FEDERAL SPECIFICATION

SILVER PLATING, ELECTRODEPOSITED: GENERAL REQUIREMENTS FOR

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 silver plate (see 6.1).

1.2 Classification.

1.2.1 Types. Silver plating shall be of the following types, as specified (see 3.3.4 and 6.3):

- Type I - Matte
- Type II - Semi-bright
- Type III - Bright

1.2.2 Grades. Silver plating shall be of the following grades, as specified (see 3.4.5 and 6.1.3):

- Grade A - With supplementary tarnish-resistant treatment (chromate treated)
- Grade B - Without supplementary tarnish-resistant treatment.

2. APPLICABLE DOCUMENTS

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

Federal Specifications:

- QQ-S-57I - Solder; Tin Alloy; Lead-Tin Alloy; and Lead Alloy

DISTRIBUTION STATEMENT A Approved for public release: distribution unlimited.
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-F 14256 - Flux, Soldering, Liquid (Rosin Base).

Military Standard:

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

(Copies of Military Specifications and Standards required by suppliers 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 specified issue is identified, the issue in effect on date of invitation for bids or requests for proposal shall apply.

American National Standards Institute (ANSI)

B46.1 - Surface Texture

(Application for copies of this standard should be addressed to the American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018, or the American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, NY 10017.)
American Society for Testing and Materials (ASTM) Standards:

B 487 - Measuring Metal and Oxide Coating Thicknesses by Microscopical Examination of a Cross Section
B 499 - Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals
B 504 - Measuring the Thickness of Metallic Coatings by the Coulometric Method
E 8 - Tension Testing of Metallic Materials

(Application for copies of ASTM standards 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 produce electrodeposits which meet the requirements of this specification.

3.2 Workmanship.

3.2.1 Basis metal. The surface of the basis metal shall be free from scratches, pits, non-conducting inclusions, and roll and die marks. The surface smoothness of the basis metal shall not affect the appearance or performance of the plating. Articles shall be cleaned, pickled, and plated as required to produce deposits as specified herein. Basis metal defects that are revealed during any of the pretreatments and plating processes shall be cause for rejection of the part.

3.2.2 Silver Plating. The silver plating shall be smooth, fine grained, adherent, free from visible blisters, pits, nodules, porosity, indications of bubing, excessive edge build-up and other defects. Superficial staining which has been demonstrated as resulting from rinsing, or slight discolorations from baking to relieve embrittlement from plating, as specified below (see 3.3.3), shall not be cause for rejection. All details of workmanship shall conform to the best practice for high quality plating.

3.3 General requirements.

3.3.1 Plating. 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.

3.3.2 Stress relief treatment. All steel parts shall be given a stress relief heat treatment at a minimum of 191°C ± 4°C (375 ± 25°F) for 3 hours or more prior to cleaning and plating if they contain or are suspected of having damaging residual tensile stresses caused by machining, grinding, or cold forming operations. Parts which are cold straightened are considered to contain damaging residual stresses. The temperature and time at temperature shall be such that maximum stress relief is obtained without reduction in hardness less than the specified minimum.
3.3.3 Embrittlement relief. All steel parts having a hardness of Rockwell C40 and above shall be baked at 375°F ± 25°F (191°C ± 14°C) for 3 hours or more beginning within four hours after plating to provide embrittlement relief. Plated springs or other parts subject to flexure shall not be flexed prior to the baking operation. The parts when tested in accordance with 4.5.6 shall not crack or fail by fracture.

3.3.4 Type of silver plating. If the type of silver plating is not specified, type I, II, or III will be acceptable.

3.3.5 Suitable undercoat. The final silver deposit shall be preceded by an electrodeposited coating of silver from silver strike solutions. The plating shall be applied over an intermediate coating of nickel or nickel over copper on steel, zinc and zinc-base alloys. Copper and copper base alloys require intermediate coatings. Copper-alloy-basis metal articles on which a nickel undercoat is not used and other basis metal where a copper undercoat is employed shall not be used for continuous service at a temperature in excess of 149°C (300°F). Adhesion of the silver plating is adversely affected because of the formation by diffusion of a weak eutectic of silver and copper at the silver-copper interface.

3.4 Detail requirements.

3.4.1 Thickness of plating. Unless otherwise specified the minimum plating thickness shall be 0.0005 inch (0.013 mm) on all surfaces on which silver is functionally necessary (for example: appearance, wear, corrosion protection, conductivity). The plating on nonfunctional surfaces and areas shall be of sufficient thickness to ensure plating continuity and uniform utility, appearance, and protection. On ferrous surfaces the total plated thickness shall be not less than 0.0010 inch (0.025 mm). This must be comprised of at least 0.0005 inch (0.013 mm) or more of silver plate over 0.0005 inch (0.013 mm) or less of nickel or copper or any combination thickness of nickel and copper from 0 percent to 100 percent. The copper shall be deposited first over the steel surface.

3.4.2 Adhesion. The adhesion of the silver plating and any undercoat(s) shall be such that when examined at a magnification of approximately four diameters neither the silver plating, nor any electrodeposited undercoat(s), shall show separation from the basis metal or from each other at their common interface(s) when subjected to the test specified in 4.5.2.1. 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 considered as nonconformance to this requirement.

3.4.3 Roughness. When a certain degree of surface roughness of the finished article is required, the standards and degree of roughness shall be specified by the procuring activity in accordance with ANSI B46.1. Methods of measuring surface roughness shall be approved by the procuring agency.

