



AEROSPACE MATERIAL SPECIFICATION

AMS2444™**REV. B**

Issued 1992-10
Reaffirmed 2019-11
Revised 2025-03

Superseding AMS2444A

Coating, Titanium Nitride
Physical Vapor Deposition

RATIONALE

AMS2444B results from a Five-Year Review and update of this specification with changes to Ordering Information, Authority (see 1.3), Thickness (see 3.2.2.1), Microstructure (see 3.2.4), Coverage (see 3.3.2.1 and 3.3.2.2), Nodules (see 3.3.3), and Note (see 8.4).

NOTICE

ORDERING INFORMATION: The following information shall be provided to the processor by the cognizant engineering organization.

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

- AMS2444B
 - Basis metal to be coated
 - Quantity of parts to be coated
 - Class of coating thickness
2. Parts should generally be supplied for coating in the finish machined condition, with all thermal processing, forming, surface finishing, and fluorescent penetrant inspection completed prior to coating. Parts supplied for coating should be free of dirt, oil, grease, stains, and other foreign materials requiring additional precleaning operations by the coating processor.
3. The parts manufacturer should ensure that surfaces of metal parts supplied to the processor are free from blemishes, pits, tool marks, and other irregularities that will affect the quality of the finished parts (see 3.3.2.1).

1. SCOPE

1.1 Form

This specification covers the requirements for the application and properties of a titanium nitride coating on metal parts applied by physical vapor deposition (PVD).

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For more information on this standard, visit
<https://www.sae.org/standards/content/AMS2444B/>

1.2 Application

This coating has been used typically for enhancing the wear resistance of parts, but usage is not limited to such applications. The process is limited to line-of-sight applications that are not damaged by process temperatures.

1.3 Authority

The cognizant engineering organization may impose requirements or approve allowances that supersede the requirements in this AMS.

1.4 Classification

1.4.1 Coatings covered by this specification are classified as follows:

Class 1 - 0.00005 to 0.00015 inch (1.27 to 3.81 μm) thick

Class 2 - 0.00010 to 0.00024 inch (2.54 to 6.10 μm) thick

Class 3 - 0.00025 to 0.00050 inch (6.35 to 12.70 μm) thick

1.4.2 Unless a specific class is specified, Class 1 shall be supplied.

2. APPLICABLE DOCUMENTS

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

2.1 SAE Publications

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

AS7766 Terms Used in Aerospace Metals Specifications

2.2 ASTM Publications

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

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

ASTM B499 Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals

ASTM B568 Measurement of Coating Thicknesses by X-ray Spectrometry

ASTM E92 Vickers Hardness and Knoop Hardness of Metallic Materials

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

ASTM E384 Microindentation Hardness of Materials

2.3 NIST Publications

Available from NIST, 100 Bureau Drive, Stop 1070, Gaithersburg, MD 20899-1070, Tel: 301-975-6478, www.nist.gov.

Crystallographic Standards Data

2.4 Definitions

Terms used in AMS are defined in AS7766.

3. TECHNICAL REQUIREMENTS

3.1 Processing Requirements

3.1.1 General

3.1.1.1 Documentation

Processing shall be performed in accordance with written procedures or work instructions covering all control factors (see 4.4.3).

3.1.1.2 Equipment

Coating in accordance with this specification requires physical vapor deposition equipment using cathodic arc, electron beam, magnetron, or other ion generation suitable for TiN coating. Coating chamber cleaning and maintenance shall be performed according to documented procedures and schedules.

3.1.1.3 Consumable Materials

Composition and quality of nitrogen and inert gas(es) as well as titanium source material shall conform to the supplier's specifications, subject to approval in accordance with 4.4.2.

3.1.1.4 Surface Finish

Cleaning and coating processes shall be established and controlled to prevent any unacceptable increase in surface roughness of the parts (see 8.3).

