METRIC

MIL-STD-1501D (USAF)
1 March 2005
SUPERSEDING
MIL-STD-1501C
2 April 1990

DEPARTMENT OF DEFENSE
STANDARD PRACTICE

CHROMIUM PLATING, LOW EMBRITTLEMENT, ELECTRO-DEPOSITION

MIL-STD-1501D,1 March 2005, is hereby reactivated, revised, and may be used for acquisition.

AMSC N/A

AREA MFFP

FOREWORD

1. This standard is approved for use by Ogden Air Logistics Center/MA., Department of the Air Force and is available for use by all Departments and Agencies of the Department of Defense.

2. This standard provides guidance on the procedures for chromium plating, low embrittlement, electro-deposition for the Air Force repair process, acquisition and manufacture of parts and/or spare parts on the landing gear of all military aircrafts.

3. Beneficial comments, recommendations, additions, deletions, clarifications, etc. and any data that may improve this document should be sent to: OO-ALC/MADL, HILL AFB, UT 84056-5609 or emailed to OOALC.MADL@HILL.af.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at http:assist.daps.dla.mil.

CONTENTS

1. SCOPE

1.1 Scope. This standard covers the engineering requirements for electro-deposition of hard chromium on high strength steel substrates and the properties of deposit. Subsequent heat treating techniques needed to insure low hydrogen embrittlement of steel is described.

1.2 Classification.

1.2.1 Classes. Chromium plating covered by this standard should be the following: :

a. Class 1 – Crack free (see 4.9)

b. Class 2 – Limited cracking allowed (see 4.10)

c. Class 3 – Moderate cracking allowed (see 4.11)

1.2.2 Types. Chrome plating covered by this standard should be of the following:

a. Type I – Plated to specified dimensions (see 4.12)

b. Type II – Processed to specified dimensions after plating (see 4.13)

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 of this standard. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, or 5 of this standard, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-R-81841 - Rotary Flap Peening of Metal Parts

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-866	-	Grinding of Chrome Plated Steel and Steel Parts Heat Treated to 180,000 PSI or over.
MIL-STD-871	-	Electro-Chemical Stripping of Inorganic Finishes
MIL-STD-1504	-	Abrasive Blast of Aircraft Components

[Note: The documents cited above are "inactive for new design."]

(Copies of these documents are available online at http://assist.daps.dla.mil/quicksearch/ or http://assist.daps.dla.mil or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

COMMERCIAL ITEM DESCRIPTIONS

A-A-55827	-	Chromium Trioxide, Technical
A-A-55828	-	Sulfuric Acid, Technical

(Copies of these documents are available online at http://assist.daps.dla.mil/quicksearch/ or http://assist.daps.dla.mil or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.3 Non-Government standards and publication. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE-AMS-S-13165	-	Shot Peening of Metal Parts
SAE-AMS2644	-	Inspection Material, Penetrant
SAE-AMS-QQ-C-320	-	Chromium Plating (Electrodeposited)

(Copies of these documents are available online at www.sae.org or from the Society of Automotive Engineers International, 400 Commonwealth Drive, Warrendale, PA 15096-1001.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E8-04	-	Tension Testing of Metallic Materials
ASTM E 1444 -01	-	Inspection, Magnetic Particle
ASTM E 1417-99	-	Inspection, Liquid

(Copies of these documents are available at www.astm.org or ASTM International, 100 Barr Harbor Dive, P.O. Box C700, West Conshohocken, PA 19428-2959.)

2.4 Order of Precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, superseded applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 High Strength Steel. For the purpose of this standard high strength steel is defined as steel heat treated to 1.24 X 10^9 Pa (180,000 psi) and above.

3.2 Material Batch. All items processed at one time through the plating bath.

4. GENERAL REQUIREMENTS

4.1 General. Chrome plating is applied for wear resistance, reconditioning worn or undersize parts, and such incidental corrosion protection as the specified thickness of the deposit may afford. Where corrosion protection is desired, an undercoat of nickel 0.025 to 0.050 millimeters (0.001 to 0.002 inches) thickness is recommended.

4.2 Materials and Equipment

4.2.1 Materials.

a. Chromium Trioxiode, Technical (A-A-55827A)
b. Sulfuric Acid, Technical (A-A-55828)
c. Anodes
    7% Tin-lead, wires, rod, or strip
    7% Antimony-lead, wires, rod, or strip

4.2.2 Equipment.

a. Power source. Either generated or rectified D.C. current may be used. Ripple value shall not exceed 10 % (percent) as measured by dividing the Root Mean Square of the A.C. voltage component by the D.C. voltage. This can best be measured by using an RMS A.C. voltage meter and dividing this value by the D.C. voltage. These measurements are to be taken across the anode and cathode bus at the tank.

b. Tanks. Tanks shall be resistant to the operating temperature and the chemical environment.

