

7 June 1983

SUPERSEDING

MIL-G-45204B

27 March 1969

*w/Amendments 1, 2 & 3*

## MILITARY SPECIFICATION

## GOLD PLATING, ELECTRODEPOSITED

This specification is approved for use by all Departments and Agencies of the Department of Defense.

## 1. SCOPE

1.1 Scope. This specification covers electrodeposited gold plating on metallic surfaces.

1.2 Classification. Gold plating shall be furnished in the following types and classes as specified (see 6.2).

1.2.1 Types (3.1).

Type I - 99.7 percent gold minimum  
 Type II - 99.0 percent gold minimum  
 Type III - 99.9 percent gold minimum

1.2.2 Grades. The following grades are assigned to the above types.

Grade A - Knoop hardness 90 max.  
 Grade B - Knoop hardness 91-129, incl.  
 Grade C - Knoop hardness 130-200, incl.  
 Grade D - Knoop hardness 201 and over.

If the hardness grade for the gold coating is not specified, Type I shall be furnished at hardness Grade A (90 Knoop, max) and Type II shall be furnished at hardness Grade C (130 to 200 Knoop).

1.2.2.1 Purity (type) and hardness (grade) relationship. The purity and hardness combinations shall be designated as follows:

<u>Purity</u>	<u>hardness (grades)</u>
Type I	A, B, or C
Type II	B, C, or D
Type III	A (only)

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 (LD Form 1426) appearing at the end of this document or by letter.

1.2.3 Classes. Unless otherwise specified, the thickness shall conform to the class designation specified (see 6.2).

Class 00 - 0.00002 inch thick, minimum  
Class 0 - 0.00003 inch thick, minimum  
Class 1 - 0.00005 inch thick, minimum  
Class 2 - 0.00010 inch thick, minimum  
Class 3 - 0.00020 inch thick, minimum  
Class 4 - 0.00030 inch thick, minimum  
Class 5 - 0.00050 inch thick, minimum  
Class 6 - 0.00150 inch thick, minimum

## 2. APPLICABLE DOCUMENTS

### 2.1 Government documents.

2.1.1 Specifications and standards. 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.

#### STANDARDS

##### MILITARY

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes  
MIL-STD-202 - Test Methods for Electronic and Electrical Component 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 B 487 - Measuring Metal and Oxide Coating Thicknesses by Microscopical Examination of a Cross Section

ASTM E 8 - Tension Testing of Metallic Materials

ASTM E 384 - Microhardness of Materials

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

### 3. REQUIREMENTS

3.1 Plating materials and processes. The materials and processes used shall produce coatings that meet the requirements of this specification. Either bright or matte deposits are acceptable unless otherwise specified (see 6.2).

3.2 Basis metal. The basis metal shall be free from defects, scratches, pits, nonconducting inclusions, and roll and die-marks that will adversely affect the appearance and the performance of coatings applied thereto despite the observance of the best plating practice.

3.2.1 Preplating operations. Unless otherwise specified in the contract or order, plating shall be applied after all basis metal heat treatments and mechanical operations such as machining, brazing, welding, forming, and impregnating have been completed. This requirement does not prohibit certain required operations after plating such as embrittlement relief, heat treatment and forming operations such as crimping electrical connections.

3.2.1.1 Unless otherwise specified in the contract or order, steel parts having an ultimate tensile strength of 220,000 psi or above shall not be plated without specific approval of the procuring activity.

3.2.2 Stress relief treatment. All steel parts shall be given a stress relief heat treatment at a range of  $375^{\circ} \pm 25^{\circ}\text{F}$  ( $191^{\circ} \pm 14^{\circ}\text{C}$ ) for 3 hours or more prior to cleaning and plating if they contain tensile stresses caused by machining, grinding, or cold forming operations. Parts which are cold straightened are considered to contain damaging stresses. The temperature and time at temperature shall be such that maximum stress relief is obtained without reducing the hardness below the specified minimum (see 6.2.1).

3.3 Pretreatment. Articles shall be cleaned, pickled, or otherwise pretreated as necessary. Acid pickling on high strength steels shall be prohibited.

