



AEROSPACE MATERIAL SPECIFICATION

AMS03™-14**REV. A**Issued 2015-04
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Superseding AMS03-14

Electrodeposition of Chromium for Engineering Purposes

RATIONALE

AMS03-14A stabilizes this document because this document contains mature technology that is not expected to change and thus no further revisions are anticipated.

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AMS2406 Plating, Chromium, Hard Deposit

AMS2438 Plating, Chromium, Thin, Hard, Dense Deposit

AMS2460 Plating, Chromium

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FOREWORD

REVISION NOTE

This Defence Standard was raised to Issue 4 to update its content and incorporate the latest MoD/DStan policy in place at the time.

HISTORICAL RECORD

This standard supersedes the following:

Def Stan 03-14 Issue 1, August 1979

Def Stan 03-14 Issue 2, February 1995

Def Stan 03-14 Issue 3, February 2005

Def Stan 03-31 Issue 1, April 1993

Def Stan 02-870 Issue 1, April 2000

Def Stan 02-870 Issue 2, August 2004

TABLE OF CONTENTS

1.	SCOPE.....	4
2.	WARNING	4
3.	NORMATIVE REFERENCES	4
4.	ABBREVIATIONS	5
5.	DEFINITIONS	6
6.	INFORMATION TO BE SUPPLIED TO THE PROCESSOR.....	6
7.	PROCESS CONTROL	7
8.	CONDITION OF SUBSTRATE	7
9.	CHROMIUM ELECTRODEPOSITION PROCESS.....	7
10.	RECLAMATION OF WORN OR OVER-MACHINED ITEMS	8
11.	DIMENSIONAL TOLERANCES	8
12.	THICKNESS OF ELECTRODEPOSIT AFTER FINAL FINISHING	8
13.	MACHINING AND GRINDING	8
14.	GENERAL	9
15.	STRESS RELIEF	9
16.	INTRODUCTION OF SURFACE COMPRESSIVE STRESSES	9
17.	PREPARATION FOR ELECTRODEPOSITION	10
17.1	Initial Cleaning	10
17.2	Masking	10
17.3	Application of Undercoats	10
17.4	Final Cleaning	10
17.5	Etching	10
17.5.1	Non-Corrosion Resisting Steel.....	10
17.5.2	Corrosion Resisting Steel (e.g., stainless steels)	10
17.5.3	Cast Iron.....	11
17.5.4	Nickel Electrodeposit on Steel	11
17.6	Rinsing	11
18.	ELECTRODEPOSITION OF CHROMIUM.....	11
19.	POST-ELECTRODEPOSITION HEAT TREATMENT	11
20.	GENERAL	13
21.	PREPARATION FOR ELECTRODEPOSITION	13
22.	ELECTRODEPOSITION OF CHROMIUM.....	13
23.	POST-ELECTRODEPOSITION HEAT TREATMENT	13
24.	GENERAL	

25.	PREPARATION FOR ELECTRODEPOSITION	14
26.	ELECTRODEPOSITION OF CHROMIUM.....	14
27.	POST-ELECTRODEPOSITION HEAT TREATMENT	14
28.	GENERAL	14
29.	PREPARATION FOR ELECTRODEPOSITION	14
30.	ELECTRODEPOSITION OF CHROMIUM.....	14
31.	ELECTRODEPOSITION OF CHROMIUM ON CHROMIUM.....	14
32.	INSPECTION AND TESTING	15
33.	VISUAL INSPECTION	15
34.	THICKNESS OF COATING	15
35.	HARDNESS	15
36.	ADHESION	16
37.	FREEDOM FROM EMBRITTLEMENT	16
38.	CORROSION TESTING	17
39.	OTHER REQUIREMENTS.....	17
40.	TREATMENT OF ITEMS REJECTED DURING FINAL INSPECTION AND TEST	17
41.	NOTES	17
ANNEX A	GUIDANCE ON CHROMIUM ELECTRODEPOSITION FOR ENGINEERING PURPOSES	18
ANNEX B	CHROMIUM ELECTRODEPOSITION PROCESS.....	23
ANNEX C	THE ANALYSIS OF CHROMIUM ELECTRODEPOSITION SOLUTION	24
ANNEX D	POST-ELECTRODEPOSITION TREATMENT FOR FERROUS METALS.....	26
ANNEX E	CHEMICAL METHODS OF STRIPPING CHROMIUM DEPOSITS	27
ANNEX F	ADHESION TESTS.....	28
Table 1	Specified minimum/maximum tensile strengths of steels	6
Table 2	Stress relief before electrodeposition (based on recommendations in BS ISO 9587)	9
Table 3	Introduction of surface compressive stresses.....	9
Table 4	Post-electrodeposition heat treatment of high-strength steels (based on recommendations in BS ISO 9588)	12
Table 5	Maximum Load versus coating thickness for hardness testing of chromium electrodeposits	16

