

AEROSPACE MATERIAL SPECIFICATION

An American National Standard

SAE AMS 2437B

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Superseding AMS 2437A

COATING, PLASMA SPRAY DEPOSITION

1. SCOPE:

- 1.1 Process: This specification covers the engineering requirements for applying coatings to parts by the plasma spray process and the properties of such coatings.
- 1.2 Application: Primarily to provide protection from wear, heat, corrosion (with sealer), and abrasion. The coating can also be used to restore dimensionally discrepant parts.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

- 2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

- AMS 2350 - Standards and Test Methods
- AMS 4027 - Aluminum Alloy Sheet and Plate, 1.0Mg - 0.60Si - 0.28Cu - 0.20Cr (6061, -T6 Sheet, -T651 Plate), Solution and Precipitation Heat Treated
- AMS 4117 - Aluminum Alloy Bars and Flash Welded Rings, 1.0Mg - 0.60Si - 0.28Cu - 0.20Cr (6061, -T6, -T651), Solution and Precipitation Heat Treated
- AMS 4911 - Titanium Alloy Sheet, Strip, and Plate, 6Al - 4V Annealed
- AMS 4928 - Titanium Alloy Bars, Forgings, and Rings, 6Al - 4V, Annealed, 120,000 psi (825 MPa) Yield Strength

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2.1.1 (Cont'd.)

AMS 5510 - Steel Sheet, Strip, and Plate, Corrosion and Heat Resistant, 18Cr - 10.5Ni - 0.40Ti (SAE 30321), Solution Heat Treated

AMS 5645 - Steel Bars, Forgings, Tubing, and Rings, Corrosion and Heat Resistant, 18Cr - 10Ni - 0.40Ti (SAE 30321), Solution Heat Treated

AMS 5791 - Powder, Plasma Spray, 56.5Co - 25.5Cr - 10.5Ni - 7.5W

AMS 5792 - Powder, Plasma Spray, 50(88W - 12Co) + 35(70Ni - 16.5Cr - 4Fe - 4Si - 3.8B) + 15(80Ni - 20Al), Three Component Mixture

AMS 5793 - Powder, Plasma Spray, (95Ni - 5Al)

AMS 6350 - Steel Sheet, Strip, and Plate, 0.95Cr - 0.20Mo (0.28 - 0.33C) (SAE 4130)

AMS 6370 - Steel Bars, Forgings, and Rings, 0.95Cr - 0.20Mo (0.28 - 0.33C) (SAE 4130)

AMS 7875 - Chromium Carbide Plus Nickel-Chromium Alloy Powder, 75Cr₂C₃ + 25 (80Ni - 20Cr Alloy)

AMS 7878 - Tungsten Carbide Powder, Cobalt Coated

AMS 7879 - Tungsten Carbide-Cobalt Powder, Cast and Crushed

AMS 7880 - Tungsten Carbide-Cobalt Powder, Sintered and Crushed

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM C633 - Adhesion or Cohesive Strength of Flame-Sprayed Coatings

ASTM E384 - Microhardness of Materials

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Military Standards:

MIL-STD-794 - Parts and Equipment, Procedures for Packaging and Packing of

3. TECHNICAL REQUIREMENTS:

3.1 Equipment:

3.1.1 Torch: A specially constructed torch that dissociates and ionizes a suitable plasma-forming gas when an electric arc is struck between an anode and cathode. Coating particles, which are injected into the resultant high-velocity, high-temperature flame, are heated to plasticity and propelled toward the workpiece to be coated.

