ENGINEERING PROCESS SPECIFICATION

Rolls-Royce Corporation
P.O. Box 420
Indianapolis, Indiana
46206-0420 USA

CAGE code 63005

Rolls-Royce

Specification number	Rev
EPS 10654	**R**
Issued: 1 Aug 1981	Revised: 28 Nov 2012
Replaces: EPS 10654 P	

Coating, Aluminum-Chromium, Electrophoretic, Diffused, for Application to Cast Cobalt-Base Components (AEP 100)

Status: **Active**

EXPORT-CONTROLLED DOCUMENT

This document contains technical data whose export is restricted by the Export Administration Act of 1979, as amended (Title 50, U.S.C., App 2401, Et Seq), and is controlled by the Export Administration Regulations (15 CFR parts 730-774) under ECCN 2E003. Diversion contrary to U.S. export law is prohibited.

Controlled per ECCN 2E003

1. SCOPE:

1.1 Purpose: This specification covers the requirements for the electrophoretic deposition of a diffused aluminide coating. Such a coating typically is used to provide oxidation/hot corrosion resistance.

1.2 Application: Primarily for cobalt-base alloy turbine components.

1.3 Precautions:

1.3.1 The electrophoretic coating process uses a high direct current (DC) voltage in the application of the coating. The coating facilities must be designed and constructed to provide the operator with maximum protection from electrical shock.

1.3.2 The electrophoretic coating solution is flammable and emits vapors that can reach an explosive concentration. Breathing the fumes may cause toxic effects. The exhaust blower must be on at all times while the coating room is occupied and must be on during all phases of the coating operation. When not in use, the coating solution tanks must be kept covered at all times to minimize evaporation.

2. APPLICABLE DOCUMENTS: The following publications form a part of this document to the extent specified herein. The applicable issue shall be the current issue, 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. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence.

2.1 Rolls-Royce Corporation Engineering Inspection Specifications (EIS's), Engineering Material Specifications (EMS's), and Engineering Process Specifications (EPS's): Available from Rolls-Royce Corporation, Speed Code U30, P.O. Box 420, Indianapolis, IN 46206-0420.

- EIS 1221 *Inspection Requirements and Acceptance Standards, Diffused Aluminide Coatings*
- EMS 27147 *Cement, Plastic, Polystyrene/Toluene/Allyl Isothiocyanate*
- EMS 56714 *Powder, Zein, AEP*
- EMS 56728 *Powder, Aluminum-Chromium Alloy, AEP*
- EMS 73654 *Cobalt Alloy, Investment Casting—Corrosion- and Heat-Resistant Vacuum Cast—Vacuum Melt (MAR-M509A)*
- EPS 12012 *Dry Honing, Aluminum Oxide Abrasive*

2.2 Rolls-Royce Aerospace Process Specifications (RRPs):

Available internally from the Standards and Specifications webpage on the capability intranet http://www.infocentre.rolls-royce.com/technical_library/default.htm and the materials web; available externally from https://suppliers.rolls-royce.com/

- RRP 51000 *General Cleaning and Degreasing*

2.3 Society of Automotive Engineers (SAE) Aerospace Material Specifications (AMS's): Available from SAE, 400 Commonwealth Dr., Warrendale, PA 15096.

- AMS 5382 *Cobalt Alloy, Corrosion- and Heat-Resistant, Investment Castings, 54Co - 25.5Cr - 10.5Ni - 7.5W, As-Cast*

3. TECHNICAL REQUIREMENTS: Processing to this specification shall be performed to a written process control instruction or process routing maintained by the processor and subject to Rolls-Royce Corporation audit and approval. These documents shall be prepared with instructions specific to each part number coated (see 4.4.2).

3.1 Equipment:

3.1.1 Direct Current Power Source: Shall be capable of maintaining a constant voltage setting (±3 V) within the range of 1 to 250 V and a current capability up to 5 amps during a specific coating cycle. Power conductors, controls, and connectors to anodes and cathodes shall provide adequate protection to prevent electrical shock to operators.

3.1.2 Tank Construction: The tank shall be constructed of corrosion-resistant material and enclosed or insulated to prevent external electrical shock hazard and/or short-circuiting. Tank material should be compatible with coating chemicals.