SECTION 1 INTRODUCTION

OVERVIEW

This standard is concerned with the electrodeposition of chromium on ferrous metals, aluminum and aluminum alloys, titanium and titanium alloys and other metals for one or more of the following purposes:

- The production of wear-resistant surfaces.
- Wear resistance coupled with corrosion resistance.
- The reclamation of engineering components.

This Standard represents a “compositing” and replacement of three previous Standards, AMS03-14/Def Stan 03-14 Issue 3, Def Stan 03-31 Issue 1 and Def Stan 02-870 Issue 2.

For technical and economic reasons, early and close liaison between designers, manufacturers, electrodepositors and inspectors is essential. As it is virtually impossible to test the adhesion of chromium coatings in a non-destructive manner, integrity of workmanship is especially important and there is clear need for careful control at each stage of processing - including visual inspection for cleanliness of the surface immediately before electrodeposition.

TYPES OF CHROMIUM COATINGS

The character of a chromium plate (e.g., hardness, crack pattern) can vary substantially depending largely on the chemistry of the electrodeposition bath. For instance, the presence of cracks in hard chromium coating is essentially an inherent feature of the process but the detailed crack pattern (and linked properties such as hardness, wear resistance and corrosion behavior) is very much dependent upon the process chemistry. The background and guidelines relating to the various types of hard chromium processes are presented in Annex A.

SECTION 2 GENERAL REQUIREMENTS

1. SCOPE

This SAE Standard gives guidance for - and specifies the requirements for - the electrodeposition of chromium for engineering purposes. It relates to both new articles and also the reclamation of worn or over-machined components. Chromium electrodeposition undertaken for decorative purposes is not considered herein.

2. WARNING

This section which appeared in DEF STAN 03-14 Issue 4 has been deliberately deleted.

3. NORMATIVE REFERENCES

- 3.1 The publications shown below are referred to in the text of this standard. Publications are grouped and listed in alpha-numeric order.

Def Stan 03-2	Cleaning and preparation of metal surfaces
AMS03-2	Cleaning and preparation of metal surfaces
Def Stan 03-4	The pre-treatment and protection of steel items of maximum tensile strength exceeding 1450 MPa
AMS03-4	The pre-treatment and protection of steel items of maximum tensile strength exceeding 1450 MPa
Def Stan 03-21	Mechanical methods for the inducement of compressive surface residual stresses
Def Stan 03-24	Chromic acid anodising of aluminium and aluminium alloys

Def Stan 03-25	Sulphuric acid anodising of aluminium and aluminium alloys
AMS03-25	Sulphuric Acid Anodizing of Aluminum and Aluminum alloys
Def Stan 03-27	Electrodeposition of nickel for engineering purposes
AMS03-27	Electrodeposition of nickel for engineering purposes
BS 5599	Specification for hard anodic oxidation coatings on aluminium and its alloys for engineering purposes
BS 6041 ISO 4519	Method of Sampling of electrodeposited metallic coatings and related finishes: procedures for inspection by attributes
BS ISO 9587	Metallic and other inorganic coatings - pretreatment of iron and steel to reduce the risks of hydrogen embrittlement
BS ISO 9588	Metallic and other inorganic coatings - post-coating treatments of iron and steel to reduce the risks of hydrogen embrittlement
BS EN 12659	Lead and lead alloys - Lead
BS EN ISO 1463	Metallic and oxide coatings - Measurement of thickness - Microscopical method
BS EN ISO 2177	Metallic coatings - Measurement of coating thickness - Coulometric method by anodic dissolution
BS EN ISO 2178	Non-magnetic coatings on magnetic substrates - Measurement of coating thickness - Magnetic method
BS EN ISO 2819	Metallic coatings on metallic substrates - Electrodeposited and chemically deposited coatings - Review of methods available for testing adhesion
BS EN ISO 3497	Metallic coatings - Measurement of coating thickness - x-ray spectrometric method
BS EN ISO 3543	Metallic and non-metallic coatings - Measurement of thickness - Beta backscatter method
BS EN ISO 4516	Methods of test for metallic and related coatings - Vickers and Knoop microhardness tests
BS EN ISO 6507-1	Metallic materials. Vickers hardness test, test method
BS EN ISO 9227	Corrosion tests in artificial atmospheres - Salt spray tests
ASTM B 602 - 88	Standard test method for attribute sampling of metallic and inorganic coatings

