

Structural Examination of Titanium Alloys
Etch-Anodize Inspection Procedure

RATIONALE

AMS2642D results from a Five Year Review and update of this specification.

1. SCOPE

1.1 Purpose

This specification covers a procedure for revealing the macrostructure and microstructure of selected titanium alloys.

1.2 Application

This procedure has been used typically for detecting segregation, inclusions, and other defects in alpha-beta and certain alpha titanium alloys.

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.

2.1 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.

AMS4901 Titanium Sheet, Strip, and Plate, Commercially Pure, Annealed, 70.0 ksi (485 MPa)

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2010 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of SAE.

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
http://www.sae.org

SAE WEB ADDRESS:

**SAE values your input. To provide feedback
on this Technical Report, please visit
<http://www.sae.org/technical/standards/AMS2642D>**

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 E 1447 Determination of Hydrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Thermal Conductivity Method

2.3 ASME Publications

Available from American Society of Mechanical Engineers, 22 Law Drive, P.O. Box 2900, Fairfield, NJ 07007-2900, Tel: 973-882-1170, www.asme.org.

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

3. TECHNICAL REQUIREMENTS

3.1 Materials and Solutions

3.1.1 Etch Solution

An aqueous acid salt solution shall be prepared, the concentration of which shall be adjusted to maintain a metal removal rate of 0.00003 to 0.00005 inch (0.76 to 1.27 μm) in 80 to 100 seconds after the onset of gas evolution. Operation shall be at room temperature.

3.1.2 Anodize Solution

An aqueous solution of 13 to 17 ounces/gallon (97 to 127 grams/L) of hydrated trisodium phosphate ($\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$) shall be prepared and maintained at $8.5 \text{ pH} \pm 0.5$ at room temperature. See 8.3.

3.1.3 Back Strip Solution

An agitated aqueous solution of 42.5 to 51.5 ounces/gallon (320 to 385 grams/liter) of nitric acid (technical grade, approximate sp gr 1.42) and 1.3 to 4.7 ounces/gallon (10 to 35 grams per liter) hydrofluoric acid (technical grade, approximate sp gr 1.15) shall be maintained at room temperature.

3.1.4 Specimens for Macrostructure

3.1.4.1 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. Specimens from stock for alpha beta forging or alpha beta extrusion shall be heated to a temperature $50 \text{ }^\circ\text{F} \pm 25$ ($28 \text{ }^\circ\text{C} \pm 14$) degrees below the beta transus as determined for the heat, held at heat for 60 minutes ± 5 , and cooled at a rate equivalent to air cool or faster. Specimens from stock for beta forging or beta extrusion shall be heated to a temperature $50 \text{ }^\circ\text{F} \pm 25$ ($28 \text{ }^\circ\text{C} \pm 14$) degrees above the beta transus as determined for the heat. Specimens shall be machined to have surface texture of 70 microinches (1.8 μm) AA or finer, determined in accordance with ASME B46.1.

3.1.4.2 Forgings

When dimensions permit, forgings shall be machined all over to remove approximately 0.040 inch (1.0 mm) of metal to ensure freedom from alpha case. If forgings are to be inspected by ultrasonic inspection procedures, the configuration used for such inspection is acceptable. Surface roughness shall be 70 microinches (1.8 μm) AA or finer, determined in accordance with ASME B46.1.

3.1.4.3 Finished Parts

Specimens shall be complete parts. No special preparation is required.

3.2 Equipment

3.2.1 A DC voltage source shall be capable of providing direct current with a maximum of 6% ripple at 30 VDC (under no load) and shall be capable of ramping up the voltage to 30 VDC in 1 to 3 seconds. Automatic control is preferred. The equipment shall include a volt and amp meter.

3.2.2 Fixtures shall be free of distortion, loose fittings, worn areas and corrosion.

3.3 Preparation

3.3.1 Specimens shall be free from water breaks. If water breaks are observed, parts shall be recleaned and reinspected for water break until no water breaks are observed. See 8.5.

