



AEROSPACE MATERIAL SPECIFICATION

AMS2449™**REV. B**Issued 2004-07
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Superseding AMS2449A

Grinding of HVOF Sprayed Tungsten Carbide Coatings Applied to High Strength Steels

RATIONALE

AMS2449B results from a Five-Year Review and update of this specification with changes to Definitions (see 2.5.1, 2.5.5, 2.5.7, 2.5.9, 2.5.13, and 2.5.18), Grinding Wheel parameters (see 3.4.1.1), Grinding Process Control (see 3.6.4), Grinding Parameters (see 3.7.1, 3.7.2.1.1, 3.7.2.1.2, 3.7.3, and Table 1), and Appendix A.

1. SCOPE

1.1 Purpose

This specification covers engineering requirements for the grinding of tungsten carbide high velocity oxygen/fuel (HVOF) thermal spray coatings applied to high strength steels (220 ksi and above).

1.2 Application

This process has been used typically to grind tungsten carbide HVOF coatings applied in accordance with AMS2447 or AMS2448 to high strength steels for applications requiring wear, heat, and corrosion resistance or dimensional restoration, such as aircraft landing gear components. However, usage is not limited to such applications. This process specification does not cover superfinishing of HVOF applied coatings.

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 which 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.

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.

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Documents

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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.

AMS2447 Coating, Thermal Spray, High Velocity Oxygen/Fuel Process

AMS2448 Application of Tungsten Carbide Coatings on Ultra High Strength Steels, High Velocity Oxygen / Fuel Process

AMS2452 Superfinishing of HVOF Applied Tungsten Carbide Coatings

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 B214 Sieve Analysis of Metal Powders

ASTM E1417 Liquid Penetrant Testing

2.3 UAMA Publications

Available from Unified Abrasives Manufacturers Association, 30200 Detroit Road, Cleveland, OH 44145, Tel: 440-899-0010, www.uama.org.

UAMA B7.1 The Use, Care, and Protection of Abrasive Wheels

UAMA B74.13 Markings for Identifying Grinding Wheels and Other Bonded Abrasives

2.4 ASME Publications

Available from ASME, P.O. Box 2900, 22 Law Drive, Fairfield, NJ 07007-2900, Tel: 800-843-2763 (U.S./Canada), 001-800-843-2763 (Mexico), 973-882-1170 (outside North America), www.asme.org.

ASME B46.1 Surface Texture (Surface Roughness, Waviness, and Lay)

2.5 Terms used in AMS are defined in AS7766 and as follows:

- 2.5.1 **BALANCE (DYNAMIC):** Dynamic balance is the balancing of the complete rotating assembly consisting of the grinding wheel, mounting arbor, and the machine spindle. Depending on the balancing machine, the balance condition is measured and corrected at wheel speed. Most modern grinders have automatic wheel balancers as standard equipment.
- 2.5.2 **BALANCE (STATIC):** Static balance is the balance of the grinding wheel mounted on an arbor, typically balanced on a pair of knife-edges.
- 2.5.3 **BEARING RATIO:** The ratio of material to air in a horizontal slice through the surface profile expressed as a percentage. The 0% or reference line for the bearing ratio is located at the top of the highest peak within the evaluated profile. The bearing ratio is measured at different depths through the profile and varies with slice depth.

