D.T.D.940

Ministry of Defence
Defence Procurement Agency, ADRP2
Abbey Wood
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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.940**

November, 1968

Process Specification
THE CADMIUM COATING OF VERY STRONG STEEL PARTS BY VACUUM EVAPORATION

NOTE 1. A cadmium coating followed by chromate passivation with or without further protection by paint is the preferred method of protecting close tolerance steel parts against corrosion. It is particularly useful for *reducing or avoiding bimetallic corrosion.*

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

1. Scope

1.1 This specification covers the requirements for the cadmium coating of carbon steel and low alloy steel parts by vacuum evaporation for protection against corrosion. The process will find most use for the coating of parts made of steel having a specified minimum tensile strength exceeding 140 hbar (90 tonf/in^2) but is equally suitable for steel of lower strength. The process avoids the risk of absorption of hydrogen and consequent hydrogen embrittlement. Although fine abrasion of the steel surface prior to coating is preferred, the process can be applied to clean fine machined surfaces.

1.2 Cadmium coating shall not be used on parts which are liable to reach temperatures above 250°C.

2. Related specifications

DEF-130, Chromate passivation of cadmium and zinc surfaces.

DEF-162, The pre-treatment and protectron of steel parts of tensile strength exceeding 90 tonf/in^2.

D.T.D. 901, Cleaning and preparation of metal surfaces.

D.T.D. 904, Cadmium plating.

3. Information to be supplied by the Design Authority

The Design Authority, or main contractor where this is he, shall provide the following information on the drawing and/or order:

(a) The specified minimum tensile strength of the steel from which the part is made, or other information from which this may be established;

(b) Instructions concerning stress relief prior to coating (c.f. clause *8(a)* of DEF-162 or clause 8 of D.T.D. 901 as appropriate). These instructions shall take into account the highest temperature to which the part may be heated and the prior physical preparation.

4. Pre-treatment

4.1 Parts made of steel of specified minimum tensile strength exceeding 140 hbar (90 tonf/in^2) shall be prepared and cleaned as described in Sections 2, 3 and 4 of DEF-162 but omitting any form of acid pickling. Dry abrasive blasting using fine non-metallic grit (Method 3B of D.T.D. 901, carried out dry) is the preferred but not essential final cleaning process. Any residual abrasive shall be blown off by a jet of clean, dry air free from oil. A final cleaning with pure organic solvent, e.g. iso-propyl alcohol, may be given if desired.

4.2 Parts in their final cleaned condition shall not be allowed to become contaminated or to rust before being introduced into the vacuum chamber. The interval between cleaning and coating should be short.

5. Coating, general

5.1 Areas not to be coated shall be stopped off with a material compatible with vacuum processing. Aluminium foil is recommended.

5.2 The coating process is carried out in a vacuum chamber in which parts are cleaned by an electrical glow discharge in argon at a low pressure and are then coated with cadmium evaporated from one or more boats. Evaporation is started in the presence of the glow discharge. Parts are held in suitable rotating and revolving jigs in such away that all surfaces are evenly cleaned and coated.

5.3 The glow discharge conditions, the number and position of the boats, the quantity of cadmium in each, the heating current and the duration of heating, and the geometry and motion of the jigs will vary with the size and shape of the parts to be coated.

5.4 The variable factors in 5.3 above shall be determined experimentally for each type of part to ensure that the requirements for thickness and adhesion of the coating are met. This may be done using a dummy part made of the same material and of the same shape and size as the production parts. Alternatively, when dummy parts are not available, the Inspecting Authority may authorise the use of production parts which, having been experimentally coated and found to pass the inspection tests, are then stripped of cadmium (para. 8) and re-coated as part of the production line.
The variable factors once established for each type of part shall be recorded and adhered to whenever that type of part is coated.

5.5 The cadmium shall be of a purity not less than 99.95% Cd (BS 2868 grade).

5.6 During processing, the parts shall not reach a temperature higher than 250°C. Unsatisfactory coatings will probably result if the part is hotter than about 100°C during deposition.