3.4 Strikes. When gold plating is preceded by a strike, or a strike and underplate, it shall be as specified (see 6.2). For exterior use and when the basis metal is low alloy steel or other non-copper base metal such as zinc, the thickness of the strike and underplate shall be a minimum of 0.001 inch minus the thickness of the specified gold plating.

3.5 Plating equipment and processes. Unless otherwise specified in the contract or order, the plating equipment and process used shall be at the option of the supplier.

3.6 Plating properties.

3.6.1 Thickness. The minimum thickness of deposited gold on significant surfaces for each class of gold plating shall be as shown in 1.2.3. Significant surfaces shall be all surfaces of the article which can be touched by a sphere 0.75 inch in diameter plus additional functional surfaces specified on the applicable drawing (see 6.2). However, the plating on non-significant, nonfunctional surfaces shall be of sufficient thickness to ensure plating continuity and uniform appearance.

3.6.2 Adhesion. Adhesion of the gold plating and of any underplating shall be such that the coating and undercoating shall not separate from each other or from the basis metal when tested according to 4.5.2.

3.6.3 Hardness. The Knoop hardness of the coating shall conform to the grade as specified (see 1.2.2 and 6.2) and shall be determined in accordance with 4.5.3.

3.6.4 Heat resistance. When heat resistance is specified, gold plated parts shall show no blistering, discoloration, or visible white or crystalline film when tested in accordance with 4.5.4.

3.6.5 Smoothness. If a degree of surface smoothness of the finished article is required, the degree shall be specified in the contract or order. Methods for measuring surface smoothness shall be approved by the procuring activity.

3.6.6 Solderability. When solderability is required by the procuring activity, the gold plating shall meet the following solderability requirements. When the gold plating is subjected to the solderability test of 4.5.5, the solder coating shall be even, free from lumps and shall not flake or peel when subjected to the adhesion test of 4.5.2. For soldering and solderability protection, a thin high purity soft gold coating shall be used. A minimum thickness of 0.00005 inch and a maximum thickness of 0.00010 inch shall be plated.

3.6.7 Composition. The type gold (purity) shall be as specified (see 1.2.1).

3.6.7.1 Impurities.

3.6.7.1.1 Type I, grade A and type III. Metallic impurities such as chromium, copper, tin, lead, silver, cadmium, or zinc shall not be present in the deposit at a concentration greater than 0.1 percent. The percent by weight of iron, nickel, and cobalt combined shall be less than 0.050 and no one of these three elements shall be present in amounts greater than 0.030 percent by weight.

3.6.7.1.2 Type I, grades B and C and type II. Individual metallic impurities in the deposit shall not exceed 0.1 percent. Metallic hardening agents, which are purposely added to a bath are not to be considered impurities.

### 3.7 Postplating procedures.

3.7.1 Removal of plating salts. Residual plating salts shall be removed from the plated articles. Articles difficult to clean, as spot-welded articles or other prefabricated articles with lap seams or joints, shall be cleaned after plating in well-agitated hot water (200° to 212°F). If any blisters appear after cleaning, the plated article shall be considered defective.

3.7.2 Heating of hardened parts (embrittlement relief). All steel parts having a hardness of Rockwell C40 and higher shall be baked at  $375^{\circ} \pm 25^{\circ}\text{F}$  ( $191^{\circ} \pm 14^{\circ}\text{C}$ ) for 3 hours or more, within one hour after plating to provide hydrogen embrittlement relief. Plated springs or other parts subject to flexure shall not be flexed prior to baking operations. No plated part shall develop cracks or fail by fracture (see 4.5.6).

3.8 Workmanship. Gold plating shall be smooth, fine grained, adherent and free from exposed basis metal or underplate, visible blisters, pits, nodules, porosity, indications of burning, excessive edge buildup and other detrimental defects. Correction of a burned condition by burnishing or tumbling is not acceptable.

3.9 Identification marking. When specified, the plated articles shall be marked with a fluid which is not affected by water and which shall not rub off or smear during shipment or storage, or shall carry a tag giving the following information:

- (a) The basis metal
- (b) The type of gold plating
- (c) The grade of gold plating
- (d) The class of gold plating
- (e) The number of this specification
- (f) Strike, if used
- (g) Underplate, if used

## 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 articles of the same basis metal, type, grade, and class, plated under the same conditions and of approximately the same size and shape, submitted for delivery at one time. In no case shall the lot exceed production for one week.