3.1.2 Gas: A suitable plasma-forming gas, as used in 3.1.1, may be any of the following, but the gas used shall be acceptable to the purchaser:

3.1.2.1 Nitrogen.

3.1.2.2 Mixtures of nitrogen and hydrogen.

- 3.1.2.3 Argon.
- 3.1.2.4 Mixtures of argon and hydrogen.
- 3.1.2.5 Mixtures of argon and helium.
- 3.1.2.6 For substrates of titanium, titanium alloys, and steels heat treated above 180,000 psi (1240 MPa) tensile strength, the plasma-forming gases shall be argon or a mixture of argon and helium.
- 3.1.3 Coating Material: Shall be a powder conforming to the specification required by the coating designation (See 3.5.1) specified on the drawing. All powder shall be dry, free-flowing, and uniformly blended.
- 3.2 Personnel: Operators or other personnel performing manual plasma spray operations shall be trained to spray using each material and gas system designated. Competence of the manual spray operator or of fully mechanized equipment shall be demonstrated by spraying a set of test specimens as in 4.5.1 which shall meet the requirements of 3.6.
- 3.3 Operation Sheets: For each different part number to be sprayed, a process procedure shall be established covering preparation, preheating, and spraying parameters. Fig. 1 shows a typical process control sheet; use of the format shown is not mandatory provided all applicable information thereon is shown. A single operation sheet may cover more than one part number if all parameters for coating the parts are the same. This process procedure shall be available for review by the purchaser upon request.
- 3.4 Preparation:
- 3.4.1 Surfaces to be coated shall be machined to allow for the finished thickness of the coating.
- 3.4.2 Parts requiring heat treatment or shot peening shall be so processed prior to coating.
- 3.4.3 When processes such as acid or alkali cleaning, electroplating, and anodizing are applied to parts to be sprayed, they shall precede plasma deposition.
- 3.4.4 Surfaces to be coated shall be cleaned to remove water, oil, grease, dirt, scale, paint, and other foreign matter detrimental to adherence of the sprayed coating. Special cleaning procedures shall be employed in treating titanium parts to avoid hydrogen embrittlement and halide contamination. Cleaned surfaces shall be handled only with clean cloth or gloves before coating.
- 3.4.5 Parts shall be suitably masked to protect surfaces not required to be coated.

- 3.4.6 **Surfaces** to be coated shall be grit blasted to produce a uniform matte finish sufficient to produce good adhesion of the coating. The grit type and size shall be reported in the approved process procedure for each part. Surfaces shall not be blasted with grit previously used on dissimilar materials.

3.5 Procedure:

- 3.5.1 Coating Designation: The required coating material may be indicated on the drawing by this specification number and a suffix number designating the powder to be used, in accordance with Table I; e.g., AMS 2437-1 indicates that parts are to be coated with AMS 7880 powder. Coating materials other than those shown in Table I may be used when specified by purchaser.

- 3.5.2 Surfaces to be coated shall be preheated, as required, to remove moisture and to control expansion of the part with respect to the coating. Preheating may be accomplished by use of the plasma torch or by other suitable means. Temperature of the part during preheating and spraying shall be controlled to prevent discoloration, oxidation, distortion, and other conditions detrimental to the coating or substrate. Special precautions shall be taken in coating high-thermal-conductivity materials, such as aluminum and magnesium, to avoid overheating.

- 3.5.3 Areas on which coating is optional shall, if coated, be prepared, handled, and coated in the same manner as the areas on which coating is required.

- 3.5.4 Coating material shall be deposited onto the designated surfaces to the thickness specified in the approved process procedure for each part. Finished coating thickness shall be as specified on the drawing. Minimum coating thickness requirements do not apply to areas designated as optional coating areas.

- 3.5.5 Surface Finishing: Procedures for grinding and lapping shall be as agreed upon by purchaser and vendor.

- 3.6 Properties: The coating on parts and representative test specimens shall conform to the following requirements:

- 3.6.1 Cup Test: Shall not show separation of the coating from the substrate when tested in accordance with 4.5.2 and examined without magnification. Standards for acceptance shall be as specified by purchaser. Test is not applicable to ceramic coatings.

- 3.6.2 Bend Test (May be substituted for cup test of 3.6.1 when permitted by purchaser): Shall not show separation of the coating from the substrate when tested in accordance with 4.5.3 and examined without magnification. Standards for acceptance shall be as specified by purchaser. Test is not applicable to ceramic coatings.

- 3.6.3 Bond Strength: Shall be as specified in Table I, determined in accordance with ASTM C633.

