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SUPERSEDING
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FEDERAL SPECIFICATION

NICKEL PLATING (ELECTRODEPOSITED)

This specification was approved by the Commissioner, Federal Supply Service, General Services Administration, for the use of all Federal agencies.

1. SCOPE AND CLASSIFICATION

1.1 Scope. This specification covers the requirements for electrodeposited nickel plating on steel, copper and copper alloys, and zinc and zinc alloys.

1.2 Classification.

1.2.1 Classes. Electrodeposited nickel plating covered by this specification shall be of the following classes, as specified (see 6.2):

Class 1 - Corrosion protective plating
Class 2 - Engineering plating

1.2.2 Grades. Class 1 plating shall be of the following grades, as specified (see 6.2):

Grade A - 0.0016 inch thick
Grade B - 0.0012 inch thick
Grade C - 0.0010 inch thick
Grade D - 0.0008 inch thick
Grade E - 0.0006 inch thick
Grade F - 0.0004 inch thick
Grade G - 0.0002 inch thick

2. APPLICABLE DOCUMENTS

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

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Federal Specification:

QQ-S-624 - Steel Bar, Alloy, Hot Rolled and Cold Finished (General Purpose).

Federal Standard:

Fed. Test Method Std. No. 151 - Metals; Test Methods.

(Activities outside the Federal Government may obtain copies of Federal Specifications, Standards, and Handbooks as outlined under General Information in the Index of Federal Specifications and Standards and at the prices indicated in the Index. The Index, which includes cumulative monthly supplements as issued, is for sale on a subscription basis by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

(Single copies of this specification and other Federal Specifications required by activities outside the Federal Government for bidding purposes are available without charge from Business Service Centers at the General Services Administration Regional Offices in Boston, New York, Washington, DC, Atlanta, Chicago, Kansas City, MO, Fort Worth, Denver, San Francisco, Los Angeles, and Seattle, WA.

(Federal Government activities may obtain copies of Federal Specifications, Standards, and Handbooks and the Index of Federal Specifications and Standards from established distribution points in their agencies.)

Military Specification:

MIL-S-5002 - Surface Treatments and Inorganic Coatings for Metal Surfaces of Weapons Systems.

Military Standard:

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

(Copies of Military Specifications and Standards required by contractors 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 specification to the extent specified herein. Unless a specific issue is identified, 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 - Measuring Metal and Oxide Coating Thickness by Microscopic Examination of a Cross Section.

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B504 - Measuring the Thickness of Metallic Coatings by the Coulometric Method.
B529 - Measurement of Coating Thickness by the Eddy Current Test Method; Nonconductive Coatings on Nonmagnetic Basis Metals.
B530 - Measurement of Coating Thickness by the Magnetic Method: Electrodeposited Nickel Coatings on Magnetic and Nonmagnetic Substrates.

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

3. REQUIREMENTS

3.1 Materials. The materials used shall be such as to produce platings which meet the requirements of this specification.

3.2 General requirements.

3.2.1 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).

3.2.2 Stress relief treatment. Unless otherwise specified, all steel parts which are machined, ground, cold formed or cold straightened, shall be given a heat treatment at a minimum of 375 ± 25°F (191 ± 14°C) for three hours or more prior to cleaning and plating for the relief of damaging residual tensile stresses (see 6.2 and 6.4).

3.2.3 Cleaning. Unless otherwise specified, all steel parts shall be cleaned in accordance with MIL-S-5002 (see 6.2). Other basis metals shall be cleaned by methods which shall not damage the substrate and shall not interfere with adhesion of the deposit (see 6.5).

3.2.4 Plating application. Unless otherwise specified, the plating shall be applied after all basis metal heat treatments and mechanical operations such as machining, brazing, welding, forming and perforating of the article have been completed (see 6.2).

3.2.5 Underplating. When specified in the contract, purchase order or applicable drawing (see 6.2), Class 1 plating shall be applied over a plating of copper on steels, copper and copper based alloys. Class 1 plating shall be applied over an underplating of copper or yellow brass on zinc and zinc based alloys. In no case, shall the copper underplate (see 3.3.1.1.2 and Table I) be substituted for any part of the specified nickel thickness.

