

MIL-C-14550B

2 December 1983

SUPERSEDING

MIL-C-14550A

14 July 1970

## MILITARY SPECIFICATION

## COPPER PLATING, (ELECTRODEPOSITED)

This specification is approved for use by the Army Materials and Mechanics Research Center, Department of the Army, and is available for use by all Departments and Agencies of the Department of Defense.

## 1. SCOPE

1.1 Scope. This specification covers electrodeposited copper plating on metal surfaces.

1.2 Classification. Copper plating covered by this specification shall be of the following classes as specified:

- Class 0 - 0.00100-0.00500 inch thick
- Class 1 - 0.00100 inch thick (min.)
- Class 2 - 0.00050 inch thick (min.)
- Class 3 - 0.00020 inch thick (min.)
- Class 4 - 0.00010 inch thick (min.)

## 2. APPLICABLE DOCUMENTS

2.1 Government documents.

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

## SPECIFICATION

## FEDERAL

QQ-S-571 - Solder, Tin Alloy, Lead-Tin Alloy and Lead Alloy

## MILITARY

MIL-F-14256 - Flux, Soldering, Liquid (Rosin Base)

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Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Director, US Army Materials and Mechanics Research Center, ATTN: DRXMR-SMS, Watertown, MA 02172 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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STANDARDS

MILITARY

- MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes
- MIL-STD-202 - Test Methods for Electronic and Electrical Components Parts

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

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. The issues of the documents which are indicated as DoD adopted shall be the issue listed in the current DoDISS and the supplement thereto, if applicable.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

- B487 - Metal and Oxide Coating Thickness by Microscopical Examination of a Cross-Section, Method of Measuring
- B499 - Coating Thicknesses by the Magnetic Method; Non-magnetic Coatings on Magnetic Basis Metals, Method of Measuring of
- E8 - Tension Testing of Metallic Materials

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

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

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

3. REQUIREMENTS

3.1 Materials. The materials used for electroplating shall produce coatings which meet the requirements of this specification.

3.2 Basis material. The basis material shall be free from defects that will be detrimental to the utility, form, fit, function or the protective value of the plating.

3.3 Preplating operations. Unless otherwise specified in the contract or order, the plating shall be applied after all machining, brazing, welding, forming and perforating of the article has been completed.

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3.4 Post plating removal of plating salts. Copper plating shall not be applied to assemblies which will entrap the plating bath in edges, joints or recesses and cannot be removed. Such parts shall be plated prior to assembly. Residual plating shall be removed from plated articles by soaking after plating for a minimum of 3 minutes in clean hot water (93° to 100°C-200° to 212°F).

3.5 Equipment and process. The articles to be plated shall be subject to such cleaning, pickling and plating procedures as are necessary to yield a coating as hereinafter specified. Acid pickling on high strength steels shall be prohibited.

3.6 Stress relief treatment. All steel parts shall be given a stress relief treatment at a minimum of 191° + 14°C (375° + 25°F) for 3 hours or more prior to cleaning and plating if they contain or are suspected of having residual tensile stresses caused by machining, grinding or cold forming operations. Parts which are cold straightened are considered to contain damaging residual tensile stresses. The temperature and time at temperature shall be such that maximum stress relief is obtained without reduction in hardness to less than the specified minimum.

3.7 Hydrogen embrittlement relief. All steel parts having a tensile strength greater than 210 Ksi (HR<sub>C</sub> of 44) shall be baked at 191 + 14°C (375 + 25°F) for 24 hours within 4 hours after plating to provide hydrogen embrittlement relief. Plated springs and other parts subject to flexure shall not be flexed prior to the baking operations.

3.8 Thickness of plating. Unless otherwise specified, the thickness of the copper shall be as specified in table I on all visible surfaces which can be touched by a ball 0.75 inch diameter. The thickness of plating on surfaces which cannot be touched by a ball 0.75 inch in diameter should be sufficient for plating continuity and uniform appearance (see 6.2).

