MIL-STD-868A(USAF)
23 March 1979
SUPERSEDING
MIL-STD-868
28 June 1972

MILITARY STANDARD

NICKEL PLATING, LOW EMBRITTLEMENT, ELECTRODEPOSITION

FSC MFFP

DEPARTMENT OF THE AIR FORCE

Washington DC 20330

NICKEL PLATING, LOW EMBRITTLEMENT, ELECTRODEPOSITION

MIL-STD-868A(USAF)

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MILITARY STANDARD

NICKEL PLATING, LOW EMBRITTLEMENT ELECTRODEPOSITION

1. SCOPE

1.1 Scope. This standard covers the process and materials required for the electrodeposition of nickel on high strength steel substrates. Subsequent heat treating techniques needed to insure low embrittlement of steel are also described.

1.2 Documentation. This standard meets and exceeds the requirements of QQ-N-290 and should be used when plating in accordance with QQ-N-290 is a requirement.

1.3 Purpose. Electrodeposited nickel is used for wear resistance, corrosion resistance, heat resistance and as an undercoat for precious metals.

1.4 Classification

1.4.1 Classes. Nickel plating covered by this standard will be of the engineering class only.

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

a. Type I - Plated to specified dimensions

b. Type II - Processed to specified dimensions after plating

2. REFERENCED DOCUMENTS

2.1 Issues of documents. The following documents of the issues 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-N-335	Nickel Salt, Electroplating
QQ-N-290	Nickel Plating (Electrodeposited)

Military

MIL-S-13165	Shot Peening of Metal Parts
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	Dry 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 Standard E8 Tension Testing of Metallic Materials (Reference Part 31)

(Copies of ASTM Standards may be obtained from the American Society for Testing and Materials, 1916 Race St. 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 1240 MPa (112 kgf/mm^2) (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 nickel plating are as follows:

4.1.1 Materials

a. Boric Acid, H_3BO_3.

b. Nickel Chloride, O-N-335.

c. Nickel Sulfate, O-N-335.

d. Sulfamate Nickle Plating SN, Barrett Chemical Products Division, Baltimore, Maryland, or approved equal.

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 R.M.S.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 plating 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 ± 10 percent of the current being measured.

e. Blast equipment. A blast cabinet 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 the parts to be plated. The oven shall be equipped with temperature indicating, recording and regulating devices.

4.2 Specification QQ-N-290. The requirements of QQ-N-290 shall be complied with on all parts, in conjunction with those specified in this standard. If there is a conflict between the two documents, the requirements of this standard shall govern.

4.3 Finish. The plated part shall 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% 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 0.05mm (0.002 inch) and the maximum thickness 0.2mm (0.008 inch) on the finished parts.

4.8 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 of 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.

4.9 Type II plating. For Type II plating a minimum of 0.05mm (0.002 inch) more nickel than desired shall be deposited (per surface). The excess shall be ground off to give the final dimension and surface finish desired. The minimum thickness for Type II shall be 0.05mm (0.002 inch) on the finished part. Steel parts heat treated to 1240 MPa (112 kg/mm^2) (180,000 psi) shall be ground in accordance with MIL-STD-866.

4.10 Reclaimed materials. Reclaimed materials shall be utilized to the maximum extent possible with the quality limits required by this document and to fulfill compliance with the Resource Conservation/Recovery Act of 1976 (public law 94-580 dated 21 Oct 76).

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°C (375 ± 25°F). Shot peening shall be performed before plating and after stress relieving.

5.1.3 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 parts.

5.1.4 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.

5.1.5 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 solution shall be used. Masking shall be performed at the most convenient step prior to plating.

5.1.6 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.

5.2 Plating procedure. The preferred method of cleaning is by dry blasting (Method 1). Other methods such as (Method 2) that can be demonstrated to be nonembrittling (5.7) can be used with the approval of the procuring activity.

5.3 Method 1. The nickel plating procedure shall be as described below:

5.3.1 Step No. 1. Parts shall be vapor degreased.

5.3.2 Step No. 2. Parts shall be dry blasted using 80-180 grit aluminum oxide (Al_2O_3), silicon dioxide (SiO_2) or garnet per MIL-STD-1504. Elapsed time between completion of cleaning and the next step shall not exceed sixty minutes.

