Society of Automotive Engineers, Inc.
TWO PENNSYLVANIA PLAZA, NEW YORK, N.Y. 10001

# AEROSPACE MATERIAL SPECIFICATION

AMS 2437

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Revised

## COATING, PLASMA SPRAY DEPOSITION



1. SCOPE:

1.1 Process: This specification covers the procedure for applying coatings to parts by plasma spraying and the properties of the coatings so deposited.

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 (AMS) shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from Society of Automotive Engineers, Inc., Two Pennsylvania Plaza, New York, New York, 10001.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods
AMS 4027 - Aluminum Alloy, Sheet, and Plate, 1.0Mg - 0.60Si - 0.30Cu - 0.25Cr
AMS 4117 - Aluminum Alloy, Bars, Rods, and Wire, Rolled, Drawn, or Cold Finished, 1.0Mg - 0.60Si - 0.30Cu - 0.20Cr
AMS 4911 - Titanium Alloy Sheet, Strip, and Plate, 6Al - 4V Annealed
AMS 4928 - Titanium Alloy Bars and Forgings, 6Al - 4V Annealed, 120,000 psi Yield
AMS 5510 - Steel Sheet, Strip, and Plate, Corrosion and Heat Resistant, 18Cr - 10Ni - Ti
AMS 5645 - Steel Bars, Forgings, Tubing, and Rings, Corrosion and Heat Resistant, 18Cr - 10Ni - Ti
AMS 6350 - Steel Sheet, Strip, and Plate, 0.95 Cr - 0.20Mo (0.28 - 0.33C)
AMS 6370 - Steel Bars and Forgings, 0.95Cr - 0.20Mo (0.28 - 0.33C)
AMS 7875 - Chromium Carbide Plus Nickel Chromium Alloy Powder
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, Pennsylvania 19103.

E92 - Vickers Hardness of Metallic Materials

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: Unless otherwise specified, 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 (1241 $MN/m^2$) 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 3.4.1) specified on the drawing. All powder shall be dry and 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 coupons which shall meet the requirements of 3.7.

3.3 Operation Sheets: For each different part number to be sprayed, a process procedure shall be established covering preparation, preheating, and spraying parameters. Figure 2 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 Parts that require heat treatment or shot peening shall be so processed prior to coating.

3.4.2 When processes such as acid or alkali cleaning, electroplating, and anodizing are applied to parts to be sprayed they shall precede plasma deposition, unless otherwise specified.

3.4.3 Surfaces to be coated shall be machined undersize, where necessary, to allow for the finished thickness of the coating.

3.4.4 Surfaces to be sprayed 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 Surfaces to be sprayed shall be roughened by grit blasting as required to provide adequate adhesion. The grit type and size shall be reported in the approved process procedure for each part, unless otherwise specified. Surfaces shall not be blasted with grit previously used on dissimilar materials.

3.4.6 Areas designated not to be sprayed shall be suitably masked to prevent overspray.

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.

3.5.2 Surfaces to be coated shall be preheated, as required, to remove moisture and to control thermal 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 must be taken in coating high thermal conductivity materials, such as aluminum and magnesium, to avoid overheating.

3.5.3 Optional coated areas, if coated, shall be prepared, handled, and coated in the same manner as the required coating areas.

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. Unless otherwise specified, minimum coating thickness requirements do not apply to areas designated as optional coating areas.

3.6 Reoperation: Stripping the coating for reoperation is permissible but, when performed by a nonmechanical method, that method shall be approved by purchaser prior to stripping.

3.7 Properties:

3.7.1 Cup Test: Test panels approximately 3 x 1.75 x 0.05 in. (76 x 44.45 x 1.27 mm), coated on one side with the same material as the parts to the applicable thickness shown in Table II, and using as far as practicable the same preparation, equipment, and machine settings as for the parts they represent shall meet the test of 3.7.1.1 without showing separation of the coating from the substrate when examined without magnification. Standards for acceptance shall be as specified by the purchaser. This test does not apply to ceramic coatings.