- 2.5.4 **CONCENTRATION:** The amount of superabrasive material contained in a unit volume of the grinding wheel. The measurement is based on the number of carats of superabrasive material per unit volume. Typical concentration numbers are in the range of 30 to 175. A concentration of 100 does not mean 100% and therefore is not the maximum concentration. A concentration of 100 means that there are 4.4 ct of abrasive per cm^3 (or 72 ct/in³ or 25 volume percent). The abrasive concentration of the selected grinding wheel, for grinding HVOF applied tungsten carbide coatings, is based upon the area of contact between the wheel and workpiece. A large contact area may dictate a low concentration and a small area of contact may dictate a higher concentration so the wheel can hold form and resist premature wear. Since OD grinding generally has smaller contact areas than ID grinding, the concentration of the abrasive in the grinding wheel should generally be higher for OD grinding and lower for most ID applications.
- 2.5.5 **COOLANT:** Grinding coolant can be either water based emulsion in a concentration of 3 to 5% as measured by refractometer, semi-synthetic or full synthetic based on the material being ground, underlying base metal compatibility, machine construction, and filtration system used. Coolant used to be determined by the cognizant engineering organization and machine tool builder.
- 2.5.6 **DRESSING:** Dressing/sharpening is the process of conditioning the wheel surface so as to achieve a certain grinding behavior. Dressing a resin-bonded grinding wheel entails removing some of the bond to expose the grain. This is accomplished by using an aluminum oxide or silicon carbide stick to "stick" the wheel. "Sticking" is best performed wet (see 3.6.3, 3.6.4, and Appendix B).
- 2.5.7 **GRADE:** The grade of a grinding wheel usually refers to the hardness of the bond system. For resin-bonded wheels this is determined by the size, type, and amount of filler materials incorporated in the plastic binder material. For the standard code for grinding wheel grades, refer to UAMA B74.13. Letter grades are increasingly not being shown in vitrified wheel specifications.
- 2.5.8 **GRAIN SIZE:** The grain size refers to a number which corresponds to the U.S. standard wire mesh size screen used for sizing the abrasive grain. This size is also defined by average particle diameter in accordance with ASTM B214.
- 2.5.9 **GRIT SIZE:** Another term for abrasive grain size. Typically, in United States mesh or FEPA micron sizes.
- 2.5.10 **INFEED:** The infeed or downfeed is the feed motion of the grinding wheel into the workpiece.
- 2.5.11 **SPARK-OUT:** This is the grinding of a workpiece at the end of the stock removal cycle without engaging any further infeed. The grinding forces are allowed to subside with time, ensuring a precision surface.
- 2.5.12 **SUPERABRASIVE:** Diamond or cubic boron nitride (CBN) abrasives.
- 2.5.13 **SUPERFINISHING:** A process used to produce high quality surface finishes with an average surface roughness equal to or less than 8 μin Ra, and a higher bearing area ratio, T_p , than ground surfaces (see AMS2452).
- 2.5.14 **SURFACE FINISH:** Surface finish is the smoothness of the machining marks on the surface of a workpiece. Surface finish is measured by moving a precision stylus across the surface and measuring the amplitude of the fluctuations of the stylus in accordance with ASME B46.1.
- 2.5.15 **SWARF:** Swarf is the mass of chips and debris remaining after a grinding process.
- 2.5.16 **THERMAL DAMAGE:** Thermal damage is metallurgical damage which occurs to a material when it is subjected to temperatures which will affect its metallurgical structure.
- 2.5.17 **TRUING:** Truing a grinding wheel is the procedure of making the grinding wheel geometrically correct for the application and to ensure it is rotating concentric to the center line of the spindle.
- 2.5.18 **BRAKE TRUING DEVICE:** For resin-bonded wheels a brake-controlled truing device is a grinding wheel mounted on an arbor and bearing housing, which has a friction brake to limit its speed. Such a brake-controlled truing device can be used to true resin-bonded superabrasive grinding wheels.

NOTE: Brake controlled truing devices are useful for truing grinding wheels up to 12-inches diameter.

2.5.19 WHEEL SPEED: Wheel speed is the peripheral speed of the grinding wheel. It is calculated by the following formula:
Wheel Speed (Surface Feet per Minute) = Wheel Diameter (in inches) x RPM x 0.262. For metric equivalent,
Meters per Second (m/s x 197 = SFPM).

3. TECHNICAL REQUIREMENTS

3.1 Parts to be ground shall have been coated with tungsten carbide coating in accordance with AMS2447 and AMS2448.

3.2 Specific surface finish requirements shall be specified by the cognizant engineering authority. Unless otherwise specified, the surface finish shall be 8 Ra maximum.

NOTE: Superfinishing of surfaces is generally indicated by measured surface finishes less than 8 Ra. Grit sizes used in the ranges above are not capable of producing super finished surfaces. Superfinished surfaces typically have higher bearing area ratios than as-ground surfaces. Ra = arithmetic average (micro-inch) surface finish.

3.3 Equipment

3.3.1 Grinding Equipment

Grinding equipment shall be capable of maintaining grinding wheel speed, workpiece speed, traverse or cross feed speed, and infeed in increments necessary to avoid surface degradation of the part. Provisions shall be made to supply a constant application of coolant (cutting fluid) to the working surface of the wheel at the grinding zone interface.

3.4 Materials

3.4.1 Grinding Wheels

Diamond abrasive resin-bonded or vitrified-bonded grinding wheels shall be used. Grinding wheels shall be labeled with the complete grinding wheel specification including abrasive type, grit size, grade, bond type, and maximum operating speed in accordance with UAMA B74.13. Care and protection of grinding wheels, including proper storage, handling, and mounting, shall be in accordance with UAMA B7.1.

3.4.1.1 Each of the following parameters shall be met when selecting a grinding wheel:

Abrasive – Diamond

Bond – Resin or Vitrified

Grit or Grain Size

- Resin bonded wheels – 100 to 400 grit
- Vitrified bonded wheels – 200 to 2800 grit

Hardness or Grade of bonded portion of wheel

- Resin bonded – H, L, M, N, P, or R
- Vitrified – H, I, J, or K if specified by the wheel manufacturer. Wheel manufacturer's equivalent is acceptable.

Concentration – 75 to 150

3.4.2 Coolants

A suitable coolant shall be used which does not have an adverse effect on the part being ground. Recirculating coolants shall be continuously filtered to minimize recycling grinding residue and swarf. A coolant nozzle sufficiently wide to flood the entire width of the grinding wheel shall be used. For proper application of the coolant, the coolant nozzle should be designed to deliver coolant at a speed equal to or slightly faster than the peripheral grinding wheel speed (see Appendix A for an example).

3.5 Cleaning

Protective coatings and other foreign materials shall be removed from parts prior to grinding to preclude contamination of coolant and wheels. Coolants and grinding residuals that have a deleterious effect on the part shall be removed after grinding. Cleaning materials shall not corrode or otherwise degrade the surfaces of the part.