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Superseding AMS4956E	

Titanium Alloy Welding Wire
6Al – 4V, Extra Low Interstitial
Environment Controlled Packaging
(Composition similar to UNS R56408)

RATIONALE

AMS4956F has been reaffirmed to comply with the SAE five-year review policy.

1. SCOPE

1.1 Form

This specification covers a titanium alloy in the form of wire for welding filler metal.

1.2 Application

This wire has been used typically as filler metal for gas-tungsten-arc welding with chemistry matched to weld low interstitial grade Ti 6Al-4V ELI (UNS R56401) intended for cryogenic or elevated temperature applications, but usage is not limited to such applications. It is particularly intended for use with equipment providing continuous inert gas shielding of the wire as it passes from the dispenser to the welding arc, where high reliability of joints is required.

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.

AMS2249	Chemical Check Analysis Limits, Titanium and Titanium Alloys
AMS2814	Packaging and Marking of Packages of Welding Wire, Premium Quality
AMS2816	Identification, Welding Wire, Tab Marking Method
AMS2819	Identification, Welding Wire, Direct Color Code System
ARP1876	Weldability Test for Weld Filler Metal Wire
ARP4926	Alloy Verification and Chemical Composition Inspection of Welding Wire

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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 539	X-Ray Emission Spectrometric Analysis of 6Al-4V Titanium Alloy
ASTM E 1409	Determination of Oxygen and Nitrogen 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/Infrared Detection Method
ASTM E 1941	Determination of Carbon in Refractory and Reactive Metals and Their Alloys
ASTM E 2371	Analysis of Titanium and Titanium Alloys by Atomic Emission Plasma Spectrometry

3. TECHNICAL REQUIREMENTS

3.1 Composition

Shall conform to the percentages by weight shown in Table 1; carbon shall be determined in accordance with ASTM E 1941, hydrogen in accordance with ASTM E 1447, oxygen and nitrogen in accordance with ASTM E 1409, and other elements in accordance with ASTM E 539 or ASTM E 2371. Other analytical methods may be used if acceptable to the purchaser.

TABLE 1 - COMPOSITION

Element	min	max
Aluminum	5.50	6.75
Vanadium	3.50	4.50
Iron	--	0.15
Oxygen (3.1.1.1)	0.03	0.11
Carbon (3.1.1.1)	--	0.03
Nitrogen (3.1.1.1)	--	0.012 (120 ppm)
Hydrogen (3.1.1.1)	--	0.005 (50 ppm)
Yttrium (3.1.1.2)	--	0.005 (50 ppm)
Other Elements, each (3.1.1.2)	--	0.03
Other Elements, total (3.1.1.2)	--	0.10
Titanium	remainder	

3.1.1 Except for carbon, oxygen, nitrogen, and hydrogen, chemical analysis of initial ingot, bar, or rod stock before drawing is acceptable provided the processes used for drawing or rolling, annealing, and cleaning are controlled to ensure continued conformance to composition requirements.

3.1.1.1 Carbon, oxygen, nitrogen, and hydrogen shall also be determined on each lot of finished wire.

3.1.1.2 Determination not required for routine acceptance.

3.1.2 Check Analysis

Composition variations shall meet the applicable requirements of AMS2249.

3.1.3 Sample size when using ASTM E 1447 for hydrogen may be as large as 0.35 gram.

3.2 Melting Practice

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

3.2.1.1 The atmosphere for nonconsumable electrode melting shall be vacuum or shall be inert gas at a 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

Vacuum annealed.

3.4 Fabrication

3.4.1 Wire shall be rolled or drawn from rod or bar descaled by a process that does not affect the composition of the wire. Surface irregularities inherent with a forming process that does not tear the wire surface are acceptable provided the wire conforms to the tolerances of 3.7.

3.4.2 In-process annealing, if required between rolling or drawing operations, shall be performed after cleaning the material and in a vacuum or in protective inert atmosphere to avoid surface oxidation and adsorption of other extraneous elements unless the contaminated surface is removed mechanically or chemically.

3.4.3 Butt welding is permissible provided both ends to be joined are either alloy verified using a method or methods capable of distinguishing the alloy from all other alloys processed within the facility, or the repair of a wire break is made at the wire processing station. The butt weld shall not interfere with the uniform, uninterrupted feeding of the wire in machine welding equipment.

3.4.4 Drawing compounds, oxides, dirt, oil, and other foreign materials shall be removed by cleaning processes which will neither result in pitting, nor cause gas absorption by the wire or deposition of substances harmful to welding operations.

3.4.5 Surface contamination or dissolved hydrogen picked up during wire processing that can adversely affect the welding characteristics, the operation of the equipment, or the properties of the weld metal, shall be removed.