#### 4.3 Sampling.

4.3.1 For visual examination. Representative samples from each lot shall be selected for examination of visual characteristics with lot acceptance based on the sampling inspection requirements in accordance with MIL-STD-105, inspection level III, with AQL equal to 1.0 percent defective.

4.3.2 For thickness, adhesion, hardness, heat resistance, embrittlement, and solderability. A representative sample shall be prepared in accordance with 4.3.2.1 or selected in accordance with MIL-STD-105, inspection level S-3 with an acceptance number of zero.

4.3.2.1 Separate specimens. When the plated articles are not suitable for a test specified herein or in sampling small size lots for destructive tests, tests may be made on separate specimens plated concurrently with the articles represented. Unless otherwise specified, at least two (2) specimens shall be used for each test and specimens may be used for more than one test where applicable. The separate specimens shall be prepared as follows except as modified in 4.3.2.1.1 and 4.3.2.1.2. The separate specimens shall be of a basis metal of the same chemical composition, temper, and surface finish as the articles represented. For still, rack or wire plating, the separate specimens shall be strips. Dimensions of the strip specimens shall be approximately 1 by 4 by 0.04 inch. All specimens shall be introduced into normal production at regular intervals and be pretreated, cleaned, plated, and processed with the articles comprising the lot. Conditions affecting plating of the specimens, such as 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. For barrel plating, rod specimens shall be used approximating the dimensions of the parts contained in the barrel, but of a size that can be easily separated from the bulk of the product.

4.3.2.1.1 Separate specimens for hardness. When separate specimens are prepared for hardness tests they shall be approximately 0.5 by 1 by 0.04 inch. The specimens shall be plated concurrently with the articles represented plus additional plating under the same conditions to a plating thickness necessary to accurately determine the Knoop hardness number. Plating thicknesses for measuring hardnesses shall be as follows:

Grades A and B	- 0.002 inch, min.
Grade C	- 0.001 inch, min.
Grade D	- 0.0005 inch, min.

All specimens must be overplated with at least 0.0005 inch of nickel or copper.

4.3.2.1.2 Separate specimens for embrittlement relief. Where separate specimens are to be subjected to the embrittlement test described in 4.5.6, separate test specimens shall be prepared of the same material, heat, and heat-treated to the same strength level and finish as the materials of the articles they represent. The configuration shall be in accordance with figure 8 of ASTM E8, for round specimens with the axis of the specimen perpendicular to the short transverse direction. Specimens shall have 60 degree V-notch with the area at the base of the Vee approximately equal to half the area of the full section of the specimen and  $0.010 \pm 0.0005$  inch radius of curvature at base of notch.

4.4 Visual examination. Each sample unit selected in accordance with 4.3.1 shall be visually examined for compliance with the requirements for removal of plating salts (see 3.7.1), workmanship (3.8), and identification marking (see 3.9). The procuring activity may specify that the samples shall be examined at four diameters magnification.

#### 4.5 Test procedures.

4.5.1 Thickness measurements. Thickness of the plating and strikes shall be determined by any method which will give results within  $\pm 10$  percent of the true thickness. With proper equipment, procedures, and reference standards, thicknesses can be determined within limitations as follows (see 6.4):

<u>Method</u>	<u>Thickness limitation</u>
Microscopic	100 microinches (0.0001 in.), minimum
Beta backscatter radiation	2000 microinches (0.002 in.), maximum
X-ray fluorescence	500 microinches (0.0005 in.), maximum

4.5.1.1 Microscopic test. Thickness shall be determined in accordance with ASTM B487 using the modifications shown in table I.

Table I. Modification in procedure for test method ASTM B487

Step in ASTM B487	Modification
Selection of section for test	Use a right angle cross section or longitudinal section.
Preparation of specimens	Plate the articles with a coating at least 0.001 inch thick of copper, nickel, or iron to protect the edges during grinding and polishing. The first layer or overplate shall be a copper strike deposited from a cyanide solution followed by the relatively thick overplate.
Preparation of section	Grind and polish, following the instructions for polishing zinc, cadmium, tin, and lead coatings.
Etching	Use an etching solution so as to obtain the maximum contrast between the coating and the adjacent metals. Obtain such contrast by etching either the coating or the adjacent metal by an appropriate reagent.
Procedure, Use of microscope	Using the metallographic microscope and a magnification of at least 1000 diameters, take a minimum of five measurements at random locations on each specimen. Measurements shall be expressed to five decimal places (0.00001 inch).