c. Temperature control. Plating tanks to be operated at temperatures other than room temperature shall be equipped with automatic temperature indicating and regulating devices.

d. Instrumentation. An ammeter shall be placed in series with the with the chromium tank cathode. The ammeter shall have sufficient shuts and switches to provide a full-scale reading equal to the maximum capacity of the power source, and an accuracy of ± 5 percent of the current being measured.

e. Blast equipment. Blast cabinets shall be located near the plating line. The size of the cabinet shall be adequate to enclose the parts to be plated. Air lines shall be suitably trapped and filtered to prevent in-process contamination of the parts to be cleaned.

f. Bake oven. An oven capable of baking parts at 191°C ± 14˚C or (375°F ± 25˚F) shall be located near the plating line. The size of the oven shall be adequate to enclose parts to be plated. The oven shall be equipped with temperature indicating, recording and regulating devices.

4.3 SAE-AMSQQC320 Plating. All parts shall be plated in accordance with the requirements of SAE-AMSQQC320 and in conjunction with those specified in this standard. If there is a conflict between the two documents; however, the requirements of this document shall govern.

4.4 Finish. The plated part will have a finish that is smooth, continuous, homogenous, adherent, and free from pits, blisters, modules and any other indications of harmful defects.

4.5 Shot Peening. All parts shall be shot peened in accordance with SAE-AMS-S13165 and MIL-R-81841, unless otherwise specified.

4.6 Embrittlement. Qualification test specimens and process control test specimens (see 5.5) shall be subjected to a sustained load test at 75 percent of the ultimate notched tensile strength. The specimens shall endure this sustained load for 200 hours minimum without failing or cracking.

4.7 Reprocessing. Parts rejected for defective plating, requiring stripping and re-plating, shall include all of the pre-plating steps of this standard. Parts shall be stripped in accordance with MIL-STD-871.

4.8 Plating Thickness. The plating thickness shall be as specified on the engineering drawing or other applicable directives. Except when otherwise specified, the minimum thickness shall be 0.05 millimeters (0.002 inches) and the maximum thickness 0.2 millimeters (0.008 inches) on the finished part.

4.9 Class 1. Parts plated to Class 1 shall show no mud cracking pattern when fluorescent penetrant inspected (see 1.2.1 and 5.3.1).

4.10 Class 2. Parts plated to Class 2 are allowed to show some cracking pattern when fluorescent penetrant inspected (see 1.2.1 and 5.3.1). As a general rule cracks exceeding 13 millimeters (1/2 inch) in length or individual areas of cracking exceeding 19 square centimeters (3 square inches) or 10 percent of plated area, whichever is smaller, will be cause for rejection of the plated area.

4.11 Class 3. Parts plated to Class 3 are allowed to show a moderate amount of cracking when fluorescent penetrant inspected (see 5.3.1). To determine part acceptability the part will be cleaned to remove the penetrant materials and the areas of cracking inspected visually using an oblique light. If the cracking pattern can be discerned, that will be cause for rejection of the plated area. (see 1.2.1)

4.12 Type I Plating. For Type I plating, the item shall be plated to the dimension and surface finish specified on the drawing. The surface finish on the item before plating shall be equal to or better than the required finish after plating. Type I plating may be buffed or lapped after plating if dimensional tolerances and surface conditions cannot be controlled in the plating operation. (see 1.2.1)

4.13 Type II Plating. For Type II plating a minimum of 0.05 millimeters (0.002 inch) more chrome than desired shall be deposited (per surface). The excess shall be ground off to give the final dimension and surface finish desired. Steel parts heat treated to 1.24 X 10^9 Pa (180,000 psi) and above shall be ground in accordance with MIL-STD-866. All ground chrome plated surfaces shall be fluorescent penetrant inspected (see 5.3.1). Chrome plated surfaces showing indications of abusive grinding (spiral, barber pole, circular, patch or linear crack patterns), spalling or blistering shall be cause for rejection of the plated area. (see 1.2.1)

5. DETAILED REQUIREMENTS

5.1 Individual Tasks, Requirements, or Test Methods.

5.1.1 Prior to plating. Except for finish grinding operations, all machining, forming, welding and shot-peening shall be completed prior to plating.

5.1.2 Baking. Parts shall be baked for stress relief before plating for four hours minimum at 191°C ± 14°C (375°F ± 25°F). Shot-peening shall be performed before plating and after stress relieving.

5.1.3 Plating sequence. If chromium and cadmium are used in combination, the chromium shall be deposited first. If chrome plating is followed by cadmium plating, then the 23 hours minimum bake period, (as specified by 5.2.7), can be replaced by a four hours bake period at 191°C ± 14°C (375°F ± 25°F); provided the part is baked for 23 hours minimum after completion of the cadmium plating.