3.3.2 Location of electrical contact points on finished parts shall be acceptable to the cognizant engineering organization.

3.3.3 Areas on finished parts that are not to be etch-anodize-inspected shall be protected by a suitable masking material. Such areas shall include inspection areas or surfaces, balance and identification markings applied by electrolytic etching, hardfaced areas, and nontitanium surfaces.

3.3.4 Etch-Anodize Macrostructure Procedure

3.3.4.1 Specimens shall be immersed for 80 to 100 seconds after the onset of gassing in an agitated acid salt solution in accordance with 3.1.1. Immersed parts shall be agitated to remove entrapped air. Immediately after removal, specimens shall be immersed in clean tap water. Specimens shall be pressure sprayed as required to remove smut.

3.3.4.2 Specimens shall be immersed in agitated anodize solution in accordance with 3.1.2 and then an anodic voltage of 30 VDC \pm 1 shall be applied for 30 seconds \pm 1 using equipment in accordance with 3.2.1. Specimens shall not be agitated when the voltage is applied. Specimens shall be removed from the anodizing solution and immediately rinsed in clean water. DO NOT TOUCH THE SPECIMEN WITH BARE HANDS. If the current does not fall below 1 ampere, the part may be anodized for up to four more additional 30-second cycles until current falls to less than 1 ampere.

3.3.4.3 Specimens shall be immersed in solution in accordance with 3.1.3 until a light blue-to-gray background color is obtained and maximum contrast between any segregation and the background develops. Immersion time shall be measured from time of complete immersion of the specimen. See 8.8.

3.3.4.4 Immediately rinse and dry.

3.3.4.5 The specimens shall be immediately inspected for macrostructure and defects such as segregation, laps, folds, cracks, inclusions, arc outs, and pitted areas using 1 to 10X magnification and light intensity not lower than 200 foot-candles (2153 lx). See 8.6.

3.3.4.6 The hydrogen pick-up permitted when this inspection procedure is used on parts shall not exceed 20 ppm when tested in accordance with ASTM E 1447.

3.4 Microstructure

If examination (3.3.4.5) results in an inconclusive disposition, further evaluation of the microstructure of etch-anodized specimens shall be established by the following procedure.

3.4.1 Specimens may be cut for examination of other planes as required.

- 3.4.2 Polish and etch the specimens to be examined using metallographic techniques or replication techniques that will clearly reveal the microstructure. See 8.7.
- 3.4.3 Specimens shall be inspected to determine the microstructure and the nature of indications found in the macrostructure.
- 3.5 All parts shall be uniform in color and appearance after inspection.

4. QUALITY ASSURANCE PROVISIONS

- 4.1 Test specimen for hydrogen pick-up (3.3.4.6) shall be a 0.040 inch (1.0 mm) maximum thickness titanium test strip in accordance with AMS4901. Test frequency shall be as specified by the cognizant engineering organization.

4.2 Acceptance Tests

Macrostructure (3.3.4), hydrogen pickup on parts (3.3.4.6), visual color and appearance (3.5), and, when applicable, microstructure (3.4) are acceptance tests and shall be performed to determine product acceptance.

4.3 Periodic Tests

Tests to maintain all of the solutions used herein are periodic tests and shall be performed at a frequency established by the processor unless frequency of testing is specified by the cognizant engineering organization. See 8.4.

5. PREPARATION FOR DELIVERY

Not applicable.

6. ACKNOWLEDGMENT

A 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 A change bar (I) located in the left margin 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 document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

8.2 Equipment

- 8.2.1 The tanks for the solutions of 3.1.1 and 3.1.3 should be lined with polyvinyl chloride or comparable lining material; all others may be unlined. Compatible plastic tanks could also be used.
- 8.2.2 Temperature indicators and controllers should be used with the alkaline cleaner, anodizing, and hot water tanks.
- 8.2.3 For best results mechanical stirrers and/or air agitation are recommended in the alkaline cleaner tank, acid tanks, and the anodizing tank.
- 8.2.4 Timers should be used on both acid tanks and the anodizing tanks.