4.5.1.2 Beta-backscatter radiation. Thickness shall be determined with back scatter radiation instruments consisting of a source of beta-radiation and a detector, so arranged that the rays from the source are backscattered from the surface at which the coating is being measured. The detector shall convert the backscattered rays to the thickness or number which is a function of the thickness.

4.5.1.3 X-ray fluorescence. Thickness shall be determined with x-ray fluorescence instruments consisting of an x-ray source, dispersing crystal and detector so arranged that the x-rays generated within the sample are separated and measured. The detector shall convert the x-rays to the thickness or a number which is a function of the thickness.

4.5.2 Adhesion tests. Adhesion of test specimens shall be performed at room temperature by means of the bend test (see 4.5.2.1) unless the plated articles are not readily adaptable. When not readily adaptable to the bend test, adhesion of the plated articles shall be determined by means of the cutting test or by the baking test.

4.5.2.1 Bend test. Plated articles 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. No detachment of the coating shall be possible by probing with a sharp instrument. Cracks in the basis metal or plating shall not be considered failure unless accompanied by flaking, peeling or blistering. Examination shall be at 4 diameter magnification.

4.5.2.2 Cutting test. The adhesion of plated articles shall be determined by cutting the plating from the basis metal at the interface(s) with the sharp instrument. The specimens shall be visually examined at four diameter magnification to determine whether removal has been caused by cutting away of an adherent plate or lifting of a non-adherent plate.

4.5.2.3 Baking test. The adhesion shall be determined by heating the plated articles at 250° to 300°F for one hour. After removal and cooling, the surface of the articles shall be examined at four diameter magnification for any evidence of flaking, peeling or blistering.

4.5.3 Hardness. The hardness shall be determined on the cross section of the plating by the use of the Knoop hardness tester using a test load of 25 grams, in accordance with ASTM Method E 384. The Knoop hardness may be determined perpendicular to the plated surface if the thickness of the plate is at least 10 times the depth of the Knoop indentation.

4.5.4 Heat resistance. The heat resistance of gold plated articles shall be determined by subjecting samples selected in accordance with 4.3.2 to a temperature of 500°  $\pm$  25°F for not less than 30 minutes and examining for compliance with 3.6.4.

4.5.5 Solderability test. When samples selected in accordance with 4.3.2 or separate specimens (see 4.3.2.1) are tested, method 208 of MIL-STD-202 shall be used. The specimens shall be examined and adhesion tested by the bend or cutting test of 4.5.2 for compliance with 3.6.6.

4.5.6 Embrittlement relief. When specified (see 6.2), samples of parts for determining compliance with 3.7.2 shall be taken as specified in 4.3.2. The article shall be subjected to a sustained tensile test, using loads applicable to the parts as contained herein. The articles or parts shall be held under the load for at least 200 hours, unless otherwise specified, and then examined for cracks. The lot shall be rejected if any plated part develops cracks or fails by fracture.

4.5.6.1 Fasteners. Parts such as steel fasteners, threaded or not threaded, which are used for mechanical joining of metal shall be subjected to a sustained tensile loading not less than 75 percent of the material specification minimum ultimate tensile strength.

4.5.6.2 Spring pins, lock rings, etc. Parts such as spring pins, lock rings, etc., which are installed in holes or on rods shall be similarly assembled using the applicable parts specification or drawing tolerances which impose the maximum sustained tensile stress on the plated parts.

4.5.6.3 Other parts. Other parts, that will be subjected to a sustained static tensile load in excess of 25 percent of the material specification minimum tensile yield strength in service use, shall be subjected to a sustained tensile load equal to 75 percent of the material notched tensile yield strength. Parts which require fixtures or extreme loads to comply with the above requirements shall be represented by four separate specimens prepared as specified in 4.3.2.1.2 to represent each lot.

