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MILITARY SPECIFICATION

NICKEL-CARBON, POROUS, ELECTRODEPOSITED, FOR CAMOUFLAGE

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 the electrodeposition of porous nickel-carbon plate on aluminum, steel and copper alloys to provide a lusterless, abrasion resistant, conductive, camouflage finish on electronic hardware (see 6.1).

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. Unless otherwise specified, the following specifications, standards, and handbooks of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation form a part of this specification to the extent specified herein."

STANDARDS

FEDERAL

Federal Test Method Standard No. 141
Federal Test Method Standard No. 151

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, US Army Electronics Research and Development Command, ATTN: DELET-R-S, Fort Monmouth, N. J. 07703, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

NO DELIVERABLE DATA REQUIRED BY THIS DOCUMENT

MILITARY

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

MIL-STD-810 - Environmental Test Methods.

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

2.1.2 Other publications. The following documents form a part of this specification 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) Standards

B487 Measurement of Metal and Oxide Coating Thicknesses by Microscopical Examination of a Cross Section.

B530 Measurement of Coating Thicknesses by the Magnetic Method Electrodeposited Nickel Coatings on Magnetic and Nonmagnetic Substrates.

E8 Tension Testing of Metallic Materials.

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

2.1.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited therein, the text of this specification shall take precedence.

3. REQUIREMENTS

3.1 General requirements.

3.1.1 Materials. The materials shall be as specified herein to produce platings which meet the requirements of this specification.

3.1.2 Cleaning. Articles shall be cleaned, pickled or otherwise pretreated by methods which shall not damage the metal surface and shall not interfere with the adhesion of the plating. Pickling of high strength steels shall be prohibited.

3.1.3 High tensile strength steel parts. Unless otherwise specified, steel parts having an ultimate tensile strength greater than 240,000 pounds per square inch (psi) shall not be plated without specific approval of the procuring activity (see 6.2).

3.1.3.1 Treated steel parts. All steel parts treated for embrittlement relief in accordance with 3.2.2, when tested in accordance with 4.5.8 shall not crack or fail by fracture (see 4.4.3.3). Plated springs and other parts subject to flexure shall not be flexed prior to the hydrogen embrittlement relief treatment.

3.1.4 Aluminum metal parts. Metallic aluminum parts that are to be plated according to this specification shall be anodized in accordance with 3.2.1.

3.2 Processing requirements.

3.2.1 Stress relief treatment. All steel parts which are machined, ground, cold formed or cold straightened, shall be given a heat treatment at a minimum of 191 ± 14°C (375 ± 25°F) for three hours or more prior to cleaning and plating for the relief of damaging residual tensile stresses (see 6.5).

3.2.2 Embrittlement relief. All steel parts having a hardness of Rockwell C40 and higher shall be baked at 171 ± 6°C (340 ± 10°F) for three hours or more, within four hours after plating, to provide hydrogen embrittlement relief (see 6.6).

3.2.3 Pretreatment of aluminum alloys (see 6.3). Aluminum alloys shall be anodized for 20 minutes in a sodium carbonate solution (60 g/l) maintained at a pH of 11.0 ± 0.2 and 52 to 57°C (125 to 135°F). The pH shall be adjusted with sodium hydroxide or sodium bicarbonate. The parts shall be placed in the solution with the current off. The current shall be started within 30 seconds at a low voltage (5 to 10 volts). The voltage shall be increased within 5 to 10 seconds until the required current density is reached (50 amp/ft^2 for 6061 alloy and 100 amp/ft^2 for 380 alloy). The current densities shall be maintained by raising the voltage gradually throughout the treatment.

3.2.4 Underplating. All surfaces shall be plated with semi-bright Watts nickel in accordance with table I.

TABLE I. Watts nickel underplating.