3.4.4 Solderability. When specified in the contract or drawings that the part is to be soldered, the silver plate shall be easy to solder according to procedures specified in 4.5.4. The soldered coating shall "wet" evenly without lump formation and shall not flake or peel when the part is tested as specified in 4.5.4.
3.4.5 Tarnish resistance, grade A only. The electrodeposited silver plate shall be made tarnish resistant by treating with a chemical solution (see 6.1.2). The tarnish resistance shall be such that the plating shall withstand the test specified in 4.5.5 for a minimum of five minutes. Lacquer, paint, clear epoxy or other organic coatings shall not be applied to the electrodeposited silver for the purpose of meeting this requirement.

4. QUALITY ASSURANCE PROVISIONS

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

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

(1) Production control inspection (see 4.3).

(2) Quality conformance inspection (see 4.4).

4.3 Production control inspection.

4.3.1 Control records. The supplier shall maintain a permanent record of the history of each processing bath, showing all additions of chemicals or treatment materials to the unit, the results of all analyses performed and the quantity of parts of each kind heat treated prior to coating and plated during operation. Upon request of the contracting agency, such records shall be made available to the Government.

4.3.2 Process control. The equipment, procedures and operations employed by a supplier shall be capable of producing high quality electrodeposited silver coatings on alloys as specified in this document. Upon request of the procurement activity, such capability shall be demonstrated by the supplier. Failure to adequately demonstrate this capability will be cause for disapproval of supplier. The tests specified in Table I for process control shall be made prior to production and once each month or more frequently as dictated by the volume, variation in shape, size or complexity of parts being plated or if required by the Government.
TABLE I. Process control tests and specimens

<table>
<thead>
<tr>
<th>Test</th>
<th>For coating grades</th>
<th>Requirements paragraphs</th>
<th>Specimen preparation paragraphs</th>
<th>Test reference paragraph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
<td>A,B</td>
<td>3.4.1</td>
<td>4.4.2, 4.4.3, 4.4.4</td>
<td>4.5.1</td>
</tr>
<tr>
<td>Adhesion</td>
<td>A,B</td>
<td>3.4.2</td>
<td>4.4.3, 4.4.4</td>
<td>4.5.2</td>
</tr>
<tr>
<td>Roughness</td>
<td>A,B</td>
<td>3.4.3</td>
<td>4.4.2</td>
<td>4.5.3</td>
</tr>
<tr>
<td>Solderability</td>
<td>A,B</td>
<td>3.4.4</td>
<td>4.4.3, 4.4.4</td>
<td>4.5.4</td>
</tr>
<tr>
<td>Tarnish resistance</td>
<td>A</td>
<td>3.4.5</td>
<td>4.4.3, 4.4.4</td>
<td>4.5.5</td>
</tr>
<tr>
<td>Hydrogen embrittlement</td>
<td>A,B</td>
<td>3.3.3</td>
<td>4.4.3, 4.5.6</td>
<td>4.5.6</td>
</tr>
</tbody>
</table>

4.4 Quality conformance inspection. Quality conformance inspection and testing of silver plate shall be for the acceptance of individual lots and shall consist of tests for all requirements specified in section 3.

4.4.1 Lot. A lot shall consist of plated articles of the same basis metal composition, type and grade, plated under the same conditions and approximately the same size and shape submitted for inspection at one time. In no case shall the lot exceed production for one week.

4.4.2 Sampling for visual examination and nondestructive tests. Sampling for visual examination and nondestructive tests shall be conducted at the option of the supplier 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, 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) and roughness. 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.

TABLE II. Sampling for visual examination and nondestructive tests

<table>
<thead>
<tr>
<th>Number of items in lot inspections</th>
<th>Number of items in samples (randomly selected)</th>
<th>Acceptance Number (maximum number of sample items nonconforming to any test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 or less</td>
<td>71/</td>
<td>0</td>
</tr>
<tr>
<td>16 to 40</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>41 to 110</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>111 to 300</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>301 to 500</td>
<td>35</td>
<td>1</td>
</tr>
<tr>
<td>501 and over</td>
<td>50</td>
<td>2</td>
</tr>
</tbody>
</table>

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 3.2.1 before plating unless otherwise specified, and 3.2.2 after plating.

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 in 4.5.1, at several locations on each article as defined in 3.4.1 for compliance with the requirements. The part or article shall be considered nonconforming if one or more measurements fail to meet the specified minimum thickness.

4.4.2.3 Roughness. Samples selected in accordance with 4.4.2 shall be examined for compliance with 3.4.3 when tested as specified in 4.5.3.

4.4.3 Sampling for destructive tests (thickness, adhesion, solderability, tarnish resistance and embrittlement relief). 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 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). Specimens may be used for more than one test where applicable. Failure of one or more of the test specimens shall reject the lot.

4.4.4 Separate specimens. 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 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, 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. Separate specimens may be strips approximately 1 inch (25 mm) wide, 4 inches (100 mm) long and 0.04 inch (1 mm) thick except specimens for embrittlement relief shall be prepared as described in 4.5.6.

4.5 Tests.

4.5.1 Thickness. Separate specimens (see 4.4.4) shall not be used for thickness measurements unless a need for such specimens has been shown.