4.5.7 Composition. The purity and the level of individual impurities of the gold coating shall be determined at least monthly by any recognized chemical assay or instrumental method capable of accurately determining quantities of 0.1 percent or less. Tests for impurities may be waived by the procuring activity when it has been determined that the process and processing procedures will produce coatings conforming to the applicable requirements of 3.6.7 and 3.6.7.1.

#### 4.6 Rejection.

4.6.1 Examination defects. Any sample unit having one or more defects shall be rejected. If the number of nonconforming sample units in the sample exceeds the acceptance number specified in 4.3.1, the entire lot shall be rejected subject to the provisions of the section on "Disposition of Non-Conforming Product" of MIL-STD-105.

4.6.2 Tests. A lot shall be rejected for failure to meet any of the test requirements when tested in accordance with 4.5.

4.7 Reduced testing. At the discretion of the procuring activity the amount of testing may be reduced provided the results on the consecutive lots indicate that a uniform product meeting the test requirements is being produced, and providing the manufacturer agrees to maintain the same manufacturing procedures or develops alternate acceptable manufacturing procedures.

### 5. PACKAGING

5.1 Packaging requirements. There are no general packaging, packing, and marking requirements applicable to this specification. Preparation for delivery shall be as specified by the procuring agency.

### 6. NOTES

6.1 Intended use. Gold plating is intended for electrical application, good corrosion resistance, good solderability, and other applications.

6.2 Ordering data. Purchasers should exercise any desired options offered herein and procurement documents should specify the following:

- (a) Title, number, and date of this specification.
- (b) Type, grade and class (or thickness) required (see 1.2).
- (c) Finish required, bright or matte (see 3.1).
- (d) Strikes and underplating required (see 3.4 and 6.3).
- (e) Location of a significant surface (see 3.6.1).
- (f) When heat resistance requirement applies (see 3.6.1).
- (g) Degree of smoothness when required and method of determination (see 3.6.5).
- (h) When embrittlement relief is required and alternate temperature when applicable (see 3.7.2).
- (i) When solderability test is required (see 3.6.6).
- (j) When identification marking is required on the articles (see 3.9).
- (k) Visual examination at 4 diameters magnification, if required (see 4.4).
- (l) Whether baking test for adhesion is required.
- (m) Preparation for delivery (see 5.1).

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

- (a) Whether heat treatment has been performed or is required for stress relief (see 3.2.2).
- (b) Hardness of steel parts.
- (c) Ultimate use.
- (d) Tensile loads required for embrittlement relief test (see 4.5.6).

6.3 Strikes and underplating. A copper, nickel, or copper plus nickel underplate may be used, depending on the application and the environment. Silver or copper plus silver may not be used unless required by item specification. A soft gold strike from a separate plating tank should follow any other undercoating and precede the final gold coating to improve adhesion and prevent contamination of the main gold plating solution by metallic impurities. When applied to a copper rich surface such as brass, bronze or beryllium copper or a copper plate or strike, an antidiffusion underplate such as nickel shall be applied.

6.3.1 Strike, as defined in this specification is the application of any plated material 10 microinches or less in thickness. An underplate is a deposit of greater thickness than a strike, that will impart some characteristic to the finished plated surface which the overplate would not otherwise impart.

6.4 National Bureau of Standards Reference Material. Standards have been devised by the National Bureau of Standards for determining weight by unit area (thickness of gold plating). These are intended for calibrating coating thickness gages. For further information, contact the National Bureau of Standards, Office of Standard Reference Materials. Since measurements by beta backscatter and X-ray fluorescence methods not only depend on the coating thickness, but also on the density of the deposit, calibration standards should have the same density as the test specimen to be measured.

6.5 Supersession data. This specification supersedes MIL-G-14548(Ord) and MIL-G-19788(NOrd). The following table provides a cross-reference between MIL-G-45204 and the superseded specifications.

Table II. Thickness cross reference

Thickness of gold plating, minimum	MIL-G-45204B	MIL-G-14548(Ord)	MIL-G-19788
0.00002 inch	00	-	-
0.00003 inch	0	-	-
0.00005 inch	1	-	1
0.00010 inch	2	1	-
0.00020 inch	3	2	2
0.00030 inch	4	-	3
0.00050 inch	5	-	4
0.00150 inch	6	3	-

Custodian:  
 Army - MR  
 Navy - OS  
 Air Force - 11

Preparing activity:  
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Review interest:  
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