3.2 This section which appeared in DEF STAN 03-14 Issue 4 has been deliberately deleted.

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4. ABBREVIATIONS

HV Vickers hardness number

Micron Micrometer, $1 \times 10^{-6}\text{m}$

5. DEFINITIONS

The following definitions apply.

5.1 PROCESS CONTROL SCHEDULE

The document which specifies/defines:

- a. The sequence of manufacturing operations and processes.
- b. The control parameters and their tolerances for each individual process within the total sequence.

5.2 SIGNIFICANT SURFACE

That area of the item, covered or to be covered by the coating, and for which the coating is essential for serviceability and/or appearance.

5.3 SHOT PEENING

Impingement of a stream of spherical particles on to the surface to be electrodeposited in order to produce compressive stresses in the surface regions of the substrate metal.

5.4 TENSILE STRENGTH OF STEELS

- 5.4.1 Throughout this Standard the tensile strength figures refer to specified maximum tensile strength. Steels shall be categorized according to specified maximum tensile strength in accordance with Table 1. Where the steel strength is available only as the minimum tensile strength, the equivalent maximum tensile strength category shall be determined from Table 1.

Table 1 - Specified minimum/maximum tensile strengths of steels

Specified Minimum Tensile Strength, MPa	Specified Maximum Tensile Strength, MPa
Up to 1000	Up to 1100
1001 to 1400	1101 to 1450
1401 to 1800	1451 to 1800
Over 1800	Over 1800

5.4.2 Tensile Strength/Hardness Relationship

If no maximum or minimum tensile strength is specified for the steel, hardness values of 310HV, 340HV, 435HV, 450HV and 545HV (as measured in accordance with BS EN ISO 6507-1) shall be regarded as equivalent to 1000, 1100, 1400, 1450, and 1800 MPa respectively. Steels that have been wholly or partly surface hardened shall be considered as being in the category appropriate to the hardness of the surface hardened layer.

6. INFORMATION TO BE SUPPLIED TO THE PROCESSOR

The following information shall be given on the drawing, contract or order:

- a. The number of this AMS Material Specification or its superseded Defence Standard.
- b. For new articles, the specification and metallurgical condition of the basis metal.
- c. For reclaimed components, the specification and metallurgical condition of the basis metal or as much relevant information as is available - including application/operating conditions, e.g., fatigue loading, corrosive environment, etc.

- d. The significant surface; this may be indicated on the drawing or by a marked sample.
- e. The process to be used.
- f. The details of any pre and post-deposition heat treatment.
- g. The thickness of the coating required or the final dimensions of the finished item - the latter is especially relevant for build-up of worn components where maximum thickness allowed should be specified (see 12.1).
- h. The details (type and thickness) of any necessary undercoat to be applied.
- i. The details of any finishing treatment required.
- j. The final finish of the chromium, e.g., as electrodeposited or ground to a specified surface texture.
- k. For titanium and its alloys, the preparation for electrodeposition.
- l. The details of any special requirements (e.g., masking).

7. PROCESS CONTROL

- 7.1 A Process Control Schedule suitable of achieving the requirements of this Standard shall be prepared by the processing contractor(s) prior to the commencement of production.
- 7.2 Details of the coating process, including all preparatory treatments, post coating treatments, processing, significant surfaces, tests and all other processes and treatments shall be included in the Process Control Schedule.
- 7.3 All stages in the complete Schedule shall follow each other without delay.