Bath composition		Operating conditions	
Nickel sulfate ($NiSO_4.6H_2O$)	330 g/l	Steel and Copper Alloys	
Nickel chloride ($NiCl_2.6H_2O$)	45 g/l	temperature	60-65°C (140-150°F)
Boric acid (H_3BO_3)	40 g/l	pH	3.5-4.0
Coumarin 1/		current density	100 amp/ft^2
Specific gravity @20°C (70°F)	1.217	Aluminum Alloys 2/	
		temperature	52-57°C (125-135°F)
		pH	3.5-4.0
		current density	50 amp/ft^2

1/ Leveling agent.

2/ Immerse racks holding the aluminum parts in the nickel bath with the current off. Start the current within 10 seconds.

3.2.5 Porous nickel-carbon electroplate. The porous nickel-carbon shall be plated in accordance with table II.

TABLE II. Porous nickel-carbon plating.

Bath composition 1/		Operating conditions 4/	
Nickel sulfate ($NiSO_4.6H_2O$)	330 g/l	temperature	60.0-65.6°C (140-150°F)
Nickel chloride ($NiCl_2.6H_2O$)	45 g/l	pH 5/	1.9-2.1
Boric acid (H_3BO_3)	40 g/l	current density 6/	100 to 200 amp/ft^2
Activated carbon, 200 mesh (see 6.4) 2/ 3/	15 g/l	agitation, air 7/	

1/ Metals such as iron and copper which may be present in the salts shall be removed by appropriate high pH and/or low current dummying treatments. The carbon will absorb and remove from the bath trace amounts of oils, grease, etc.

2/ Add after initial purification of bath.

3/ The concentration of the carbon particles in solution shall be determined by direct filtering, washing, drying and weighing of the carbon contained in a known volume of the bath solution.

4/ No rinse is used between the two nickel plating steps. Place racks in the plating bath with the current on.

5/ Addition of 0.10 ml H_2SO_4 per liter of plating solution will change the pH 0.10 units.

6/ Porous nickel-carbon can be plated on simple shaped parts in 10 minutes at 100 amp/ft^2. However, for complex shaped parts, higher current densities are required to insure uniform deposition in low current density areas. Plating at the lowest current density within the recommended range provides a uniform coating. Racking techniques should be adequate to carry the current required without overheating the contact points. Current will rise during plating about 10 percent because of increased surface area.

7/ Air agitation should be directly under the plated parts.

3.2.6 Petroleum jelly impregnation. The pores in the nickel-carbon plate shall be impregnated with petroleum jelly using an oven maintained at 100°C (212°F) for heating as follows: Preheat the parts in the oven to 100°C (212°F). Remove the parts and immerse in molten petroleum jelly. Remove the parts after one minute, place the coated parts in the oven and heat for 2 to 5 minutes. Remove the parts and wipe off the excess petroleum jelly by rubbing the hot parts with a clean cheese cloth. Reheat the parts in the oven for 2 to 3 minutes, remove, and again wipe off the excess petroleum jelly with a clean cheese cloth.

3.3 *DETAIL REQUIREMENTS*

3.3.1 Appearance. The applied finish to all parts covered by this specification shall be uniform and light grey in color. The plating shall be free from edge buildup, nodules and pitting.

3.3.2 Finish. Unless otherwise specified by the procuring activity, the plated parts shall be processed in a vibratory finishing machine for four minutes maximum using a resin-bonded abrasive media to remove edge buildup and large nodules from the surface (see 6.2) and shall be uniform to assure no large pits, nodules or edge buildup. If a degree of surface smoothness of the plated parts is required, the degree shall be specified in the contract or order. Methods for measuring the required surface smoothness shall be approved by the procuring activity (see 6.2).

3.3.3 Thickness.

3.3.3.1 Underplate. The thickness of the Watts-type nickel underplate shall be 0.8 mils (0.002 cm) minimum when measured in accordance with 4.5.2.

