



AEROSPACE MATERIAL SPECIFICATION

AMS2448™**REV. D**Issued 2004-10
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Superseding AMS2448C

Application of Tungsten Carbide Coatings on Ultrahigh-Strength Steels,
High-Velocity Oxygen/Fuel Process

RATIONALE

AMS2448D results from a Five-Year Review and update of this specification with changes to Ordering Information, Authority (see 1.4), Periodic Tests (see 4.2.2.1), and Bend Test (see 4.3.3.1).

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:

- AMS2448D
- Basis metal to be coated
- Quantity of parts to be coated
- Procedures for finishing (see 3.6)

2. Parts manufacturing operations such as heat treating, forming, joining, and media finishing can affect the condition of the substrate for coating or, if performed after coating, could adversely affect the coated part. The sequencing of these types of operations should be specified by the cognizant engineering organization and is not controlled by this specification.

1. SCOPE

1.1 Purpose

This specification covers engineering requirements for applying tungsten carbide thermal spray coatings to ultrahigh-strength steels (220 ksi and above) utilizing high-velocity oxygen fuel (HVOF) combustion-driven processes and the properties for such coatings. The processes and procedures herein apply only to the properties of the as-deposited coating.

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1.2 Application

This process has been used typically to provide coatings that possess lower porosity and higher adhesive and/or cohesive strength than generally attainable with plasma spray and for applications requiring wear, heat, and corrosion resistance or dimensional restoration that were traditionally chrome plated. However, usage is not limited to such applications.

1.3 Safety - Hazardous Materials

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards that may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

1.4 Authority

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

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 (U.S. and Canada only) or +1 724-776-4970 (outside U.S. and Canada), www.sae.org.

AMS6345	Steel, Sheet, Strip, and Plate, 0.95Cr - 0.20Mo (0.28 - 0.33C) (SAE 4130), Aircraft Quality, Normalized or Otherwise Heat Treated
AMS6356	Steel, Sheet, Strip, and Plate, 0.95Cr - 0.20Mo - (0.30 - 0.35C) (SAE 4132), Aircraft Quality
AMS6454	Steel, Sheet, Strip, and Plate, 1.8Ni - 0.80Cr - 0.25Mo (0.38 - 0.43C) (SAE 4340), Vacuum Consumable Electrode Remelted
AMS7881	Tungsten Carbide-Cobalt Powder, Agglomerated and Sintered
AMS7882	Tungsten Carbide-Cobalt Chrome Powder, Agglomerated and Sintered
ARP5935	Use of HVOF Thermal Spray Coatings for Hard Chrome Replacement in Landing Gear Applications
AS7766	Terms Used in Aerospace Metals Specifications
SAE J442	Test Strip, Holder, and Gage for Shot Peening

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 C633	Adhesion or Cohesion Strength of Thermal Spray Coatings
ASTM E384	Microindentation Hardness of Materials
ASTM E408	Total Normal Emittance of Surfaces Using Inspection-Meter Techniques

ASTM E1245 Determining the Inclusion or Second-Phase Constituent Content of Metals by Automatic Image Analysis

ASTM E1920 Metallographic Preparation of Thermal Sprayed Coatings

2.3 U.S. Government Publications

Copies of these documents are available online at <https://quicksearch.dla.mil>.

MIL-STD-871 Electro-Chemical Stripping of Inorganic Finishes

2.4 Definitions

Terms used in AMS are defined in AS7766.

3. TECHNICAL REQUIREMENTS

Parts shall be prepared and coated in accordance with the approved Coating Process Control Sheet described in 4.4.

3.1 Equipment

3.1.1 Torch

A specially constructed gun that utilizes combustion products to generate a high-velocity gas stream for heating of the coating material to a molten or plasticized state and transfer of the coating material to the workpiece shall be used. The torch shall be microprocessor-controlled and fitted with an automated device for regulating the gas(es) and fuel(s). The torch shall be mounted on an automated manipulating device during the deposition process to maintain a constant working distance and traverse rate or maintained in a fixed position with the component mounted on a manipulating device that will maintain a constant working distance.

3.1.2 Gauges

3.1.2.1 Pressure gauges shall have a minimum accuracy of $\pm 1.5\%$ of full scale.

3.1.2.2 Flow meters shall have a minimum accuracy of $\pm 2\%$ of full scale.

3.1.3 Powder Feeder

The powder feed system shall supply a metered flow of material.

3.2 Materials

3.2.1 Gases and fuels specifications used by the processor for procurement shall be acceptable to the CEO.

3.2.2 Coating material shall conform to AMS7881 or AMS7882. All powders shall be dry, free flowing, and uniformly blended.

3.3 Preparation

3.3.1 Cleaning

Surfaces to be coated shall be thoroughly cleaned to remove oil, grease, dirt, paint, and other foreign material. Final cleaning shall take place no more than 4 hours prior to coating. Cleaning procedures shall not embrittle, pit, or damage surfaces to be coated.

3.3.2 Masking

Parts shall be masked by any appropriate means to protect all surfaces that are not being coated.