5.3.3 Step No. 3. Rinse parts in cold water (optional).

5.3.4 Step No. 4. Nickel plate at 3.2 to 5.4 A/dm^2 (30 to 50 A/ft^2) to the required thickness. Nickel plate in either of the following solutions:

5.3.4.1 Solution number 1:

a.	Nickel Sulfate	300-360 g/l (40-48 oz/gal)
b.	Nickel Chloride	30-60 g/l (4-8 oz/gal)
c.	Boric Acid	30-45 g/l (4-6 oz/gal)
d.	pH	1.5-4.5
e.	Temperature	46-60°C (115-140°F)

5.3.4.2 Solution number 2:

a.	Nickel Sulfamate	323 g/l (43 oz/gal) Make up
b.	Nickel Metal	60-90 g/l (8-12 oz/gal)
c.	Boric Acid	22.5-41.2 g/l (3-5.5 oz/gal)
d.	pH	3-5
e.	Temperature	38-60°C (100-140°F)

5.3.5 Step No. 5. Rinse all parts in cold water.

5.3.6 Step No. 6. Rinse 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.

5.3.7 Step No. 7. Bake all parts heat treated above 1240 MPa (180,000 psi) after plating for twenty-three hours minimum, at 191 ± 14°C (375 ± 25°F).

5.4 Method 2. The nickel plating procedure shall be as described below:

5.4.1 Step No. 1. Parts shall be vapor degreased.

5.4.2 Step No. 2. Parts shall be dry blasted using 80-180 grit aluminum oxide (Al_2O_3), silicon dioxide (SiO_2), or garnet per MIL-STD-1504.

5.4.3 Step No. 3. Parts shall be vapor degreased.

5.4.4 Step No. 4. Anodic etch in the following solution at 3 to 6 volts for ninety seconds:

a. Sodium Hydroxide 3.8-11.2 g/l (0.5-1.5 oz/gal)

b. Sodium Phosphate 30-90 g/l (4.0-12.0 oz/gal)

c. Sodium Carbonate 7.5-45 g/l (1.0-6.0 oz/gal)

d. Temperature 52-58°C (125-135°F)

5.4.5 Step No. 5. Rinse all parts in cold water.

5.4.6 Step No. 6. Acid dip in 5 to 10 percent sulfuric acid at room temperature for fifteen to thirty seconds.

5.4.7 Step No. 7. Rinse parts in cold water.

5.4.8 Step No. 8. Nickel plate in nickel plating solution (5.3.4) to required thickness.

5.4.9 Step No. 9. Rinse parts in cold water.

5.4.10 Step No. 10. Rinse parts in hot water and blow dry with compressed air, elapsed time between completion of plating and start of baking, Step No. 11, shall not exceed four hours.

5.4.11 Step No. 11. Bake all parts heat treated above 1240MPa (180,000 psi) after plating for twenty-three hours minimum, at 191 ± 14°C (375±25°F).

5.5 Inspection. Inspection shall be in accordance with the production control inspection and tests in QQ-N-290 and this standard.

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

5.7 Qualification embrittlement test. The processor shall demonstrate his ability to provide nickel plating which meets the requirements of (4.5) of this standard as follows:

a. Four round notched 4340 steel specimens from four separate heats, heat treated to a tensile strength of 1791 to 1929 MPa (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 ± 0.013mm (0.010 ± 0.0005 inch) 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 between the specimen rack and the cathode. The specimens will be plated at 5A/dm^2 (45 ampere/ft^2) to a minimum of 0.05mm (0.002 inch) thickness. The specimens 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).

5.7.1 Analysis report. A complete analysis report of the plating bath shall be submitted to the procuring activity with the qualification tests.

5.8 Process control embrittlement acceptance test. The process control embrittlement acceptance test shall be as follows:

a. Two standard specimens of the type noted in (5.7.a) shall be plated per 5.7.b in conjunction with the plating of items. The specimens shall be subjected to a sustained load test of 75 percent of the ultimate notched tensile strength of the material for two hundred hours minimum and shall meet the requirements of 4.5. Failure of any one of these specimens shall constitute failure of the test and production shall cease until the bath is requailified. Acceptance of items completed after the last successfully completed acceptance test shall be withheld until the extent and cuase of failure have been determined.

b. The test for embrittlement shall be conducted as often as deemed necessary with a maximum interval of every thirty calendar days. If the embrittlement test has not been performed in the thirty days proceeding the processing of a material batch the bath must be requalified in accordance with 5.7.

5.8.1 Hydrogen detection instrument testing. Hydrogen detection instrument testing can be used for the process control testing with the approval of the procuring activity.

5.9 Caution. The procedures specified herein utilize materials listed in Department of Labor (DOL) Occupational Safety and Health Standards as "Toxic and Hazardous Substances." Personnel exposure to these materials must be limited to those values specified in 29 CFR 1910.1000.

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