3.3.3.2 Porous nickel-carbon plating. The thickness of the porous nickel-carbon plating after treatment in accordance with 3.3.2 shall be 0.8 mils (0.002 cm) minimum when measured in accordance with 4.6.2.

3.3.4 Contact resistance. The voltage drop is not to exceed 4 millivolts when the porous nickel-carbon plating is tested in accordance with 4.6.3.

3.3.5 Gloss. The porous nickel-carbon plating after treatment in accordance with 3.2.6 and 3.3.2 shall exhibit a specular gloss not in excess of an index value of 3 when measured in accordance with 4.6.4.

3.3.6 Abrasion resistance. The gloss index value of the porous nickel-carbon plating treated in accordance with 3.3.2 shall not exceed a value of 5 when measured in accordance with 4.6.5.

3.3.7 Adhesion-flexibility. The combined porous nickel-carbon plating and the Watts nickel underplating shall not peel or show any interfacial separation from each other or from the base metal when tested in accordance with 4.6.6.

3.3.8 Corrosion resistance. There shall be no evidence of corrosion when the plating, treated in accordance with 3.2.6 and 3.3.2, is tested in accordance with 4.6.7. Corrosion is defined here as the destructive alteration of the metal caused by chemical or electromechanical action.

3.4 Workmanship. Porous nickel-carbon plating shall be uniform in surface smoothness, color and luster. The plating shall be adherent, continuous and free from nodules and excessive edge buildup (see 3.3.2).

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 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 assure supplies and services conform to prescribed requirements.

4.2 Classification of inspection. The inspection requirements specified herein are classified as follows:

a. Process control inspection (see 4.4).

b. Quality conformance inspection (see 4.5).

4.3 Inspection conditions. Unless otherwise specified in the contract, all inspections shall be performed in accordance with the test conditions specified in the applicable paragraphs of this specification.

4.4 Process control inspection.

4.4.1 Control records. The processor shall maintain a record of the history of each processing bath showing all additions of replenishing chemicals to the bath, the results of all analyses performed, and the quantity of each kind of parts treated in the bath. These records shall be maintained for not less than one year after completion of the contract or purchase order. Upon request of the procuring activity, such records shall be made available.

4.4.2 Process control inspection. Inspection of equipment and plating procedures shall be made to ascertain compliance with this specification. Inspection of the plating process shall consist of the observation of the plating time, operating temperatures, current density, voltage, pH and all other pertinent plating conditions as specified. The plating process shall be examined for compliance with the requirements of this specification at the beginning of each production run and at the beginning of the reuse of any equipment following any period of one week or longer during which the

equipment is not used for production in accordance with this specification. When specified by the procuring activity (see 6.2), the supplier, prior to production, shall demonstrate the capability of the process used to show freedom from hydrogen embrittlement damage as indicated by satisfactory behavior of specimens prepared (see 6.2.2) and tested in accordance with 4.4.2.1.

4.4.2.1 Control. For preproduction control, four round notched steel specimens shall be prepared in accordance with 4.5.2.1 from four individual heats for a total of 16 specimens. The specified steel alloy for which preproduction examination of the process is to be demonstrated shall be used. Specimens shall be heat treated to the maximum tensile strength representing production usage. The specimens shall be given the same pretreatments proposed for production. The specimens shall be subject to the test detailed in 4.6.8. The process shall be considered satisfactory if all specimens show no indication of cracks or failure. The test results and production control information shall be submitted to the procuring activity for approval. Parts shall not be plated until approval has been received.

4.4.3 Process control specimens. The results of tests made to determine conformance of porous nickel-carbon plating to the requirements of this specification for definite contracts or purchase orders are acceptable as evidence of the properties being obtained with the equipment and procedures employed.

4.5 Quality conformance inspection. Quality conformance inspections shall consist of groups A and B testing.

4.5.1 Lot. A lot shall consist of plated articles of the same base metal composition in accordance with 3.1.3 or 3.1.4, treated under the same conditions, of approximately the same size and shape, and submitted for acceptance at the same time.

