

INCH-POUND

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## MILITARY SPECIFICATION

### COATINGS, ELECTROLESS NICKEL, REQUIREMENTS FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

#### 1. SCOPE

1.1 Scope. This specification covers the requirements for electroless (autocatalytic chemical reduction) deposition of nickel or nickel coatings on metal surfaces.

#### 1.2 Classification

1.2.1 Classes. The nickel coatings shall be classified in accordance with the thermal treatment applied subsequent to plating.

Class 1 - As plated, no subsequent heat treatment. A bake for hydrogen embrittlement relief is not considered a heat treatment.

Class 2 - Heat treated to obtain required hardness. May be used on all metals not affected by heating to 500°F and above.

Class 3 - Aluminum alloys nonheat-treatable, and beryllium alloys processed to improve adhesion of the nickel deposit.

Class 4 - Aluminum alloys, heat-treatable, processed to improve adhesion of the nickel deposit.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: ASD/ENES, Wright-Patterson AFB OH 45433-6503, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMEC N/A

AREA MFFP

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1.2.2 Grades. The nickel coatings shall be of the following grades:

Grade A - 0.0010-inch minimum thickness

Grade B - 0.0005-inch minimum thickness

Grade C - 0.0015-inch minimum thickness

## 2. APPLICABLE DOCUMENTS

### 2.1 Government documents

2.1.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2)

## SPECIFICATIONS

### MILITARY

MIL-I-13165 Shot Peening of Metal Parts

## STANDARDS

### MILITARY

MIL-STD-105 Sampling Procedures and Tables for Inspection by Attributes

MIL-STD-1949 Inspection, Magnetic Particle

(Unless otherwise indicated, copies of the military specifications and standards are available from the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DODISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

## AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B487 Measurement of Metal and Oxide Coatings Thickness by Microscopical Examination of a Cross Section, Method for (DoD adopted)

ASTM B499 Standard Test Method for Measurement of Coating Thickness by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals (DoD adopted)

ASTM B568	X-Ray Spectrometry (DoD adopted)
ASTM E18	Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials, Tests for (DoD adopted)
ASTM E384-84	Microhardness of Materials, Test Method for
ASTM F519	Mechanical Hydrogen Embrittlement Testing of Plating Processes and Aircraft Maintenance Chemicals (DoD adopted)

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103-1137.)

2.3 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, supersedes applicable laws and regulations unless a specific exemption has been obtained.

### 3. REQUIREMENTS

#### 3.1 Materials

3.1.1 Basis metal. The coating may be used on iron, copper, aluminum, nickel, cobalt, beryllium and titanium based alloys.

3.1.2 Tensile strength. All steel parts having an ultimate tensile strength of 220,000 psi, or above, shall not be coated without approval of the procuring activity.

#### 3.2 Precoating procedures

##### 3.2.1 General requirements.

3.2.1.1 Unless otherwise specified, parts shall be cleaned, pickled, or otherwise preheated as necessary.

3.2.1.1.1 Unless approved by the procuring activity, high strength steels above Rockwell C40 hardness shall not be subjected to acid pickling.

3.2.1.2 Unless otherwise specified, the coating shall be applied after all basis metal heat treatments and mechanical operations such as machining, brazing, welding, forming and perforating of the part have been completed.

3.2.1.3 Hardness measurement. Prior to coating, steel parts shall be measured for hardness in accordance with ASTM E-18.

3.2.2 Stress relief heat treatment. Prior to cleaning and coating, all steel parts having a hardness greater than Rockwell C40 shall be given a stress-relief heat treatment at a temperature that will produce maximum stress relief without reducing the hardness to less than the specified minimum.

3.2.3 Shot peening. Prior to coating, all steel parts having a hardness of Rockwell C40, or above, and are designed for unlimited life under dynamic loads, shall be shot peened in accordance with MIL-S-13165. Unless otherwise

specified, the shot peening shall be accomplished on all surfaces for which the coating is required and all immediately adjacent surfaces when they contain notches, fillets, or other abrupt changes of section size where stresses will be concentrated.

