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# AEROSPACE MATERIAL SPECIFICATION

| SAE AMS4959 | REV. E |
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| Revised | 2003-04 |
| Noncurrent | 2008-02 |
| Reaf Nonc | 2012-10 |

Superseding AMS4959D

## Titanium Alloy Wire
## 13.5V - 11Cr - 3Al
## Spring Temper

(Composition similar to UNS R58010)

RATIONALE

AMS4959E has been reaffirmed to comply with the SAE five-year review policy.

NONCURRENT NOTICE

This specification has been declared "NONCURRENT" by the Aerospace Materials Division, SAE, as of February 2008. It is recommended, therefore, that this specification not be specified for new designs.

"NONCURRENT" refers to those specifications which have previously been widely used and which may be required for production or processing of existing designs in the future. The Aerospace Materials Division, however, does not recommend these specifications for future use in new designs. "NONCURRENT" specifications are available from SAE upon request.





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1. SCOPE:

1.1 Form:

This specification covers a titanium alloy in the form of cold drawn wire.

1.2 Application:

This wire has been used typically for springs requiring corrosion resistance and high tensile strength, but usage is not limited to such applications.

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

1.3 Classification:

Wire shall be classified as follows:

Type 1 - Centerless ground
Type 2 - As drawn

1.3.1 Either Type 1 or Type 2 may be supplied unless a specific type is ordered.

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, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or 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 2809 | Identification, Titanium and Titanium Alloy Wrought Products |
| 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.

| | |
|---|---|
| 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 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 the 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 | -- | 0.050 (500 ppm) |
| Hydrogen (3.1.3) | -- | 0.030 (300 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 ASTM E 1447 is used, sample size may be as large as 0.35 gram.

3.1.3 Hydrogen shall be determined on the finished wire.

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

3.2 Melting Practice:

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

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

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

3.3 Condition:

Spring temper, cold drawn to required size. When Type 1 is supplied, wire shall be centerless ground to size after the final cold drawing operation.

3.3.1 Wire ordered in coil form shall be coated with a lubricant suitable for use on automatic spring winding machines and containing not more than traces of halogen bearing compounds.

3.4 Properties:

Wire shall conform to the following requirements:

3.4.1 As Cold Drawn:

3.4.1.1 Wrapping: Wire shall withstand, without cracking, wrapping at room temperature one full turn around a diameter equal to the nominal diameter of the wire.

3.4.1.2 Coiling: Wire shall show a uniform pitch with no splits or fractures when wound in a tightly closed coil on an arbor having a diameter as specified in Table 2 and the resultant coil stretched to a permanent set of four times its wound length.



TABLE 2A - Coiling Parameters, Inch/Pound Units

| Nominal Diameter (D) Inches | Arbor Diameter Inch |
|---|---|
| Up to 0.034, incl | 0.102 |
| Over 0.034 to 0.045, incl | 0.145 |
| Over 0.045 to 0.055, incl | 0.212 |
| Over 0.055 to 0.125, incl | 0.250 |
| Over 0.125 | 2D |

TABLE 2B - Coiling Parameters, SI Units

| Nominal Diameter (D) mm | Arbor Diameter mm |
|---|---|
| Up to 0.86, incl | 2.59 |
| Over 0.86 to 1.14, incl | 3.68 |
| Over 1.14 to 1.40, incl | 5.38 |
| Over 1.40 to 3.18, incl | 6.35 |
| Over 3.18 | 2D |

3.4.2 After Aging: Wire shall have the following properties after being aged by heating to 800 °F ± 10 (427 °C ± 6), holding at heat for 10 hours ± 0.25, and cooling in air:

3.4.2.1 Tensile Properties: Shall be as specified in Table 3, determined in accordance with ASTM E 8 or ASTM E 8M.

TABLE 3A - Minimum Tensile Properties, Inch/Pound Units

| Nominal Diameter Inch | Tensile Strength ksi | Elongation in 2 in. or 4D % | Reduction of Area % |
|---|---|---|---|
| Up to 0.65, incl | 250 to 300 | 4 | 17 |
| Over 0.65 to 0.100, incl | 240 to 290 | 5 | 17 |
| Over 0.100 to 0.160, incl | 230 to 280 | 5 | 18 |
| Over 0.160 to 0.225, incl | 220 to 270 | 6 | 18 |
| Over 0.225 to 0.376, incl | 210 to 260 | 6 | 20 |
| Over 0.376 to 0.500, incl | 200 to 240 | 6 | 20 |
| Over 0.500 to 0.561, incl | 180 to 220 | 6 | 20 |

TABLE 3B - Minimum Tensile Properties, SI Units

| Nominal Diameter Millimeters | Tensile Strength MPa | Elongation in 4D % | Reduction of Area % |
|---|---|---|---|
| Up to 1.65, incl | 1724 to 2069 | 4 | 17 |
| Over 1.65 to 2.54, incl | 1655 to 2000 | 5 | 17 |
| Over 2.54 to 40.6, incl | 1586 to 1931 | 5 | 18 |
| Over 40.6 to 5.72, incl | 1517 to 1862 | 6 | 18 |
| Over 5.72 to 9.55, incl | 1448 to 1793 | 6 | 20 |
| Over 9.55 to 12.70, incl | 1379 to 1655 | 6 | 20 |
| Over 12.70 to 14.25, incl | 1241 to 1517 | 6 | 20 |

3.5 Quality:

Wire, 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 wire.

3.5.1 The surface of the wire shall have a smooth finish free from pits and abrasions, and shall be cylindrical, clean, and free from kinks, twists, laps, seams, scrapes, splits, and other imperfections.

3.6 Tolerances:

Wire shall conform to all applicable requirements of AMS 2241.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The vendor of wire 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 wire conforms to the specified requirements.

4.2 Classification of Tests:

Tests for all technical requirements are acceptance tests and shall be performed on each heat or lot as applicable.

4.3 Sampling and Testing:

Shall be in accordance with the following; a lot shall be all wire of the same nominal size from the same heat processed at one time:

4.3.1 Composition: One sample from each heat, except that for hydrogen determinations one sample from each lot obtained after thermal and chemical processing is completed.

4.3.2 Tensile Properties, Wrapping, and Coiling: Two samples from each 1500 feet (457 m) of wire.

4.4 Reports:

The vendor of wire shall furnish with each shipment a report showing the results of tests for chemical composition of each heat and for the hydrogen content and tensile properties of each lot, and stating that the wire conforms to the other technical requirements. This report shall include the purchase order number, heat and lot numbers, AMS 4959D, size, and quantity.