METRIC

MIL-STD-1501C (USAF)
2 APRIL 1990
SUPERSEDES
MIL-STD-1501B (USAF)
14 DECEMBER 1984

MILITARY STANDARD

CHROMIUM PLATING, LOW EMBRITTLEMENT, ELECTRODEPOSITION

AMSC N/A FSC MFFP

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

F O R W A R D

1. This Military Standard is approved for use by Ogden ALC/MMDSA, Department of the Air Force, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Ogden ALC/MMDSA, Hill AFB, Ogden, UT 84056-5609, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

C O N T E N T S

1. SCOPE

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

1.2 Documentation. This standard meets and exceeds the requirements of QQ-C-320 and can be used when plating in accordance with QQ-C-320.

1.3 Purpose. 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 nickle 0.025 to 0.050 millimeters (0.001 to 0.002 in) thickness is recommended.

1.4 Classification

1.4.1 Classes. Chromium plating covered by this standard shall be of the following classes:

a. Class 1 - Crack free (see 4.8)

b. Class 2 - Limited cracking allowed (see 4.9)

c. Class 3 - Moderate cracking allowed (see 4.10)

NOTE: When not specified, plating class shall be Class 3.

1.4.2 Types. Chrome plating covered by this standard shall be of the following types:

a. Type 1 - Plated to specified dimensions (see 4.11)

b. Type II - Processed to specified dimensions after plating (see 4.12)

2. REFERENCED DOCUMENTS

2.1 Documents. The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein.

SPECIFICATIONS

Federal

O-C-303	Chromium Trioxide, Technical
O-S-809	Sulfuric Acid, Technical
QQ-C-320	Chromium Plating (Electrodeposited)

Military

MIL-S-13165	Shot Peening of Metal Parts
MIL-I-25135	Inspection Materials, Penetrant
MIL-R-81841	Rotary Flap Peening of Metal Parts

STANDARDS

Military

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
MIL-STD-1949	Inspection, Magnetic Particle
MIL-STD-6866	Inspection, Liquid Penetrant

(Copies of specifications, standards, drawings and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer).

2.2 Other publications. The following documents form a part of this standard to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

American Society for Testing and Materials

ASTM E8 Standard	Tension Testing of Metallic Materials

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103).

Aerospace Material Specifications

AMS 2640	Magnetic Particle Inspection
AMS 2645	Fluorescent Penetrant Inspection

(Applicxations for copies should be addressed to SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001)

2.3 Order of precedence. In the event of a conflict between

the text of this specification and the references cited herein, the text of this specification shall take precedence.

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 squared (180,000 psi) and above.

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

4. GENERAL REQUIREMENTS

4.1 Materials and equipment. Materials and equipment used in chromium plating are as follows:

4.1.1 Materials

a. Chromium Trioxide, Technical (O-C-303)

b. Sulfuric Acid, Technical (O-S-809)

c. Anodes

7% Tin-lead; wires, rod, or strip
7% Antimony-lead; wires, rod, or strip

4.1.2 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 chromium tank cathode. The ammeter shall have sufficient shunts and switches to provide a full-scale reading equal to the maximum capacity of the power source, and an accuracy of $\pm$ 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 ± 14°C (375 ± 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.

4.2 Specification QQ-C-320. The requirements of QQ-C-320 shall be plated to be complied with on all parts, in conjunction with those specified in this standard. If there is a conflict between the two documents, however, the requirements of this standard shall govern.

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

4.4 Shot peening. All parts shall be shot peened in accordance with MIL-S-13165 or MIL-R-81841, unless otherwise specified.

4.5 Embrittlement. Qualification test specimens and process control test specimens 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.

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

4.7 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 0.5 millimeters (0.002 in) and the maximum thickness 0.2 millimeters (0.008 in) on the finished part.

4.8 Class 1. Parts plated to Class 1 shall not show a mud cracking pattern when fluorescent penetrant inspected. (see 5.3.1)

4.9 Class 2. Parts plated to Class 2 are allowed to show some cracking pattern when fluorescent penetrant inspected (see 5.3.1). As a general rule cracks exceeding 13mm (1/2 in) in

length or individual areas of cracking exceeding 19 square centimeters (3 sq in) or 10 percent of plated area whichever is smaller should be cause for rejection of the part.

4.10 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 part.