### 3.3 Coating properties

#### 3.3.1 General requirements

3.3.1.1 Manufacturers are given latitude in the selection of raw materials for formulating the coating bath provided the finish meets the requirements of this specification.

3.3.1.2 Equipment, solutions and process procedures shall be subject to the approval of the procuring activity.

3.3.2 Thickness. Unless otherwise specified, minimum thickness of the nickel coating shall be 0.0010 (Grade A) for aluminum based alloys; 0.005 (Grade B) for copper, nickel, cobalt, titanium and beryllium alloys; and 0.0015 (Grade C) for iron based alloys.

3.3.3 Adhesion. The adhesion shall be such that when examined at a magnification of approximately four diameters, the nickel coating shall not show separation from the basis metal at the interface when tested as specified in 4.5.2. The interface between the nickel and the basis metal is the surface of the basis metal before coating. Occurrence of any defect in the coating which could lead to failure of the coating shall be considered as nonconformance to this specification. Coating should not be accomplished on parts which contain defects that would lead to failure of the part, or coating, in service.

#### 3.4 Postcoating procedures

3.4.1 Hydrogen embrittlement relief bake. Within 4 hours after coating, coated class 1 and class 2 steel parts which have a hardness of Rockwell C40 or above shall require a hydrogen embrittlement relief bake at  $375^{\circ}\text{F} \pm 25^{\circ}\text{F}$  for not less than 3 hours. When tested in accordance with section 4, the baked parts shall not crack or fracture.

#### 3.4.2 Heat treatments

3.4.2.1 Class 2 hardness coatings. Class 2 coatings shall have a minimum hardness of 700 Vickers or equivalent. The hardness can be achieved by heating the part per the schedule given in 6.3.

3.4.2.2 Class 3 coatings. Coated nonheat-treatable aluminum parts shall be heated for 1 to 1 1/2 hours at  $375^{\circ}\text{F} \pm 15^{\circ}\text{F}$  ( $191^{\circ}\text{C} \pm 8^{\circ}\text{C}$ ) to improve adhesion of nickel deposit.

3.4.2.3 Class 4 coatings. Coated heat-treatable aluminum alloys shall be heated between  $240^{\circ}\text{F}$  to  $260^{\circ}\text{F}$  ( $116^{\circ}\text{C}$  to  $127^{\circ}\text{C}$ ) for 1 to 1 1/2 hours to improve adhesion of nickel deposit. (NOTE: These alloy types and grades may undergo microstructural changes when heated to  $375^{\circ}\text{F}$ .)

3.5 Identification marking. When specified, the coated parts shall be marked with a fluid not affected by water and which shall not rub off or smear during shipment or storage, and shall carry a tag giving the following information:

- a. Basis metal
- b. Number of this specification
- c. Class and grade of coating

### 3.6 Workmanship

3.6.1 Basis metal. The basis metal shall be free from defects that will be detrimental to the utility, appearance or serviceability of the finished product or part and coating.

3.6.2 Nickel coating. The nickel coating shall be smooth, adherent, and free from visible blisters, pits, nodules, porosity, cracks and other defects. All details of workmanship shall conform to the best practices for high quality coating.

## 4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

4.2 Classification of inspections. The inspection requirements specified herein are classified as quality conformance inspection (see 4.4).

4.3 Inspection conditions. Unless otherwise specified, all inspections shall be performed in accordance with the methods of inspection specified in 4.5.

4.3.1 Inspection lot. A lot shall consist of coated parts of the same type and class, same basis metal, and of approximately the same size and shape, coated under the same conditions and by means of the same coating process, and submitted for acceptance at one time.

