AEROSPACE MATERIAL SPECIFICATION

AMS-QQ-N-290	REV. C

Issued 2000-07
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Revised 2015-07

Superseding AMS-QQ-N-290B

Nickel Plating (Electrodeposited)

RATIONALE

This Revision is the result of a 5 year review for technical currency - update and to harmonize with Government and Industry standards. Numerous updates and changes have been made in the areas of hydrogen embrittlement prevention, control and test methodologies to align with standard practices and procedures contained within other AMS specifications and standards.

NOTICE

The original issue of this document was taken directly from U.S. Military Specification QQ-N-290A and contained only minor editorial and format changes required to bring it into conformance with the publishing requirements of SAE technical standards. The initial release of AMS-QQ-N-290 is intended to replace QQ-N-290A. Any part numbers established by the original specification remain unchanged.

The original Military Specification was adopted as an SAE standard under the provisions of the SAE Technical Standards Board (TSB) Rules and Regulations (TSB 001) pertaining to accelerated adoption of government specifications and standards. TSB rules provide for (a) the publication of portions of unrevised government specifications and standards without consensus voting at the SAE Committee level, and (b) the use of the existing government specification or standard format.

Under Department of Defense policies and procedures, any qualification requirements and associated qualified products lists are mandatory for DOD contracts. Any requirement relating to qualified products lists (QPL's) has not been adopted by SAE and is not part of this SAE technical document.

NOTICE

ORDERING INFORMATION: The following information shall be provided to the plating processor by the purchaser.

1. Purchase order shall specify not less than the following:

   - AMS-QQ-N-290C
   - Class of plating (See 1.2.1)
   - Grade of Class 1 plating if applicable (See 1.2.2)
   - Basis metal to be plated

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMSQQN290C

- Tensile strength or hardness of the basis metal
- Preplate stress relief to be performed by plating processor (time and temperature) if different from 3.2.2
- Underplating required of Class 1 plating if required (See 3.2.5)
- Control Record if required (4.3.1)
- Sampling plan (See 4.4.2)
- Number of samples for destructive testing (See 4.4.3)
- Special features, geometry or processing present on parts that requires special attention by the plating processor
- Hydrogen embrittlement relief to be performed by plating processor (parameters or reference document) if different from 3.2.11
- If plating is subject to mild or moderate service conditions (See Table 4, Note 2)
- Quantity of pieces to be plated

2. Parts manufacturing operations such as heat treating, forming, joining and media finishing can affect the condition of the substrate for plating, or, if performed after plating, could adversely affect the plated part. The sequencing of these types of operations should be specified by the cognizant engineering organization or purchaser and is not controlled by this specification.

1. SCOPE

1.1 Form

These products have been used typically for electrodeposited nickel plating on steel, copper and copper alloys, and zinc and zinc alloys, but usage is not limited to such applications.

1.2 Classification

1.2.1 Classes

Electrodeposited nickel plating covered by this specification shall be of the following classes, as specified:

Class 1 - Corrosion protective plating
Class 2 - Engineering plating

1.2.2 Grades

Class 1 plating shall be of the following grades, as specified:

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

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS2750 Pyrometry

AMS2759/9 Hydrogen Embrittlement Relief (Baking) of Steel Parts

2.2 U.S. Government Publications

Copies of these documents are available online at http://quicksearch.dla.mil.

MIL-DTL-5002 SurfaceTreatments and Inorganic Coatings for Metal Surfaces of Weapons Systems

MIL-STD-1916 DoD Preferred Methods for Acceptance of Product

2.3 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM B487 Measurement of Metal and Oxide Coating Thickness by Microscopic Examination of a Cross Section

ASTM B504 Measurement of Thickness of Metallic Coatings by the Coulometric Method

ASTM B529 Measurement of Coating Thickness by the Eddy Current Test Method; Non-Conductive Coating on Non-Magnetic Basis Metals

ASTM B530 Measurement of Coating Thickness by the Magnetic Method: Electrodeposited Nickel Coatings on Magnetic and Nonmagnetic Substrates

ASTM B568 Measurement of Coating Thickness by X-Ray Spectrometry

ASTM B571 Qualitative Adhesion Testing of Metallic Coatings

ASTM E376 Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Testing Methods

ASTM F519 Mechanical Hydrogen Embrittlement Evaluation of Plating/Coating Processes and Service Environments

2.4 Other Publications

ANSI/ASQ Z1.4 Sampling Procedures and Tables for Inspection by Attributes

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 psi (HRC48) shall not be plated without specific approval of the cognizant engineering organization (See 6.4.3).

