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AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

SAE

AMS 2643B

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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 alloys.

1.2 Application:

This inspection procedure has been used typically for detecting defects and segregation in titanium alloys. This procedure should not be used on finished parts.

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 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 following publications form a part of this specification to the extent specified herein. The applicable issue of referenced publications shall be the issue in effect on the date of the purchase order.

2.1 ANSI Publications:

Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ANSI B46.1 Surface Texture

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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 0.50 inch (12.7 mm) thick cut from the product to be tested in the transverse direction. Specimens from stock for forging or extruding shall be heated to 50 F \pm 25 (28 C \pm 14) degrees below the beta transus as determined for the heat, held at heat for 60 minutes \pm 5, and cooled at a rate equivalent to an air cool or faster. Specimens shall be machined to have surface texture of 70 microinches (1.8 μ m) 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 ensure freedom from alpha case. A minimum of 0.030 inch (0.76 mm) of material shall be left on the surfaces of the forgings between final etching and finish machined configuration to ensure 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 μ m) 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 (R) Specimens shall be etched in an aqueous acid solution, maintained at room temperature, for sufficient time to develop a well-defined macrostructure (see 8.2). The solution in Table 1, or an alternate solution acceptable to purchaser, shall be used.

TABLE 1 - Etchant

Ingredient	Percent by Volume
Nitric Acid, Technical Grade, 42° Baume'	15 \pm 2
Hydrofluoric Acid (48%)	10 \pm 1.5
Water	Balance

3.1.2.3.1 The etching rate of the solution shall be maintained to remove 0.002 to 0.004 inch (0.05 to 0.10 mm) of metal in a five minute period. The etching rate shall be determined periodically.

- 3.1.2.4 Remove specimen from etch solution and immediately rinse in clean water for several minutes.
- 3.1.2.5 Finish rinsing with pressurized tap water to remove smut.
- 3.1.2.6 Remove water from specimens by blowing dry with clean air.
- 3.1.2.7 Visually inspect the specimen for macrostructure and defects, such as segregation, (see 8.3), laps, folds, cracks, inclusions, and heavy non-cleanup areas, using 1X magnification and a light intensity not lower than 200 foot-candles (2153 lx).

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 8.4).
- 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:

Processor shall mention this specification number and its revision letter in all quotations and when acknowledging purchase orders.

7. REJECTIONS:

Not applicable.

8. NOTES:

8.1 The (R) symbol is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this specification. If the symbol is next to the specification title, it indicates a complete revision of the specification.

8.2 Equipment:

8.2.1 The tank for the solution of 3.1.2.3 shall be lined with or fabricated from a material compatible with the solution.

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.

8.3 Appearance:

Segregation appears as follows:

8.3.1 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 Figure 1.

8.3.2 Segregation will not erase, whereas staining or discoloration will disappear with the use of a rubber eraser.

8.3.3 Segregation will reappear after removal by sanding and localized re-etching.

8.3.4 Segregation is similar to other material defects in that it can occur throughout the product in any frequency, size, shape, form, or severity. However, the extreme ends of the ingot are most likely to have segregation.

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

8.4.1 Polish electrolytically in the following solution at 40 volts \pm 1 direct current for approximately five seconds:

78 mL perchloric acid
120 mL distilled water
700 mL ethanol
100 mL butylcellosolve

8.4.2 Etch with Kroll's reagent (5% hydrofluoric acid, sp gr 1.15, 12% nitric acid, sp gr 1.42, 83% water, by volume), 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.