SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 4959D

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Superseding AMS 49596C

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

(Composition similar to UNS R58010)

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.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: custsvc@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

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 ºF ± 10 (427 ºC ± 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.