3.2.2 Stress Relief Treatment

3.2.2.1 All steel parts having a hardness of 40 HRC and above and that are machined, ground, cold formed or cold straightened after heat treatment shall be cleaned to remove surface contamination and thermally stress relieved before plating. (Residual tensile stresses have been found to be damaging during electroplating). Furnaces used for stress relief shall be controlled per AMS2750; the minimum requirements shall be Class 5 and Type D Instrumentation. Temperatures to which parts are heated shall be such that stress relief is obtained while still maintaining hardness of parts within drawing limits. Unless otherwise specified, the following treatment temperatures and times shall be used:

3.2.2.1.1 For parts, excluding nitrided parts, having a hardness of 55 HRC and above, and for carburized and induction hardened parts, stress relieve at 275 °F ± 25 (135 °C ± 14) for 5 to 10 hours.

3.2.2.1.2 For parts having a hardness less than 55 HRC, and for nitrided parts, stress relieve at 375 °F ± 25 (191 °C ± 14) for a minimum of 4 hours. Higher temperatures shall be used only when specified or approved by the cognizant engineering organization.

3.2.2.1.3 For peened parts: If stress relief temperatures above 375 °F (191 °C) are elected, the stress relieve shall be performed prior to peening or the cognizant engineering organization shall be consulted and shall approve the stress relief temperature.

3.2.3 Cleaning

Unless otherwise specified, all steel parts shall be cleaned in accordance with MIL-S-5002. 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.

3.2.4.1 On aluminum, magnesium, beryllium, and their alloys and corrosion resistant steels or similarly passive materials, a preliminary chemical coating, immersion plate and/or flash acceptable to the cognizant engineering organization is permissible.

3.2.5 Underplating

When specified in the contract, purchase order or applicable drawing, 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 1) be substituted for any part of the specified nickel thickness.

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 Table 4).

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 cognizant engineering organization.

3.2.8 Coverage

Unless otherwise specified, the plating shall cover all surfaces including roots of threads, corners and recesses.

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, semi-bright or dull shall be acceptable.

3.2.11 Embrittlement Relief

Steel parts plated to this specification shall be subjected to a hydrogen embrittlement relief bake in accordance with AMS2759/9. The baked parts, when tested in accordance with 4.5.3, shall not crack or fail by fracture. Plated springs and other parts subject to flexture or stress, shall not be flexed prior to the hydrogen embrittlement relief. The following alloys are not considered susceptible to hydrogen embrittlement from the nickel plating process and do not require the hydrogen embrittlement relief bake

a. UNS S66286 (A286 alloy) UNS N07718 (Inconel 718) UNS R30159 (MP-159 alloy) , UNS R30035 (MP-35N alloy), UNS N04400 (Monel 400 alloy), UNS N06600 (Inconel 600), UNS N07750 (Inconel X750),

b. 300 series stainless steels (18-8 stainless steels)

c. Aluminum, copper and their alloys

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 1 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 1.

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.

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 in Table 1. The thickness of the underplate shall not be used in the determination of the specified nickel plating thickness.

Table 1 - 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. All (See 3.3.1.1)		All other surfaces 5/	
		Inch-Min.	Equiv.-Micro-meters 4/ (approx.)	Inch-Min.	Equiv.-Micro-meters 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% 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. If a thickness is not specified, it shall be 0.002 to 0.003 inch (0.051 to 0.076 mm) for the finished part. 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 4-10X magnification 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 not be cause for rejection.

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 of 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 specified requirements.

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, 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 cognizant engineering organization, 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 as specified in this document. The supplier shall demonstrate the capability of the process used to show freedom from hydrogen embrittlement damage as indicated by satisfactory behavior of specimens prepared and tested in accordance with 4.5.3 to comply to the requirements of MIL-S-5002 for preproduction process qualification.

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 2, shall be made once each month or more frequently if required by the cognizant engineering organization. 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.

Table 2 - 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	4.4.4, and 4.4.4.2	4.5.3

1/ Test specimens shall be in accordance with AS2390, Chemical Process Test Specimen Material, with the exception that hydrogen embrittlement test specimens shall be in accordance with ASTM F519.

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

A sample of coated parts or articles shall be taken at random from each lot, the number of articles in accordance with MIL-STD-1916 VL=II, or ANSI/ASQ Z1.4, or as indicated in Table 3, as specified by the purchaser. When the sampling plan is not specified by the purchaser, the choice of sampling plan in accordance with MIL-STD-1916, ANSI/ASQ Z1.4, or Table 3 shall be at the discretion of the processor. 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 3 - 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	0
301 to 500	35	0
501 and over	50	0

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 nonconforming 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 (4) plated parts or articles shall be taken from each lot for each destructive test or four (4) 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 (4) or less, the number of articles in the sample shall be specified by the cognizant engineering organization.