3.1.3 Anodes: Primary and auxiliary anodes shall be fabricated from corrosion-resistant metals or alloys that are good electrical conductors.

3.1.4 Masking: Masking material shall have good resistance to repetitive immersions in the dispersing media. Approved materials are listed in 8.3.

3.2 Materials: Electrophoretic solution composition shall be as follows:

3.2.1 Dispersing Media:

	Percent by Weight	Percent by Volume
Isopropanol (99% minimum)	60 ± 5	68.5 ± 4.5
Nitromethane (95% minimum)	40 ± 5	31.5 ± 4.5

A pre-mix solvent of 60 wt % isopropanol and 40 wt % nitromethane (PMI 1222925) is also allowed as a dispersing media.

3.2.2 Solubles:

Zein (see EMS 56714)	0.27 ± 0.04 oz/gal (2.0 ± 0.3 g/L)
Cobalt nitrate hexahydrate (see 8.3.3)	0.016 ± 0.004 oz/gal (0.12 ± 0.03 g/L)

3.2.3 Insoluble Dispersant (1.9 to 6.6 oz/gal [14 to 50 g/L] total): Prealloyed aluminum–chromium powder: see EMS 56728.

3.2.3.1 All powder sources (see 8.1) shall be approved by Rolls-Royce Corporation (see section 4.4).

3.2.4 Coating Solution Precautions:

3.2.4.1 Water Content: Shall be less than 2.7 oz/gal (20 g/L) during all coating operations. Isopropanol is hygroscopic and may become contaminated with moisture from exposure to air. Water in excess of 2.7 oz/gal (20 g/L) can cause pitting of the green coating. The solvent shall be discarded when the water content is greater than 2.7 oz/gal (20 g/L).

3.2.4.2 Bath: Shall be operated between 60 and 90°F (16 and 32°C).

3.2.4.3 Agitation of Solution: Moderate and continuous agitation is absolutely necessary to provide and maintain a homogenous dispersion of the suspended particles (dispersants). Excessive paddle speed can create thin spots in the coating. Baffles in the tank are required to eliminate eddies and/or swirling of the bath, which can interfere with the electrophoretic migration of particles, creating a wash or thin spots in the coating. Newly prepared baths, or baths having agitation interrupted for more than 15 minutes, must be stirred long enough to ensure homogenous dispersion of the particles before coating deposition. Minimum stirring time required must be established for each coating tank and baffle design.

3.2.4.4 Additions: Shall be made, as necessary, to maintain the required metal powder concentrations as defined in 3.2.3.

3.2.4.5 Specific Gravity of Solvent: The specific gravity of the 60% by weight isopropanol/40% by weight nitromethane solvent shall be checked before addition to the bath. The specific gravity shall be 0.880 to 0.915.

3.3 Cleaning and Surface Preparation:

3.3.1 Parts shall be thoroughly cleaned (both exterior and internal passages, where applicable) to remove all dirt, grease, oil, and other foreign materials in accordance with RRP 51000, by heating to 1100–1300°F (595–705°C) for 20 to 60 minutes in air, or by other approved cleaning method.

3.3.2 Solid and Cored Castings: Abrasive clean all exterior surfaces to be coated by dry honing in accordance with EPS 12012 using 120-grit or finer aluminum oxide at 20–30 psi (1.4–2.1 bar) for pressure-type equipment or 20–50 psi (1.4–3.4 bar) for suction-type equipment.

3.3.3 Finished Machined Parts: Abrasive clean all exterior surfaces to be coated by dry honing in accordance with EPS 12012 using 220-grit or finer aluminum oxide at 20–30 psi (1.4–2.1 bar) for pressure-type equipment or 20–50 psi (1.4–3.4 bar) for suction-type equipment.

3.3.3.1 Extreme care must be taken to ensure removal of residual abrasive media from cored castings and hollow assemblies.

3.3.4 Parts to be coated shall be handled with clean gloves until coating is applied.

3.4 Masking: Parts shall be masked and/or fixtured as required to prevent coating deposition in "no-coat" areas. Masks and fixtures shall be periodically cleaned by wiping with 70% isopropanol/30% water or by lightly blasting with aluminum oxide to remove excessive coating buildup.