4.5.2 Separate specimens for destructive tests. When the plated articles are of such form as to be not readily adaptable to test specified herein, or at the discretion of the inspector for the sampling of small lot sizes, the test may be made by the use of separate specimens plated concurrently with the articles represented. The separate specimens shall be of the same base metal as that of the articles represented. These specimens shall be introduced into a lot at regular intervals prior to the cleaning operations before plating and shall not be separated therefrom until after completion of the processing. Conditions affecting the plating of the specimens, including spacing and positioning with respect to anodes and to other objects being plated, shall correspond as nearly as possible to those affecting the significant surfaces of the articles represented.

4.5.2.1 Separate specimens for embrittlement relief. Separate specimens for embrittlement relief test shall be round notched specimens with the axis

of the specimen (load direction) perpendicular to the short transverse grain flow direction. The configuration shall be in accordance with figure 8 of ASTM E8 for rounded specimens. Specimens shall have a 60-degree V-notch located approximately at the center of the gage length. The cross section area at the root of the vee shall be approximately equal to half the area of the full cross section area of the specimen's reduced section. The vee shall have a 0.010 ± 0.0005 inch (20.54 ± 0.001 cm) radius of curvature at the base of the notch (see 6.2.2).

4.5.3 Sampling.

4.5.3.1 Sampling procedure for visual examination and nondestructive tests. Random samples shall be drawn from each lot in accordance with MIL-STD-105, Level II.

4.5.3.2 Sampling procedure for destructive tests. Four plated articles shall be chosen at random from each lot or four separately plated specimens shall be prepared in accordance with 4.5.2 to represent each lot. Separate specimens (see 4.5.2) shall not be used for thickness measurements unless a need has been demonstrated.

4.5.3.3 Sampling procedure for hydrogen embrittlement relief. A random sample of four plated articles shall be taken from each lot or four specimens, prepared in accordance with 4.5.2 and 4.5.2.1, shall be used to represent the lot. When tested as specified in 4.5.8 cracks or failure by fracture shall be cause for rejection.

4.5.4 Group A inspection. Samples selected in accordance with 4.5.3.1 shall be inspected in accordance with the Group A inspection in table III.

TABLE III. Group A inspection requirements.

Inspection	Requirement paragraph	Test method paragraph	AQL
Visual	3.3.1, 3.3.2, 3.4	4.6.1	1.5%
Thickness	3.3.3.1 and 3.3.3.2	4.6.2	
Contact resistance	3.3.4	4.6.3	
Gloss	3.3.5	4.6.4	

4.5.5 Group B inspection. Samples selected in accordance with 4.5.3.2 shall be tested in accordance with the Group B inspection in table IV.

TABLE IV. Group B inspection requirements.

Inspection	Requirement paragraph	Test method paragraph
Thickness	3.3.3.1 and 3.3.3.2	4.6.2
Abrasion resistance	3.3.6	4.6.5
Adhesion-flexibility	3.3.7	4.6.6
Corrosion resistance	3.3.8	4.6.7
Embrittlement relief	3.2.2	4.6.8

4.5.6 Noncompliance. If a sample fails to pass Group B inspection, the contractor shall notify the procuring activity and the cognizant inspector of such failure and shall take corrective action on the material or process, or both, as warranted. Acceptance and shipment of the product shall be discontinued until corrective action, acceptable to the procuring activity has been taken. After the corrective action has been taken all inspections shall be repeated on additional samples. In the event of failure after reinspection, information concerning the failure and the corrective action taken, shall be furnished the cognizant inspection activity and the procuring activity.

4.6 Test methods.

4.6.1 Visual examination. Samples shall be visually examined for compliance with the requirements for appearance (see 3.3.1), surface finish (see 3.3.2), and workmanship (see 3.4).