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3.2.6 Class 1 processing. Parts for Class 1 deposition shall be plated to specific dimensions as specified (see 3.3.1.1). When specified, parts shall be processed in accordance with procedural instructions for form of nickel deposit (see 6.2 and 6.7).

3.2.7 Class 2 processing. Parts for Class 2 deposition shall be plated to specific dimensions as specified (see 3.3.1.2). When specified, parts shall be processed in accordance with procedural instructions of the procuring activity (see 6.2).

3.2.8 Coverage. Unless otherwise specified, the plating shall cover all surfaces including roots of threads, corners and recesses (see 6.2).

3.2.9 Boundaries. Boundaries of Class 2 plating which cover only a portion of the surface shall be free from beads, nodules, jagged edges and other irregularities.

3.2.10 Surface finish. Unless otherwise specified, either a fully bright or dull (semi-bright finish shall be acceptable (see 6.2 and 6.7)).

3.2.11 Embrittlement relief. All steel parts having a hardness of Rockwell C40 and higher shall be baked at a minimum of 375 ± 25°F (191 ± 14°C) for three hours or more, within four hours after plating, to provide hydrogen embrittlement relief (see 6.6). The baked parts, when tested in accordance with 4.5.3, 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.

3.3 Detail requirements.

3.3.1 Thickness of plating.

3.3.1.1 Class 1. Unless otherwise specified, the minimum thickness of Class 1 nickel plating shall be as specified in Table I on all visible surfaces which can be touched by a ball 0.75 inch (19 mm) in diameter. All other surfaces which cannot be touched by the 0.75 inch (19 mm) diameter ball shall not be less than the minimum thickness specified in Table I.

3.3.1.1.1 Unless otherwise specified, the minimum nickel plating for ferrous materials or for zinc and zinc base alloys shall be Grade C. Unless otherwise specified, the minimum nickel plating for copper and copper alloys shall be Grade D. If the maximum thickness for Grade A is not specified in the contract, order or applicable drawing, the thickness shall not exceed 0.0020 inch (51 micrometers) on all visible surfaces which can be touched by the 0.75 inch (19 mm) diameter ball.

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3.3.1.1.2 Underplate. When an underplate is employed (see 3.2.5), the thickness of the copper or other copper base alloy shall be as specified (see Table I). The thickness of the underplate shall not be used in the determination of the specified nickel plating thickness.

TABLE I. Minimum thickness of class 1 nickel plating

Basis Metal		Plating Thickness			
Steels 1/, Zinc and Zinc Alloys 2/ - Coating Grade	Copper and Copper Alloys 3/ - Coating Grade	Surface touched by 0.75 inch dia. ball (see 3.3.1.1) -		All other surfaces 5/	
		Inch-Min.	Equiv.- Micrometers 4/ (approx.)	Inch-Min	Equiv.- Micrometers 4/ (approx.)
A	-	0.0016	40	0.0012	30
B	B	0.0012	30	0.0010	25
C	C	0.0010	25	0.0008	20
D	D	0.0008	20	0.0006	15
E	E	0.0006	15	0.0004	10
F	F	0.0004	10	0.0002	5
-	G	0.0002	5	0.0001	3

1/ Copper underplate shall be 0.0002 inch minimum. May range to 0.0010 inch depending on thickness of nickel plating. Use of extremely thin strikes may cause operational difficulties.

2/ Zinc and zinc alloys shall have a copper underplate of 0.0002 inch minimum thickness.

3/ Copper alloys containing zinc equal to or greater than 40 percent shall have a copper underplate of 0.0003 inch minimum thickness.

4/ 0.001 inch = 1 mil = 25.4 micrometers (microns).

5/ Threads, holes, deep recesses, bases of angles and similar areas.

3.3.1.2 Class 2. The thickness for Class 2 nickel plating shall be as specified in the contract, purchase order or on the applicable drawing (see 6.2). If a thickness is not specified, it shall be 0.003 inch (0.076 mm) for the finished part. In no case, shall the minimum nickel

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plating thickness be less than 0.002 inch (0.051 mm). The thickness requirement for Class 2 plating shall apply after all metal finishing operations have been completed.