3.5 Coating:

3.5.1 Immerse masked and/or fixtured parts in the electrophoretic solution, and coat using the following parameters. Voltage shall be set initially to achieve the desired current density and maintained at a constant level during the coating cycle. The current will drop during the coating cycle for a properly formulated bath. Initial voltage will vary with total surface area to be coated and with bath composition.

Note: A bath with suitable throwing power should exhibit a current decay of half the initial amperage in 3 minutes or less. Baths that do not exhibit this current decay can normally be rebuilt and restored to a useful condition by allowing the powders to settle and replacing the solvents and soluble ingredients.

3.5.1.1 Initial current density shall not exceed 13 mA/in.^{2} (2 mA/cm^2). Continuous deposition time shall be sufficient to deposit the required green coating weight of 0.0034–0.0068 oz/in.^{2} (0.015–0.030 g/cm^2).

Note: Green coating deposition varies with anode and component configuration and is controlled by current density and deposition time.

3.5.1.2 Green Coating Metal Composition:

	Percent by weight
Aluminum	70 ± 2
Chromium	30 ± 2

3.5.1.3 Remove parts from solution, drain off coating solution, and allow to dry for not less than 1 minute.

3.5.1.4 Remove masking and/or fixturing in a manner to avoid damaging the undiffused coating.

3.5.1.5 Coated parts shall be visually inspected for evidence of any coating material on surfaces to be left bare. Any stray green coating on surfaces intended to be left uncoated shall be removed by brushing and/or wiping with 70% isopropanol/30% water solution.

3.5.1.6 Each coating lot shall be analyzed for the requirements of 3.5.1.1 for weight in accordance with procedures established by Rolls-Royce Corporation. If the results are not in accordance with 3.5.1.1, the lot shall be rejected, the green coating removed, and the parts reprocessed. Periodic chemical analysis of the green coating shall be performed to confirm compliance with 3.5.1.2.

3.5.2 Touch-up Procedure for Damaged Green Coating: Parts with green (undiffused) coating having areas of damage such as nicks, scratches, or thin or bare areas of greater than 10% of the surface area to be coated shall be completely reprocessed, starting with paragraph 3.3.1. Parts with damaged areas of less than 10% of the surfaces to be coated may be touched up as follows:

3.5.2.1 Touch up parts with a small artist-type brush using a slurry of the same composition as the damaged coating being touched up.

3.5.2.2 Powder content of the slurry shall be as described in section 3.2.

3.5.2.3 For each 0.35 oz (10 g) of powder (see EMS 56728), mix with approximately 0.2–0.3 oz (5–10 mL) of zein solution (see EMS 56714), or about 2.7–4.0 oz/gal (20–30 g/L) in 60% by weight isopropanol/40% by weight nitromethane solvent. Maintain mechanical agitation during use. Adjust the amount of zein solution to give proper consistency for slurry application. Replace solvent lost by evaporation with 60/40 solvent as necessary to maintain proper consistency.

3.5.2.4 As necessary, apply slurry two or more times to ensure adequate green coat thickness, and dry.

3.5.2.5 Parts with touched-up coatings shall be diffused as defined in section 3.5.3.

3.5.3 Diffusion Heat Treatment:

3.5.3.1 If necessary, surfaces to be left bare may be masked (see 8.3.7) to prevent aluminum vapor transport from adjacent coated surfaces.

3.5.3.2 Parts shall be positioned on fixtures, racks, or screens to minimize contact with gas path surfaces. Surfaces to be left uncoated must not be in contact with any stray undiffused coating or previously coated surfaces of the fixtures, racks, or screens.

3.5.3.3 All coated parts shall be heated in dry, high-purity (99.9% minimum) argon or hydrogen. For atmosphere furnaces, the dew point of the gas at the furnace entrance before heating shall be -50°F (-45°C) or lower. Vacuum furnaces require a leak rate of no more than 15 microns per hour after pumping down to at least 5×10^{-5} torr. A burnout schedule shall be established for each type of furnace to eliminate any deleterious contamination of the parts during the diffusion cycle. The temperature uniformity of all furnaces shall be ±25°F (±14°C). Overshoot shall be limited to 25°F (14°C) above temperature set point.

3.5.3.3.1 Furnace controls, calibration, surveys, and pyrometry shall be as agreed between Rolls-Royce Corporation and the user of the specification.

