74011

QQ-C-320B
June 17, 1974
SUPERSEDING
Fed. Spec. QQ-C-320A
July 25, 1967

FEDERAL SPECIFICATION

CHROMIUM PLATING (ELECTRODEPOSITED)

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

1. SCOPE AND CLASSIFICATION

1.1 Scope. This specification covers the requirements for electrodeposited chromium plating.

1.2 Classification.

1.2.1 Classes. Electrodeposited chromium plating shall be of the following classes, as specified (see 6.2):

Class 1 - Corrosion protective plating (see 3.3.1)
Class 2 - Engineering plating (see 3.3.2)

1.2.2 Finish. Class 1 plating shall be of the following types of finish, as specified (see 6.2):

Type I - Bright finish
Type II - Satin finish

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 this specification to the extent specified herein.

Federal Specifications

QQ-N-290	Nickel Plating (Electrodeposited)
QQ-S-624	Steel Bar, Alloy, Hot Rolled and Cold Finished (General Purpose)

(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.

(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 Specifications:

MIL-S-5002	Surface Treatments and Inorganic Coatings for Metal Surfaces of Weapons Systems
MIL-S-13165	Shot Peening of Ferrous Parts
MIL-R-81841	Rotary Flap Peening of Metal Parts

Military Standards:

MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-1312	Fasteners, Test Methods

(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:

ASTM B-487	Measurement of Metal and Oxide Coating Thickness by Microscopic Examination of a Cross Section

ASTM B-499	Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metal
ASTM B-504	Measuring the Thickness of Metallic Coatings by the Coulometric Method
ASTM B-556	Thin Chromium Coatings by the Spot Test, Guideline for Measurement of
ASTM B-578	Measurement of Microhardness of Electrplated Coatings
ASTM E-8	Tension Testing of Metallic Materials

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 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 steel parts. Unless otherwise specified (see 6.2), steel parts having an ultimate tensile strength greater than 240,000 psi (1655 MPa) shall not be plated without specific approval of the procuring activity.

3.2.2 Stress relief treatment. All steel parts having an ultimate tensile strength of 150,000 psi (1034 MPa) and above, which are machined, ground, cold formed or cold straightened, shall be baked 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. When peening is required (see 3.3.2.3 and 3.3.2.5), thermal stress relief shall be performed prior to shot or rotary flap peening.

3.2.3 Cleaning. Unless otherwise specified (see 6.2), 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.

3.2.4 Plating application. Unless otherwise specified (see 6.2), 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.

3.2.5 Underplating. Unless otherwise specified (see 6.2), class 1 plating shall be applied over an intermediate plating of nickel in accordance with QQ-N-290 on steel, zinc and zinc-based alloys or copper and copper-based alloys. Unless otherwise specified (see 6.2), class 2 plating shall be deposited on the basis metal without a preliminary plating of another metal. In no case shall any underplate be substituted for any part of the specified chromium thickness.

3.2.6 Embrittlement relief. All coated 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 6.4). The baked parts, when tested in accordance with 4.5.5, shall not crack or fail by fracture (see 4.4.3.5). Plated springs and other parts subject to flexure shall not be flexed prior to hydrogen embrittlement relief treatment.

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

3.2.8 Boundaries. Boundaries of class 2 plating which covers only a portion of the surface shall be free from beads, nodules, jagged edges and other irregularities.

3.2.9 Finish. For class 1 plating, the finish or luster shall be as specified (see 1.2.3 and 6.2). Type I of class 1 shall be a fully bright finish, smooth, uniform in appearance and free from frosty areas. Type II of class 1 shall be a satin finish, smooth and uniform in appearance. Unless otherwise specified (see 6.2), either a fully bright or a dull matte finish, smooth and free from frosty areas shall be acceptable for class 2 plating finish.

3.3 Processing.

3.3.1 Class 1 processing. Parts for class 1 deposition shall be plated to specific dimensions as specified (see 3.4.1.1). When specified (see 6.2), parts shall be processed in accordance with procedural instructions for form of chromium deposit (see 6.5).

