

# AEROSPACE MATERIAL SPECIFICATION

## Titanium Alloy Bars, Forgings and Forging Stock 13V - 11Cr - 3Al Solution Heat Treated

(Composition Similar to UNS R58010)

### 1. SCOPE:

#### 1.1 Form:

This specification covers a titanium alloy in the form of bars, forgings, and stock for forging.

#### 1.2 Application:

This material has been used typically for parts to be machined in the solution heat treated condition and subsequently precipitation heat treated, requiring high strength-to-weight ratio and stability up to 550 °F (288 °C) in the precipitation heat treated condition, but usage is not limited to such applications.

- 1.2.1 Certain processing procedures and service conditions may cause these products to become subject to stress-corrosion cracking; ARP982 recommends practices to minimize such conditions.

### 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.

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## 2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or [www.sae.org](http://www.sae.org).

|             |                                                                                                        |
|-------------|--------------------------------------------------------------------------------------------------------|
| AMS 2241    | Tolerances, Corrosion and Heat-Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Bars and Wire |
| AMS 2249    | Chemical Check Analysis Limits, Titanium and Titanium Alloys                                           |
| AMS 2368    | Sampling and Testing of Wrought Titanium Raw Materials, Except Forging and Forging Stock               |
| AMS 2631    | Ultrasonic Inspection, Titanium and Titanium Alloy Bar and Billet                                      |
| AMS 2643    | Structural Examination of Titanium Alloys, Chemical Etch Inspection                                    |
| AMS 2808    | Identification, Forgings                                                                               |
| AMS 2809    | Identification, Titanium and Titanium Alloy Wrought Products                                           |
| AMS-H-81200 | Heat Treatment of Titanium and Titanium Alloys                                                         |
| ARP982      | Minimizing Stress-Corrosion Cracking in Wrought Titanium Alloy Products                                |

## 2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959 or [www.astm.org](http://www.astm.org).

|             |                                                                                                               |
|-------------|---------------------------------------------------------------------------------------------------------------|
| ASTM E 8    | Tension Testing of Metallic Materials                                                                         |
| ASTM E 8M   | Tension Testing of Metallic Materials, Metric                                                                 |
| ASTM E 120  | Chemical Analysis of Titanium and Titanium Alloys                                                             |
| ASTM E 1409 | Determination of Oxygen in Titanium and Titanium Alloys by the Inert Gas Fusion Technique                     |
| ASTM E 1447 | Determination of Hydrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Thermal Conductivity Method |

## 3. TECHNICAL REQUIREMENTS:

### 3.1 Composition:

Shall conform to the percentages by weight shown in Table 1. Oxygen shall be determined in accordance with ASTM E 1409, hydrogen in accordance with ASTM E 1447, and other elements by wet chemical methods in accordance with ASTM E 120, by spectrochemical methods, or by other analytical methods acceptable to purchaser.

TABLE 1 - Composition

| Element                          | min       | max             |
|----------------------------------|-----------|-----------------|
| Vanadium                         | 12.50     | 14.50           |
| Chromium                         | 10.00     | 12.00           |
| Aluminum                         | 2.50      | 3.50            |
| Iron                             | --        | 0.35            |
| Oxygen                           | --        | 0.17            |
| Carbon                           | --        | 0.05            |
| Nitrogen                         | --        | 0.05 (500 ppm)  |
| Hydrogen (3.1.2)                 | --        | 0.025 (250 ppm) |
| Yttrium (3.1.1)                  | --        | 0.005 (50 ppm)  |
| Residual Elements, each (3.1.1)  | --        | 0.10            |
| Residual Elements, total (3.1.1) | --        | 0.40            |
| Titanium                         | remainder |                 |

3.1.1 Determination not required for routine acceptance.

3.1.2 When using ASTM E 1447 for hydrogen determination, sample size may be as large as 0.35 gram.

3.1.3 Check Analysis: Composition variations shall meet the applicable requirements of AMS 2249.

### 3.2 Melting Practice:

3.2.1 Alloy shall be multiple melted. Melting cycle(s) prior to the final melting cycle shall be made using vacuum consumable electrode, nonconsumable electrode, electron beam cold hearth, or plasma arc cold hearth melting practice. The final melting cycle shall be made under vacuum using vacuum arc remelting (VAR) practice with no alloy additions permitted.

3.2.1.1 The atmosphere for nonconsumable electrode melting shall be vacuum or shall be argon or helium at an absolute pressure not higher than 1000 mm of mercury.