3.5.3.4 Diffusion cycles shall be as required to produce the coating thickness and structure per section 3.6.3. Unless otherwise specified on the applicable part drawing, diffusion times shall be within the range specified in Table 1.

Table 1. Diffusion Cycles

Specification	Alloy	Temperature Set Point	Diffusion Time	Minimum Cooling Rate to 1400°F (760°C)
EMS 73654	MM509	1900°F (1040°C)	2–5 hr	No requirement
AMS 5382	X40	1900°F (1040°C)	2–5 hr	No requirement

3.5.3.5 Heat-up rate must not exceed 30°F (17°C) per minute. Rate is defined between 200°F (93°C) and 1000°F (540°C), but not points in between. At 1000°F (540°C), burn-off of the green coat binder is essentially complete. Rapid heat-up rates will cause lifting of the green coat from the substrate and will result in thin or bare spots in the diffused coatings.

3.5.3.6 Diffusion cycles for touch-up repair of brazed components shall be as determined by Rolls-Royce Corporation.

3.5.4 Surface Conditioning for Coating Inspection: Remove diffusion scale by blast cleaning in accordance with EPS 12012 using 220-grit or finer aluminum oxide at 15–30 psi (1.0–2.1 bar) for pressure-type equipment or 20–50 psi (1.4–3.4 bar) for suction-type equipment.

Note: Since suction-type machine pressures vary considerably from one machine to another, it is recommended that each processor establish his own pressures within this range that remove the undiffused scale but avoid removal of diffused coating.

Caution: The blast cleaning operation requires proper technique and careful execution. A 3- to 12-inch (8- to 30-cm) standoff distance from the parts shall be maintained to ensure proper cleaning and avoid removal of the coating.

3.5.4.1 By means of an air blast, remove residual blast media. **Special attention must be paid to internal passages of hollow parts; all residual material shall be removed before use.**

3.6 Quality:

3.6.1 Visual and Fluorescent Penetrant Inspection: The coating, when visually or fluorescent penetrant inspected, shall be in accordance with EIS 1221.

3.6.2 Heat Tint: A heat-tint test shall be used to determine whether parts are coated or whether coating is present in a no-coat area in accordance with EIS 1221. If parts fail to comply with the requirements of EIS 1221, a metallographic evaluation (see 3.6.3) may be performed to determine the acceptability of the heat-tint lot. Coating present in no-coat areas shall be subject to rejection in accordance with 3.6.3.3.

3.6.2.1 Parts shall be 100% heat-tint inspected. Parts must be cleaned per EPS 12012 (see 3.5.4). To avoid erroneous heat-tint coloration, part cleanliness must be preserved from the cleaning operation through heat-tint processing by using clean gloves to handle the parts.

3.6.2.2 Cleaned parts shall be heat tinted in a circulating air furnace at temperatures of 1100–1300°F (595–705°C), depending on the base material, for 20 to 60 minutes, and then air cooled.

3.6.2.3 Heat-tint film shall not be removed. Heat-tint film is very thin, and grit blasting may remove part of the protective coating.

3.6.3 Metallographic Inspection:

3.6.3.1 Sectioning and polishing of specimens for metallographic examination of the coating shall use procedures that produce minimal heat and physical damage to the coating and base alloy. Since many coatings on cobalt alloys are quite brittle, nickel plating or other edge retention polishing techniques shall be used before mounting to preserve the original coating surface.

3.6.3.2 Representative coated parts from each diffusion furnace lot shall be metallographically inspected at 500x magnification for coating thickness, coating structure, and evidence of coating in no-coat areas. Parts for sectioning shall be heat-tint inspected before sectioning to aid in selecting areas for evaluation.

3.6.3.3 Unless otherwise specified on the part drawing, the average coating thickness shall be 0.0015–0.0035 inches (0.038–0.089 mm). The coating thickness may be 0.0010–0.0042 in. (0.025 to 0.107 mm) in localized areas. Unless otherwise specified on the part drawing, the average coating thickness shall be determined on unetched or suitably etched airfoil cross sections at 50% span with a minimum of eight measured values approximately evenly spaced around the airfoil and including both the leading edge and the trailing edge. Additional measurements shall be taken and recorded to include the minimum and maximum thicknesses, which must be included in determining average coating thickness. The coating thickness measurements on other part configurations—saddles, thermocouple probes, etc.—shall be conducted as determined by Rolls-Royce Corporation and the user of this specification. Stray coating on surfaces intended to be left bare is acceptable to 0.0007 in. (0.018 mm) maximum, unless otherwise specified on the part drawing.

