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

AEROSPACE MATERIAL SPECIFICATION

AMS 2643

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Revised

STRUCTURAL EXAMINATION OF TITANIUM ALLOYS
Chemical Etch Inspection Procedure

1. SCOPE:

1.1 Purpose: This specification covers a procedure for revealing the macrostructure and microstructure of titanium-base alloys.

1.2 Application: Primarily for detecting defects and segregation in titanium-base alloys. This procedure should not be used on finished 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

2.2 ANSI Publications: Available from American National Standards Institute, Inc., 1430 Broadway, New York, New York 10018.

ANSI B46.1 - Surface Texture

3. TECHNICAL REQUIREMENTS:

3.1 Macrostructure:

3.1.1 Specimens:

3.1.1.1 Bars, Extrusions, Plates, and Stock For Forging or Extruding: Specimens shall be transverse cross-sections not less than 0.5 in. (13 mm) thick cut from the product to be tested and then cut in half longitudinally to permit examination of both transverse and longitudinal surfaces. Specimens from stock for forging or extruding shall be heated to 50 F ± 25 (27.8 C ± 14) degrees below the beta transus as determined for the heat, holding at heat for 60 min. ± 5, and cooled at a rate equivalent to air cool or faster. Specimens shall be machined to have surface texture of 70 microinches (1.78 µm) AA or finer, determined in accordance with ANSI B46.1.

3.1.1.2 Forgings: When dimensions permit, forgings shall be rough-machined to clean up and to assure freedom from alpha case. A minimum of 0.030 in. (0.76 mm) of material shall be left on the surfaces of the forgings between final etching and finish machined configuration to insure freedom from intergranular attack and hydrogen pickup on finished parts. If forgings are to be inspected by ultrasonic inspection procedures, the configuration used for such inspection is acceptable. Optimum surface texture shall be 130 microinches (3.3 µm) AA or finer, determined in accordance with ANSI B46.1.

3.1.2 Procedure:

3.1.2.1 Specimens shall be cleaned free from dirt, grease, oil, and other foreign materials.

3.1.2.2 Specimens shall be rinsed with clean tap water.

3.1.2.3 Specimens shall be etched in an aqueous acid solution maintained at room temperature for sufficient time to develop a well-defined macrostructure. The following solution or an alternate agreed upon by purchaser and vendor shall be used:

15% ± 2 by volume, technical grade nitric acid, 42° Baume'
10% ± 1.5 by volume, hydrofluoric acid (48%)
Balance water

3.1.2.3.1 The etching rate of the solution shall be maintained to remove 0.002 - 0.004 in. (0.50 - 0.10 mm) of metal in a 5 min. period. The etching rate shall be determined periodically.

3.1.2.4 Remove specimen from etch solution and immediately wash in clean water for several minutes.

3.1.2.5 Finish rinsing with pressurized tap water to remove smut.

3.1.2.6 Drain water from specimens by blowing dry with clean air.

3.1.2.7 Visually inspect the specimen at 1X using a light intensity not lower than 200 ft-candles (2153 lm/m^2) for macrostructure and defects such as segregation, laps, folds, cracks, inclusions, and heavy non-cleanup areas.

3.2 Microstructure: If examination of the macrostructure indicates the need for further evaluation, the microstructure shall be developed as follows:

3.2.1 Specimens: The specimens on which macrostructure was developed shall be cut through the areas of concern and, where practical, shall also be cut for examination of other planes.

3.2.2 Procedure:

3.2.2.1 Polish and etch the specimens to be examined using metallographic techniques which will clearly reveal the microstructure to be evaluated (See 8.3).

3.2.2.2 Examine the specimens to determine the microstructure and the nature of indications found in the macrostructure.

4. QUALITY ASSURANCE PROVISIONS: Not applicable.

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: Not applicable.

8. NOTES:

8.1 Alkaline liquid steam cleaning materials which have been found satisfactory for the solution of 3.1.2.1 are either of the following:

DuBois Chemical Co., Aerostream 20
Texize Chemical Co., Spraytex 8201

These products are diluted, 2 parts by volume of compound to 100 parts by volume of water. Pressure rinsing is suggested after cleaning.

8.2 Equipment:

8.2.1 The tank for the solution of 3.1.2.4 must be lined with polyvinyl chloride or comparable lining material.

8.2.2 Adequate ventilation is necessary because of evolution of gases due to vigorous reaction.

8.2.3 Fixtures, racks, and baskets shall be coated with acid resistant material that will not react with the nitric-hydrofluoric acid solution.

8.2.4 Appearance: Segregation appears as follows:

8.2.4.1 Segregation will appear after macroetching as an area of high silvery luster on a matte grey background. Typical segregation in titanium 6Al-4V alloy billet is shown in Fig. 1.

8.2.4.2 Segregation will not erase, whereas staining or discoloration will disappear when the use of a rubber eraser is applied.

8.2.4.3 Segregation will reappear after removing by sanding and localized re-etching.

8.2.4.4 Segregation is similar to other material defects in that it can occur throughout the product in any frequency, size, shape, form, or severity.

8.3 The preferred procedure for preparing specimens for examination of microstructure is as follows:

8.3.1 Polish electrolytically in the following solution at 40 v ± 1 for approximately 5 seconds:

78 cm^3 perchloric acid
120 cm^3 distilled water
700 cm^3 ethanol
100 cm^3 Butylcellosolve

8.3.2 Etch with Kroll's reagent (5% hydrofluoric acid (HF) sp gr 1.15), 12% nitric acid (HNO_3) (sp gr 1.42), 83% water) for sufficient time to develop the microstructure, wash in warm running water, and dry. Specimens may be rinsed in a solution of sodium bicarbonate and again rinsed in warm running water if desired between the rinsing and drying operations above.