3.2.1.2 The electrode tip for nonconsumable electrode melting shall be water-cooled copper.

### 3.3 Condition:

The product shall be supplied in the following condition:

3.3.1 Bars: Hot finished with or without subsequent cold reduction, solution heat treated, and descaled. A machined or ground surface is permitted unless prohibited by purchaser.

3.3.2 Forgings: Solution Heat treated and descaled.

3.3.3 Stock for Forging: As ordered by the forging manufacturer.

### 3.4 Heat Treatment:

Bars and forgings shall be solution heat treated in accordance with AMS-H-81200.

### 3.5 Properties:

The product shall conform to the following requirements:

#### 3.5.1 Bars and Forgings as Solution Heat Treated

3.5.1.1 Tensile Properties: Shall be as specified in Table 2, determined in accordance with ASTM E 8 or ASTM E 8M with the rate of strain maintained at 0.003 to 0.007 inch/inch/minute (0.003 to 0.007 mm/mm/minute) through the yield strength and then increased so as to produce failure in approximately one additional minute. When a dispute occurs between purchaser and vendor over the yield strength values, a referee test shall be performed on a machine having a strain rate pacer, using a rate of 0.005 inch/inch/minute (0.005 mm/mm/minute) through the yield strength and a minimum cross head speed of 0.10 inch (2.5 mm) per minute above the yield strength.

3.5.1.1.1 Tensile property requirements apply in both the longitudinal and transverse directions. Transverse tensile properties of Table 2 apply only to product from which a test specimen not less than 2.50 inches (63.5 mm) in length can be obtained.

3.5.1.1.2 Longitudinal requirements in Table 2 apply to specimens from product taken with the axis of the specimen within 15 degrees of parallel to the grain flow.

3.5.1.1.3 Yield strength and reduction of area requirements do not apply to product under 0.125 inch (3.18 mm) in nominal diameter.

TABLE 2 - Minimum Tensile Properties (See 8.2)

| Nominal Diameter or Distance<br>Between Parallel Sides<br>Inch (mm) | Tensile<br>Strength<br>ksi (MPa) | Yield Strength<br>At 0.2% Offset<br>ksi (MPa) | Elongation in<br>2 Inches (50.8 mm)<br>or 4D, % | Reduction<br>of Area<br>% |
|---------------------------------------------------------------------|----------------------------------|-----------------------------------------------|-------------------------------------------------|---------------------------|
| Up to 7.00 (177.80), incl.                                          | 125 (861)                        | 120 (827)                                     | 10                                              | 25                        |

3.5.1.2 Microstructure: Shall be uniform and essentially that structure resulting from beta processing. Microstructure shall not be cause for rejection unless standards have been agreed upon by purchaser and vendor.

3.5.1.3 Surface Contamination: Except as specified in 3.5.1.3.1, the product shall be free of any oxygen-rich layer (See 8.3), such as alpha case, or other surface contamination, determined by microscopic examination at not lower than 400X magnification or by other method agreed upon by purchaser and vendor.

- 3.5.1.3.1 When permitted by purchaser, product to be machined all over may have an oxygen-rich layer, provided such layer is removable within the machining allowance on the product.
- 3.5.1.4 Macrostructure: Product shall be uniform in quality and condition, homogenous, sound, and free from foreign materials and from internal imperfections detrimental to fabrication or performance of parts.
- 3.5.2 After Precipitation Heat Treatment: Product shall conform to the following requirements after being precipitation heat treated in accordance with AMS-H-81200, and cooled in air to room temperature. Precipitation heat treatment shall precede final machining of specimens.
- 3.5.2.1 Tensile Properties: Shall be as shown in Table 3, determined in accordance with ASTM E 8 or ASTM E 8M with the rate of strain maintained at 0.003 to 0.007 inch/inch/minute (0.003 to 0.007 mm/mm/minute) through the yield strength and then increased so as to produce failure in approximately one additional minute. When a dispute occurs between purchaser and vendor over the yield strength values, a referee test shall be performed on a machine having a strain rate pacer, using a rate of 0.005 inch/inch/ minute (0.005 mm/mm/minute) through the yield strength and a minimum cross head speed of 0.10 inch (2.5 mm) per minute above the yield strength.