3.3.2 Class 2 processing. Parts for class 2 deposition shall be plated to specific dimensions as specified (see 3.4.2.1). Unless otherwise specified (see 6.2), steel parts shall be processed in accordance with the procedural instructions of the procuring activity as follows:

3.3.2.1 Class 2a. Parts plated or plated and processed to specific dimensions in accordance with procedures and criteria specified by the procuring activity. Parts not covered by procedural instructions which do not specify baking procedures shall be baked in accordance with 3.2.6 after plating.

3.3.2.2 Class 2b. Plated parts below Rockwell C40 hardness, which are subjected to static loads or designed for limited life under dynamic loads or combinations thereof, need not be peened prior to plating.

3.3.2.3 Class 2c. Plated parts below Rockwell C40 hardness, which are designed for unlimited life under dynamic loads, shall be peened in accordance with MIL-S-13165 or MIL-R-81841 prior to plating. Unless otherwise specified in the applicable drawings, the peening shall be accomplished on all surfaces for which the plating is required and on all immediately adjacent surfaces when they contain notches, fillets or other abrupt changes of section size where stress will be concentrated.

3.3.2.4 Class 2d. Plated parts, Rockwell C40 hardness or above, which are subjected to static loads or designed for limited life under dynamic loads or combinations thereof, shall be baked in accordance with 3.2.6 after plating. The load for the static load test (see 4.5.5, the embrittlement relief test) shall be as specified in the contract, order or applicable drawing (see 6.2).

3.3.2.5 Class 2e. Plated parts, Rockwell C40 hardness or above, which are designed for unlimited life under dynamic loads, shall be peened in accordance with MIL-S-13165 or MIL-R-81841 prior to plating. Unless otherwise specified in the applicable drawings, the peening shall be accomplished on all surfaces for which the plating is required and on all immediately adjacent surfaces when they contain notches, fillets or other abrupt changes of section size where stress will be concentrated. The plated parts shall be baked in accordance with 3.2.6 after plating. The load for the static load test (see 4.5.5, the embrittlement relief test) and the dynamic load conditions shall be as specified in the contract, order or applicable drawing (see 6.2).

3.4 Detail requirements.

3.4.1 Class 1.

3.4.1.1 Thickness. Unless otherwise specified (see 6.2), the minimum thickness of class 1 chromium plating shall be 0.00001 inch or 0.01 mil (0.25 micrometre) on all visible surfaces which can be touched by a ball 0.75 inch (19 mm) in diameter. Unless otherwise specified (see 6.2), holes, deep recesses and other openings, bases of angles, and articles with internal threads from which the external environment is completely excluded and where a controlled deposit cannot be normally obtained shall not be subjected to a thickness requirement but shall show evidence of plating. There shall be no bare areas.

3.4.1.2 Underplating. Class 1 plating is normally used with an underplate system of nickel or copper. Where such requirements exist (see 3.2.5), the underplate thickness shall be in accordance with QQ-N-290. The thickness of the underplate shall not be used in determination of the specified chromium plating thickness.

3.4.1.3 Adhesion. The adhesion of the plating and any underplate shall be such that, when examined at a magnification of approximately 4 diameters, neither the chromium plating nor any electrodeposited underplate(s) 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 plate or the basis metal which does not result in flaking, peeling or blistering of the plate shall not be cause for rejection.

3.4.2 Class 2.

3.4.2.1 Thickness. The minimum, maximum or range of thickness for class 2 plating shall be as specified in the contract, purchase order or on the applicable drawing (see 6.2). If a thickness is not specified, the minimum thickness for the finished part shall be 0.002 inch or 2 mils (51 μm). The thickness requirement for class 2 plating shall apply after all metal finishing and post-plating grinding operations have been completed.

3.4.2.2 Adhesion. The adhesion of the plating and any underplate shall be such that when examined at a magnification of approximately 4 diameters, neither the plating, nor any electrodeposited underplate 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 the plate which do not result in flaking, peeling or blistering of the plate shall not be cause for rejection.

3.4.2.3 Hardness. The minimum hardness of a cross-section class 2 plating, when subjected to the microhardness test detailed in 4.5.3, shall be 600 Vickers Hardness Number (VHN) or equivalent if the plating is finished to a semi-bright or matte luster (see 3.2.9). If the plating is finished to a bright or bright pebbly luster, the minimum hardness shall be 850 Vickers Hardness Number (VHN) or equivalent.

