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MILITARY STANDARD

CHROMIUM PLATING, LOW EMBRITTLEMENT, ELECTRODEPOSITION

FSC MFFP

DEPARTMENT OF THE AIR FORCE
WASHINGTON DC 20330

CHROMIUM PLATING, LOW EMBRITTLEMENT, ELECTRODEPOSITION

MIL-STD-1501B(USAF)

1. This Military Standard is approved for use by HQ AFLC CASO/LODS, 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) and any pertinent data which may be of use in improving this document should be addressed to: HQ AFLC CASO/LODS, Federal Center, Battle Creek, MI 49016) by using the self-addressed Standardization Document Improvement Proposal (Form DD1426) appearing at the end of this document or by letter.

C O N T E N T S

MILITARY STANDARD
CHROMIUM PLATING, LOW EMBRITTLEMENT, ELECTRODEPOSITION

1. SCOPE

*1.1 Scope. This standard covers the process and materials required for the electrodeposition of chromium on high strength steel substrates. 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 and such incidental corrosion protection as the specified thickness of the plate may afford. Where corrosion protection is desired, an undercoat of nickel 0.0254 to 0.0508 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-I-6866	Inspection, Penetrant, Method of
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

(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

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

3. DEFINITIONS

*3.1 High strength steel. For the purpose of this standard high strength steel is defined as steel heat treated to 1100 megapascals or 112 kilograms force/millimeters 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 should be resistant to the operating temperature and the chemical environment. Tanks in which any electrolytic action takes place must be free of short circuits.

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 ± 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° celsius (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 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, homogeneous, 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 preplating 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 0.05 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 1.27 centimeters ($\frac{1}{2}$ in) in length or individual areas of cracking exceeding 19.35 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 then 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 1100 mega pascals or 112 kilograms force/ millimeter squared (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 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° celsius (375 ± 25 degrees 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 degrees celsuis (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 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 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.

*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 non-embrittling 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 at 16 amps to 48 amps/decimeter squared (1 to 3A per sq. in.) for ½ to 10 minutes. Etch in the following solution (preferred) or in the plating bath, 5.2.4:

Chromic Acid	210-280 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.

*5.2.4 Step No. 4. Chromium plate at 16 amps to 48 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 210-252 gram/liter (30-36 oz/gal)

b. Sulfuric Acid 2.10-2.5 gram/liter (.30-.36 oz/gal)

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

d. Iron 5 grams per liter (g/l) max

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

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

*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 compressed air. Elasped 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 1100 megapascals or 112 kilograms force/millimeters squared (180,000 psi) and above for twenty three hours minimum, at 191 ± 14 degrees celsius (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-I-6866, Type I, Method A, B or C using material per MIL-I-25135 Group VI. Penetrant penetration time will be 20 minutes minimum.

5.4 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 from four separate heats, heat treated to a tensile strength of 1590 to 1710 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° celsius (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 Analysis report. A complete chemical analysis of the plating solution shall be submitted to the procuring activity with the qualification tests.

5.8 Asterisks. The margin of this specification is marked with an asterisk to indicate where changes (additions, modifications, corrections, deletions) from the previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the last pervious issue.

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5. PROBLEM AREAS

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