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CADMIUM PLATING LOW EMBRITTLEMENT, ELECTRODEPOSITION

SPECIFICATION

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Defence Group:	AIR
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Approving Authority:	OIC AMPTS

NOTE

All listed reference documents should be viewed as the latest edition, unless stated otherwise.

Implementation Document(s):

Document Number	Title
AAP 7002.005-1	Electroplating of Aircraft Components

Referenced Document(s):

Document Number	Title
AS/NZS ISO 10012	Measurement management systems-Requirements for measurement processes and measuring equipment
ASTM B 117	Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B 322	Standard Guide for Cleaning Metal Prior to Electroplating
ASTM B 244	Standard Test Method for Measurement of Thickness of Anodic coatings and of other Nonconductive Coatings on Nonmagnetic Basis Metals with Eddy Current Instruments
ASTM B 374	Standard Terminology Relating to Electroplating
ASTM B 487	Standard Test Method for Measurement of Metal and Oxide Coating Thickness by Microscopical Examination of a Cross Section
ASTM B 499	Standard Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic basis Metals
ASTM B 504	Standard Test Method for Measurement of Thickness of Metallic Coatings by the Coulometric Method
ASTM B 555	Standard Guide for Measurement of Electrodeposited Metallic Coating Thicknesses by the Dropping Test
ASTM B 567	Standard Test Method for Measurement of Coating Thickness by the Beta Backscatter Method
ASTM B 568	Standard Test Method for Measurement of Coating Thickness by X-Ray Spectrometry

ASTM B 571	Standard Practice for Qualitative Adhesion Testing of Metallic Coatings
ASTM B 602	Standard Test Method for Attribute Sampling of Metallic and Inorganic Coatings
ASTM B 697	Standard Guide for Selection of Sampling Plans for Inspection of Electrodeposited Metallic and Inorganic Coatings
ASTM B 762	Standard Test Method of Variables Sampling of Metallic and Inorganic Coatings
ASTM B 766	Standard Specification for Electrodeposited Coatings of cadmium
ASTM E 376	Standard Practice for Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Examination Methods
ASTM E 1444	Standard Practice for Magnetic Particle Testing
ASTM F 519	Standard Test Method for Mechanical Hydrogen Embrittlement Evaluation of Plating/Coating Processes and Service Environments
ASTM G 85	Standard Practice for Modified Salt Spray (Fog) Testing
DEF(AUST) 1000	Australian Defence Force Packaging Standard
MIL-STD-870	Cadmium Plating, Low Embrittlement, Electrodeposition
NAS 672	Plating, High Strength Steels, Cadmium
SAE AMS 2400	Plating, Cadmium
SAE AMS 2401	Plating, Cadmium Low Hydrogen Content Deposit
SAE AMS 2750	Pyrometry
SAE AMS QQ-P-416	Plating Cadmium (Electrodeposited)
TT-C-490	Chemical Conversion Coatings and Pre-treatments for Ferrous Surfaces

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AUSTRALIAN DEFENCE STANDARD
DEF (AUST) 9008
CADMIUM PLATING
LOW EMBRITTLEMENT, ELECTRODEPOSITION
SPECIFICATION

Specific inquiries regarding the application of this specification to Requests for Tender or contracts should be addressed to the Ordering Authority named in the Request for Tender, or to the Quality Assurance Authority named in the contract, as appropriate.

WARNING

This specification may call for the use of substances and test procedures that may be injurious to health if adequate precautions are not taken. It refers to technical suitability only and in no way absolves the supplier or user from statutory obligations relating to health and safety at any stage of manufacture or use.

The use of cadmium has been restricted due to environmental and health concerns. The user should consult applicable environmental regulations regarding its uses and disposal.

1. INTRODUCTION

- 1.1 This specification is approved for use within the Australian Defence Organisation (ADO) and is available for use by all Departments, Agencies and Contractors of the ADO.