3.4.2.4 Porosity. The class 2 plating, by being as free from porosity as possible, shall be capable of protecting the basis metal from corrosion due to pits, pores or cracking. When subjected to the test detailed in 4.5.4, specimens shall show no more than a total of 15 isolated spots or pits, none larger than 1/32 inch (0.79 mm) in diameter, in a total of 150 square inches (967.8 sq. cms) of test area grouped from five or more test pieces; nor more than five isolated spots or pits, none larger than 1/32 inch (0.79 mm) in a total of 30 square inches (193.6 sq. cms) from one or more test pieces, except those areas within 1/16 inch (1.59 mm) from identification markings and contact marks after processing.

3.5 Workmanship.

3.5.1 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 subjected to such cleaning and plating procedures as necessary to yield deposits herein specified.

3.5.2 Plating. The 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 deposit, such as excessively powdered or darkened plating, 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 3.2.6), 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.

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

a. Production control inspection (see 4.3).

b. 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 chemical analyses performed, and the quantity of parts plated during operation. Upon request of the procuring activity, such records as well as reports of the test results 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 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 4.4.4.3 from four individual heats for a total of 16 specimens, using the specified steel alloy for which preproduction examinations 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 pretreatments and treatments proposed for production. The specimens shall be subject to the test detailed in 4.5.5. 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 I 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 are acceptable as evidence of the properties being obtained with the equipment and procedures employed.

4.3.4 Production control specimens. Test specimens for production control shall be prepared in accordance with 4.4.4, 4.4.4.1 and 4.4.4.2, as applicable for the thickness, adhesion, hardness and porosity tests detailed in table I. 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 4.4.4.3.

4.4 Quality conformance inspection.

4.4.1 Lot. A lot shall consist of plated articles of the same basis metal composition, class, deposition form and finish, 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 nondestructive tests. Sampling for visual examination and nondestructive tests shall be conducted as directed by the procuring activity (see 6.2) in accordance with MIL-STD-105

or using table II. 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 percent defective or as indicated in table II. 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 I. Production control tests and specimens

Test	For coating classes	Requirement paragraphs	Specimen preparation paragraph 1/	Test reference paragraphs
Thickness	1 and 2	3.4.1.1 and 3.4.1.2 or 3.4.2.1	4.4.4 and 4.4.4.1	4.5.1
Adhesion	1 and 2	3.4.1.3 or 3.4.2.2	4.4.4 and 4.4.4.1	4.5.2
Hardness	2	3.4.2.3	4.4.4 and 4.4.4.1	4.5.3
Porosity	2	3.4.2.4	4.4.4 and 4.4.4.2	4.5.4
Hydrogen embrittlement relief	1 and 2	3.2.6	4.4.4 and 4.4.4.3	4.5.5

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.

Table II. Sampling for visual examination and nondestructive tests

Number 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 3.2.7, 3.2.8, 3.2.9 and 3.5.2 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 test detailed in 4.5.1 at several locations on each article as defined in 3.4.1.1 and 3.4.1.2 or in 3.4.2.1; as applicable, for compliance with the requirement. Measurements on fastener hardware shall be made on location defined in MIL-STD-1213, Test 12. The part or 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 five 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, 4.4.4.2 and 4.4.4.3 to represent each lot. If the number of articles in the lot is five or less, the number of articles in the sample shall be specified by the procuring activity (see 6.2).

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 3.4.1.1 and 3.4.1.2 or in 3.4.2.1, as applicable, for compliance with the requirements. Measurements for fastener hardware shall be made at locations defined in MIL-STD-1312, Test 12. 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 3.4.1.3 or 3.4.2.2. Failure of one or more of the test pieces shall constitute failure of the lot.

4.4.3.3 Hardness (destructive tests). When specified in the contract or order (see 6.2), compliance with the requirements for hardness shall be determined. The articles or specimens, used for the destructive thickness test (see 4.4.3.1) if of suitable size and form, may be used for the test pieces for examination to determine compliance with the requirement

of 3.4.2.3. Failure of one or more of the test pieces shall constitute failure of the lot.

4.4.3.4 Porosity (destructive tests). When specified in the contract or order (see 6.2), compliance with the requirements for porosity shall be determined. A set of five separate test specimens prepared in accordance with 4.4.4 and 4.4.4.2 in lieu of treated plated articles shall be used to determine compliance with the requirements for porosity (see 3.4.2.4). Failure of one or more of the test specimens shall reject the lot.