3.6.3.4 Evaluation of the coating structure shall be performed on suitably etched specimens. A typical microstructure is shown in Figure 1.

3.6.3.5 When required to resolve coating microstructure, the following etch procedures are recommended:

- Etchant A-1: Immerse or swab in concentrated hydrochloric acid for the time necessary to resolve the coating microstructure (see Figure 1).

- Etchant A: Immerse or swab in 10% hydrochloric acid (reagent grade) in methanol with two to three drops of hydrogen peroxide for the time necessary to resolve the coating microstructure.

- Etchant B: Immerse or swab in No. 2 stainless etchant consisting of 0.18 oz (5 g) ferric chloride ($FeCl_3$ - $6H_20$), 1.7 oz (50 mL) hydrochloric acid, and 3.4 oz (100 mL) methanol for the time necessary to resolve the coating microstructure.

- Etchant C: Immerse or swab in 1% hydrofluoric acid, 33% nitric acid, 33% acetic acid, and 33% water for the time necessary to resolve the coating microstructure (typically 5–10 seconds).

3.7 Touch-up Procedure for Damaged Diffused Coatings:

3.7.1 Parts with **diffused** coatings having localized areas of damage such as chips, nicks, and/or small bare areas may be locally repaired only if repeated heat treatments are authorized by Rolls-Royce Corporation for the specific base material involved. Size of the area requiring touch-up is limited to 10% of the non-airfoil surfaces, such as inner and outer bands on vane segments. Touch-up is limited to areas that are 0.2 in. (5.1 mm) in diameter or equivalent on all other surfaces. No more than three spots up to 0.2 in. (5.1 mm) in diameter or equivalent may be touched up.

3.7.2 Clean/degrease per RRP 51000 or clean using a Rolls-Royce Corporation-approved method, if necessary.

3.7.3 Air dent the areas to be touched up per EPS 12012, removing any sharp transition to the surrounding sound areas. Use 220-grit aluminum oxide at a pressure and a standoff distance sufficient to prepare the area without damaging the base metal.

3.7.4 Touch up parts according to the procedure described in paragraphs 3.5.2 through 3.5.2.4.

3.7.5 Heat treatment and cleaning steps as described in 3.5.3 shall be repeated, except that diffusion cycles for touch-up repair of brazed components shall be determined by Rolls-Royce Corporation.

3.7.6 No part shall be touched up more than twice (original coating cycle plus two reworks).

3.7.7 Heat Tint: An acceptable heat-tint test, as defined in paragraphs 3.6.2 through 3.6.2.3, shall be adequate evidence of satisfactory coating coverage for touch-up coatings.

3.8 Strip and Recoat Procedure for Unacceptable Coatings: Parts with coatings not conforming to the requirements of this specification may be stripped according to procedures approved by Rolls-Royce Corporation and recoated per EPS 10654, provided stripping and repeated heat treatment are authorized by Rolls-Royce Corporation for the specific base material involved. Since stripping of diffused coating also removes some base material, the maximum number of reprocessing cycles allowed shall be two, unless otherwise agreed to by the Rolls-Royce Technical Authority.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The coating processor shall be responsible for performing all tests. Results of such tests shall be reported to Rolls-Royce Corporation as required by paragraph 4.5. Rolls-Royce Corporation may perform confirmation testing as required to ensure conformance to all requirements.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to the requirements of section 3.6 are classified as acceptance tests and shall be performed to represent each coating lot in the furnace lot.

4.2.2 Tests to determine conformance to requirements of green coat deposition weight in paragraph 3.5.1.1 and composition in paragraph 3.5.1.2 are classified as in-process acceptance tests and shall be performed as described in section 4.3.