2. SCOPE

- 2.1 This specification covers the performance requirements for the electrodeposition of cadmium on a substrate of high strength steel with an ultimate tensile strength between 1100 and 1650 MPa (160000 to 240000 psi) and for minimising hydrogen embrittlement.
- 2.2 This DEF (AUST) is not advocating routine cadmium plating of steel with tensile strength of 1650 MPa (240000 psi), as there are significant risks associated with this. Where this requirement is deemed necessary specialist technical advice should be sought and, as a minimum, the associated extra precautions detailed in this DEF (AUST) will need to be applied.
- 2.3 Parts having a tensile strength of 1650 MPa (240000 psi) and above must be individually evaluated and approved by the respective Authorised Engineering Organisation (AEO) for applicability of this specification. (In doing this, AEOs shall consider criticality of the component, tensile stress level sustained in-service and material, specialist technical advice can be sought from sponsor of this DEF (AUST) or DSTO).
- 2.4 This specification meets or exceeds the requirements of MIL-STD-870, ASTM B 766, NAS 672, SAE AMS-2400, SAE AMS-2401 and SAE AMS-QQ-P-416 standards and may be used whenever plating as per these standards is specified.
- 2.5 Cadmium plating should not be done on parts that exceed a temperature of 232° C in service or come in contact with other parts that reach those temperatures as cadmium starts emitting toxic fumes at 232° C.

3. ORDER OF PRECEDENCE

- 3.1 In the event of a conflict between the requirements of this specification, and the references cited herein, the requirements of this specification take precedence. Nothing in this specification however, overrides applicable laws and regulations, unless a specific exemption has been obtained.

4. DEFINITIONS

- 4.1 **Lot.** A lot shall consist of parts of the same metal composition, plated and treated at the same time, in the same bath, by the same production process and submitted for inspection and testing at the same time. An individual, traceable number shall identify the lot.
- 4.2 **Processor.** A processor is the maintenance organisation performing electroplating operations.
- 4.3 **Process Control Plan.** The process control plan is the document which specifies/defines the process parameters, tolerance limits and control actions for each individual process.
- 4.4 **Quality Assurance Authority.** The Quality Assurance Authority (QAA) is an authority that has the power to control the inspection and testing of products to ensure their compliance with relevant processes, procedures, standards and legislation. The QAA for the purpose of this specification is Director Quality Assurance – Air (DQA-Air) or a nominated representative.
- 4.5 All other terminology used in this specification is in accordance with the definitions contained in ASTM B 374.

5. CLASSIFICATION

- 5.1 Plating shall be of a type and class as specified in paragraphs 5.2 and 5.3.

5.2 Post-plating Treatment Types:

- (a) TYPE I - as plated (no supplemental treatment),
- (b) TYPE II - supplemental chromate treatment
- (c) TYPE III - supplemental phosphate treatment

5.3 Cadmium Plating Thickness Classes:

- (a) CLASS 1 - 13 micrometers minimum thickness (0.0005 in)
- (b) CLASS 2 - 8 micrometers minimum thickness (0.0003 in)
- (c) CLASS 3 - 5 micrometers minimum thickness (0.0002 in)

6. PROCESS REQUIREMENTS

- 6.1 If subjected to any of the following operations, those operations must be completed and parts shall be stress relieved, as specified in paragraph 6.2, before undergoing plating operation:

- (a) machining;
- (b) grinding;
- (c) straightening;
- (d) welding;
- (e) heat treatment;
- (f) other cold worked (except residual compressive stress-inducing operations like shot peening, cold working); or
- (g) proof testing.

- 6.2 Unless otherwise specified, parts requiring stress relief shall be stress relieved at 200⁰ C (± 5⁰ C) for not less than 4 hours. Alloys that have their minimum tempering or aging temperature below

200⁰ C shall be stress relieved for 8 hours at a temperature 30⁰ C below their minimum tempering or aging temperature.

- 6.3 If required, shot peening shall be performed after stress relieving but before plating.
- 6.4 Parts shall be free from visible defects and cleaned prior to plating to remove surface contamination and have a water break free surface prior to plating. Parts shall be cleaned in accordance with ASTM B 322.
- 6.5 Unless otherwise specified, plating shall be carried out after all basis metal heat treatments, brazing, welding and perforating on the part have been completed.
- 6.6 Equipment used in the plating process shall be checked periodically in accordance with the requirements of AS/NZ ISO 10012.
- 6.7 Cadmium shall be deposited from a suitable cadmium plating solution without brighteners, directly onto the base metal. There is to be no underplating or prior flash coat of other metal before applying the cadmium plating.
- 6.8 Manufacturers are given latitude in the selection of specific plating bath formulations used for the electrodeposition of cadmium provided the coating obtained meets the requirements of this specification.
- 6.9 If a part, after plating, fails to meet the performance requirements of this specification it must be adequately stripped and subjected to the entire plating process again as specified in this specification.
- 6.10 **Removal of Cadmium Plating.** Where a faulty cadmium coating or reworked part requires stripping, an appropriate stripping bath formulation and process must be selected that does not cause hydrogen embrittlement to the part. After stripping, parts shall be stress relieved as specified in paragraph 6.2.