TABLE I. Thickness

Class	Thickness (min. unless a range is specified)
	<u>Inch</u>
0	0.00100-0.00500
1	0.00100
2	0.00050
3	0.00020
4	0.00010

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3.9 Solderability. Where required by the procuring activity, plated specimens or parts shall be easily and completely coated with solder when tested as specified in 4.5.4. The solder shall be deposited uniformly without lumps or peaks and shall be essentially free from evidence of blistering, bubbling, foaming, voids and other defects. The solder shall firmly adhere to the plating and the plating shall be firmly adherent to the basis metal. There shall be no separation at the solder-plating interface, or at the plating-basis metal interface, so that they cannot be lifted when a sharp edged instrument is applied.

3.10 Adhesion. The adhesion of the plating shall be such that when examined at a magnification of four diameters, it does not show separation from the basis metal at the interface when subjected to the test specified in 4.5.2. The interface between the copper 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 failing this requirement.

3.11 Workmanship. The copper plating shall be smooth, fine grained, adherent, free from blisters, pits, scale, nodules and other defects which are detrimental to the utility, form, fit or function of the part.

#### 4. QUALITY ASSURANCE PROVISIONS

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

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

#### 4.3 Sampling.

4.3.1 Visual inspection and nondestructive thickness measurement. Representative samples from each lot shall be selected in accordance with MIL-STD-105, inspection level II, with acceptable quality level equal to 1.5 percent defective to verify compliance with all requirements of this specification for visual examination and nondestructive tests for plating thickness.

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4.3.2 Destructive tests for plating thickness, adhesion, solderability, and hydrogen embrittlement. A random sample of four items shall be selected from each lot or four separately plated specimens shall be prepared to represent the lot for each destructive test. If the number of items in the inspection lot is 4 or less, the number of items in the sample shall be determined by the procuring agency. Separate specimens shall not be used for thickness measurements unless a need has been demonstrated. The articles or specimens used for the destructive thickness test, if of suitable size and form, may be used as the specimens for the adhesion test. Failure of any sample to conform to the applicable tests shall reject the lot represented.

4.3.3 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 the 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, heat treated condition and finish of surface prior to plating. For example, a cold-rolled steel surface shall 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 shall be used to represent forged and cast-steel articles. Also, separate specimens should be cut from scrap castings when ferrous alloy castings are being plated. These 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 and positioning in 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.

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

4.3.3.2 For embrittlement relief. Testing for hydrogen embrittlement relief (see 3.7) on parts which will be subjected to a sustained tensile load in use shall be made on separate specimens. When hydrogen embrittlement relief testing is specified (see 6.2) for those parts which will be subjected to a sustained tensile load in use, separate specimens, if required, shall be prepared. They shall be round notched specimens with the axis of the specimen (load direction) perpendicular to the short transverse grain flow direction. The configuration shall be in accordance with figure 8 of ASTM E8 for rounded specimens. Specimens shall have a 60° V-notch located approximately at the center of the gage length. The cross section area at the root of the vee shall be approximately equal to half the area of the full cross section area of the specimen's reduced section. The vee shall have a  $0.010 \pm 0.0005$  inch radius of curvature at the base of the notch.

#### 4.4 Inspection.

4.4.1 Visual inspection. The number of items indicated in 4.3.1 shall be taken at random from the lot to be inspected and examined visually to ensure compliance with requirements of 3.11. If the number of nonconforming items in any sample exceeds the acceptance number for that sample, the lot represented by that sample shall be rejected.

#### 4.5 Test methods.

4.5.1 Thickness test. Measurements should be made in accordance with ASTM method B487 or method B499. At the option of the supplier, instruments which use the principal of beta-radiation back scatter may also be employed for thickness measurements.

4.5.2 Adhesion test. Wherever possible the test shall be made on a specimen representing the basis material which can be bent 180°. The article or test specimen shall be clamped in a vise and the projecting portion bent back and forth until rupture occurs, or specimens shall be bent repeatedly over a mandrel until rupture occurs. Following fracture of the basis metal, it shall not be possible to detach any appreciable area of the coating with a sharp instrument.