4.3 Sampling:

4.3.1 Green Coating Weight and Composition: The green coating weight shall be determined on a minimum of one representative part from each coating lot. A coating lot is defined as a maximum of 500 parts of a single part number submitted for coating application at one time. (Normally one part from each rack of parts being coated is weighed before and after coating as an in-process control, and those weights are recorded for future use.) If any analysis fails to meet the requirements of section 3.5, the coating lot shall be rejected. The green coating composition (3.5.1.2) shall be determined per a sampling plan agreed by Rolls-Royce Corporation and the user of this specification. Unless otherwise specified, green coat composition shall be determined, at a minimum, *once per calendar quarter.*

4.3.2 AEP Bath Analysis: Perform daily or, at a minimum, after the total green coating weight deposited from the bath equals 0.53 oz/gal (4 g/L) of solution in the bath. A gravimetric analysis for the solids and zein (see EMS 56714) is acceptable. The zein (see EMS 56714) determination is performed on a centrifuged solution sample. The cobalt nitrate level can be determined only by chemical analysis, but the ratio of zein/cobalt nitrate can be used to estimate quantities of cobalt nitrate for the purpose of making additions to the bath. The bath analysis is used to calculate the required additions to the coating bath. The coating solution shall be chemically analyzed for both solubles and insolubles, at a minimum, after 2.0 oz/gal (15 g/L) have been deposited from the bath.

4.3.3 Finished Parts (coated and diffusion heat treated): A furnace lot is defined as all parts loaded into the diffusion furnace and diffused at the same time. A furnace lot may include more than one coating lot.

4.3.3.1 Furnace lots shall be 100% visually or fluorescent penetrant inspected to determine conformance to 3.6.1.

4.3.3.2 All parts in each furnace lot shall be visually inspected to determine conformance to heat-tint standards (3.6.2).

4.3.3.3 A minimum of one representative coated and diffusion-treated part from each coating lot included in each furnace lot shall be inspected to determine conformance to coating thickness and microstructure standards per paragraph 3.6.3.2.

Note: When parts are very large or complex, or when part quantities are limited, Rolls-Royce Corporation may authorize use of control pieces of a different configuration, provided they are of the same base material as the actual parts, and correlation of coating thickness and microstructure between the control configuration and the actual part configuration has been established.

4.4 Approval:

4.4.1 Raw Material Source Approval: Sources for certain coating raw materials, including zein (see 3.2.2) and insoluble powder (see 3.2.3), shall be approved by Rolls-Royce Corporation before materials are supplied for production use. Approved sources are listed in 8.1.

4.4.2 Coating Source Approval: Processing to this specification shall be performed only by sources approved by Rolls-Royce Corporation. Approval shall be based on review of the processor's capabilities and process control provisions and on evaluation of coated sample hardware.

4.4.2.1 Coating Process Approval: Processing for each part number coated shall be approved by Rolls-Royce Corporation before parts are used in production. Approval shall be based on evaluation of the coated parts.

4.4.2.2 Changes in materials, type of equipment, processing method or parameters, process control, or inspection procedures that could affect the parts require approval by Rolls-Royce Corporation Engineering. For such changes, the supplier shall submit:

a. a description of the change and its potential effect(s) on the product
b. sample parts and/or test material as requested by Rolls-Royce Corporation for evaluation

4.5 Reports: With each shipment of coated parts, the coating supplier shall furnish a report of coating thickness test results on test pieces processed with each furnace lot and a statement that the coated parts conform to all requirements of this specification. This report shall include the purchase order number, this specification number and its latest revision letter, part number, and quantity in each furnace lot. Records of processing parameters established for each part number shall be maintained by the coating supplier and be subject to Rolls-Royce Corporation audit.

4.6 Resampling and Retesting: If any part fails to meet the requirements of this specification, three additional parts may be taken at random from that furnace lot (see 4.3.1). If any of the three parts fails to meet the requirements of this specification, the coating lot shall be rejected.

5. PREPARATION FOR DELIVERY:

5.1 Parts shall be handled and packaged in a manner ensuring 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 applicable rules and regulations pertaining to handling and packaging the parts to ensure safe delivery.

6. ACKNOWLEDGMENT: A supplier shall refer to this specification number and its revision letter in all quotations and when acknowledging purchase orders.

7. REJECTIONS: Parts not processed in accordance with this specification and/or not meeting the acceptance standards herein shall be subject to rejection.