SECTION 3 PROCESS REQUIREMENTS

8. CONDITION OF SUBSTRATE

- 8.1 All plastic forming, and heat treatment (excluding post electrodeposition heat treatment) shall be completed before electrodeposition.
- 8.2 Operations for the removal of metal may be carried out after electrodeposition.
- 8.3 The significant surface shall be free from harmful defects and, where possible, all edges and re-entrant angles should be rounded. It is particularly important to avoid stress concentration sites such as sharp notches, small radii and sudden changes of section in the design of the item because of the tendency of cracks to penetrate the chromium deposit thereby producing stress-raisers, coupled with the difficulty of depositing chromium in re-entrant angles thus accentuating notch effects.
- 8.4 Although most chromium coatings relevant to this Standard normally require grinding, items on which the chromium coating is not to be ground after electrodeposition shall have an initial surface texture at least as smooth as that required for the finished chromium coating.
- 8.5 Where more than one type of coating is to be applied on different areas of the same item, the chromium electrodeposition operation shall normally be the first to be applied.

9. CHROMIUM ELECTRODEPOSITION PROCESS

- 9.1 Details of a suitable chromium electrodeposition process are given in Annex B and suitable methods of analysis of the electrolyte are given in Annex C.

- 9.2 Any other chromium electrodeposition process (see A.2.2 and A.2.3) may be used provided that the alternative produces a coating at least equivalent to that produced using the standard process in relation to hardness, fatigue properties, freedom from hydrogen embrittlement and protection against corrosion where these are significant to the particular application.
- 9.3 For items not subject to corrosion, electrodeposition should be confined to surfaces free from sudden changes of contour and electrodeposition should stop short of stressed fillet radii.
- 9.4 It is desirable to maintain well-defined edges of the deposit on components that are electrodeposited over only part of the surface. Suitable pre- and post-electrodeposition machining procedures should be used to avoid stress concentrations at the edges of these deposits. Stresses introduced during assembly, including those produced by press and shrink fits and taper pins, should be kept to a minimum.

10. RECLAMATION OF WORN OR OVER-MACHINED ITEMS

- 10.1 Surfaces which have been damaged, e.g., by wear, scoring or corrosion, shall be machined, ground or chemically stripped to ensure that existing electrodeposits are removed and to provide a new surface free from sharp changes of section. The requirements of Section 39 shall apply where appropriate.
- 10.2 Before chromium electrodeposition, worn items shall be visually inspected to ensure freedom from cracks and grinding abuse.
- 10.3 If large coating thicknesses are required, it is useful to employ an undercoat, of say nickel, followed by a chromium electrodeposit of thickness sufficient to satisfy operational requirements (see also 12.4).

11. DIMENSIONAL TOLERANCES

In addition to specifying the final dimensions and tolerances of the item, it is essential that allowances be made for thickness of electrodeposition, electropolishing, machining or grinding and eccentricity.

12. THICKNESS OF ELECTRODEPOSIT AFTER FINAL FINISHING

- 12.1 If wear resistance only is required, the thickness of chromium necessary will depend on the service condition for each application. As a guide, 15 microns is satisfactory under mild conditions of loading and 80 microns under moderately severe loading but, under heavy loading or when abrasives are present, a minimum thickness of 250 microns may be required. The thickness of chromium should not normally exceed 300 microns.
- 12.2 Where both corrosion resistance and wear resistance are required the coating may, if desired, include an undercoat of nickel to AMS03-27/Def Stan 03-27 on ferrous items, and nickel or copper on items made from aluminum and titanium or their alloys, but the final coating of chromium shall not be less than 15 microns.
- 12.3 For protection in severe corrosive conditions, nickel undercoats to AMS03-27/Def Stan 03-27 are preferred on steels of specified maximum tensile strength exceeding 1450 MPa. The total coating thickness shall not be less than 50 microns but a minimum total coating thickness of 75 microns shall be specified for the more severe corrosive conditions.
- 12.4 Where worn or over machined items are electrodeposited for building-up purposes, the coating may consist of chromium or of an undercoat of nickel to AMS03-27/Def Stan 03-27 with a top coat of chromium. On items made of aluminum or titanium or their alloys, an undercoat of copper followed by nickel or an undercoat of nickel may be used. If wear and corrosion resistance are required the minimum thickness shall comply with 12.1, 12.2, and 12.3. Where a thickness of more than 250 microns is needed to restore dimensions, an undercoat of electrodeposited nickel shall be used, and where necessary this undercoat shall be machined before final chromium electrodeposition.

13. MACHINING AND GRINDING

- 13.1 Electrodeposited chromium, because of its hardness, can only be machined by grinding. Care should be taken to avoid heavy cuts and overheating because these can cause cracking in the underlying steel. The recommendations of grinding wheel manufacturers for the grinding of chromium should be followed.