3.3.3 Surface Conditioning

After cleaning, surfaces to be coated shall be grit-blasted with aluminum oxide blast media to clean and prepare the surface for HVOF deposition. Grit and the air producing the blasting shall be free from moisture, oil, dirt, and other contaminants. Grit size shall be of the finest possible size necessary to achieve a 120 to 150 Ra surface roughness but shall never be coarser than 54 grit. A surface profilometer shall be used to verify the proper surface conditioning for each procedure used.

3.4 Application

3.4.1 Process Determination

The parameters for gas flows and pressures, powder feed rates, and spray distance, as well as deposition rates and traverse speeds, shall be determined by a statistical method designed to achieve the desired coating properties specified by this document and/or by the CEO.

3.4.2 Preheating

Surfaces to be coated shall be heated to remove moisture. Surface temperature shall not exceed 300 °F (149 °C). Preheating may be accomplished with the torch or by other suitable means and shall be monitored as specified in 3.4.3.5.

3.4.3 Coating

The coating material shall be deposited on the designated surface in sufficient thickness to permit finishing to specified dimensions.

3.4.3.1 The coating shall cover the entire area specified. A tolerance of -0 to +0.125 inch (3.2 mm) is allowed on the boundaries of the coated area.

3.4.3.2 Areas on which coating is optional must be prepared and handled in the same manner as the area on which coating is required, and adhesion requirements still apply.

3.4.3.3 A spray angle of 90 degrees $\pm$ 5 degrees should be maintained. For cylindrical components, angle is measured relative to the centerline axis of the cylinder. For any application that requires a spray angle at less than 85 degrees, all test specimens shall be sprayed at the same angle as the component and all minimum mechanical property requirements will apply.

3.4.3.4 Spray deposition shall be continuous except for interruptions to measure coating thickness and/or for cooling cycles to maintain part below maximum allowable temperature.

3.4.3.5 Substrate Temperature

The maximum temperature of the substrate during preheating and coating application shall not exceed 300 °F (149 °C). Temperature measurements shall be made utilizing a laser-sighted infrared (IR) pyrometer with adjustable emissivity (0.1 to 0.99) and response time of less than 1 second. Measurement shall be taken on the parent metal adjacent to the edge of the coating as it traverses the area to be coated or on the coating itself. Emissivity shall be set to a value for the coating or substrate material being measured. The emissivity value shall be determined in accordance with ASTM E408, Method A. Alternatively, the emissivity level of the infrared pyrometer may be adjusted such that the temperature output agrees to within 5% of the value obtained with a contact temperature measurement device. Resolution of the infrared pyrometer shall be 1 °C or 1 °F, depending on the scale used, and spot diameter should be less than 2.5 inches (64 mm) or equivalent to the actual diameter of the IR beam. If geometric constraints, part size, or other considerations do not allow the use of an IR pyrometer, then the CEO shall approve an alternative temperature measurement method.

3.5 Process Monitoring

Process monitoring is an optional procedure that, when used, allows for reduced testing frequency.

3.5.1 Equipment

Process monitoring requires the use of diagnostic equipment that is capable of periodically monitoring particle velocity, particle temperature, and flame plume geometry (length and width).

3.5.1.1 The equipment shall record each of the parameters being monitored.

3.5.1.2 The equipment shall be capable of notifying the operator when any parameter being monitored goes outside the approved range.

3.5.2 Process Monitoring Procedure

3.5.2.1 A process monitoring procedure shall be established for each part number specifying the equipment and the parameters to be monitored and the ranges the parameters are to stay within during the coating process. At a minimum, the parameters shall be particle velocity, particle temperature, and flame plume geometry (length and width).

3.5.2.2 The allowable limits or ranges for each of the parameters being monitored shall be established by a statistical method that correlates to those used for the initial process determination in 3.4.1.

3.5.2.3 Each process monitoring procedure and any revisions to them requires approval by the CEO as stated in 4.4.4.

3.5.3 Parameters Out of Limit or Range

At any time during monitoring, if any of the parameters being monitored go outside the approved limits or ranges, testing shall revert back to acceptance lot testing until such time as the parameter(s) return to within the approved limits or ranges.

3.5.4 Reduced Testing

If process monitoring is being used, and as long as the process parameters are within the approved limits or ranges, the properties indicated in 4.2.1 instead of being acceptance tests may be performed as periodic tests as stated in 4.2.2.

3.6 Surface Finishing

Procedures for finishing shall be in accordance with the CEO's specifications.

3.7 Properties

3.7.1 Adhesion

3.7.1.1 Bend Test

Specimens, as in 4.3.3.4 and tested as in 4.3.3.1, shall not show separation of the coating from the substrate when examined visually without magnification. Cracking of the coating and minimal separation at the specimen edges shall be considered acceptable.

3.7.1.2 Bond Strength

Specimens, as in 4.3.3.4 and tested as in 4.3.3.2, shall have a bond strength of 10 ksi (69 MPa) minimum.

3.7.2 Coating Hardness

Specimens, as in 4.3.3.4 and tested as in 4.3.3.3, shall have a hardness of HV_{300g} 950 minimum.