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.

4.4.4 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 in accordance with AS2390. 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 tests 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 there from 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 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

Specimens for the embrittlement relief test shall be in accordance with ASTM F519 Type 1a1.

4.5 Tests

4.5.1 Thickness

For nondestructive measuring of plating thickness, procedures in accordance with ASTM E376, ASTM B529, ASTM B568 or ASTM B530 may be used. For destructive measuring of plating thickness, procedures in accordance with ASTM B487 or ASTM B504 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 4-10X magnification for evidence of non-adhesion. Alternatively, adhesion shall be tested in accordance with ASTM B571 by the Bend Test method – no mandrel. When examined at 4-10x magnification, there shall be no evidence of internal delamination or loss of adhesion from the basis metal. The article or specimen shall 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 4-10X magnification, adhesion is not satisfactory.

4.5.3 Hydrogen Embrittlement Relief

Conformance to the requirements of 3.2.11 shall be determined for those parts having a tensile strength of 160 000 psi (HRC 36) or above. Testing shall be in accordance with the requirements of ASTM F519 Type 1a1 using notched round specimens, unless a different specimen is specified by the cognizant engineering organization, and stressed in tension under sustained load. For test purposes the plating thickness shall be 0.003 inch minimum (0.076 mm) measured on the smooth section of the specimen, but with visual evidence of plating in the root of the notch. The notch and 0.5 inch on both sides of the notch sample shall be plated. Testing beyond the 200 hour test period is not required. The test samples shall be exposed to all steps of the documented plating process including stress relieve, surface preparation (reagent-electrocleaning, or abrasive blasting as applicable).

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 A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

6.2 Terms used in AMS are clarified in ARP1917. Test specimens are defined in AS2390

6.3 Dimensions and properties in inch/pound units and the Fahrenheit temperatures are primary; dimensions and properties in SI units and the Celsius temperatures are shown as the approximate equivalents of the primary units and are presented only for information.

6.4 Intended Use

6.4.1 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.

6.4.2 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 buildup of worn or undersized parts, or for salvage purposes, and to provide protection against corrosive chemical environments.

6.4.3 Processes used for cleaning and nickel plate deposition on parts heat treated to 160 000 psi (HRC 36) or greater should incorporate practices and procedures to minimize hydrogen embrittlement. Unless otherwise specified on the engineering drawing, parts heat treated to an ultimate tensile strength greater than 240 000 psi (HRC 48) shall not be plated in accordance with this specification due to potential susceptibility to hydrogen embrittlement.

6.5 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.

6.6 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).

6.7 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).

6.8 Baking Time

For high strength materials (40 HRC and above), it may be beneficial to extend the baking time to 23 hours to ensure complete hydrogen embrittlement relief (See 3.2.11).

6.9 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% sulfur and having an elongation greater than 8%. 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% sulfur and have an elongation greater than 8%. The top layer should contain more than 0.04% sulfur. In a double-layer coating, the thickness of the bottom layer should be not less than 60% of the total nickel thickness, except on ferrous parts where the bottom thickness should be not less than 75% of the total nickel thickness. In a triple-layer coating, the thickness of the bottom layer should be not less than 50% 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% of the total nickel thickness. The thickness of the top layer of either double- or triple-layer coating should be not less than 10% of the total nickel thickness.

6.9.1 Correlation

The correlation between the grades of nickel plating used in this specification and the forms of nickel deposition are indicated in Table 4.

Table 4 - 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/ When the nickel deposit and top coat are subject to mild or moderate service conditions as stated in the ordering information, nickel deposited under Forms SD or M conditions may be substituted for nickel deposited in Form SB condition.

6.9.2 Thickness Measurements

Thickness measurements for the single layer Class 1 plating should be made whenever applicable by the nondestructive 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:

Etchant No. 1

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

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.

6.9.3 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.

6.9.4 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.

6.10 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 5.

Table 5 - Correlation of class 1 nickel plating

	QQ-N-290	QQ-N-290A	
Basis Metal	Types	Grades	Suggested forms of plating deposition (See 6.9)
Steel	I (DS)	C	M
	II (FS)	E	SB
	III (KS)	F	SB
	IV (QS)	G	SB
Copper and Copper-based alloys	V (FC)	E	SB
	VI (KC)	F	SB
	VII (QC)	G	SB
Zinc and Zinc-based alloys	VIII (FZ) 1/	E	SB
	IX (KZ) 2/	F	SB
	X (QZ)	F	SB

1/ When copper undercoat is omitted, the minimum 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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