3.3.2 Adhesion. The adhesion of the nickel plating and any undercoat or nickel layers shall be such that when examined at a magnification of approximately 4 diameters, neither the nickel plating, any layers of nickel plating nor any electrodeposited undercoat shall show separation from the basis metal or from each other at their common interface(s) when subjected to the test described in 4.5.2. The interface between a plating and the basis metal is the surface of the basis metal before plating. The formation of cracks in the basis metal or plate which do not result in flaking, peeling or blistering of the plate shall be considered as conformance to this requirement.

3.4 Workmanship.

3.4.1 Basis metal. The basis metal shall be free from visible defects that will be detrimental to the appearance or protective value of the plating. The basis metal shall be subject to such cleaning and plating procedures as necessary to yield deposits herein specified.

3.4.2 Plating. The nickel plating shall be smooth, fine grained, adherent, uniform in appearance, free from blisters, pits, nodules, excessive edge build-up and other defects. The plating shall show no indication or contamination or improper operation of equipment used to produce the nickel deposit, such as excessively powdered or darkened platings, build-up and other defects. The size and number of contact marks shall be at a minimum consistent with good practice. The location of contact marks shall be in areas of minimum exposure to service environmental conditions where important to the function of the part. Superficial staining which has been demonstrated as resulting from rinsing, or slight discoloration resulting from baking operations to relieve embrittlement, as specified above (see 3.2.11), shall not be cause for rejection. All details of workmanship shall conform to the best practice for high quality plating.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier 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 that supplies and services conform to prescribed requirements.

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

1 - Production control inspection (see 4.3)
2 - Quality conformance inspection (see 4.4)

4.3 Production control inspection.

4.3.1 Control records. When specified in the contract or order (see 6.2), the supplier shall maintain a record of each processing bath, showing all additional chemicals or treatment solutions to the unit, the results of all analyses performed and the quantity of parts plated during operation. Upon request of the procuring activity, such records shall be made available. These records shall be maintained for not less than one year after completion of the contract or purchase order.

4.3.2 Production control. The equipment, procedures and operations employed by a supplier shall be capable of producing high quality electrodeposited platings of nickel on ferrous alloys, copper and copper alloys, zinc and zinc alloys as specified in this document. 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 4.3.2.1 to comply to the requirements of MIL-S-5002 for preproduction process qualification.

4.3.2.1 Preproduction control. For preproduction control four round notched steel specimens shall be prepared in accordance with 4.4.4.2 from four individual heats for a total of 16 specimens, using the specified steel alloy for which preproduction examination of the process is to be demonstrated. Specimens shall be heat treated to the maximum tensile strength representing production usage. The specimens shall be given the same pre-treatments, proposed for production. The specimens shall be subject to test detailed in 4.5.3. 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. Until approval has been received, parts shall not be plated.

4.3.3 Frequency of tests. To assure continuous control of the process as required by MIL-S-5002 and to prevent detrimental hydrogen embrittlement during production, the satisfactory behavior of specimens, prepared and tested in accordance with Table II, shall be made once each month or more frequently if required by the procuring activity. The results of tests made to determine conformance of electrodeposited platings to all requirements of this specification for definite contracts or purchase order are acceptable as evidence of the properties being obtained with the equipment and procedures employed.

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TABLE II. Production control tests and specimens

Test	For coating classes	Requirement paragraphs	Specimen preparation paragraphs 1/	Test reference paragraphs
Thickness	1 and 2	3.3.1, 3.3.1.1 and 3.3.1.2	4.4.4 and 4.4.4.1	4.5.1
Adhesion	1 and 2	3.3.2	4.4.4 and 4.4.4.1	4.5.2
Hydrogen embrittlement	1 and 2	3.2.11	4.3.4, 4.4.4, and 4.4.4.2	4.5.3

1/ Standard alloy steels shall be used for production control specimens. The selection shall be at the option of the supplier; however, alloy steels such as AISI or SAE numbers 4130, 4135, 4140, 4145, 4340, 8645 and 8740 conforming to QQ-S-624 shall be used.