Thickness measurements may be made by any suitable method provided the specific method and equipment used shall be such that the coating thickness
will be determined within plus or minus 10 percent of its true thickness. The following test methods for thickness may be used as applicable: ASTM B487 (microscopic), ASTM B 504 (coulometric), ASTM B 499 (magnetic), beta radiation backscatter, or X-ray spectrometry. Measurements on threaded fasteners shall be made on the shank or other smooth surface as close to the threads as possible.

4.5.1.1 Nondestructive tests for thickness. Each item in the sample selected to accordance with 4.4.2.2 shall be measured for plating thickness. The measurements shall be made in several representative locations on each item and the item shall be considered defective if one or more of the measurements fail to meet the specified minimum thickness.

4.5.1.2 Destructive tests for thickness. Each item selected in accordance with 4.4.3 shall be tested in several locations by one of the destructive test methods for thickness. If the plating thickness at any one place on any one item is less than the specified minimum, the lot shall be rejected.

4.5.2 Adhesion. Each item selected in accordance with 4.4.3 shall be tested for adhesion. The items used for the thickness test of 4.5.1 shall be used for the adhesion test if the items are of suitable size and form. When specified (see 6.2), an alternate adhesion test may be used.

4.5.2.1 Method of test. The test specimens shall be bent repeatedly through an angle of 180° on a diameter equal to the thickness of the specimen until fracture of the basis metal occurs. Following fracture of the basis metal, it shall not be possible to detach any areas of the coatings with a sharp instrument. When the plated articles are not readily adaptable to the bend test, adhesion may be determined on the plated article by cutting the plating from the basis metal at the interface(s) in a continuous path, and examining at four diameters magnification to determine whether removal has been caused by the cutting away of an adherent plate or by the lifting of a non-adherent plate. At the option of the procuring agency, an alternate adhesion test may be used. In this test, parts are placed in an oven and heated at 150° to 200°C (300° to 392°F). This temperature shall be maintained long enough to bring the items to temperature and then continued for 30 minutes. The test specimens shall be removed, cooled in air and examined at four diameters magnification for evidence of blistering of the silver deposit. Any blistering constitutes failure of the specimen. The quench test for adhesion may have an adverse effect on mechanical properties of the articles being tested.

4.5.3 Roughness. Each item selected in accordance with 4.4.2 shall be measured for the specified degree of roughness. Measurements shall be made at several locations on each item. Measurements shall be made by techniques approved by the procuring agency in accordance with ANSI Method B46.1. The item shall be considered defective if one or more of the measurements fail to meet the roughness requirement. If the number of nonconforming items equals or exceeds the rejection number for that sample, the lot shall be rejected.

4.5.4 Solderability. Each item in the sample of 4.4.3 shall be tested for solderability. The items used for the thickness and adhesion tests of 4.5.1 and 4.5.2 may be used for the solderability test if the items are of suitable size and form. Failure of one or more of the test specimens shall reject the lot.
4.5.4.1 Method of test. Test specimens shall be suitably fluxed with non-corrosive rosin flux conforming to ASTM B 678, type R. The solder shall be an alloy of 60% tin and 40% lead conforming to alloy Grade 60A of ASTM B 32. The temperature of the solder shall be 245°F ± 5°F (473°F ± 9°F).

4.5.5 Tarnish resistance (grade A only). Each item selected in accordance with 4.4.3 shall be tested for tarnish resistance. Failure of one or more of the test specimens shall reject the lot.

4.5.5.1 Method of test. Pipette one ml of 20 to 24 percent ammonium sulfide (light), reagent grade, into a one-liter volumetric flask. Fill to the mark with distilled water and agitate thoroughly. Place one drop of the solution on a specimen without tarnish resistant coating (grade B) and one drop on a specimen with supplementary tarnish-resistant-chromate treatment (grade A). The drop on the grade B specimen should begin to show a black or brown color in about one minute. The treated specimen shall conform to the requirements of 3.4.5.

4.5.6 Embrittlement relief test for steel parts (see 3.3.3).

4.5.6.1 Preproduction process qualification test for embrittlement (destructive tests). Four round notched steel specimens, with the axis of the specimen (load direction) perpendicular to the short transverse grain flow direction shall be selected from four individual heats (total of sixteen specimens). These specimens shall be prepared using the specific steel alloy for which preproduction qualification of the process is to be demonstrated. They shall be heat treated to the maximum tensile strength range representing production usage. The configuration shall be in accordance with figure 8 of ASTM E 8 for round 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 of the specimen's reduced section. The Vee shall have a 0.0100 inch (0.25 mm) ± 0.0005 inch (0.013 mm) radius of curvature at the base of the notch. The specimens shall be given the same pretreatments, electroplating and post plating treatments in accordance with the process proposed for production. The specimens shall be subjected to a sustained tensile load equal to 75 percent of the ultimate notch tensile strength of the unplated material for a minimum of 200 hours (see 6.2.1). The process shall be considered satisfactory if all specimens show no indication of cracks or failure. The test results and process control information shall be submitted to the procuring activity for approval. Until approval has been received, parts shall not be plated.
4.5.6.2 Production process control test for embrittlement (destructive tests). To assure adequacy of the procedures and operations employed for continuous production of high quality plating, four round notched steel specimens shall be prepared and tested as detailed in 4.5.6.1. Specimens may be from one or more heats. The results of tests made to determine conformance to definite contracts or purchase orders are acceptable as evidence of the properties being obtained during production.

4.5.7 Workmanship. Each item selected in accordance with 4.4.2 shall be examined for compliance with each of the requirements of 3.2.2. If the number of nonconforming items equals or exceeds the rejection number for that sample, the lot shall be rejected.