3.7.1.1 Panel shall be cup tested on a Detroit or equivalent testing machine, using a 0.875 in. (22.225 mm) ball and die with a 1.375 in. (34.925 mm) diameter opening to form a depression in the panel to a depth of 0.300 in. (7.620 mm), except 0.200 in. (5.080 mm) for fine powders (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.

3.7.2 Bend Test (May be substituted for the cup test specified in 3.7.1 when requested by purchaser): Test panels approximately 3 x 1 x 0.05 in. (76 x 25 x 1.27 mm), coated on one side with the same material as the parts to a thickness as shown in Table II, and using as far as practicable the same preparation, equipment, and machine settings as for the parts they represent shall be tested by bending the panel 90 deg (1.57 rad) around a 0.500 in. (12.700 mm) diameter bar in a direction away from the coating (coating on OD of bend) at a rate of approximately 4 deg per sec (0.07 rad per sec). Tested specimens shall not show separation of the coating from the substrate when examined without magnification. Standards for acceptance shall be as specified by the purchaser. This test does not apply to ceramic coatings.

3.7.3 Bond Strength: Bond strength test specimens machined to dimensions as shown in Fig. 1, prepared with No. 24 nonmetallic grit, using 60 psig (414 kN/m$^2$ gage pressure) air pressure, with a nozzle to target distance of 3 in. (76 mm), and tested as in 3.7.3.1, shall have bond strengths not lower than those shown in Table I.

3.7.3.1 Mask bond test specimens on the OD to prevent overspray. Blast test specimen end and coat that end to a thickness as shown in Table II with the coating to be tested. After spraying, remove the masking material. To the uncoated end of a separate, clean, dry, and grit-blasted identical bond specimen, apply an epoxy adhesive capable of producing a bond strength not lower than 10,000 psi (69 MN/m$^2$) when applied to uncoated specimens. Join and align the ends of the two specimens, taking care to avoid entrapment of air bubbles. To facilitate alignment of the specimens during the bonding operation, lay them in a 45 deg (0.79 rad) "V" shaped trough. Cure adhesive in a circulating air oven as applicable. After bonding, dress the edge of the coating flush with the OD of the test specimen. An abrasive disc or wheel may be used for this purpose. Take care that the abrasive moves axially parallel to the centerline of the test specimen. Trim excess adhesive from periphery

of the specimens and then pull them apart using a standard laboratory tensile tester that is equipped with a universal joint arrangement for each end of the joined specimens. This is necessary to eliminate shear or bend stresses in the bonded joint. Set the no-load crosshead speed at approximately 0.05 in. per min. (1.27 mm/min.).

3.7.4 Cup, bend, bond, and micro-examination test specimens shall be made from the following materials, unless otherwise specified:

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

3.7.5 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.

3.7.6 Hardness: Average hardnesses as calculated from a minimum of 10 representative readings of coatings, determined in accordance with ASTM E92 on cross-sections of those coatings, shall be as specified in Table I.

3.8 Quality: The coating shall be adherent to the substrate material and shall have a uniform, continuous surface free from spalling, chipping, flaking, cracking, or other objectionable imperfections.

3.9 Tolerances: Unless otherwise specified, a tolerance of -0 and +1/8 in. (3.1 mm) will be allowed on the boundaries of areas designated to be coated.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor shall supply all samples and shall be responsible for performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.5. Purchaser reserves the right to perform such confirmatory testing as he deems necessary to assure that coatings conform to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Routine Control Tests: Tests to determine conformance to the cup test (3.7.1) or the bend test (3.7.2) as required by the purchaser, and the microexamination test (3.7.5) are classified as routine control tests.

4.2.2 Periodic Control Tests: Tests to determine conformance to bond strength (3.7.3) and hardness (3.7.6) requirements are classified as qualification and/or periodic control tests.

4.3 Sampling:

4.3.1 Routine Control Tests:

4.3.1.1 Cup Test or Bend Test: One sample shall be tested for each production run and the test shall be repeated for each 2 hr of production.