4.3.4 Production control specimens. Test specimens for production control shall be prepared in accordance with 4.4.4 and 4.4.4.1 as applicable for the thickness and adhesion tests detailed in Table II. Specimens for the production control embrittlement relief test shall be four round notched steel specimens of alloy steel 4340 conforming to QQ-S-624, heat treated to the maximum tensile strength, from one or more heats, and prepared in accordance with 4.4.4.2.

4.4 Quality conformance inspection.

4.4.1 Lot. A lot shall consist of plated articles of the same metal composition, class and grade plated and treated under the same conditions and approximately the same size and shape submitted for inspection at one time.

4.4.2 Sampling for visual examination and non destructive tests. Sampling for visual examination and non destructive tests shall be conducted as directed by the procuring activity (see 6.2) in accordance with MIL-STD-105 or using Table III. A sample of coated parts or articles shall be drawn by taking at random from each lot the number of articles in accordance with MIL-STD-105, Level II, Acceptable Quality Level (AQL) 1.5

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percent defective, or as indicated in Table III. The lot shall be accepted or rejected according to the procedures in 4.4.2.1 for visual examination and 4.4.2.2 for plating thickness (nondestructive tests).

TABLE III. Sampling for visual examination and nondestructive tests

Numbers of items in lot inspections	Number of items in samples (randomly selected)	Acceptance number (maximum number of sample items nonconforming to any test)
15 or less	7 1/	0
16 to 40	10	0
41 to 110	15	0
111 to 300	25	1
301 to 500	35	1
501 and over	50	2

1/ If the number of items in the inspection lot is less than 7, the number of items in the sample shall equal the number of items in the inspection lot.

4.4.2.1 Visual examination. Samples selected in accordance with 4.4.2 shall be examined for compliance with the requirements of 3.4.2 after plating. If the number of non conforming articles exceeds the acceptance number for the sample, the lot represented by the sample shall be rejected.

4.4.2.2 Thickness of plating (nondestructive tests). Samples selected in accordance with 4.4.2 shall be inspected and the plating thickness measured by the applicable tests detailed in 4.5.1, at several locations on each article as defined in 3.3.1, 3.3.1.1 or 3.3.1.2, as applicable, for compliance with the requirements. The part of article shall be considered nonconforming if one or more measurements fail to meet the specified minimum thickness. If the number of defective items in any sample exceeds the acceptance number for the specified sample, the lot represented by the sample shall be rejected. Separate specimens (see 4.4.4.1) shall not be used for thickness measurements unless a need has been demonstrated.

4.4.3 Sampling for destructive tests. A random sample of four plated parts or articles shall be taken from each lot for each destructive test or separately plated specimens shall be prepared in accordance with 4.4.4, 4.4.4.1 and 4.4.4.2 to represent each lot. If the number of articles in the lot is four or less, the number of articles in the sample shall be specified by the procuring activity (see 6.2).

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4.4.3.1 Thickness of plating (destructive tests). If sampling and testing for thickness of plating by nondestructive testing is not the option of the supplier, samples selected in accordance with 4.4.3 shall be measured for plating thickness by the applicable tests detailed in 4.5.1 at several locations as defined in 3.3.1, 3.3.1.1 or 3.3.1.2, for compliance with the requirements. If the plating thickness at any place on any article or specimen is less than the specified minimum thickness, the lot shall be rejected. Separate specimens (see 4.4.4.1) shall not be used for thickness measurements unless a need has been demonstrated.

4.4.3.2 Adhesion (destructive tests). The articles or specimens used for the destructive thickness test (see 4.4.3.1), if of suitable size and form, may be used as the test pieces for the adhesion test to determine compliance with the requirements of 3.3.2. Failure of one or more of the test pieces shall constitute failure of the lot.