4.5.2.1 When the plated articles are not readily adaptable to the bend test, adhesion may be determined on the plated article or on a plated sample representative of the plated article (see 4.3.2) by cutting the plating from the basis metal at the interface in a continuous path. The plate shall then be examined 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 nonadherent plate.

4.5.3 Embrittlement relief. When specified (see 6.2), samples of parts for determining compliance with 3.7 shall be taken as specified in 4.3.2. ~~Parts such as spring pins, lock rings, etc., which are installed in holes or rods~~ shall be similarly assembled using the applicable parts specifications or drawing tolerances which impose the maximum sustained tensile load on the coated part. The selected samples shall be subjected to a sustained tensile load equal to 115 percent of the maximum design load for which the part was designed. Parts which require special fixture, extreme loads to comply with the above requirements, or where the maximum design load is not known, may be represented by separate specimens prepared in accordance with 4.3.2 and 4.3.3. The notched specimens shall be subject to sustained tensile load equal to 75 percent of the ultimate notch tensile strength of the material. Unless otherwise specified, the articles, parts or specimens shall be held under load for at least 200 hours and then examined visually for cracks or fractures.

NOTE: frequency of testing may be held to monthly when satisfactory results are being obtained, otherwise testing shall be as outlined in 4.3.2.

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4.5.4 Solderability. Solderability shall be determined where required (see 6.2) by coating with a flux conforming to type R of MIL-F-14256D and then partially immersing in a solder conforming to composition SN 60 of QQ-S-571 for 3 seconds at a solder pot temperature of  $450 \pm 25^{\circ}\text{F}$  ( $232 \pm 14^{\circ}\text{C}$ ). The specimen or part shall be preheated prior to immersion or held in the bath until the specimen or part reaches pot temperature. A mechanical dipping device, similar to that detailed in method 208 of MIL-STD-202, may be used to immerse the part or specimen at the rate of  $1 \pm 1/4$  inch per second. Upon removal, the specimen or part shall be shaken lightly to remove excess solder and allowed to cool in air. After examination, the article or specimen shall be subjected to the bend test detailed in 4.5.2.

4.5.5 Retests. Plated items which have been rejected or withdrawn because of the presence of plating defects may be resubmitted after stripping and replating or after screening of the entire lot. Complete details of replating shall be furnished to, and by approved by, the procuring activity.

## 5. PACKAGING

5.1 Packaging requirement. There are no packaging, packing or marking requirements applicable to this specification.

## 6. NOTES

6.1 Intended use. The copper plating classes are intended for such applications as the following

- Class 0 - 0.00100-0.00500 inch for heat treatment stop-off shield.
- Class 1 - 0.00100 inch for carburizing shield, decarburizing shield and printed circuit board plated through holes or as specified on the engineering drawing.
- Class 2 - 0.00050 inch as undercoating for nickel and other metals.
- ~~Class 3 - 0.00020 inch to prevent basis metal migration into tin layer to poison solderability.~~
- Class 4 - 0.00010 inch same as 0.00020 inch.

6.2 Ordering data. Procurement documents should specify the following:

- (a) Title, number and date of this specification.
- (b) Class as required (see 1.2).
- (c) Exact thickness for class 0 commensurate with heat treat case thickness and furnace environment.
- (d) Thickness of plating on surfaces which cannot be touched by a ball 0.75 inch diameter, i.e., where holes on printed circuit boards are required to be plated to meet electrical conductivity and solderability requirements (see 3.8).
- (e) When embrittlement relief test is not required (see 4.5.3).
- (f) Whether solderability test is required (see 4.5.4).

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

- (a) Hardness of steel parts.
- (b) Whether heat treatment for stress relief has been performed or is required.
- (c) Ultimate use and tensile loads.

**Custodians:**

Army - MR  
Navy - AS  
Air Force - 20

**Preparing activity:**

Army - MR

**Project No. MFFP-0156**

**Review activities:**

Army - AL, AR  
Navy - SH, EC  
Air Force - 20

**User activity:**

Army - M1  
Navy - SH

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