4.6.2 Thickness. For nondestructive measuring of plating thickness, procedures in accordance with Federal Test Method Standard No. 151, Method 520 (electronic test), or ASTM B530 (magnetic test), shall be used. For destructive measuring of plating thickness, procedures in accordance with ASTM B487 (microscopic) shall be used. At the option of the manufacturer other instruments, such as those employing the principle of beta-radiation back scatter of x-ray spectrometry may be used.

4.6.3 Contact resistance. The voltage drop shall be measured when 2.5 volts dc, 1 amp, is impressed upon the plated surface under a pressure of 100 grams per square centimeter. Figure 1 illustrates the circuit for measuring contact resistance.

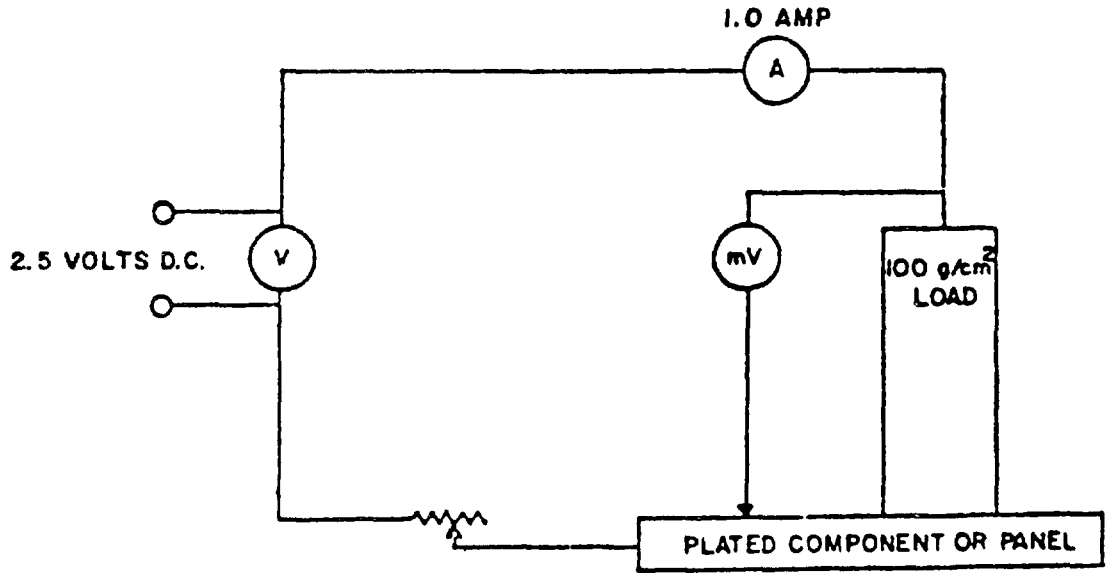

FIGURE 1. Circuit for measuring contact resistance.

4.6.4 Gloss. The gloss shall be measured in accordance with Method 6101 of Federal Test Method Standard No. 141. The measurement shall be made at an angle of 60 degrees without correction for diffuse reflection for compliance with 3.3.5.

4.6.5 Abrasion resistance. The unimpregnated plating shall be abraded for 100 cycles of a Taber Abrader using CS10 wheels at 500 gram load. The abraded area shall then be tested in accordance with 4.6.4 for compliance with 3.3.6.

4.6.6 Adhesion-flexibility. The specimen shall be bent back to back, straightened, then bent to the reverse position. The double bending cycle shall be repeated until the specimen is broken. The broken edge shall be examined at 4 diameters magnification for compliance with 3.3.7. Cast alloys shall be cut with a band saw and the cut edges shall be examined for compliance with 3.3.7.

4.6.7 Corrosion resistance. The sample shall be exposed to 96 hours of salt-spray in accordance with Method 509 of MIL-STD-810 and examined for compliance with 3.3.8.