4.4.3.3 Hydrogen embrittlement relief (destructive tests). Unless otherwise specified in the contract or order, conformance to the requirements of 3.2.11 for hydrogen embrittlement relief of treated steel parts shall be determined for those parts having a tensile strength of or heat treated to a tensile strength level of 240,000 psi or above and which will be subject to a sustained tensile load in use (see 6.2). A random sample of four plated articles shall be taken from each lot or four specimens, prepared in accordance with 4.4.4 and 4.4.4.2, shall be used to represent the lot. When tested as specified in 4.5.3, cracks or failure by fracture shall be cause for rejection. Failure of one or more of the test pieces shall reject the lot.

4.4.4 Quality conformance specimen preparation. When the plated articles are of such form, shape, size and value as to prohibit use thereof, or are not readily adaptable to a test specified herein, or when destructive tests of small lot sizes are required the test shall be made by the use of separate specimens plated concurrently with the articles represented. The separate specimens shall be of a basis metal equivalent to that of the articles represented. "Equivalent" basis metal includes chemical composition, grade, condition and finish of surface prior to plating. For example, a cold-rolled steel surface should not be used to represent a hot-rolled steel surface. Due to the impracticality of forging or casting separate test specimens, hot-rolled steel specimens may be used to represent forged and cast-steel articles. The separate specimens may be also cut from scrap castings when ferrous alloy castings are being plated. These separate specimens shall be introduced into a lot at regular intervals prior to the cleaning operations, preliminary to plating, and shall not be separated therefrom until after completion of plating. Conditions affecting the plating of specimens including the spacing, plating media, residual air pressure, temperature, etc. in respect to other objects being plated shall correspond as nearly as possible to those affecting the significant surfaces of the

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articles represented. Separate specimens shall not be used for thickness measurements, however, unless the necessity for their use has been demonstrated.

4.4.4.1 Specimens for thickness and adhesion tests. If separate specimens for thickness and adhesion tests are required, they shall be strips approximately 1 inch wide, 4 inches long and 0.04 inch thick.

4.4.4.2 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 $\pm$ 0.0005 inch radius of curvature at the base of the notch (see 6.2.2).

4.5 Tests.

4.5.1 Thickness. For nondestructive measuring of plating thickness, procedures in accordance with Federal Test Method Standard No. 151, Method 520 (electronic test), ASTM B529 (eddy current), or ASTM B530 (magnetic test) may be used. For destructive measuring of plating thickness, procedures in accordance with ASTM B487 (microscopic) or ASTM B504 (coulometric) may be used. At the option of the supplier other instruments, such as those employing the principle of beta-radiation back scatter or X-ray spectrometry may be used.

4.5.2 Adhesion. Adhesion may be determined by scraping the surface or shearing with a sharp edge, knife, or razor through the plating down to the basis metal and examining at four diameters magnification for evidence of non-adhesion. Alternately the article or specimen may be clamped in a vise and the projecting portion bent back and forth until rupture occurs. If the edge of the ruptured plating can be peeled back or if separation between the plating and the basis metal can be seen at the point of rupture when examined at four diameters magnification, adhesion is not satisfactory.

4.5.3 Embrittlement relief. Compliance with 3.2.11 shall be determined with samples of plated parts taken as specified in 4.4.3.3. 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 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. Parts which require special fixtures,

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extreme loads to comply with the above requirements, or where the maximum design yield load is not known, may be represented by separate specimens prepared in accordance with 4.4.4.3. 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 fracture.

5. PREPARATION FOR DELIVERY

5.1 Packaging and packing. Preservation, packaging and packing methods for electrodeposited nickel plated parts or articles employed by a supplier shall be such as to preclude damaging during shipment and handling.

6. NOTES

6.1 Intended use.

6.1.1 Class 1 plating. Class 1 plating is used to protect iron, copper, or zinc alloys against corrosive attack in rural, industrial or marine atmospheres depending upon the thickness of the nickel deposit or is used as an undercoat for chromium or one of the precious metals. Class 1 plating is used also for decorative purposes.

6.1.2 Class 2 plating. Class 2 plating is used for wear resistance, abrasion resistance and such incidental corrosion protection of parts as the specified thickness of the nickel plating may afford. Heavy deposits of the Class 2 plating, especially when the Watts bath process is employed, may be used for build up of worn or undersized parts, or for salvage purposes, and to provide protection against corrosive chemical environments.