3.1.1.5 Undesignated Coating Areas

Coating may be present on areas that are not designated to require coating. When present, coating on these areas shall meet the same property requirements as the coating on designated areas, except for thickness (see 3.2.2.3).

3.1.2 Procedure

3.1.2.1 Precleaning

Parts to be coated shall be free of dirt, oil, stains, and any other foreign materials. Cleaning methods and parameters are subject to approval as in 4.4.

3.1.2.2 Bond Layer Coating

When approved in accordance with 4.4, a layer of titanium may be applied prior to TiN coating to aid in bonding.

3.1.2.3 Application of Coating

3.1.2.3.1 Parts and material for test sampling shall be positioned in the chamber so that surfaces to be coated are fully exposed to the coating vapor.

3.1.2.3.2 Exposure times and vapor concentration shall be established to meet coating thickness requirements.

3.1.2.3.3 During the coating process, part temperature shall be maintained within a range that does not damage the parts.

3.2 Properties

Coatings shall conform to the following requirements:

3.2.1 Coating Composition

Shall be titanium nitride, determined by comparison to crystallographic standards for TiN. There shall be no discernible background extraneous pattern of Ti₂N or other elements.

3.2.2 Thickness

3.2.2.1 Coating thickness shall be determined using a destructive method such as ASTM B487 or nondestructive methods such as ASTM B499, ASTM B568, or ASTM E376, as approved by the cognizant engineering organization (see 4.4).

3.2.2.2 Coating thickness on areas designated to require coating shall be within the range listed in 1.4.1 for the class specified.

3.2.2.3 When coating is present on undesignated areas, thickness may be any value up to the maximum limit specified for the areas that require coating.

3.2.3 Hardness

Shall be not lower than 2000 VHN, or equivalent, determined in accordance with ASTM E92, directly on a suitably prepared and coated surface. Alternatively, hardness may be determined in accordance with ASTM E384 on a coated specimen.

3.2.4 Microstructure

Metallographic examination of a suitably prepared specimen cross section, at 400 to 500X magnification, shall show no separation at the coating-substrate interface. Oxide or other contamination of the coating-substrate interface shall not exceed 10% in any field of view when viewed at a minimum of 200X magnification on the specimen cross section.

3.2.5 Adhesion

There shall be no visible evidence of coating separation from the basis metal when the following test is performed. Tape, 1 inch (25 mm) wide or wider, having adhesive strength of not less than 60 oz/in (0.66 N/mm) of width, shall be firmly applied to the coated area. It shall then be pulled manually from the coated area, at approximately 90 degrees to the coated surface, in one sharp movement. Visual inspection shall show no damage to the coated surface and no coating particles adhering to the tape.

3.3 Quality

3.3.1 Color and Luster

Coating, as delivered, shall exhibit a color and bright luster similar to metallic gold. There shall be no visible evidence of other materials in the coating.

3.3.2 Coverage

Parts shall exhibit a uniform surface free from chips, cracks, pits, blisters, edge peeling, and delaminations. Visual inspection shall be performed using a magnification of 5 to 10X. Voids or discontinuities in the coating shall not exceed 0.010 inch (0.25 mm) in any direction, except that not more than two voids up to 0.030 inch (0.76 mm) in any direction may be permitted in any 0.25-inch (6.4-mm) diameter area. When present, voids shall be uniformly distributed and shall not exceed the following:

Class 1 - 4% of the surface

Class 2 - 2% of the surface

Class 3 - 1% of the surface

3.3.2.1 Imperfections in appearance that arise from surface conditions of the substrate, such as weld areas, variations in surface finish roughness, porosity, scratches, or inclusions, that persist in the finished coating despite observance of industry-accepted coating practices shall not be considered as cause for rejection of the coating (see 8.4).

3.3.2.2 If the coating is specified to be subsequently ground or machined, the above requirements are not required to be inspected for.