7. HYDROGEN EMBRITTLEMENT RELIEF

- 7.1 Parts shall be baked as soon as possible after completion of the plating process. Baking shall commence within 4 hours after completing the plating process and be in a forced convection oven.
- 7.2 All parts shall be baked continuously and within the specified temperature range. Interruption for loading and unloading parts is permitted, provided the time between opening the furnace door and re-establishing the specified baking temperature is not included when determining the total bake time. The specified baking temperature shall be considered re-established when all control, indicating and recording thermocouples reach the specified baking temperature.
- 7.3 Parts having a tensile strength up to 1650 MPa (240000 psi) shall be baked for a **minimum of 23 hours** at 200⁰ C ± 5⁰ C.
- 7.4 Parts having a tensile strength above 1650 MPa (240000 psi) shall be baked for a **minimum of 40 hours** at 200⁰ C ± 5⁰ C. The baking period shall be specified and approved for each part by an approved authority.
- 7.5 Alloys that have their minimum tempering or aging temperature below 200⁰ C shall be baked at a temperature 30⁰ C below their minimum tempering or aging temperature for a **minimum of 23 hours**.
- 7.6 The bake furnace pyrometry shall confirm to SAE AMS 2750.

8. SUPPLEMENTARY TREATMENTS

- 8.1 Supplementary treatments as specified in paragraph 5.2 shall be applied to parts after baking. Unless otherwise specified, parts that are completely coated in cadmium plating shall be treated to Type II. For parts not completely coated in cadmium plating, Type III treatment is required.

- 8.2 **Type II treatment.** Unless otherwise specified, the chromate treatment required for conversion to Type II shall be a treatment in or with an aqueous solution of salts, acid, or both to produce a continuous smooth, adherent, distinctly coloured film. Chromate conversion film colour shall be:
- (a) iridescent yellow,
 - (b) iridescent bronze to brown,
 - (c) olive drab,
 - (d) yellow, or
 - (e) forest green.
- 8.3 **Type III treatment** Unless otherwise specified, the phosphate treatment required for conversion to Type III shall produce a tightly adherent film conforming to TT-C-490 Type I.
- 8.4 After treatment, parts shall be thoroughly rinsed and dried according to the requirements of the process used.

9. PLATING REQUIREMENTS

9.1 Test Specimen

- 9.1.1 Unless otherwise specified, corrosion resistance, thickness and adhesion tests are to be performed either on the parts being plated, or a similar material test specimen. Testing for cracks shall be performed on the parts being plated.
- 9.1.2 Test specimens are to be sized in accordance with relevant test standards. If no size is specified by the standard, the recommended test specimen size is 152 mm long, 100 mm wide and 1.02 mm thick to ensure that accurate test results are achieved. The test specimen size shall be agreed to by the processor and purchaser to reflect the required result and may vary with the complexity, criticality and cost of the items to be plated as well as the equipment limitations of the processor. If required, specialist technical advice on test specimen size and numbers can be sought from the sponsor of this DEF (AUST) or DSTO.

9.2 Appearance

- 9.2.1 Unless otherwise specified, the plating shall cover all part surfaces including roots of threads, corners and recesses.
- 9.2.2 The cadmium plating shall have a dull matt to frosty white finish and be smooth, adherent, uniform in appearance, and free from blisters, pits, nodules, burning, and other defects when examined visually without magnification. The plating shall show no indication of contamination or improper operation of equipment in producing the cadmium deposit, such as excessively powdered or darkened plating, and must not exhibit any bright or lustrous areas. Superficial staining or slight discolouration resulting from rinsing, drying or baking shall not be cause for rejection provided the integrity of the cadmium plating is retained.

9.3 Corrosion Resistance

- 9.3.1 Corrosion resistance testing is only required for parts post-treated to Type II.
- 9.3.2 Parts or specimens shall be aged for a minimum of 24 hours at room temperature before being subjected to the salt spray test.
- 9.3.3 Parts or specimens shall be tested in accordance with ASTM B 117 or ASTM G 85 for 96 hours. At the end of testing the plating shall not show white corrosion products of cadmium, pitting, or base metal corrosion products. The appearance of corrosion products visible to the unaided eye shall be cause for rejection, except for white corrosion products at the edges of specimens, which shall not constitute failure.