6. Coating, process*

6.1 The parts shall be loaded onto the jig in the established manner, and the established quantity of cadmium placed in the boats and the assemblies placed in the vacuum chamber.

6.2 The chamber shall be pumped down to a pressure of below 2×10^{-2} torr (20 microns Hg).

6.3 A D.C. potential difference shall then be applied between the workpiece and a suitable electrode in the chamber, such that the workpiece is held negative with respect to the electrode. This is most simply done by applying a negative D.C. voltage to the workpiece and earthing the electrode (which may, for example, be the metal vacuum chamber). Argon shall then be bled into the chamber to a suitable pressure, usually in the range 3×10^{-2} to 5×10^{-2} torr, to give a glow discharge enveloping the parts to be coated.

A discharge produced by a P.D. of 0.3 to 0.5kV in argon at a pressure of 5×10^{-2} torr and one produced by a P.D. of 2kV in argon at a pressure of 3×10^{-2} ton have been found suitable in particular cases, but these parameters may need to be varied for other systems to obtain deposits with satisfactory adhesion.

6.4 The discharge current should correspond to a current density of not less than $0.05 mA/cm^2$ over the parts to be coated.

6.5 The discharge shall normally be maintained for a period of at least 10 mins. unless the temperature of the workpiece rises to greater than about 100°C in which case a shorter period may be found adequate.

6.6 The cadmium source shall then be raised to a suitable evaporation temperature. If desired, snutters may be included in the rig to prevent coatings being deposited on the workparts before the boats have reached full temperature

6.7 The argon bleed, glow discharge and simultaneous evaporation at full temperature shall be maintained for a period of not less than half a minute and not more than two minutes.

6.8 The argon bleed and glow discharge shall then be discontinued and the chamber pumped down to a pressure below 2×10^{-4} torr. (0.2 microns Hg).

6.9 Evaporation shall be continued until the required thickness of cadmium has been deposited. It is normally arranged that this stage coincides with complete evaporation of cadmium from the boats.

6.10 The boats shall be allowed to cool before air is admitted into the chamber. The parts shall be removed and any loose deposit on the surface removed by brushing or wiping with a cloth.

7. Repeated coating

7.1 If the coating does not meet the thickness requirements, parts may be coated a second time according to the procedure laid down in section 6 above, provided the parts have been kept clean and free from finger prints and any other contamination. If parts are given a second coating, perhaps jigged in a different way to throw sufficient thickness into awkward recesses or holes, care must be taken not to deposit too great a thickness on to other surfaces.

7.2 Parts which have become contaminated shall be stripped as described in para. 8 below and re-coated in accordance with para. 6.

8. Removal of coating

Parts may be stripped of cadmium by immersion in a 10 to 30% w/v solution of ammonium nitrate in water at room temperature, followed by washing and drying. If desired, the parts may then be baked at up to 200°C.

9. Removal of embrittlement

When correctly carried out, the vacuum cadmium coating process is non-embrittling. No baking treatment is required.

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*Clauses 6.3 to 6.7 are covered by B.P. 1,109,316.

10. Treatment after coating, passivation

Parts shall normally be chromate passivated. The passivation shall comply with DEF-130. Passivation may only be omitted when the parts are to be etch primed or at the specific request of the Design Authority.

The dichromate or chromic acid rinse given to electroplated parts which are not to be passivated, does not apply.

11. Inspection

11.1 *Visual.* The parts shall be examined before they are chromate passivated. The coating shall be smooth and white (matt or bright) and of uniform appearance. It shall be free from blisters, pits or nodules, and shall appear to be adherent and continuous.

11.2 *Thickness.*

11.2.1 *Limits.*

The thickness of the cadmium coating shall comply with the minimum requirements shown in Table I. Wherever practicable the local thickness test shall be used on parts coated to the normal requirements. Fasteners coming within categories 2 to 4 in Table I shall comply with the requirements for minimum average thickness.