5.1.4 Storage of parts. Storage of parts between stress relief and cleaning shall be controlled to prevent contact with water or other corrosive materials. Parts shall be stored to permit free circulation of air around the parts.

5.1.5 Handling of parts. After the parts have been cleaned, they shall be handled in such a manner (white gloves, etc) that will assure a minimum of contamination.

5.1.6 Masking. Sections or areas of a part that are not to be plated shall be masked off. Plug and masking materials that do not contaminate the plating bath shall be used. Masking shall be performed at the most convenient step prior to plating.

5.1.7 Racking. Sufficient contact area and pressure shall be provided to carry the current without overheating. Racking should be performed at the most convenient step prior to plating. When gang plating (two or more like parts) care should be taken to assure a uniform division of current flow to each part by uniform tank spacing and meticulous cleaning and shaping of racking contact surfaces or by providing isolated controlled current paths to each individual part; amperage limits specified (see 5.2.4.)

5.2 Plating Procedure. The chromium plating procedure shall be as follow:

5.2.1 Step No. 1. Parts shall be vapor degreased, solvent cleaned or alkaline cleaned. Cathodic cleaning is not permitted.

WARNING
PROVIDE ADEQUATE VENTILATION DURING DEGREASING OPERATIONS. AVOID SKIN AND EYE CONTACT WITH SOLVENT SOLUTIONS.

5.2.2 Step No. 2. The preferred method of cleaning is by dry blasting using 80-180 grit aluminum oxide ($A1_2O_3$) silicon dioxide (SiO_2) garnet per MIL-STD-1504 or hand sanding. Other non-embrittlement cleaning processes can be used with the approval of the procuring activity. Elapsed time between completion of cleaning and Step No. 3 shall not exceed sixty minutes.

5.2.3 Step No. 3. Anodic etch 15.5 to 46.5 amps/decimeter squared (1 to 3A per square inch) for 30 seconds to 10 minutes. Etch in the following solution (preferred) or in the plating bath, per this paragraph:

Chromic Acid: 225 - 300 gram/liter (30 - 40 ounce/gallon)
Temperature: 32°C - 60°C (90°F - 140°F).

CAUTION

Etching increases iron contamination in the plating bath; therefore, the use of solution in (see 5.2.3) is recommended.

5.2.3.1 Alternate reverse etch solutions. A sulfuric acid or a sulfuric-hydrofluoric acid mixture can be used as an alternate (reverse etch solution) to the solution specified (see 5.2.3). The conditions for the employment of either the sulfuric acid or sulfuric-hydrofluoric acid mixtures are as follows:

a. Forty (40) percent sulfuric acid:
   (1) Operating range – 35 to 45 percent sulfuric acid by volume.
   (2) Temperature – ambient.
   (3) Current density – 31.0 to 62.0 amps/decimeter squared (2 to 4A per square inch), anodic.
   (4) Time – 30-120 seconds.

b. Sulfuric-hydrofluoric acid.
   (1) Operating range – sulfuric acid at 20-30 percent by volume and hydrofluoric acid at 2 – 7 percent by volume.
   (2) Temperature – ambient.
   (3) Current density – 31.0 to 62.0 amps/decimeter squared (2 to 4A per square inch), anodic.
   (4) Time – 60-90 seconds.

5.2.4 Step No. 4. Chromium plate at 15.5 to 77.5 amps/decimeters squared (1 to 5A per square inch) to the required thickness. (See 5.1.7 and 6.1.1). When feasible, apply voltage so that the current will flow upon immersion of parts. Chromium plate in the following solutions:

a. Chromic Acid 225-270 gram/liter (30-36 ounce/gallon)
b. Sulfuric Acid 2.25-2.7 gram/liter (.30-.36 ounce/gallon)
c. Trivalent Chrome 4 grams per liter (g/l) maximum
d. Iron 5 g/l maximum
e. Ratio Chromic Acid/Sulfuric Acid 80/l to 120/l
f. Temperature 52°C - 62°C (125°F - 145°F)

CAUTION

It is general practice to start plating after reversing at a higher current density (two to three times the plating current) and continue for a short time (0.5 to 1.0 minute). This helps in activating the surface.

WARNING

PROVIDE ADEQUATE VENTILATION WHEN USING CHROMIC PLATING SOLUTIONS. WEAR PROTECTIVE RUBBER GLOVES AND CHEMICAL GOOGLES TO PREVENT SKIN AND EYE EXPOSURE.

5.2.5 Step No. 5. Rinse parts in cold water and inspect for defects and adequate buildup. If undersize, return to plating tank and continue plating. If plating is adequate, remove masking, racking, and clean as necessary.

5.2.6 Step No. 6. Rinse all parts in hot water and blow dry with compressed air. Elapsed time between completion of plating and start of baking, Step No. 7, shall not exceed four hours.