3.4.6 Wire shall be vacuum degassed after cleaning as in 3.4.4.

3.5 Properties

Wire shall conform to the following requirements:

3.5.1 Weldability

Melted wire shall flow smoothly and evenly during welding and shall produce acceptable welds. ARP1876 may be used to resolve disputes.

3.5.2 Spooled Wire

Shall conform to 3.5.2.1, 3.5.3.2 and 3.5.2.3.

3.5.2.1 Winding

Filler metal in coils and on spools shall be wound so that kinks, waves, sharp bends, overlapping, or wedging are not encountered, leaving the filler metal free to unwind without restriction. The outside end of the electrode (the end where welding is to begin) shall be identified so it can be located readily and shall be fastened to avoid unwinding. The winding shall be level winding.

3.5.2.2 Cast

Wire, wound on standard diameter spools as shown in Table 3 shall have imparted to it a curvature such that a specimen sufficient in length to form one loop with a 1-inch (25-mm) overlap, when cut from the spool and laid on a flat surface, shall form a circle (cast) within the limits shown in Table 2.

3.5.2.3 Helix

The specimen on which cast was determined, when laid on a flat surface and measured between adjacent turns, shall show a vertical separation (helix) not greater than shown in Table 2.

TABLE 2A - CAST AND HELIX REQUIREMENTS – INCH-POUND UNITS

Spool Diameter Inches	Cast Inches		Helix Inch
	min	max	max
4	2.5	9	0.50
8	10	20	0.75
12	15	30	1.00

TABLE 2B - CAST AND HELIX REQUIREMENTS, SI UNITS

Spool Diameter millimeters	Cast millimeters		Helix millimeters
	min	max	max
102	64	229	13
203	254	508	19
305	381	762	25

3.6 Quality

Wire, as received by purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and from imperfections detrimental to welding operations, operation of welding equipment, or properties of the deposited weld metal.

3.7 Sizes and Tolerances

Wire shall be supplied in the sizes and to the tolerances shown in 3.7.1 and 3.7.2.

3.7.1 Diameter

Shall be as shown in Table 3.

TABLE 3A - SIZES AND DIAMETER TOLERANCES, INCH/POUND UNITS

Form	Nominal Diameter Inch	Tolerance, Inch	
		Plus	Minus
Cut Lengths	0.030, 0.045, 0.062, 0.078	0.002	0.002
Cut Lengths	0.094, 0.125, 0.156, 0.188	0.002	0.002
Spools	0.007, 0.010, 0.015	0.0005	0.0005
Spools	0.020, 0.030, 0.035, 0.045	0.001	0.002
Spools	0.062, 0.078, 0.094	0.002	0.002

TABLE 3B - SIZES AND DIAMETER TOLERANCES, SI UNITS

Form	Nominal Diameter Millimeters	Tolerance, Millimeter	
		Plus	Minus
Cut Lengths	0.76, 1.14, 1.57, 1.98	0.05	0.05
Cut Lengths	2.39, 3.18, 3.96, 4.78	0.05	0.05
Spools	0.18, 0.25, 0.38	0.013	0.013
Spools	0.51, 0.76, 0.89, 1.14	0.03	0.05
Spools	1.57, 1.98, 2.39	0.05	0.05

3.7.2 Length

Cut lengths shall be furnished in 36 inch (760 mm) length, unless specified otherwise. Other standard lengths are 12, 18, 27, or 36 inch (305, 457, 686, or 914 mm). Length, as ordered, shall not vary more than +0, -1/2 inch (+0, -13 mm) from the length ordered.

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 specified requirements.

4.2 Classification of Tests

4.2.1 Acceptance Tests

Composition (3.1), sizes and tolerances (3.7), and alloy verification (5.2) are acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Periodic Tests

Weldability (3.5.1), cast (3.5.2.2), and helix (3.5.2.3) are periodic tests 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 as follows; a lot shall be all wire of the same nominal size from the same heat processed under the same conditions in the same production run:

4.3.1 For Acceptance Tests

4.3.1.1 Composition

One sample from each heat; except that for carbon, oxygen, nitrogen, and hydrogen, one sample from each lot at finished diameter, obtained after thermal and chemical processing is completed.

4.4 Reports

The vendor shall provide a copy of the original material manufacturer's report (material certification) including: producer name, product form, mill produced size, and country where the metal was melted (i.e., final melt in the case of metal processed by multiple melting operations). The vendor of welding wire shall furnish with each shipment a report showing the results of tests of the filler metal per 3.1.1.1 for composition of each heat and for the carbon, oxygen, nitrogen, and hydrogen content 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, AMS4956F, nominal size, and quantity.