4.4.3.5 Hydrogen embrittlement relief (destructive tests). Unless otherwise specified in the contract or order (see 6.2), conformance to the requirements of 3.2.6 for hydrogen embrittlement relief of treated steel parts shall be determined for those parts, comprising a lot, having a tensile strength of or heat treated to a tensile strength level of 240,000 psi (1655 MPa) or above and which will be subjected to a sustained tensile load in use. A random sample of five plated articles shall be taken from each lot or five specimens, prepared in accordance with 4.4.4 and 4.4.4.3 shall be used to represent the lot. When tested as specified in 4.5.5, 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 article 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 specimens may be used to represent forged and cast-steel articles. The separate specimens may also be cut from the scrap casting when ferrous alloy castings are being plated. These separate specimens may be introduced into a lot at regular intervals prior to the cleaning operations, prior to plating and shall not be separated therefrom until after completion of plating. Conditions affecting the plating of specimens, including the spacing, plating media, bath agitation, 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, adhesion, and hardness tests. If separate specimens for thickness, adhesion, and hardness tests are required, they shall be strips approximately 1 inch (25 mm) wide, 4 inches (102 mm) long and 0.04 inch (1 mm) thick.

4.4.4.2 Specimens for porosity tests. If separate specimens for porosity tests are required, they shall be panels not less than 10 inches (254 mm) in length, 3 inches (76 mm) in width and approximately 0.04 inch (1 mm) thick.

4.4.4.3 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 E-8 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 (0.254 $\pm$0.0127 mm) radius of curvature at the base of the notch (see 6.2.2).

4.5 Tests.

4.5.1 Thickness. For nondestructive measurement of plating thickness, procedures in accordance with ASTM B-499 (magnetic test method) may be used. For destructive measurement of plating thickness, procedures in accordance with ASTM B-487 (microscopic) or ASTM B-504 (coulometric) may be used. In addition to the above, other procedures embodied in MIL-STD-1312, Test 12, may be used for thickness measurement of plated fastener hardware. Class 1 plating may be measured for thickness in accordance with ASTM B-556 (spot test) within its limitations, as a destructive procedure.

4.5.2 Adhesion. Adhesion may be determined by scooping 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 Hardness. The hardness of class 2 plating shall be determined by a microhardness traverse in accordance with ASTM B-578, except that a Vicker indenter and 100 gram load shall be used. A minimum of three hardness readings shall be made to establish the basis metal hardness in an area at least 0.125 inch (3.175 mm) from the outer surface or at mid radius of the cross section which ever is less. Readings shall be taken at 0.0005 inch (0.013 mm) intervals starting at 0.001 inch (0.025 mm) from the outer surface in a staggered pattern until the pre-established basis metal hardness is reached. The hardness reading may be plotted versus distance from the outer surface. The point at which the hardness shows a vast decrease may be taken as the limits of chromium plating.

4.5.4 Porosity. Prior to determining porosity by the ferroxyl test, the specimen surface shall be cleaned to remove any oil or grease. Contamination removal shall be accomplished with any acceptable solvent in accordance with MIL-S-5002. A sheet of filter paper, saturated by dipping in a ferroxyl solution heated to 180 to 200°F (82 to 94°C), shall be applied to the flat surface of the specimen or of the article. The solution composition shall be as follows:

Potassium ferricyanide ($K_3Fe(CN)_6$)	1 gm.
Sodium chloride (NaCl)	10 gms.
Agar	10 gms.
Water (distilled or deionized) to make	1 litre

After 10 minutes, the heated filter paper shall be removed. Both the plated surface and the filter paper shall be examined. Where corrosion of the basis metal will occur at pores or other defects due to the plating, dark blue spots will have been developed. Contact may further be assured by the use of a soft bristle brush moistened with the reagent solution. For a permanent record, the filter paper can be dried.

4.5.5 Embrittlement relief. Compliance with 3.2.6 shall be determined with samples of plated parts taken as specified in 4.4.3.5. 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 drawings 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, 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 samples shall be subjected to a sustained tensile load equal to 75 percent of the ultimate notch tensile strength of the material. The articles, parts or specimens shall be held under load for at least 200 hours and then examined for cracks or fracture.