9.4 Thickness

- 9.4.1 Parts or specimens shall be tested for thickness in accordance with either of ASTM B 244, ASTM B 487, ASTM B 499, ASTM B 504, ASTM B 555, ASTM B 567, ASTM B 568 or ASTM E 376 test methods.
- 9.4.2 Average plating thickness is specified in paragraph 5.3. Plating thickness must remain within $\pm 10\%$ of the specified thickness for each class unless otherwise specified.

9.5 Adhesion

- 9.5.1 Parts or specimens shall be tested for adhesion in accordance with ASTM B 571.
- 9.5.2 The adhesion of the plating shall be such that when examined at 4x magnification, plating shall not show any separation from the substrate.

9.6 Hydrogen Embrittlement

- 9.6.1 Specimens shall not show any evidence of hydrogen embrittlement when tested in accordance with ASTM F 519.

9.7 Cracks

- 9.7.1 All parts having a tensile strength above 1650 MPa (240000 psi) shall be tested for cracks in accordance with ASTM E 1444. Parts shall not show any evidence of cracking. Parts showing evidence of cracking shall be rejected.

10. QUALITY ASSURANCE**10.1 Process**

- 10.1.1 The processor shall have a detailed process, which should include various process parameters including bath compositions, operating conditions, bath analysis and control, and methods to fulfil all plating property requirements of paragraph 9 before processing.

10.2 Process Qualification

- 10.2.1 The process shall be qualified by the processor to ensure that the process is capable of consistently meeting the plating property requirements of paragraph 9.
- 10.2.2 Process qualification shall be conducted every 30 calendar days. If the process is not operated on a regular basis, then the process is to be qualified before commencing each lot.

10.3 Process Control

- 10.3.1 The processor shall have a process control plan that ensures that all process equipment and solution parameters are within the required tolerances prior to, and throughout, the process.
- 10.3.2 The processor shall record statistical evidence showing the process is in a state of control and is capable of producing the specified properties.
- 10.3.3 The control plan shall ensure the process remains capable of meeting the plating property requirements of paragraph 9 throughout the production.

10.4 Process Control Records

- 10.4.1 Records shall be maintained detailing the history of each processing bath, showing all additions of chemicals or treatments, chemical analysis and testing report for plating properties. These records shall be maintained for a period not less than 5 years, unless otherwise specified.

11. QUALITY CONFORMANCE

- 11.1.1 Inspection of finished parts shall be carried out to determine conformance with the plating property requirements of paragraph 9. Sampling for lot inspection shall be in accordance with either ASTM B 602, ASTM B 697 or ASTM B 762 standards.
- 11.1.2 Unless otherwise specified, the processor shall be responsible for quality control inspections.
- 11.1.3 The Quality Assurance Authority (QAA) reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to ensure that supplies and services conform to prescribed requirements.

12. PREPARATION FOR DELIVERY

- 12.1 **Packing and packaging.** Preservation, packaging and packing methods are to be carried out in accordance with DEF (AUST) 1000.

13. ORDERING DATA

- 13.1 Ordering documents provided by the purchaser should clearly specify:
- (a) post plating treatment type and thickness class in accordance with paragraph 5;
 - (b) tensile strength of the parts;
 - (c) stress relieving requirements due to pre plating operations in accordance with paragraph 6.1;
 - (d) shot peening requirements in accordance with paragraph 6.3 and
 - (e) test specimen size and numbers for plating properties requirements of paragraph 9 in accordance with paragraph 9.1.2.

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TECHNICAL STANDARDS DOCUMENT CENTRE

Requests for copies of this Specification/Standard, or certain copies of the listed Applicable Documents, may be obtained from Defence Technical Standards Document Centres listed below:

DEPARTMENT OF DEFENCE (Maritime)

Director Naval Platform Systems

CP4-SP-013

Campbell Park Offices

CANBERRA ACT 2600

Attention: OIC NTSDC

Telephone: (02) 6266 2906

Facsimile: (02) 6266 4994

<http://defweb.cbr.defence.gov.au/navsyscom/mrs/homepage.htm>

DEPARTMENT OF DEFENCE (Land)

Land Engineering Agency (LEA)

DPM3

661 Bourke Street

Melbourne VIC 3000

Attention: Equipment Information Officer

Telephone (03) 9282 2758/2834

Facsimile: (03) 9282 7618

<http://vbmweb.sor.defence.gov.au/SPECS/Triservice/tritoc.htm>

DEPARTMENT OF DEFENCE (Air)

Common Service System Support Office (CSSSO)

Aerospace Technical Standards Document Centre (ATSDC)

Building L7

RAAF Williams

LAVERTON VIC 3027

Telephone: (03) 9256 4236/4568

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