For certain parts, where close tolerance of mating surfaces or interchangeability applies, it may be necessary to impose an upper limit on thickness of coating. In such cases the maximum thickness shall be stated on the order or on a drawing supplied to the plater.

11.2.2 *Selection of samples and determination of thickness.*

Prior to production, the variable conditions for each type of part are to be determined by trial runs as described in para. 5.4. These trials include establishing the conditions for meeting the thickness requirements.

On parts coated to the normal requirements, the local thickness shall be determined during these trials, first by a non-destructive method approved by the Inspection Authority, and then by the BNF Jet Test Method or by micro-sectioning. From the true thickness obtained by BNF or micro-sectioning, a correction factor shall be determined to apply to the non-destructive method for that particular type of part. For production control the local thickness shall be determined by that non-destructive method on not less than one part from each load from the coating chamber, and the same correction factor applied.

The points selected for the local thickness 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 not less than 1 inch diameter.

On fasteners coming within the categories 2 to 4 in Table I, the average thickness shall be determined during these trials by the stripping and weighing method described in Appendix I. For production control the average thickness shall be determined by this method on not less than one part from each load from the coating chamber.

11.2.3 *Penetration into recesses.*

Holes, recesses, internal threads and other similar areas shall not be subject to thickness requirements, but a coating shall be present on all visible surfaces including the roots of threads and all sharp corners and shall extend into holes and recesses to a distance equal to twice the diameter of the opening.

11.3 *Adhesion.*

11.3.1 *Selection* of *samples.*

For the establishment of process variables as described in para. 5.4, adhesion tests shall be made on a number of areas of parts from all positions on the mounting jig. For production control, adhesion tests shall be made on not less than one part from each load from the coating chamber, or, at the discretion of the Inspecting Authority, on a test panel coated with the load. The test panel shall be of the same composition and metallurgical condition as the production parts.

11.3.2 *Adhesion test.*

A small area of the plated surface shall be rubbed rapidly and firmly with a suitable tool for about fifteen seconds at a pressure sufficient to burnish the coating at each stroke but not to cut the deposit. The coating shall not become blistered or otherwise detached from the basis metal. A suitable tool is a steel rod of ¼ inch diameter with a smooth hemispherical end or a copper disc used edgewise and broadside.

APPENDIX I

Determination of average thickness of cadmium coating

If the part has become contaminated, clean it in a suitable solvent vapour. Weigh the clean part and then immerse it in an aqueous solution containing 10 to 30% w/v ammonium nitrate at room temperature with occasional stirring until the cadmium coating is dissolved (usually about ten minutes). Remove the part, wash, dry and reweigh it.

$$\text{Cadmium thickness} = \frac{\text{Loss of weight (g)}}{\text{Area (in}^2\text{) x 141}} \text{ inch} = \frac{\text{Loss of weight (g) x } 10^4}{\text{Area (cm}^2\text{) x 8.64}} \ \mu\text{m}$$

TABLE 1

Thickness requirements

	Local thickness, min.		Average thickness, min.	
	in	µm	in	µm
1. Normal requirements	0.0004	10	0.0006	15
2. Threaded parts less than 0.75 inch dia.* Screws, bolts and nuts of nominal major thread diameter :				
(i) up to and including 0.126 in	—	—	0.0015	4
(ii) 0.127 in to 0.249 in	—	—	0.00020	5
(iii) 0.250 in to 0.375 in	—	—	0.00025	6
(iv) 0.376 in to 0.75 in	—	—	0.00030	7.5
3. Washers				
(i) up to and including 0.126 in nominal bore	—	—	0.00020	5
(ii) exceeding 0.126 in nominal bore	—	—	0.00030	7.5
4. Rivets, taper pins and split cotters	—	—	0.00030	7.5

*The coating thickness requirements are dictated by dimensional tolerance limits. Such thicknesses do not necessarily provide adequate protection against corrosion.

Approved for issue,

E. W. RUSSELL,

Director of Materials Research and Development /Aviation.

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