- 3.6.4 Hardness: Average hardnesses as calculated from a minimum of 10 representative readings of coatings, determined in accordance with ASTM E384 on cross-sections of those coatings, shall be as specified in Table I.
- 3.6.5 Micro-Examination: Examination of the deposited coatings shall show the coatings to be free from cracks, excessive and massive oxides, and excessive porosity. Coatings shall be essentially free from grit particles and contamination at the interface between the coating and substrate. Metallographic standards for acceptance shall be as specified by purchaser.
- 3.6.6 Hardness of Finished Parts: Shall be as specified in Table I, determined in accordance with ASTM E384 as the average of not less than 10 microhardness readings taken on a cross-section of the part.
- 3.7 Quality: The coating, as received by purchaser, shall be adherent to the basis metal and shall have a uniform, continuous surface free from spalling, chipping, flaking, and other imperfections detrimental to usage of the coating. Standards for acceptance shall be as agreed upon by purchaser and vendor.
- 3.8 Tolerances: A tolerance of -0 and +0.125 in. (+3.12 mm) is permissible on the boundaries of areas designated to be coated.
4. QUALITY ASSURANCE PROVISIONS:
- 4.1 Responsibility for Inspection: The vendor of coated parts shall supply all samples for vendor's tests and shall be responsible for performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.6. 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: Tests to determine conformance to requirements for thickness (3.5.4), properties of test specimens (3.6.1 or 3.6.2, 3.6.4, and 3.6.5), quality (3.7), and tolerances (3.8) of coated parts are classified as acceptance tests and shall be performed to represent each lot.
- 4.2.2 Periodic Tests: Tests to determine conformance to requirements for composition of coating material (3.5.1), bond strength of test specimens (3.6.3), and hardness of coated parts (3.6.6) are classified as periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.
- 4.2.3 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests and shall be performed prior to or on the initial shipment of coated parts to a purchaser, when a change in processing requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

- 4.2.3.1 For direct U.S. Military procurement, substantiating test data and, when requested, preproduction test material shall be submitted to the cognizant agency as directed by the procuring activity, the contracting officer, or the request for procurement.
- 4.3 Sampling: Shall be not less than the following; a lot shall be all parts of essentially the same configuration coated in a continuous operation to the same range of thickness with powder from the same batch and presented for vendor's inspection at one time:
- 4.3.1 For Acceptance Tests:
- 4.3.1.1 Thickness and Properties of Test Specimens: Two sets of specimens, one coated at the beginning and one coated at the end of each lot.
- 4.3.1.2 Quality and Tolerances of Coated Parts: As agreed upon by purchaser and vendor.
- 4.3.2 For Periodic Tests and Preproduction Tests: As agreed upon by purchaser and vendor.
- 4.4 Approval:
- 4.4.1 Coated parts shall be approved by purchaser before parts for production use are supplied, unless such approval be waived by purchaser. Results of tests on production parts shall be essentially equivalent to those on the approved sample parts.
- 4.4.2 Vendor shall use manufacturing procedures, processes, and methods of inspection on production parts which are essentially the same as those used on the approved sample parts. If necessary to make any change in type of equipment, in established composition limits, or in processing parameters, vendor shall submit for reapproval a statement of the proposed changes in processing and, when requested, test specimens, sample coated parts, or both. Production parts coated by the revised procedure shall not be shipped prior to receipt of reapproval.
- 4.5 Test Methods:
- 4.5.1 Test Specimens: Cup, bend, bond, and micro-examination test specimens shall be made from the following materials, unless otherwise specified or agreed upon by purchaser and vendor:

Material of Part to be Coated	Bond Strength Specimen	Cup and Bend Specimens
All Steels	AMS 6370	AMS 6350
Nickel Alloy or Cobalt Alloy	AMS 5645	AMS 5510
Aluminum Alloy or Magnesium Alloy	AMS 4117	AMS 4027
Titanium or Titanium Alloy	AMS 4928	AMS 4911