5. PREPARATION FOR DELIVERY

5.1 Packaging and packing. Preservation, packaging and packing methods for electrodeposited 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 applied as a decorative finish, usually over nickel, or copper and nickel, on basis metals such as iron and steel, copper and copper-base alloys, and zinc and zinc-base diecasting where necessary to protect the basis metal from corrosion and

wear and to provide a pleasing appearance. The function of the underlayers of nickel is to provide a pore-free continuous underplate for the chromium outer layer. Generally, the thicker the nickel layer, the better the corrosion resistance. The systems of an outer layer of chromium over the combined plated nickel and copper are generally used in a combined total thickness of 0.0001 to 0.002 inch (2.5 to 51 μm) depending upon service conditions and the basis metal.

6.1.1.1 Chromium platings 0.0005 inch (13 μm) or more in thickness are likely to crack nickel plating on brass basis metal. The minimum thickness of chromium should be obtained under conditions such that the maximum thicknesses are less than 0.00005 inch (1.3 μm).

6.1.2 Class 2 plating. Class 2 plating, also known as "industrial chromium" or "hard chromium", is used for wear resistance, abrasion resistance and such incidental corrosion protection of parts as the specified thickness of the plating may afford. Engineering chromium is usually applied directly to the basis metal and is finished by grinding to the specified dimensions. It lacks the brightness of class 1 plating. Additional corrosion resistance can be obtained by use of an undercoat of electrodeposited nickel in thickness of 0.001 to 0.002 inch (25 to 51 μm) on ferrous parts, the minimum thickness to be determined by service conditions. Heavy deposits of the class 2 plating may be used for buildup of worn or undersized parts, or for salvage purposes, and to provide protection against corrosive chemical environments. Final grinding of the chromium plating can increase the number of cracks in the deposit. For greater corrosion resistance, based upon equal thickness, unground deposits should be selected rather than ground deposits.

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, 3.3.1, 3.3.2, 3.3.2.1, 3.3.2.2, 3.3.2.3, 3.3.2.4 and 3.3.2.5).

c. Deposition and finish, if applicable (see 1.2.2, 3.2.9 and 3.3.1).

d. When plating is to be applied, if other than specified (see 3.2.1, 3.2.4, 3.3.1, 3.3.2, 3.3.2.1, 3.3.2.2, 3.3.2.3, 3.3.2.4 and 3.3.2.5).

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

f. Underplating, if other than specified or required (see 3.2.5).

g. Coverage, if other than specified (see 3.2.7).

h. Surface finish; if particular finish required (see 3.2.9).

i. Thickness of plating, as specified (see 3.3.1, 3.3.2, 3.3.2.1, 3.4.1.1, 3.4.1.2, and 3.4.2.1).

j. Control record requirement (see 4.3.1).

k. Preproduction control examination (see 4.3.2).

l. Sampling plan (see 4.4.2).

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

n. Hardness, porosity and hydrogen embrittlement tests, whether required for quality conformance inspection (see 4.4.3.3, 4.4.3.4 and 4.4.3.5).

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, 3.2.2, 3.2.6 and 3.3.2).

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 3.2.6 and 4.5.5).

6.2.2 The manufacturer of the basis metal parts should provide the plating facility with notched specimens (see 4.4.4.3) to be plated for conformance with 3.2.6 required for production control (see 4.3.2.1 and 4.3.4) and for lot acceptance (see 4.4.3 and 4.4.3.5).

6.3 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 shall have a suitable heat treatment for stress relief prior to cleaning and plating (see 3.2.2).

6.4 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 3.2.6).

6.5 Class 1 processing. Class 1 chromium plating may be processed for the following forms of deposition:

R- Regular or conventional
MP- Micro-porous
MC- Micro-cracked

Generally, a nominal coating thickness, approximately 0.00001 inch (0.01 mil or 0.25 μm) is used for all forms of the chromium deposition. The thickness of Form R plating should not exceed 0.00002 inch (0.02 mil or 0.51 μm) as the resultant chromium coating tends to crack spontaneously. Form MP deposition should contain a minimum of 64,500 pores per square inch (100 pores per square millimetre), invisible to the unaided eye. Form MC desposition should have more than 750 cracks per inch (80 cracks per millimetre) in any direction over the significant surfaces.