4.11 Type I Plating. For Type I Plating, the items 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.

4.12 Type II Plating. For Type II plating a minimum of 0.05 millimeters (0.002 in) 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, cirular, patch or linear crack patterns), spalling or blistering shall be cause for rejection of the parts.

5. DETAILED REQUIREMENTS

5.1 General notes

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 ± 14° cersius (375 ± 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. When chrome plating is to be followed by cadmium plating, the 23 hour minimum bake period, required by 5.2.7, can be replaced by a four hour bake period at 191 ± 14°C (375 ± 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 should 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 of 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 in 5.2.4.

5.2 Plating procedure. The chromium plating procedure shall be as described below:

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 (Al_2O_3) or silicon dioxide (SiO_2) or garnet per MIL-STD-1504. Other nonembrittling 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 sq. in.) for 30 seconds to 10 minutes. Etch in the following solution (preferred) or in the plating bath, 5.2.3:

Chromic Acid 225-300 gram/liter (30-40 oz/gal)

Temperature 32 to 60 degrees C (90 to 140°F)

NOTE: Etching increases iron contamination in the plating bath, therefore, the use of solution 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 in 5.2.3. The conditions for the employment of either the sulfuric acid or the sulfuric-hydrofluoric acid mixtures are as follows:

a. Forty percent sulfuric acid.

(1) Operating range - 35-45 percent sulfuric acid by volume.

(2) Temperature - ambient.

(3) Current density - 15.5 to 46.5 amps/decimeter squared (1 to 3A per sq. in.), anodic.

(4) Time - 30-120 seconds.

b. Sulfuric-hydrofluoric acid.

(1) Operating range - sulfuric acid, 20-30 percent by volume; 70 percent hydrofluoric acid, 3-10 percent by volume.

(2) Temperature - ambient.

(3) Current density - 31.0 to 62.0 amps/decimeter squared (2 to 4A per sq. in.), anodic.

(4) Time - 60-90 seconds.

5.2.4 Step No. 4. Chromium plate at 15.5 to 46.5 amps/decimeters squared (1 to 3A per sq. in.) to the required thickness. When feasible, apply voltage so that the current will flow upon immersion of parts. Chromium plate in the following solution:

a. Chromic Acid 225-270 gram/liter (30-36 oz/gal)

b. Sulfuric Acid 2.25-2.7 gram/liter (.30-.36 oz/gal)

c. Trivalent Chrome 4 grams per liter (g/l) max

d. Iron 5 g/l max

e. Ratio Chromic Acid/Sulfuric Acid 80/1 to 120/1

f. Temperature 52 to 60°C (125 to 140°F)

NOTE: It is general practice to start plating at a higher current (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.

NOTE: Other plating solutions may be used when approved by the responsible engineering organization provided the deposit meets the requirements of this standard.

WARNING
PROVIDE ADEQUATE VENTILATION WHEN USING CHROMIC PLATING SOLUTIONS. WEAR PROTECTIVE RUBBER GLOVES AND CHEMICAL GOGGLES 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 and racking, and clean as necessary.

5.2.6 Step No. 6. Rinse all parts in hot water and blow dry with compessed air. Elapsed time between completion of plating and start of baking, step number 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 ± 14° C (375 ± 25°f) (see 5.1.3).

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

5.3.1 Penetrant inspection. The parts shall be cleaned and inspected for the requirements of paragraphs 4.8, 4.9, 4.10 and 4.12 in accordance with MIL-STD-6866, Type I, Method A, B or C using material per MIL-I-25135 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 MIL-STD-1949, for any deleterious processing effects on the part. The acceptance standard should be a s required by the 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 of 4.5 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 standard E8 for round 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 in.) 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 ± 14°C (375 ± 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 of 4.5.

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 5.5a shall be plated per 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 4.5. Failure of any one of the specimens shall constitute failure of the test, and production shall cease until the cause of failure is determined and the bath requalified. Acceptance of items completed after the last successfully completed acceptance test shall be withheld until the extent and cause of failure have been determined.

b. The test for embrittlement shall be conducted as often as deemed necessary with a maximum interval of every ninety (90) calendar days. If the embrittlement test has not been performed in the ninety (90) days preceeding the processing of a material batch, the bath must be qualified in accordance with 5.5.

5.7 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 OSHA Standard 1910.1000.

Custodian:
Air Force - 99

Preparing Activity:
Air Force - 70

Project Number:
MFFP-F423