TABLE 3 - Minimum Tensile Properties (See 8.2)

| Nominal Diameter or Distance<br>Between Parallel Sides<br>Inch (mm)<br>(3.5.2.2) | Tensile<br>Strength<br>ksi (MPa) | Yield Strength<br>At 0.2% Offset<br>ksi (MPa) | Elongation in<br>2 Inches<br>(50.8 mm) or<br>4D, %<br>(3.5.2.3) | Reduction<br>of Area<br>%<br>(3.5.2.3) |
|----------------------------------------------------------------------------------|----------------------------------|-----------------------------------------------|-----------------------------------------------------------------|----------------------------------------|
| Up to 4.00 (101.60), incl.                                                       | 170 (1172)                       | 160 (1103)                                    | 6 [2]                                                           | 10[5]                                  |

- 3.5.2.2 Minimum tensile properties for product over 4 inches shall be as agreed upon by the procuring activity and producer.
- 3.5.2.3 Values in brackets [ ] apply to the short transverse direction for short transverse dimensions of 3.00 inches or greater.
- 3.5.3 Forging Stock: When a sample of stock is forged to a test coupon and heat treated as in 3.4 and/or 3.5.2, specimens taken from the heat treated coupon shall conform to the requirements of 3.5.1.1 and 3.5.2.1 respectively. If specimens taken from the stock after heat treatment as in 3.4 and/or 3.5.2 conform to the requirements of 3.5.1.1 and/or 3.5.2.1 respectively, the tests shall be accepted as equivalent to tests of a forged coupon.

### 3.6 Quality:

The product, as received by purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and from imperfections detrimental to usage of the product.

3.6.1 Ultrasonic Inspection: When specified, the product shall be ultrasonically inspected in accordance with AMS 2631 and shall meet the quality standards agreed upon between the purchaser and vendor.

3.7 Tolerances:

Bars shall conform to all applicable requirements of AMS 2241.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The vendor of the product shall supply all samples for vendor's tests and shall be responsible for the performance of all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to the specified requirements.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: The following requirements are acceptance tests and shall be performed on each heat or lot as applicable.

4.2.1.1 Composition (3.1) of each heat.

4.2.1.2 Hydrogen content (3.1), tensile properties (3.5.1.1), tensile properties after precipitation hardening (3.5.2.1), microstructure (3.5.1.2), surface contamination (3.5.1.3), macrostructure (3.5.1.4), and ultrasonic quality (3.6.1) when specified, of each lot of bars and forgings.

4.2.1.3 Tolerances (3.7) of bars.

4.2.2 Periodic Tests: Ability of forging stock (3.5.3) to develop specified properties is a periodic test and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.3 Sampling and Testing:

Shall be in accordance with AMS 2368 and as follows: A lot shall be all product of the same nominal size from the same heat processed at the same time.

4.3.1 For Acceptance Tests:

4.3.1.1 Composition: At least one sample from each heat, except that for hydrogen determinations, one sample from each lot obtained after all thermal and chemical processing is completed.

- 4.3.1.2 Tensile Properties: At least one sample from bars from each lot. The number, location, and orientation of samples from each lot of forgings shall be as agreed upon by purchaser and vendor.
- 4.3.1.3 A specimen at least 0.5 inch (6.3 mm) long by full cross-section from each end of the bars selected for sampling shall be macrostructurally examined for conformance to the quality requirements. Unless otherwise specified, macrostructural examination shall be performed in accordance with AMS 2643. The number of bars selected for examination shall not be less than the amounts shown in Table 4.

Table 4 - Number of Bars selected for Macrostructural Examination

| Number of Bars in Lot |     | Number of Bars Selected         |
|-----------------------|-----|---------------------------------|
| 1 to                  | 15  | 1                               |
| 16 to                 | 50  | 2                               |
| 51 to                 | 100 | 3                               |
| 151 to                | 500 | 5                               |
| over                  | 500 | 4 + amount shown above over 500 |

#### 4.4 Reports:

The vendor of the product shall furnish with each shipment a report showing the results of tests for chemical composition of each heat and for the hydrogen content, tensile properties, ultrasonic quality when specified, and surface contamination of each lot, and stating that the product conforms to the other technical requirements. The report shall include the purchase order number, heat and lot numbers, AMS 6925, size, specific solution heat treatment used, specific aging treatment used to develop precipitation hardened properties, and quantity. If forgings are supplied, the size and melt source of stock used to make the forgings shall also be included.

#### 4.5 Resampling and Retesting:

Shall be in accordance with AMS 2368.

### 5. PREPARATION FOR DELIVERY:

#### 5.1 Identification:

Shall be as follows:

- 5.1.1 Bars: In accordance with AMS 2809, as applicable.
- 5.1.2 Forgings: In accordance with AMS 2808, except that marking shall be applied using a marking fluid whose residue shall contain not more than traces of halogen containing compounds.
- 5.1.3 Stock for Forging: As agreed upon by purchaser and vendor.