4.6 Rejection.

4.6.1 Rejection by visual inspection, nondestructive thickness tests and roughness tests. Any item in the sample having one or more defects shall be rejected and if the number of defective items exceeds the acceptance number for that sample as specified in 4.4.2, the lot represented by the sample shall be rejected.

4.6.2 Rejection by adherence, destructive thickness, solderability, tarnish resistance and embrittlement relief tests. If any item in the sample selected in accordance with 4.4.3 fails the requirement for either adherence, thickness, solderability, tarnish resistance or embrittlement tests, the lot shall be rejected.

5. PACKAGING

5.1 Packaging, packing, and marking requirements are not applicable to this specification (see 6.4).

6. NOTES

6.1 Intended use. The following applications of various thicknesses of coating are submitted for informative purposes only and are not to be construed as mandatory requirements in the use of this specification.

- 0.0003" (0.008mm) - for articles such as terminals which are to be soldered
- 0.0005" (0.013mm) - for corrosion protection of nonferrous basis metals
- 0.005-0.010" (0.013-0.25mm) - for electrical contacts, depending on pressure, friction and electrical load
- 0.0005" (0.013mm) - for increasing the electrical conductivity of basis metals

6.1.1 For applications wherein corrosion protection is important, the use of an electrodeposited nickel undercoat will be advantageous.
6.1.2 Grade A silver plating with tarnish-resistant coating when produced using chromate-type supplementary dips have a low contact resistance in the order of 300 to 400 microhms per square inch (0.5 to 0.6 microhms per square mm). The items must be solderable with rosin cored solder.

6.1.3 The dimensional tolerance of most threaded articles, such as nuts, bolts, screws and similar fasteners with complimentary threads, normally does not permit the application of coating thickness much greater than 0.00015 inch (0.004 mm). The limitations of coating thickness on threaded fasteners imposed by dimensional tolerances (including class or fit) should be a subject for consideration wherever practicable, both by the manufacturer and the purchaser, to prevent the application of greater coating thicknesses than are generally permissible. If heavier coatings are required for satisfactory corrosion resistance, allowances must be made in the manufacture of threaded fasteners for the tolerance necessary for plate build-up.

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

(a) Title, symbol, and date of this specification.
(b) Type and grade of plating (see 1.2 and 6.3).
(c) Thickness, if other than specified (see 3.4.1).
(d) Surface roughness, if necessary (see 3.4.3).
(e) Solderability requirement, if necessary (see 3.4.4).
(f) Place of inspection and test.
(g) Methods of roughness and thickness measurements (see 4.5.3 and 4.5.1).
(h) Alternate adhesion test, if required (see 4.5.2.1)
(i) Packaging data (see 6.4).
(j) Embrittlement relief (see 3.3.3 and 4.5.6).
(k) Suitable undercoat (see 3.3.5).

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

(a) Hardness of steel parts (see 3.3.3).
(b) Heat treatment for stress-relief; whether has been performed or is required (see 3.3.2).
(c) Tensile loads required in embrittlement relief test, if applicable (see 4.5.6).

6.2.2 The manufacturer of the basis metal parts should provide the plating facility with notched tensile specimens (see 4.5.6) to be plated for conformance to 3.3.3 as required for production control (see 4.5.6.1) and lot acceptance (see 4.5.6.2).
6.3 Definition of types. For the purpose of this specification, matte (type I), semi-bright (type II), and bright (type III) deposits are defined as follows:

(a) Matte. Deposits without luster comparable to those normally obtained from a silver-cyanide plating solutions operated without the use of brighteners.
(b) Semi-bright. Semi-lustrous deposits comparable to those normally obtained from silver-cyanide plating solutions operated with brighteners.
(c) Bright. Sometimes obtained by polishing or by use of "brighteners".

6.3.1 Should the procuring agency desire a more specific requirement for luster or brightness the procuring agency should furnish the manufacturer with a suitable reference standard.

6.4 Packing information. If it is desired that the silver (grade B) remain in an unatmished state, the packaging of silver should be sufficiently tight to prevent the entrance of sulfur-bearing atmospheres. Since cardboard or chipboard containers, newspapers, and other paper stock ordinarily contain sufficient sulfur in a form to cause tarnishing of silver, packing materials, especially produced for silver, should be employed; or the packing material may be selected according to the following test:

A sample of the packing material in contact with silver-plated parts (grade B) is placed in a clean glass-stoppered bottle and heated in an oven at some elevated temperature such as 100°C (212°F) for approximately 24 hours. If the packing material is free of sulfiding sulfur compounds, there will be little or no tarnishing of the silver plated parts in contact with the packing material. An antitarnish packaging material is described in NNN-P-40.
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SILVER PLATING, ELECTRODEPOSITED; GENERAL REQUIREMENTS FOR

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 silver plate (see 6.1).

1.2 Classification.

1.2.1 Types.—Silver plating shall be of the following types, as specified (see 3.2.4 and 6.3):
   Type I.—Matte.
   Type II.—Semi-bright.
   Type III.—Bright.

1.2.2 Grades.—Silver plating shall be of the following grades, as specified (see 3.3.5 and 6.1.3):
   Grade A.—With supplementary tarnish-resistant treatment (chromate treated).
   Grade B.—Without supplementary tarnish-resistant treatment.

2. APPLICABLE SPECIFICATIONS AND STANDARDS

2.1 The following specifications and standards, of the issues in effect on date of invitation for bids, form a part of this specification.