4.3.1.2 Microexamination: One sample shall be tested.

4.3.2 Periodic Control Tests:

4.3.2.1 Bond Strength: Three samples shall be tested.

4.3.2.2 Hardness: One sample shall be tested.

4.4 Approval:

4.4.1 Parts coated in accordance with this specification shall be approved by purchaser before parts for production use are supplied, unless such approval be waived.

4.4.2 Vendor shall use materials, manufacturing procedures, processes, and methods of inspection on production parts to determine conformance to this specification which are essentially the same as those used on the approved sample parts. If any change is necessary in processing parameters as detailed in Fig. 2, or its equivalent, the vendor shall submit samples for reapproval of the process unless purchaser grants written approval after review of a detailed statement of operations performed on the approved samples and those proposed. No production parts coated by the revised procedure shall be shipped prior to receipt of approval of such procedure.

4.5 Reports: The vendor of coated parts shall furnish with each shipment three copies of a report showing the purchase order number, part and coating material specification numbers and their revision letters, contractor or other direct supplier of part and coating materials, part number, and quantity. When material for making parts or the coating material 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 a statement that the materials conform, or shall include 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 requirements of this specification.

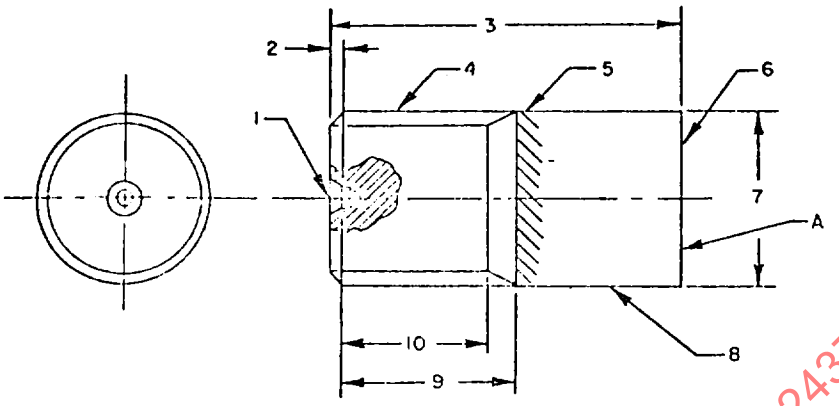
4.6 Resampling and Retesting: If any specimen used in the above tests fails to meet the specified requirements, disposition of the coated parts may be based on the results of testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the coated parts represented and no additional testing shall be permitted. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY: Not applicable.

6. ACKNOWLEDGMENT: A vendor shall mention this specification number in all quotations and when acknowledging purchase orders.

7. REJECTIONS: Parts on which the coating does not conform to this specification or to authorized modifications will be subject to rejection.

8. NOTES: None.




1. 0.088 Inch (2.350 mm) Diameter Maximum
   (#2 Center Drill Ref) Depth 0.110 In. (2.790 mm) Maximum
   Chamfer 60 deg. ± 5 to 0.120 In. (3.050 mm) Diameter Maximum (Optional)
2. Chamfer 45 deg (0.788 rad.) Approx. to 0.050 - 0.080 Inch (1.27 - 2.03 mm)
3. 1.500 to 2.250 Inches (38.100 - 57.150 mm)
4. 1.000-12-UNF-3A, Pitch - 0.9415 to 0.9459 In.
   Major Diameter 0.9866 to 0.9905
   Minor Diameter 0.8978 in. (See Note)
5. Vibration Peen Identification in Shaded Area.
6. Coat This End. Surface A Must be Square with Center Line
   Within 0.001 Inch (0.025 mm) FIR
7. 0.9895 - 0.9905 Inch (25.1333 - 25.1587 mm) Diameter
8. No Overspray Permitted. Mask OD of Specimen
9. 1.000 Inch (25.400 mm) Maximum. Full or Imperfect Thread
   (See Note)
10. 0.834 In. (21.184 mm) Minimum Full Thread

Note. A 1/2-20-UNF-3A internal thread 0.500 in. (12.700 mm) deep may be used in lieu of the external thread shown.

BOND STRENGTH SPECIMEN
Figure 1