4.3.2 Separate specimens. When the coated parts are of such form as to be not readily adaptable to a test specified herein, or at the discretion of the inspector for destructive tests for the sampling of small lot sizes, the test may be made by the use of separate specimens coated concurrently with the parts represented. The separate specimens shall be of a basis metal equivalent to that of the parts represented. 'Equivalent' basis metal includes chemical composition and finish of surface prior to coating. For example, a cold-rolled steel surface shall not be used to represent a hot-rolled steel surface; owing to the impracticability of forging or casting separate test specimens, hot-rolled steel specimens may be used to represent forged and cast steel parts. The separate specimens shall be strips approximately 1-inch wide, 4 inches long, and 0.04-inch thick except those required for determination of embrittlement relief (see 4.5.4). These specimens shall be introduced into a lot at regular intervals prior to the cleaning operations preliminary to coating and shall not be separated therefrom until after completion of the processing.

4.4 Quality conformance inspection. Quality conformance inspections shall consist of sampling plans A, B, C and D.

4.4.1 Sampling plan A - Sampling procedures for visual examination and nondestructive tests of coating thickness. Samples shall be selected from each lot (see 4.3.1) and acceptance of the lot shall be determined in accordance with inspection level II and acceptable quality level (AQL) 1.5 of MIL-STD-105. Periodic thickness and adhesion tests may be performed to verify comparable nondestructive tests so as to assure proper process control.

4.4.1.1 Visual inspection. Each of the sample parts selected in accordance with 4.4.1 shall be examined visually for conformance to requirements of 3.6.2.

4.4.1.2 Thickness (nondestructive tests). Each of the sample parts selected in accordance with 4.4.1 shall be inspected and the coating thickness measured in several locations on each part in accordance with 4.5.1.2. The part shall be considered nonconforming if one or more measurement fail to meet the specified minimum thickness.

4.4.2 Sampling plan B - Sampling procedures for evaluating hydrogen embrittlement relief destructive tests - Classes 1 and 2. A hydrogen embrittlement relief test shall be run once per month, as specified in 4.5.4.

4.4.3 Sampling plan C - Sampling procedure for adhesion tests and destructive tests of coating thickness. A random sample of four parts shall be selected from each inspection lot (see 4.3.1) or four separately coated specimens shall be prepared in accordance with 4.3.2 to represent each inspection lot. If the number of parts in an inspection lot is four or less, the number of parts in the sample shall be determined by the procuring activity or shall be left to the discretion of the inspector.

4.4.3.1 Thickness (destructive) test. Each part shall be tested in accordance with 4.5.1.1 in several locations. If the coating thickness at any place on any part is less than the specified thickness, the lot shall be rejected.

4.4.3.2 Adhesion. The parts used for the thickness test (4.4.3.1) may be used as specimens for the adhesion tests specified in 4.5.2 provided they are of suitable size and form. Failure of one or more of the test specimens shall constitute failure of the lot.

4.4.4 Sampling plan D - Sampling procedure for hardness test. All class 2 coated parts selected from 4.3.1 shall be subjected to a hardness test in accordance with 4.5.3.

#### 4.5 Methods of inspection

##### 4.5.1 Thickness test

4.5.1.1 Microscopic method. The coating thickness shall be determined in accordance with ASTM B487.

4.5.1.2 Instrument method. The instrument used, its calibration, and its operation for testing given parts shall be such that the coating thickness shall be determined with  $\pm 10$  percent of its true thickness; or the instrument shall be of a type approved by the procuring activity (see 6.4). The coating thickness shall be determined in accordance with ASTM B499.

4.5.2 Adhesion test. The test specimen shall be bent 180 degrees over a mandrel diameter 4 times the thickness (1 cm minimum) of the specimen and examined at 4X power magnification for flaking or separation of the interface. It shall then be impossible to detach any appreciable areas of the coating with a sharp instrument on the outside radius of the bent test specimen. When the coated parts are not readily adaptable to the bent test, adhesion may be determined on the coated part by cutting the coating from the basis metal at the interface in continuous path and examined as above.