Military Specifications:
   MIL-F-20329 — Flux, Soldering, Non-Corrosive.

Military Standards:
   MIL-STD-105 — Sampling Procedures and Tables for Inspection by Attributes.

(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, Standards, and Handbooks 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 25, D. C.

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3. REQUIREMENTS

3.1 Materials.—The materials used shall produce platings which meet the requirements of this specification.

3.2 General requirements.

3.2.1 Unless otherwise specified, the plating shall be applied after all basis-metal heat treatments and mechanical operations such as
3.2.2 The basis metal shall be free from visible defects that will be detrimental to the appearance or performance of the plating. Articles shall be cleaned, pickled, and plated as required to produce deposits as specified herein. Harmful basis-metal defects that are revealed during any of the pretreatment and plating processes shall be cause for rejection of the part.

3.2.3 The final silver deposit shall be preceded by an electrodeposited coating of silver from silver strike solution(s). An undercoat of nickel, copper, or other suitable initial deposit may be used on the basis metal as required (see 6.1.2).

3.2.4 If the type of silver plating is not specified, either type I, II, or III will be acceptable.

6 All steel parts having a hardness greater than Rockwell C 40 shall be given a suitable stress-relief heat treatment prior to cleaning and plating if they contain objectional residual stresses. The temperature shall be such that maximum stress relief is obtained without reduction in hardness to less than the specified minimum.

3.2.6 Steel springs and other steel parts subject to flexure or repeated impact and of hardness greater than Rockwell C 40 shall be heated at 191° ± 14° C. (375° ± 25° F.) for 3 hours after all plating. Hardened parts which have been heat treated at less than 191° C. (375° F.), including carburized parts, shall not be heated as above but treated by any method approved for such parts by the contracting agency. Plated springs shall not be flexed prior to the baking operation.

3.2.6.1 When approved by the procuring agency, the plated articles described above need not be heat treated as above if the pretreatment and plating processes used have been demonstrated not to have harmfully affected the performance of the plated articles.

3.3 Detail requirements.

3.3.1 Thickness of plating.—Unless otherwise specified, the minimum plating thickness shall be 0.0005 inch on all surfaces on which silver is functionally necessary (for example: appearance, wear, corrosion protection, conductivity). All visible surfaces which can be touched by a ball 0.75 inch in diameter shall be measured in accordance with 4.5.1. Unless otherwise specified, interior surfaces and similar inaccessible areas which cannot be touched by the 0.75-inch-diameter ball (holes or recesses which cannot be plated with a controlled deposit) shall be exempt from the minimum thickness requirement. However, the plating on such surfaces and areas shall be of sufficient thickness to ensure plating continuity and uniform utility, appearance, and protection. On ferrous surfaces the total plated thickness shall be not less than 0.001 inch. This must be comprised of at least 0.0005 inch or more of silver plate over 0.0005 inch or less of nickel or copper or any combination thickness of nickel and copper from 0 percent to 100 percent. The copper shall be deposited first over the steel surface.

3.3.2 Adhesion.—The adhesion of the silver plating and any undercoat(s) shall be such that when examined at a magnification of approximately four diameters neither the silver plating, nor any electrodeposited undercoat(s), shall show separation from the basis metal or from each other at their common interface(s) when subjected to the test specified 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 considered as nonconformance to this requirement.
3.3.3 Roughness.—If a certain degree of surface roughness of the finished article is required, the standards and degree of roughness shall be as specified in the order or contract. Methods of measuring surface roughness shall be approved by the procuring agency.

3.3.4 Solderability.—When specified in the contract or drawings that the part is to be soldered, the silver plate shall be easy to solder according to procedures specified in 4.5.4. The soldered coating shall “wet” evenly without lump formation and shall not flake or peel when the part is tested as specified in 4.5.4.

3.3.5 Tarnish resistance, grade A only. — The electrodeposited silver plate shall be made tarnish resistant by treating with a chemical solution (see 6.1.3). The tarnish resistance shall be such that the plating shall withstand the test specified in 4.4.4 for a minimum of five minutes. Organic coatings shall not be applied to the electrodeposited silver for the purpose of meeting this requirement.

3.4 Workmanship.—Silver plating shall be smooth, fine grained, adherent, and free from visible blisters, pits, nodules, porosity, and indications of burning, excessive edge build-up, and free from other detrimental defects. Superficial staining shall not be cause for rejection.

4. SAMPLING, INSPECTION, AND TEST PROCEDURES

4.1 Unless otherwise specified, the supplier is responsible for the performance of all inspection requirements prior to submission for Government inspection and acceptance. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the Government. Inspection records of the examinations and tests shall be kept complete and available to the Government.

4.2 Lot.—A lot shall consist of plated articles of the same type, plated under similar conditions, of approximately the same size and shape, and submitted for inspection at one time.

4.3 Sampling.

4.3.1 Separate specimens. — When the plated articles are of such form as to be not readily adaptable to a test specified herein, or at the discretion of the inspector for destructive tests for the sampling of small lot sizes, the test may be made by the use of separate specimens 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, condition, heat treatment, 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 hot 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 strips approximately 1 inch wide, 4 inches long and 0.04 inch thick for adhesion tests but shall be at least 4 inches wide, 6 inches long and approximately 0.04 inch thick for all other tests. These specimens shall be introduced into a lot at regular intervals prior to the cleaning operations before plating and shall not be separated therefrom until after completion of the processing. Conditions affecting the plating of the specimens, including spacing and positioning with respect to anodes and to other objects being plated, shall correspond as nearly as possible to those affecting the significant surfaces of the articles represented.

