AEROSPACE RECOMMENDED PRACTICE

ARP5935

Issued 2007-02
Reaffirmed 2013-10

Use of HVOF Thermal Spray Coatings for Hard Chrome Replacement in Landing Gear Applications

RATIONALE

ARP5935 has been reaffirmed to comply with the SAE five-year review policy.

1. SCOPE

Electrolytically deposited chrome plate is the current standard surface treatment for landing gear component interface surfaces that require good wear resistance and corrosion protection. Chrome plated components are typically plagued by a slight debit in fatigue performance, detrimental mud cracking surface pattern, susceptibility to scoring, wear, and seal leakage. In addition, recent changes in environmental compliance standards place further restrictions on the use of electrolytically deposited chromium. Some commercial applications have already eliminated the use of chrome plate on current and future products. As a result, a substitute for electrolytically deposited chrome plate has been sought for several years.

High Velocity Oxygenated Fuel (HVOF) thermal spray coatings have been developed to the point where they are being implemented as an alternative to hard chrome plate on high strength low alloy steels for external surfaces on landing gear applications. Some of the characteristics of HVOF coatings, such as fatigue and wear resistance are superior to hard chrome plate. Yet, performance characteristics, such as adhesion under very high strains, are clearly different. This document is intended to outline and describe the design and usage guidelines for HVOF tungsten carbide coatings to assure adequate quality and performance of the landing gear equipment. This document is not intended to act as a detailed process specification for applying HVOF coatings. Also, the recommendations in this document do not necessarily apply to certain proprietary spraying systems (i.e., D-Gun™).

The information in this document pertains to HVOF tungsten carbide based coatings applied to high strength steel alloys only, and is not necessarily applicable to other substrates.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

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http://www.sae.org/technical/standards/ARP5935

2.1.1 SAE Publications

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

AMS-QQ-C-320 Chromium Plating, Electrodeposited

AMS 2447B Coating, Thermal Spray High Velocity Oxygen/Fuel Process

AMS 2448 Application of Tungsten Carbide Coatings on Ultra High Strength Steels High Velocity Oxygen Fuel Process

AMS 2449 Grinding of HVOF Sprayed Tungsten Carbide Coatings Applied to High Strength Steels

AMS 2649 Etch Inspection of High Strength Steel Parts

ARP 4462 Barkhausen Noise Inspection for Detecting Grinding Burns in High Strength Steel Parts

AMS 7881 Tungsten Carbide-Cobalt Powder

AMS 7882 Tungsten Carbide-Cobalt-Chrome Powder

2.1.2 ASME Publications

Available from ASME, 22 Law Drive, P.O. Box 2900, Fairfield, NJ 07007-2900, Tel: 973-882-1170, www.asme.org.

ASME B46.1 Surface Texture

2.1.3 ASTM Publications

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

ASTM B 117 Standard Practice for Operating Salt Spray (Fog) Apparatus

ASTM E 1417 Standard Practice for Liquid Penetrant Examination

ASTM E 1444 Standard Practice for Magnetic Particle Testing

2.1.4 ISO Publications

Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ISO 4287 Geometrical Product Specifications - Surface Texture

2.2 Definitions

HVOF (High Velocity Oxygenated Fuel): A combustion process in which the combustion gases are accelerated through a nozzle to supersonic velocities. Gas/particle temperatures can reach 4500 °F (2482 °C) with a particle velocity up to 2500 fps (762 m/s).

SPALLING: Co-adhesive and adhesive failure of the coating material through cracking within the coating and/or debonding from the substrate surface.

THERMAL SPRAY: A process in which thermal energy is used to create an aerosol of finely divided materials to be deposited in a molten or semi molten condition on to a prepared substrate to form a new surface deposit. Thermal spray processes include combustion, plasma, and arc/wire.

FPI: Fluorescent penetrant inspection.

Ra: Roughness average is a measurement of the average distance between the median line of the surface profile and its peaks and troughs.

Rp: The maximum profile peak height measured from the median line.

Rz: The average of the five maximum peak to trough separations for one evaluation length.

Rmr: The symbol Rmr has two meanings. First, it is used generically as the abscissa of the bearing ratio curve. It is a percent bearing ratio. Second, as described in 3.6, 'Rmr' as a parameter refers to the bearing ratio at a specified height. The most common way of specifying the height is to move over a certain percentage (the reference percent) on the bearing ratio curve and then to move down a certain depth (the slice depth). The bearing ratio at the resulting point is 'Rmr'. The bearing ratio curve mathematically is the integral of the amplitude distribution function. It is a cumulative probability distribution. Ordinarily, the integral is performed from the highest peak downward, so each point on the bearing ratio curve has the physical significance of showing what linear fraction of a profile lies above a certain height. Rmr was formerly referred to as Tp, bearing length ratio.

3. RECOMMENDATIONS

3.1 Coating Materials

The spray powder materials should be limited to either WC-17Co or WC-10Co-4Cr per AMS 7881 or AMS 7882. The choice of material should be made based partly on corrosion protection required. Coating thickness limitations are described in 3.5.

3.2 Spraying Equipment

The HVOF gun should be capable of spraying coatings by injecting powdered materials into a supersonic jet stream created by the combustion of oxygen and a fuel (typically hydrogen, kerosene, natural gas, etc.). When spraying, fixtures should be employed to maintain gun-to-target distances and traverse rates. Note: changing powders, guns, fuels, spray facilities, or environment can alter the performance of the resulting coating and will require re-qualification of the process/component combination.

3.3 Spraying Process

Heat treatment, stress relief, shot peening, and other cold working should be done prior to spraying. Prior to shot peening, the surface should have a finish 125 Ra or better. The substrate surface should be grit blasted with coarse grit prior to spraying to assure good adhesion.