oz/gal (31g/l)	10.0 oz/gal (62g/l)
Sodium cyanide	(to B.S.622	9.0 oz/gal (56g/l)	18.0 oz/gal (112g/l)
Sodium hydroxide		1.5 oz/gal (9.5g/l)	3.0 oz/gal (19g/l)

3. Operation

(a) Temperature. The electrolytes given above may be operated at room temperature but should preferably be used at about 32°C (90°F). Higher temperatures may give a further increase in cathode efficiency but may not be suitable for use in the presence of organic addition agents.

(b) Current density. The current density used with electrolytes of the above composition should preferably be equivalent to 10-20 amp/ft^2 of cathode surface for vat plating and 3-7 amp/ft^2 for barrel plating.

APPENDIX II

Detection of mercury in the coating

Cut a piece of clean steel sheet 4½ in x 4½ in which has been electro-plated to produce a zinc coating 0.0002 in thick into pieces 1½ in square and place the pieces in a 250 ml beaker. Pour 25 ml of hot nitric acid (d. 1.42) over the pieces, completely covering them, and swirl the beaker until effervescence has ceased. Transfer the liquid to another beaker, rinse the specimens with cold distilled water and add the rinsings to the main solution. Boil the solution to remove oxides of nitrogen, cool, dilute to 100 ml in a Nessler cylinder and immerse a 3 in length of clean 16 S.W.G. copper wire in the solution for 15 minutes. A deposit will be visible on the copper wire if the test solution contains 0.0002g or more of mercury.

APPENDIX III

Determination of average thickness of zinc coating

Clean the plated sample in a suitable solvent vapour, weigh and then totally immerse in a solution containing 2.5 g of antimony trichloride and 600 ml of hydrochloric acid (d. 1.16) per litre. Stir the solution occasionally until the plating is dissolved, two minutes being usually sufficient. Immediately effervescence has ceased, remove the sample from the solution, wash, dry and reweigh.

$$\text{Zinc thickness (in)} = \frac{\text{Loss in weight(g)}}{\text{Area (in}^2\text{) x 116}}$$

Approved for issue.

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