4.5.3 Hardness tests. Vickers hardness measurements shall be in accordance with ASTM E384 for class 2 coatings.

4.5.4 Embrittlement relief. Compliance with 3.4.1 shall be determined with samples of plated parts. Parts such as spring pins, lock rings, etc. which are installed in holes or rods, shall be similarly assembled using the applicable parts specifications or drawing tolerances which impose the maximum sustained tensile load on the plated part. The selected samples shall be subjected to a sustained tensile load equal to 115 percent of the maximum design yield load for which the part was designed. Testing shall conform to ASTM F519. Parts which require special fixtures, extreme loads to comply with the above requirements, or where the maximum design yield load is not known, may be represented by separate specimens. The notched samples shall be subjected to a sustained tensile load equal to 75 percent of the ultimate notch tensile strength of the material. The articles,

parts or specimens shall be held under load for at least 200 hours and then examined for cracks or fracture. Inspection of parts for cracks in the basis metal and the coating shall be in accordance with MIL-STD-1949 using the fluorescent magnetic particle method. The lot shall be rejected if any coated part develops cracks.

## 5. PACKAGING

5.1 Coated surfaces shall be protected from damage during shipment and storage.

## 6. NOTES

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

6.1 Intended uses. The coating is intended for use when hard and smooth surfaces are required on coated parts. Excellent uniform deposits are produced on irregular parts. Coated parts, such as used in air compressors, missile fuel injector plates, pumps, reciprocating surfaces, etc., are protected from oxidation, corrosion and wear. With aluminum electronic devices, not only is product contamination prevented, but the coated parts facilitate soldering. Coated parts of stainless steel similarly facilitate brazing.

6.2 Acquisition requirements. Acquisition documents should specify the following:

- a. Title, number and date of the specification.
- b. Class and grade, and heat treatment or condition (see 1.2 and 3.5).
- c. Issue of DODISS to be cited in the solicitation, and if required, the specific issue of individual documents reference (see 2.1.1 and 2.2).
- d. Method of determining compliance with 4.3.

## 6.3 Coating hardness

6.3.1 Required hardness on class 2 coating on steel alloys may be achieved by heating per the following baking schedule:

<u>°F. Temperature</u>	<u>Hours</u>
500	4 or more
550	2 or more
650	1 or more
750	0.5 or more

6.3.2 Coating hardness on nickel, copper, cobalt and titanium based alloys can be achieved by heating at  $650^{\circ}\text{F} \pm 10^{\circ}\text{F}$  ( $343^{\circ}\text{C} \pm 6^{\circ}\text{C}$ ) for 1 to 1-1/2 hours.



6.4 Nondestructive thickness measurements. Thickness measurements of electroless nickel coatings containing more than 8 percent phosphorous are sufficiently nonmagnetic to be measured for thickness in accordance with ASTM B499, Method of Measurement of Coating Thickness by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals, if deposited on a magnetic basis metal. When measuring heat-treated coatings containing more than 8 percent phosphorous, the instrument should be calibrated against heat-treated standards of known coatings thickness or equivalent calibration foils. Heat treatment increases coating magnetism. Measurement of electroless nickel coatings containing less than 8 percent phosphorous by a magnetic method is not recommended.

6.5 Subject term (key word) listing.

nickel  
electroless (autocatalytic chemical reduction)

6.6 Recycled material. It is encouraged that recycled material be used when practical as long as it meets the requirements of the document (see 3.1).

6.7 Changes from previous issues. Asterisks (or vertical lines) are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Custodians:

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Army - MR  
Navy - AS

Preparing activity:  
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Navy - OS  
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STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions - Reverse Side)

1. DOCUMENT NUMBER

MIL-C-26074D

2. DOCUMENT TITLE

Coatings, Electroless Nickel, Requirements For

3a. NAME OF SUBMITTING ORGANIZATION

4. TYPE OF ORGANIZATION (Mark one)

VENDOR

USER

MANUFACTURER

OTHER (Specify): \_\_\_\_\_

3b. ADDRESS (Street, City, State, ZIP Code)

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER (Last, First, MI) - Optional

7b. WORK TELEPHONE NUMBER (include Area Code) - Optional

8. MAILING ADDRESS (Street, City, State, ZIP Code) - Optional

9. DATE OF SUBMISSION (YYMMDD)

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