3.3.3 Nodules

Coatings shall be free from nodules that are visible when examined at a minimum of 5X magnification.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The processor shall supply all test specimens for the processor's tests and shall be responsible for the performance of all required tests. When parts are to be tested, such parts shall be supplied by the purchaser. The purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the coating conforms to the requirements of this specification.

4.2 Classification of Tests

4.2.1 Acceptance Tests

Thickness (see 3.2.2), adhesion (see 3.2.5), and quality (see 3.3) are acceptance tests and shall be performed on each lot.

4.2.2 Periodic Tests

Coating composition (see 3.2.1), hardness (see 3.2.3), and microstructure (see 3.2.4) are periodic tests and shall be performed at a frequency selected by the processor.

4.2.3 Preproduction Tests

All technical requirements are preproduction tests and shall be performed prior to or on the initial shipment of the coated parts to a purchaser, when a significant change in material and/or processing requires approval as in 4.4.2, and when the purchaser deems confirmatory testing to be required.

4.3 Sampling and Testing

For this specification, a lot shall be all parts of the same part number coated in the same chamber at the same time and presented for the processor's inspection at one time.

4.3.1 Sampling for Acceptance Tests

Test samples shall be selected randomly from all parts in the lot. Unless the cognizant quality organization supplies a sampling plan, the minimum number of samples shall be as shown in Table 1.

Table 1 - Sampling for acceptance tests

Number of Parts	Quality, Nondestructive Thickness, and Adhesion
1 to 3	All
4 to 25	4
26 to 65	6
66 to 180	13
181 to 300	20
301 to 800	32
Over 800	50

4.3.2 Coating Thickness

Coating thickness may be determined by any of the following methods:

4.3.2.1 Destructive Tests

One part or test specimen processed with each 100 parts or fraction thereof. Coating thickness shall be determined on metallographically prepared cross sections (see 3.2.2.1). Sections shall be taken to represent all required coated surfaces, such as the full circumference of cylindrical surfaces.

4.3.2.2 Nondestructive Tests

Test frequency shall be in accordance with Table 1. The processor shall have and use calibration standards simulating part geometry and generic substrate material when nondestructive testing is used.

4.3.3 Coating Substrate - Interface Adhesion (Tape Test)

Test frequency shall conform to Table 1.

4.3.4 Separate specimens simulating part geometry and substrate material may be used for coating composition, hardness, and microstructure testing.

4.4 Approval

4.4.1 The process description and control factors, a coated part, or both, whichever is specified, shall be approved by the cognizant engineering organization before production coated parts are supplied.

4.4.2 The processor of coated parts shall make no significant change to the process description or to the materials, processes, or controls referenced in the process description unless the change is approved by the cognizant engineering organization. A significant change is one which, in the judgment of the cognizant engineering organization, could affect the properties or performance of the coating.

4.4.3 The processor shall establish a written process description covering preparation, coating, and inspection for each part number. The description shall include control factors and parameters that provide coated parts meeting the requirements of this specification. Control factors considered proprietary by the processor may be assigned codes within the process description. Each variation in such control factor shall be assigned a modified code designation. The processor shall maintain a complete record of all proprietary factors and codes.

4.4.4 Control factors shall include, but are not limited to, the following:

- Precleaning procedures and parameters
- Equipment used, including type, size, make, and model of coating apparatus
- Equipment minimum vacuum level and maximum leak-up rate
- Part masking and loading procedures
- Number and locations of parts in chamber
- Ion cleaning parameters, if applicable
- Bond layer parameters, if applicable
- Composition and impurity limits of gases used
- Titanium source composition and impurity limits
- Vacuum/nitrogen levels
- Coating process parameters and electrical settings
- Part time and temperature cycles for outgassing, ion cleaning, bond coating, and TiN coating, as applicable
- Size, geometry, and location of test coupons, if used
- Methods used for determining coating composition, thickness, hardness, and adhesion
- Periodic test plan