4.3.2 Sampling for visual inspection, thickness (nondestructive tests) and roughness.—Samples shall be selected at random from each inspection lot in accordance with Military Standard MIL-STD-105 and Acceptable Quality Level (AQL) equal 1.5 percent defective.
4.3.3 Sampling for adhesion, thickness (destructive tests), solderability, and tarnish resistance.—A sample of 4 items shall be selected at random from each lot or 4 separately plated specimens shall be prepared as specified in 4.3.1 to represent the lot. If the number of items in a lot is 4 or less, the number of items in the sample shall be determined by the procuring agency.

4.4 Testing.—The inspection and testing of silver plate shall be for the acceptance of individual lots and shall consist of tests for all requirements specified in section 3.

4.5 Test methods.

4.5.1 Thickness.—Separate specimens (see 4.3.1) shall not be used for thickness measurements unless a need for such measurements has been shown. The specific method and equipment used shall be such that the coating thickness will be determined within 10 or minus 10 percent of its true thickness. Measurements shall be made by the microscopic method, instrument method, or by measurements made at the same points before and after plating with a micrometer caliper or other suitable mechanical gauge except that for referee tests the microscopic method shall be used. Measurements on threaded fasteners shall be made on the shank or other smooth surfaces as close to the threads as possible. The method or instrument used for determining the coating thickness shall be of a type approved by the procuring agency.

4.5.1.1 Nondestructive tests for thickness.—Each item in the sample selected in accordance with 4.3.2 shall be measured for plating thickness. The measurements shall be made in several representative locations on each item and the item shall be considered defective if one or more of the measurements fail to meet the specified minimum thickness.

4.5.1.2 Destructive tests for thickness.—Each item selected in accordance with 4.3.3 shall be tested in several locations by one of the following test methods for thickness. If the plating thickness at any one place on any one item is less than the specified minimum, the lot shall be rejected.

4.5.1.2.1 Microscopic method.—The specimen shall consist of a right-angle cross section of a selected surface suitably mounted and ground polished. The polished surface shall be etched with a suitable reagent to differentiate the silver plating from the basis metal. The thickness of coating at any desired point on the exposed section shall be measured by either of the methods described below. One or more test specimens may be held in a clamp or the specimens may be mounted in a plastic material such as a phenolic or acrylic resin. In mounting, care shall be taken that voids do not form between the specimen and the mounting material. The specimen shall be held rigidly and in such a position that the surface to be tested is perpendicular to the flat face that is to be ground and polished. (A deviation of 10° from normal introduces an error of about 2 percent in thickness.) The pieces shall be plated first with a relatively thick coating of copper to protect the edges during grinding and polishing. The first layer of copper shall be deposited from a cyanide solution, after which, if desired, an acid-copper solution may be used. The section to be examined shall be ground and polished by regular metallographic methods, using successively finer abrasives, the last of which shall not be coarser than 500 mesh. The polishing shall be continued with minimum pressure in the direction from the hard base metal to the soft coating and alternately at 45° and 135° to the plated surface.

4.5.1.2.1.1 The thickness shall be measured with a filar micrometer ocular that has been calibrated against a standard scale. The accuracy of the calibration shall be within plus or minus 2 percent.

4.5.1.2.1.2 The image of the specimen shall be projected at a known magnification on the
ground-glass focusing plane of the camera of a metallographic microscope. The width of the projected line of deposit, when measured with a graduated linear scale and divided by the magnification (for example, 500) gives the thickness of the coating.

4.5.1.2.2 Chord thickness method. — The chord method can be applied by just cutting through a coating on a flat surface with a grinding wheel of known radius or on a curved surface with a fine flat file. The thickness of the coating can be computed from the equation:

\[ T = \frac{C^2}{8R} \]

where \( T \) is the thickness, \( C \) is the chord (that is the width of cut where the basis metal is just exposed) and \( R \) is the radius of the grinding wheel or of the curvature of the surface tested. The width of cut may be measured with a steel scale graduated to 0.01 inch with the aid of a lens with a magnification of about 12 diameters. The chord should be measured with a precision of at least 5 percent and the radius of the grinding wheel or the curvature of the surface should be known to within 2 percent in order to obtain the thickness with an accuracy of plus or minus 10 percent. The chord method is not accurate for thin coatings and may not be used for coating thickness less than 0.00020.

4.5.1.2.2.1 Measurement of coating thickness on curved surfaces. — The coating is rubbed through with a fine flat file (No. 6) until the basis metal is just exposed. The file must travel in a plane and must not “rock”. Rocking can be prevented by attaching to a vise which holds the specimen, a steel support that is level with the surfaces to be tested and a few inches away. The file rests on this support and the article is thus kept in a plane.