8. NOTES:

8.1 Approved Raw Material Sources:

8.1.1 Zein: See EMS 56714.

8.1.2 Prealloyed Aluminum-Chromium Powder: See EMS 56728.

8.2 Approved Coating Sources: Rolls-Royce Corporation, Indianapolis, IN 46206, or its licensed and approved suppliers (AEP 100—a proprietary process).

8.3 Demonstrated Products: The following products have demonstrated capability for use in accordance with this specification. Product brand names and sources are referenced for information only; equivalent products may be procured from other sources.

8.3.1 Isopropanol (99% Minimum): Available from Union Carbide or Shell Chemical Co.

8.3.2 Nitromethane (95% minimum): Available from Angus Chemical Co., 1500 E. Lake Cook Rd., Buffalo Grove, IL 60089, or W. R. Grace, 55 Hayden Ave., Lexington, MA 02173.

8.3.3 Cobalt Nitrate Hexahydrate (Reagent Grade): Available from Fisher Scientific Co. or J. T. Baker Chemical Co.

8.3.4 Microsol E-1003: A product of Michigan Chrome and Chemical Co., 8611-35 Grinnell Ave., Detroit, MI 48213.

8.3.5 GE RTV 108 Silicone Rubber: A product of General Electric, Silicone Products Dept., Waterford, N.Y.

8.3.6 Ethylene Propylene EPDM or Hypalon (Hydro-Xyproline): Available from Acme Masking Co., 240 Production Dr., Avon, IN 46123.

8.3.7 Maskants:
1. Testor No. 3501 Model Cement: See EMS 27147.
2. 323 Red Stop-Off Lacquer: A product of BASF, 1500 Latham St., Batavia, IL 60510.

8.3.8 ASC-2N Stripper: Alloy Surfaces, Inc., West Chester, Penn.

8.4 Licensing: AEP 100 is proprietary to Rolls-Royce Corporation. Requests for license to apply AEP 100 must be directed to Rolls-Royce Corporation.

8.5 General: This specification is issued by Rolls-Royce Corporation for use in manufacturing items described by Rolls-Royce Corporation drawings. The user is responsible for compliance to the latest revision of this specification.

8.6 Figure 1 is an integral part of this specification.

8.7 Inch/pound units are primary; SI units are approximate conversions and are provided for informational purposes only.

8.8 Marginal Indicia: Revision bars indicate changes from the previous issue of this specification.

8.9 Revision R is authorized by ESC 500017238566.

Signed Peter J. Breitzmann

Chief, Materials Design Services

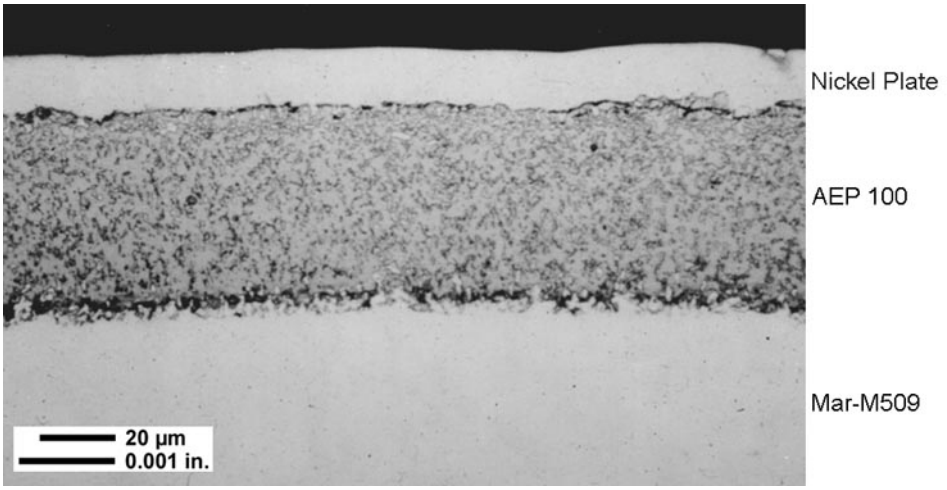

Figure 1. Typical AEP 100 microstructure on MAR-M509 after diffusion heat treatment
(Etchant: concentrated HCl)