6.5.1 Correlation. The correlation between the chromium plating forms and the grades and forms of nickel deposition as detailed in QQ-N-290 are indicated in table III.

6.5.2 Determination of deposition form. The micro-porous or micro-cracked deposition characteristic can be determined by examination of electrodeposited copper at discontinuities in the unbuffed chromium plated surfaces. The color contrast between the smallest dot or streak of copper and the surrounding chromium can be readily observed.

6.5.2.1 Preparation. All cut edges and those surfaces of selected specimens which are not chromium plated should be masked with a pressure sensitive PVC tape conforming to HH-T-0025, Tape, Pressure-Sensitive Adhesion, Plastic (For Electroplating). The conductor (wire, rack or hook)which will carry the current to the specimen while copper plating should also be masked below the plating bath level, except where electrical contact is made with the specimen. The masked specimen should be cleaned by soaking in a hot alkali cleaner until the chromium plated surface is free from water breaks after thorough rinsing in cold water and dipping in a 5 percent sulfuric acid solution. Gentle brushing the plated surface with a soft brush, while in the cleaner, can be helpful.

6.5.2.2 Copper deposition. When the specimen is immersed in a solution whose composition is as follows, the current should be on:

Copper Sulfate ($CuSO_4 \cdot 5H_2O$)- 28 to 32 oz/gal (210 to 240 gm/1)

Sulfuric Acid (H_2SO_4) - 6 to 8 fl oz/gal (47 to 62 ml/1)

Table III. Correlationship of Class 1 chromium plating deposition and Class 1 nickel plating grades and deposition

Grades of Nickel Deposition (See QQ-N-290)	For Steels, Zinc and Zinc Alloys		For Copper and Copper Alloys	
	Nickel 1/ (See QQ-N-290)	Chromium	Nickel 1/ (See QQ-N-290)	Chromium
A	M and SD	R	-	
B	M	R, MP and MC	M and SB	R
	SD	MP and MC		
C	M	MP and MC	M	R, MP and MC
			SD	R
			SB	MP and MC
D	SB, M and SD 2/	R	M and SD	MP and MC
E	SB, M and SD 2/	MP and MC	SB, M and SD 2/	R
F	SB, M and SD 2/	R, MP and MC 3/	SB, M and SD 2/	MP
G	-	-	SB, M and SD 2/	R, MP and MC 3/

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

2/ SD or M nickel deposition may be substituted for SB nickel deposition where the nickel-chromium system is subjected to mild or moderate service conditions.

3/ MC or MP chromium deposition may be substituted for R chromium deposition where the nickel-chromium system is subjected to mild service conditions.

Brightness and additional agents should be used in the plating bath for the purpose of brightening the deposit as detailed above in 6.5.2. Operating conditions should be as follows:

Temperature - Room (65 to 75°F or 18 to 24°C)
Current density - 3 amperes per square foot (0.32 amperes per square decimetre)
Time - 15 minutes
Anode - Copper (conforming to QQ-A-673)

The specimen should be removed, carefully rinsed in cold water, then hot water and allowed to dry. Where the pores or cracks will be counted, the specimens should not be wiped. Copper nodules, deposited at the sites, are not firmly attached. Any physical contact after plating may remove some of the copper depositions and cause erroneous results. Photomicrographs may be used for determining the deposition forms and they could be prepared in accordance with ASTM E2, Micrographs of Metals and Alloys (Including

Recommended Practice for Photography as Applied to Metallography). The number of pores or the number of cracks may be estimated by counting on a ground-glass screen, on a photomicrograph of a representative field of the specimen, or on the specimen itself. A circle or rectangle of known area (such as 100 square mm to simplify calculations) on a micrograph or on the ground-glass screen of the metallograph can be inscribed. The selected magnficiation, usually about 100X, should be suitable to properly count the pores or cracks for observation of any limitations permitted for deposition.

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

Review activities:
Army - EL, MI, ME, AV, MU, WC
Navy - OS
Air Force - 84, 70
Defense Supply Agency - IS

User activities
Army - AT, GL
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US GOVERNMENT PRINTING OFFICE 1976 703-020:941

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