4.5.1.2.2.2 Measurement of coating thickness on flat surfaces. — For measuring thick-ness on nearly flat surfaces, a precision surface grinder with a magnetic chuck is convenient for steel basis metal. A 6- or 8-inch grinding wheel (radius equals 3 or 4 inches) with a face 0.15 to 0.5 wide is usually satisfactory. For soft basis metals, or for soft coatings such as silver, a coarser-grained wheel (such as 90-grain Norton 3890) is most suitable in respect to filling up and dragging of the metal. The wheel radius should be measured to within about 2 percent. The wheel must revolve rapidly (at about 3,000 r.p.m.). The surface of the wheel should be dressed at intervals with a diamond to keep it cylindrical. Precise feed of the wheel is necessary to make sharp cuts. It is essential that the specimen be held very rigidly. Steel pieces can be usually held directly on the magnetic chuck and nonferrous metals by clamps. For flat surfaces, the surfaces are tilted slightly by putting a piece of paper under one edge of the chuck in order to taper the cut and render it easy to determine where the base metal is just exposed.

4.5.1.2.2.3 Measurement of multiple-coating thickness.—With multiple coatings, the thickness of each layer is computed from width of cut when the next layer is just exposed.

4.5.1.2.3 Determination of the weight of silver and average coating thickness.—The average thickness method may be used for large production runs of identical articles. The distribution of plating thickness should be first established by other thickness methods to determine the location of minimum coating thickness. From such data average thickness requirements shall be established for the basis of acceptable minimum thickness.

4.5.1.2.3.1 On nickel silver, copper-nickel alloys, copper, brass or similar high-copper alloys.—The articles shall be thoroughly cleaned of grease by washing with an alkaline solution; e.g., 4 ounces of trisodium phosphate (Na₃PO₄·12H₂O), per gallon of water
maintained at 180° to 200° F. The articles are then rinsed in water, dried with alcohol, acetone, or ether, and weighed. They shall then be suspended with an iron wire or iron hook and introduced into a suitable vessel containing a mixture of 19 parts by volume of C. P. concentrated sulphuric acid (sp. gr. 1.84) and 1 part by volume of C. P. concentrated nitric acid (sp. gr. 1.42) which has been heated (e.g., on a sand bath) to 80° C. (176° F.). (The stripping bath should be kept covered when not in use, to prevent absorption of water.) The articles shall be kept in the solution until all the silver is dissolved as indicated by the production of a dark color over the entire surface. They shall then be thoroughly rinsed, dried, and reweighed, and the loss in weight calculated as silver. The area stripped shall be measured for calculation of coating thickness. Calculate the average thickness of coating as follows:

Average thickness =

\[
\text{Loss in weight (in grams) } \times 0.10
\]

\[
\frac{10.5 \times \text{area (in square decimeters)}}
\]

Average thickness in inches =

\[
\text{Average thickness in mm. } \times 0.03937.
\]

Area, if measured in square inches, may be converted to square decimeters by multiplying the number of square inches by 0.0645.

4.5.1.2.3.2 On Britannia metal, iron, carbon steel, nickel and nickel underplate.—The articles shall be cleaned, dried, and weighed as in 4.5.1.2.3.1 then hung suspended on iron wires as anodes in a solution containing 30 grams per liter (4 oz./gal.) of sodium cyanide, in which a silver cathode is suspended. Current densities may be from 10 to 20 amperes per square foot. The higher current densities are preferable for coating on nickel or nickel underplate. The potential use will depend upon the distance of the work from the cathode and the resistivity of the solution which changes as the silver content is increased. Considerably more silver can be recovered with the consumption of a given amount of chemicals if the work is slowly moved, rather than agitated, until all the silver is dissolved. The articles shall be then rinsed, dried, and weighed, and the loss in weight considered as silver. Coating thicknesses are calculated as described in 4.5.1.2.3.1.

4.5.2 Adhesion.—Each item selected in accordance with 4.3.3 shall be tested for adhesion. The items used for the thickness test of 4.5.1 may be used for the adhesion test if the items are of suitable size and form. Failure of one or more of the test specimens shall reject the lot.

4.5.2.1 Method of test.—The test specimens shall be bent repeatedly through an angle of 180° on a diameter equal to the thickness of the specimen until fracture of the basis metal occurs. Following fracture of the basis metal, it shall not be possible to detach any areas of the coatings with a sharp instrument. When the plated articles are not readily adaptable to the bend test, adhesion may be determined on the plated article by cutting the plating from the basis metal at the interface(s) in a continuous path, and examining at four diameters magnification to determine whether removal has been caused by the cutting away of an adherent plate or by the lifting of a non-adherent plate. At the option of the procuring agency, an alternate adhesion test may be used. In this test, parts are placed in an oven and heated at 150° to 200° C. (302° to 392° F.). This temperature shall be maintained long enough to bring the items to temperature and then continued for 30 minutes. The test specimens shall be removed, cooled in air and examined at four diameters magnification for evidence of blistering of the silver deposit. Any blistering constitutes failure of the specimen.

4.5.3 Roughness.—Each item selected in accordance with 4.3.2 shall be measured for the specified degree of roughness. Measurements shall be made at several locations on
NOTES

6.1 Intended use.—The following applications of various thicknesses of coating are submitted for informative purposes only and are not to be construed as mandatory requirements in the use of this specification:

0.0003—for articles such as terminals which are to be soldered

0.0005—for corrosion protection of non-ferrous basis metals

0.0005–0.010—for electrical contacts, depending on pressure, friction and electrical load

0.0005—for increasing the electrical conductivity of basis metals

6.1.1 For applications wherein corrosion protection is important, the use of an electrodeposited nickel undercoat will be advantageous.

6.1.2 Copper-alloy-basis metal articles on which a nickel undercoat is not used and for basis metals wherein a copper undercoat is employed should not be used for continuous service at a temperature in excess of 300° F. Adhesion of the silver plating is adversely affected because of a development by diffusion, of a weak eutectic of silver and copper at the basis-metal-coating interface.