- 4.5.2 Cup Test: Test panels, approximately 3 x 1.75 x 0.05 in. (75 x 45 x 1.2 mm), shall be coated on one side with the same material as the parts to the applicable thickness shown in Table II, using as far as practicable the same preparation, equipment, and machine settings as for the parts they represent. Panel shall be cup tested on a Detroit or equivalent testing machine, using a 0.875-in. (22-mm) diameter ball and die with a 1.375 in. (35 mm) diameter opening to form a depression in the panel to a depth of 0.300 in. (7.5 mm) except 0.200 in. (5.0 mm) for fine powders up to 20 microns (20 μ m). Cup shall be drawn at a slow, uniform deformation rate with the coated side of the panel on the outside of the cup.
- 4.5.3 Bend Test: Test panels, approximately 3 x 1 x 0.05 in. (75 x 25 x 1.2 mm), shall be coated on one side with the same material as the parts to a thickness as shown in Table II, using as far as practicable the same preparation, equipment, and machine settings as for the parts they represent. Panels shall be tested by bending the panel 90 deg around a 1/2-in. (12.5-mm) diameter bar in a direction away from the coating (coating on OD of bend) at a rate of approximately 4 deg per second.
- 4.6 Reports: The vendor of coated parts shall furnish with each shipment a report showing the purchase order number, part and coating material specification numbers and their revision letters, if any, contractor or other direct supplier of part and coating materials, part number, and quantity. When material for making parts, coating material, or both is produced or purchased by the coated parts vendor, that vendor shall inspect each lot of material to determine conformance to the applicable material specification and shall include in the report either a statement that the materials conform or copies of laboratory reports showing the results of tests to determine conformance. This report shall also include the results of tests to determine that the coating conforms to the acceptance test requirements of this specification.
- 4.7 Resampling and Retesting: If any specimen used in the above tests fails to meet the specified requirements, disposition of the coated parts may be based on the results of testing three additional specimens, except as specified in 4.7.1, for each original nonconforming specimen. Except as specified in 4.7.2, failure of any retest specimen to meet the specified requirements shall be cause for rejection of the parts represented and no additional testing shall be permitted.
- 4.7.1 If a bond strength specimen fails at the adhesive-bonded joint, the test may be repeated on another specimen; such retest shall not be considered one of the retests specified in 4.7.
- 4.7.2 If any part fails to meet the specified requirements, either on the original sampling as in 4.3 or upon resampling as in 4.7 and 4.7.1, the parts in that lot may be stripped by a method approved by purchaser which does not roughen, pit, or embrittle the basis metal, recoated, and retested.

5. PREPARATION FOR DELIVERY:

- 5.1 Parts shall be handled and packaged in such a manner as will ensure that the required physical characteristics and properties of the coated parts are preserved.
- 5.2 Packages of parts shall be prepared for shipment in accordance with commercial practice and in compliance with applicable rules and regulations pertaining to the handling, packaging, and transportation of the parts to ensure carrier acceptance and safe delivery. Packaging shall conform to carrier rules and regulations applicable to the mode of transportation.
- 5.3 For direct U.S. Military procurement, packaging shall be in accordance with MIL-STD-794, Level A or Level C, as specified in the request for procurement. Commercial packaging as in 5.1 and 5.2 will be acceptable if it meets the requirements of Level C.
6. ACKNOWLEDGMENT: A vendor shall mention this specification number and its revision letter in all quotations and when acknowledging purchase orders,
7. REJECTIONS: Parts on which coating does not conform to this specification or to modifications authorized by purchaser will be subject to rejection.
8. NOTES:
- 8.1 Marginal Indicia: The phi (Ø) symbol is used to indicate technical changes from the previous issue of this specification.
- 8.2 Dimensions and properties in inch/pound units are primary; dimensions and properties in SI units are shown as the approximate equivalents of the primary units and are presented only for information.
- 8.3 For direct U.S. Military procurement, purchase documents should specify not less than the following:
- Title, number, and date of this specification
Coating thickness desired
Quantity of pieces to be coated
Standards for acceptance of cup test or bend test, and
microexamination (See 3.6.1 and 3.6.2)
Quality standards for acceptance (See 3.7)
Applicable level of packaging (See 5.3)
- 8.4 Coatings meeting the requirements of this specification have been classified under Federal Standardization Area Symbol "MFFP".