6.2 Ordering data. Purchasers should select the preferred options permitted herein and include the following information in procurement documents:

(a) Title, number, and date of this specification.

(b) Class of plating (see 1.2.1).

(c) Grade of Class 1 plating if applicable (see 1.2.2).

(d) When plating is to be applied, if other than specified (see 3.2.1, 3.2.4, 3.2.6 and 3.2.7).

(e) Stress relief treatment, if other than specified (see 3.2.2).

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(f) Cleaning of steel, if other than specified (see 3.2.3).

(g) Underplating required (see 3.2.5).

(h) Coverage, if other than specified (see 3.2.8).

(i) Surface finish, if particular finish required (see 3.2.10).

(j) Thickness of coating, if other than specified (see 3.3.1, 3.3.1.1, 3.3.1.1.1 and 3.3.1.2).

(k) Control record requirement (see 4.3.1).

(l) Preproduction control examination (see 4.3.2).

(m) Sampling plan (see 4.4.2).

(n) Number of samples for destructive testing (see 4.4.3).

(o) Whether hydrogen embrittlement relief test is required (see 4.4.3.3).

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

(a) Hardness of steel parts (see 3.2.1).

(b) Heat treatment for stress relief, whether has been performed or is required (see 3.2.2).

(c) Tensile loads required for embrittlement relief test, if applicable (see 4.5.3).

6.2.2 The manufacturer of the basis metal parts should provide the plating facility with notched tensile specimens (see 4.4.4.2) to be plated for conformance with 3.2.11 required for production control (see 4.3.2.1, and 4.3.4) and lot acceptance (see 4.4.3 and 4.4.3.3).

6.3 Black nickel plating. Electrodeposited black nickel plating, in accordance with MIL-P-18317, has little protective value and is used primarily to obtain a dark, nonreflective, decorative finish on steel and copper alloy instrument parts.

6.4 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 3.2.2).

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6.5 Cleaning. Copper and copper-based alloys may be cleaned as detailed in ASTM B281, Recommended Practice for Preparation of Copper and Copper-Base Alloys for Electroplating. Zinc and zinc-based alloys may be cleaned as detailed in ASTM B252, Recommended Practice for Preparation of Zinc-Base Die Castings for Electroplating (see 3.2.3).

6.6 Baking time. For high strength materials (Rockwell C40 and above), it may be beneficial to extend the baking time to 23 hours to insure complete hydrogen embrittlement relief (see 3.2.11).

6.7 Class 1 processing. Class 1 plating may be processed for the following forms of nickel deposition:

SB - Single layer coating in a fully bright finish.
SD - Single layer coating in a dull or semi-bright finish, containing less than 0.005 percent sulfur and having an elongation greater than 8 percent. A full brightness finish may be obtained by polishing the coating.
M - Multilayer coating, either double-layer or triple layer. The bottom layer should contain less than 0.005 percent sulphur and have an elongation greater than 8 percent. The top layer should contain more than 0.04 percent sulfur. In a double-layer coating, the thickness of the bottom layer should be not less than 60 percent of the total nickel thickness, except on ferrous parts where the bottom thickness should be not less than 75 percent of the total nickel thickness. In a triple-layer coating, the thickness of the bottom layer should be not less than 50 percent of the total nickel thickness. The intermediate layer of the triple-layer coating should contain more sulfur than the top layer and the thickness should be not greater than 10 percent of the total nickel thickness. The thickness of the top layer of either double- or triple-layer coating should be not less than 10 percent of the total nickel thickness.

6.7.1 Correlation. The correlation between the grades of nickel plating used in this specification and the forms of nickel deposition are indicated in Table IV.

6.7.2 Thickness measurements. Thickness measurements for the single layer Class 1 plating should be made whenever applicable by the non-destructive test methods, especially the magnetic method. Thickness measurements for the double or triple layer Class 1 plating, should be made on cross sections taken perpendicular to the significant surfaces by the microscopic method. This permits measurements of the thickness of the individual nickel layers when suitable etchants are used. Suitable etchants are as follows:

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(a) Etchant No. 1.