6.1.3 Grade A silver plating with tarnish-resistant coating when produced using chromate-type supplementary dips have a low contact resistance in the order of 300 to 400 microhms per square inch. The items are easily soldered with rosin cored solder.

6.2 Ordering data. — Procurement documents should specify the following:

a. Title, symbol, and date of this specification.

b. Type and grade of plating (see 1.2 and 6.3).

c. Thickness, if other than specified (see 3.3.1).

d. Surface roughness, if necessary (see 3.3.3).

e. Soldering requirement, if necessary (see 3.3.4).

f. Place of inspection and test.

g. Methods of roughness and thickness measurements (see 4.5.3 and 4.5.1).

h. Packaging data (see 6.4).

6.3 Definition of types.—For the purpose of this specification, matte (type I), semi-bright (type II), and bright (type III) deposits are defined as follows:

a. Matte—Deposits without luster, normally obtained from silver-cyanide plating solutions operated without the use of brighteners.

b. Semi-bright — Semi-lustrous deposits normally obtained from silver-cyanide plating solutions operated with brighteners.

c. Bright—Sometimes obtained by polishing or by use of “brighteners”.

6.3.1 Should the procuring agency desire a more specific requirement for luster or brightness the procuring agency should furnish the manufacturer with a suitable reference standard.

6.4 Packaging information.—If it is desired that the silver (grade B) remain in an un tarnished state, the packaging of silver-plated parts for storage and shipment is important. The container should be sufficiently tight to prevent the entrance of sulfur-bearing atmospheres. Since cardboard or chipboard containers, newspapers, and other paper stock ordinarily contain sufficient sulfur in a form to cause tarnishing of silver, packing materials, especially produced for silver, should be employed; or the packing material may be selected according to the following tests:

A sample of the packing material in contact with silver-plated parts (grade B) is placed in a clean glass-stoppered bottle and
heated in an oven at some elevated temperature such as 100° C. (212° F.) for approximately 24 hours. If the packing material is free of sulfiding sulfur compounds, there will be little or no tarnishing of the silver-plated parts in contact with the packing material.

Notice. — When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

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Navy—Sh A
Air Force.
each item. Measurements shall be made by techniques approved by the procuring agency such as the Proflometer, Brush Surface Analyzer, or other suitable means. The item shall be considered defective if one or more of the measurements fail to meet the roughness requirement. If the number of nonconforming items equals or exceeds the rejection number for that sample, the lot shall be rejected.

4.5.4 Solderability.—Each item in the sample of 4.3.3 shall be tested for solderability. The items used for the thickness and adhesion tests of 4.5.1 and 4.5.2 may be used for the solderability test if the items are of suitable size and form. Failure of one or more of the test specimens shall reject the lot.

4.5.4.1 Method of test. — Test specimens shall be suitably fluxed with a noncorrosive flux conforming to type IV of Military Specification MIL-F-20329 and then immersed in a solder composed of 40 percent tin and 60 percent lead for 3 seconds at a solder-pot temperature of 288° ± 5°C. (550° ± 9°F.), removed, and shaken lightly to remove excess of solder. The soldered coating shall adhere evenly without lump formation and shall not flake or peel when the specimen is subjected to the bend test specified in 4.5.2.1. This test shall be performed as soon as practical after plating. It shall not be performed on items which display visible signs of corrosion. The test shall not be performed on massive items which would heat up too slowly. Special 1/8-inch-thick specimens of the same alloy and pretreatment shall be plated concurrently and used to represent such massive items.

4.5.5 Tarnish resistance (grade A only).—Each item selected in accordance with 4.3.3 shall be tested for tarnish resistance. Failure of one or more of the test specimens shall reject the lot.

4.5.5.1 Method of test.—Pipette one ml. of 20 to 24 percent ammonium sulfide (light), reagent grade, into a one-liter volumetric flask. Fill to the mark with distilled water and agitate thoroughly. Place one drop of the solution on a specimen without tarnish resistant coating (grade B) and one drop on a specimen with complementary tarnish-resistant-chromate treatment (grade A). The drop on the grade B specimen should begin to show a black or brown color in about one minute. The treated specimen shall conform to the requirements of 3.3.5.

4.5.6 Workmanship.—Each item selected in accordance with 4.3.2 shall be examined for compliance with each of the requirements of 3.4. If the number of nonconforming items equals or exceeds the rejection number for that sample, the lot shall be rejected.

4.6 Rejection.

4.6.1 Rejection by visual inspection, nondestructive thickness tests and roughness tests.—Any item in the sample having one or more defects shall be rejected and if the number of defective items exceeds the acceptance number of the appropriate sampling plan of Military Standard MIL-STD-105, the lot represented by the sample shall be rejected.

4.6.2 Rejection by adhesion, destructive thickness, solderability or tarnish resistance tests.—If any item in the sample selected in accordance with 4.3.3 fails the requirement for either adhesion, thickness, solderability or tarnish resistance the lot shall be rejected.

4.7 Retests.—Plated articles which have been rejected or withdrawn because of the presence of plating defects, determined as the result of nondestructive tests, may be resubmitted after stripping and replating or after screening of the entire lot. Complete details of the replating shall be furnished to, and be approved by, the inspector or procuring agency.

5. PREPARATION FOR DELIVERY

5.1 Packaging, packing, and marking requirements are not applicable to this specification (see 6.4).