4.6.8 Embrittlement relief. Compliance with 3.2.2 shall be determined with samples of ferrous plated parts taken as specified in 4.5.3.3. 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 coated part. The selected samples shall be subjected to a sustained tensile load equal to 115 percent of the maximum design load for which the part was designed. Parts which require special fixtures, extreme loads to comply with the above requirements, or where the maximum design load is not known, may be represented by separate specimens prepared in accordance with 4.5.2.1. The notched specimens shall be subject 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 fractures.

5. PREPARATION FOR DELIVERY

5.1 Packaging and Packing. The packaging must provide adequate item protection during shipment, storage, and redistribution operations. The preservation, packaging and packing methods for porous nickel-carbon coated parts or articles employed by a supplier shall be such as to preclude any physical damage during shipment and handling.

6. NOTES

6.1 Intended use. The porous nickel-carbon plating covered in this specification is intended for use on metallic sliding, threading or mechanical-electrical mating surfaces such as telescope-whip antennas, connectors and moving components with exposed sliding contact areas to provide grounding or shielding. This coating is applied where paint cannot be used because of the need for a conductive electrical path between sections such as the antenna tip and its base. The coating is abrasion resistant and will not develop a "shiny" appearance after frequent telescoping, extending of antennas, and scraping over terrain of connector shells. The coating is corrosion resistant to protect the base metal inasmuch as corrosion products are insulating.

6.1.1 This plating can be deposited on all steel and copper alloys and on aluminum alloys commonly used for connector and antenna structures such as alloys 6061 and 380.

6.2 Ordering data. Purchasers should exercise any desired options offered herein and procurement documents should specify the following:

a. Title, number, and date of the specification.

b. When plating is to be applied if other than specified (see 3.1.3).

c. Whether vibratory finishing is or is not required (see 3.3.2).

d. Surface finish if other than as specified (see 3.3.2).

e. Process control inspection (see 4.4.2).

f. Number of samples for destructive testing (see 4.5.3.2).

g. Whether hydrogen embrittlement relief test is required (see 4.5.3.3).

6.2.1 The manufacturer of the base metal parts should provide the plating facility with the following data:

a. Hardness of steel parts (see 3.1.3).

b. Heat treatment for stress relief, whether it has been performed or is required (see 3.2.1).

c. Tensile loads required for embrittlement relief test, if applicable (see 4.6.8).

6.2.2 The manufacturer of the base metal parts should provide the plating facility with notched tensile specimens (see 3.1.4 and 4.5.2.1), to be plated for conformance with 3.2.2 or 3.2.3 required for process control inspection (see 4.4.2.1) and lot acceptance (see 4.5.3.3).

6.3 Nickel plating of aluminum anodically conditioned in sodium .bonate solution was found to be an improvement over the zinc-copper-nickel system usually specified. No difficulty was experienced with the following alloys: 40E, 356, 380, 1100, and 6061. Alloy 2024 was borderline in meeting the adhesion-flexibility test. Alloy 5052 was rated not satisfactory for this test.

6.4 Activated carbon having a particle size of 200 mesh has been found desirable in inducing porosity in the nickel deposits. Darco G-60 (Atlas Chemical Industries, Wilmington, Delaware) or similar not only has the required size distribution, but was satisfactory for this plating because it permitted the bath to be maintained at a surface tension of >54 dynes/cm without the addition of a wetting agent. The addition of surface active agents are difficult to control and platings from baths below 54 dynes/cm were not porous.

6.5 Stress relief. There is a hazard that hardened and tempered cold-worked or cold-straightened steel parts may crack during cleaning and plating. Such parts should have a suitable heat treatment for stress relief prior to cleaning and plating (see 3.2.1).

6.6 Baking time. For higher strength materials it may be beneficial to extend the baking treatment to 23 hours to insure complete hydrogen embrittlement relief (see 3.2.2).

6.7 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

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DOCUMENT IDENTIFIER *(Number)* AND TITLE MIL-N-55392A - Nickel-Carbon, Porous, Electrodeposited, for Camouflage

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