5.2.7 Step No. 7. Bake all parts heat treated to 1.24 X 10^9 Pa (180,000 psi) and above for twenty three hours minimum, at 191°C ± 14˚C (375°F ± 25˚F). (See 5.1.3)

5.3 Inspection. Inspection shall be in accordance with the inspection and tests in AMS-QQ-C-320 and this standard.

5.3.1 Penetrant inspection. The parts shall be cleaned and inspected for the requirements of paragraphs 4.9, 4.10, 4.11 and 4.13 in accordance with ASTM-E1417, Type I, Method A, B, and C using materials per SAE-AMS-2644 Group VI. Penetrant penetration time will be 20 minutes minimum.

5.3.2 Magnetic particle inspection. When specified, parts shall be cleaned and inspected per ASTM-E1444, for any deleterious processing effects on the part. The acceptance standard should be as required by responsible engineering organization.

5.4 Process Controls. Solutions used in the plating process shall be checked periodically and maintained in accordance with the requirements of this process standard.

5.5 Qualification Embrittlement Test. The vendor shall demonstrate his ability to provide chromium plate, which meets the requirements (see 4.6) as follows:

a. Four round notched 4340 steel specimens each from separate heats, heat treated to a tensile strength of 1793 to 1931 megapascals (260,000 to 280,000 psi) shall be prepared. The configuration shall be in accordance with Figure 8 of ASTM E8-04 for specimens. Specimens shall have a 60 degree V-notch located approximately at the center of the gauge length. The cross section area at the root of the V-notch shall be approximately equal to half the area of the full cross section area of the specimen's reduced section. The V-notch shall have a 0.254 ± 0.00127 millimeter (0.010 ± 0.0005 inches) radius of curvature at the base of the notch.

b. During plating the specimens shall be mounted symmetrically on a rack by themselves. All areas of the rack except the contact area shall be coated with a suitable maskant. An ammeter, having a sensitivity of 0.5 amperes or better shall be connected to the specimen rack and the cathode bar. The specimen shall be plated at two amperes per square inch for three hours. The specimen shall be baked for twenty-three hours at 191 °C ± 14°C (375°F ± 25°F) within four hours of removal from the bath.

c. The specimens will be subjected to 200 hours of static loading at 75 percent of the ultimate notched tensile strength. The test shall be considered passed if all four specimens meet the requirements (see 4.6.)

d. Upon successful completion of the static load test, one of the notched tensile specimens shall be sectioned across the notch parallel to the axis of the specimen. Photomicrographs shall be taken of the notched area and examined for complete coverage of the notch (Use 80-100x magnification).

5.6 Process Control Embrittlement Acceptance Test. The process control embrittlement acceptance test shall be as follows:

a. Two standard specimens of the type noted in (see 5.5) shall be plated per (see 5.5b) in conjunction with the plating of items. The specimens shall be subjected to a sustained load test of 75 percent of the ultimate notch tensile strength of the material for 200 hours minimum and shall meet the requirements of (see 4.6.) Failure of any one of the specimens shall constitute failure of the test, and production shall cease until the cause of the failure is determined and the bath re-qualified. Acceptance of items completed after the last successfully completed acceptance test shall be withheld until the extent and cause of the failure have been determined.

b. The test for embrittlement shall be conducted as often as deemed necessary with a maximum interval of every ninety calendar days. If the embrittlement test has not been performed in the ninety days preceding the processing of a material batch, the bath must be qualified in accordance with (see 5.5.)

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. This standard provides guidance on the procedures for chromium plating, low embrittlement, electro-deposition for the verification of the Air Force repair process on the landing gear of all aircrafts. It is an Air Force unique manufacturing standard that will be used only by the Air Force at Hill Air Force Base.

6.2 Plating options. Chrome plating is applied for wear resistance, reconditioning worn or undersize parts, and such incidental corrosion protection as the specified thickness of the deposit may afford. Where corrosion protection is desired, an undercoat of nickel 0.025 to 0.050 millimeters (0.001 to 0.002 in) thickness is recommended. Other plating solutions may be used when approved by the responsible engineering organization provided the deposit meets the requirements of this standard. (5.2.4). When not specified, plating class shall be Class 3 (see 1.2.1).

6.3 Safety and health. This document specifies the use of certain materials, which have been listed in 29 CFR 1910 (OSHA Standards) as “Toxic and Hazardous Substances.” Personnel exposure to these materials during the process must be limited to the values specified in applicable portions of the OSHA Standard 1910.1000.

6.4 Subject term (key word) listing.

Chrome
Corrosion
Process control

6.5 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

CONCLUDING MATERIAL

Custodian:
Air Force – 99

Preparing Activity:
Air Force – 70

Agent:
Air Force – 99

(Project MFFP-0711)

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at http://assist.daps.dla.mil.