Nitric acid (sp. gr. 1.42)	1 volume
Glacial acetic acid	1 volume

(b) Etchant No. 2.

Sodium cyanide	100 gms per liter of water
Sodium or ammonium persulfate	100 gms per liter of water

NOTE: Equal parts of the two water solutions (the cyanide and the persulfate) are mixed. Caution must be taken as toxic fumes are evolved when these solutions of the chemicals are mixed. Use of this etchant must be confined to a well ventilated hood.

When either of the two etchants are used, the microstructure of the dull or semi-bright nickel layer will be shown to be columnar, whereas that of the bright nickel layer will be banded or unresolved.

TABLE IV

CORRELATION OF CLASS 1 NICKEL PLATING GRADES AND DEPOSITION 1/

Grades	Forms of Deposition for Steels, Zinc and Zinc Alloys	For Copper and Copper Alloys
A	SD, and M	-
B	SD, and M	SB, and M
C	M	SB, SD and M
D	SB, SD and M 2/	SD and M
E	SB, SD and M 2/	SB, SD and M 2/
F	SB, SD and M 2/	SB, SD and M 2/
G	-	SB, SD and M 2/

1/ Where a dull or satin-like finish is required, unbuffed Form SD processed nickel may be substituted for Form SB processed nickel or for the bright layer of Form M processed nickel.

2/ Nickel deposited under Forms SD or M conditions may be substituted for nickel deposited in Form SB condition where the nickel deposit and top coat is subject to mild or moderate service conditions.

6.7.3 Sulfur contents. The sulfur contents stated in 6.7 indicate the kind of nickel plating solution that is to be used by the supplier. No simple method exists for the determination of the sulfur content of a nickel deposit on a coated article; however, X-ray fluorescence techniques can be used.

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6.7.4 Corrosion protection. In a double-layer nickel deposition, as the undercoat with other electrodeposited top coats, the nickel immediately under the top coat is a bright nickel containing sulfur while the bottom layer under that is a semi-bright nickel essentially free of sulfur. In any galvanic electrolytic cell set up with the top coat, the bright nickel reacts anodically to the purer semi-bright nickel. If microscopic corrosion sets in through pores in the top coat material and penetrates the bright nickel layer, galvanic action between the two kinds of nickel tends to cause the microscopic pit to spread laterally in the outer nickel layer. The net effect is to retard penetration toward the base metal, hence to lengthen the useful life of the coating. This galvanic corrosion system may be further complicated by the use of three layers of nickel of different sulfur contents with further improvement against corrosion at a slightly greater cost.

6.8 Cross reference. The correlation between the grades of Class 1 nickel plating used in this specification and the previous designation (types) of Class 1 in QQ-N-290 are indicated in Table V.

TABLE V. Correlation of class 1 nickel plating

Basis Metal	QQ-N-290	QQ-N-290A	
	Types	Grades	Suggested forms of plating deposition (see 6.7)
Steel	I (DS) II (FS) III (KS) IV (QS)	C E F G	M SB SB SB
Copper and Copper-based alloys	V (FC) VI (KC) VII (QC)	E F G	SB SB SB
Zinc and Zinc-based alloys	VIII (FZ) 1/ IX (KZ) 2/ X (QZ)	E F F	SB SB SB

1/ When copper undercoat is omitted, the nimimum nickel should be equivalent to Grade B, deposition forms SD or M (see 6.7).

2/ When copper undercoat is omitted, the minimum nickel should be equivalent to Grade D, plating form SB (see 6.7).

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CUSTODIANS:
Army - MR
Navy - AS
Air Force - 11

Review activities:
Army - MR, MI, MU, WC, EL, GL, AV
Navy - AS, OS, SH, EC
Air Force - 84, 70

User activities:
Army - AT
Navy - None
Defense Supply Agency - IS

CIVIL AGENCIES INTEREST:
GSA - FSS
COM - NBS

Preparing activity:
Navy - AS
(Project No. MFFP-0027)

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