



AEROSPACE MATERIAL SPECIFICATION	AMS4951™	REV. K
	Issued	1958-03
	Revised	2022-05
Superseding AMS4951J		
Titanium Welding Wire Commercially Pure Environment Controlled Packaging (Composition similar to UNS R50120)		

RATIONALE

AMS4951K results from a Five-Year Review and update of this specification with changes to update general agreement language related to unauthorized exceptions (3.8, 4.4.1, 5.3, 8.5), update applicable documents (Section 2, 8.2), composition (3.1), and allow the use of the immediate prior specification revision (8.4).

1. SCOPE

1.1 Form

This specification covers one grade of commercially pure titanium in the form of wire for welding filler metal.

1.2 Application

This wire has been used typically as filler metal for gas-metal-arc and gas-tungsten-arc welding with chemistry matched to unalloyed titanium UNS R50400, but usage is not limited to such applications.

1.3 Classification

Product covered by this specification is classified by melting practice as follows:

Type I: Multiple melted with vacuum arc remelting as the last melting cycle.

Type II: Single melted using either the electron beam cold hearth or plasma arc cold hearth method.

1.3.1 Unless a specific type is ordered, either type may be supplied.

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.

SAE Executive Standards Committee 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 revised, reaffirmed, stabilized, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2022 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

For more information on this standard, visit
<https://www.sae.org/standards/content/AMS4951K/>

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (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
AS7766	Terms Used in Aerospace Metals Specifications

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 E8/E8M Tension Testing of Metallic Materials

ASTM E539	Analysis of Titanium Alloys by Wavelength Dispersive X-Ray Fluorescence Spectrometry
ASTM E1409	Determination of Oxygen and Nitrogen in Titanium and Titanium Alloys by Inert Gas Fusion
ASTM E1447	Determination of Hydrogen in Titanium and Titanium Alloys by Inert Gas Fusion Thermal Conductivity/Infrared Detection Method
ASTM E1941	Determination of Carbon in Refractory and Reactive Metals and Their Alloys by Combustion Analysis
ASTM E2371	Analysis of Titanium and Titanium Alloys by Direct Current Plasma and Inductively Coupled Plasma Atomic Emission Spectrometry (Performance-Based Test Methodology)
ASTM E2994	Analysis of Titanium and Titanium Alloys by Spark Atomic Emission Spectrometry and Glow Discharge Atomic Emission Spectrometry (Performance-Based Test Method)

3. TECHNICAL REQUIREMENTS

3.1 Wire Composition

Shall conform to the percentages by weight shown in Table 1; carbon shall be determined in accordance with ASTM E1941, hydrogen in accordance with ASTM E1447, oxygen and nitrogen in accordance with ASTM E1409, and other elements in accordance with ASTM E539, ASTM E2371, or ASTM E2994. Other analytical methods may be used if acceptable to the purchaser.

Table 1 - Composition

Element	Min	Max
Iron	--	0.12
Oxygen (3.1.1.1)	0.08	0.16
Carbon (3.1.1.1)	--	0.03
Nitrogen (3.1.1.1)	--	0.015
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)	--	0.05
Other Elements, total (3.1.1.2)	--	0.20
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.

3.2 Melting Practice

Type I shall be multiple melted with the last melting cycle under vacuum. When 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(s). The final melting cycle shall be made using vacuum arc remelting (VAR) practice with no alloy additions permitted.

Type II shall be single melted using electron beam cold hearth or plasma arc cold hearth melting practice.

3.2.1 The atmosphere for nonconsumable electrode melting shall be vacuum or shall be inert gas at a pressure not higher than 1000 mm of mercury (Hg).

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

3.3 Condition

As drawn, having tensile strength not higher than 130 ksi (896 MPa), determined in accordance with ASTM E8/E8M, and descaled.

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 cold 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 subsequently removed mechanically or chemically.

3.4.3 Butt welding is permissible provided both ends to be joined are from the same heat and lot of material being processed at the same time, or the repair of a wire break is made at the wire processing station, or identity of the ends maintained if the wire break is butt welded away from 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, nor deposition of substances harmful to welding operations.

3.4.5 Surface contaminants 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.

3.5 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, 3.5.2.2, 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 2 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 Inches
	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	Tolerance, Inches	
	Inches	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	Tolerance, Millimeters	
	Millimeters	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 (914 mm) length, unless specified otherwise. Other standard lengths are 12, 18, or 27 inch (305, 457, or 686 mm). Length, as ordered, shall not vary more than +0, -0.5 inch (+0, -13 mm) from the length ordered.

3.8 Exceptions

Any exceptions shall be authorized by purchaser and reported as in 4.4.1.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The producer of wire shall supply all samples for producer'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), condition (3.3), 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 producer 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 all thermal and chemical processing is completed.

4.3.1.2 Condition

At least one sample from each lot.

4.4 Reports

The producer shall furnish with each shipment a report showing producer identity, country where the metal was melted (i.e., final melt in the case of metal processed by multiple melting operations). The producer of welding wire shall furnish with each shipment a report showing the results of tests for composition of each heat and for the carbon, oxygen, nitrogen, and hydrogen content of each lot, and stating that the weld wire conforms to the other technical requirements of this specification. This report shall include the purchase order number, heat and lot numbers, AMS4951K, size, and quantity.

4.4.1 When material produced to this specification is beyond the sizes allowed in the scope or tables, or other exceptions authorized by purchaser are taken to the technical requirements listed in Section 3, the report shall contain a statement "This material is certified as AMS4951K(EXC) because of the following exceptions:" and the specific exceptions shall be listed.

4.5 Resampling and Retesting

If any specimen used in the above tests fails to meet specified requirements, disposition of the wire may be based on the results of testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the wire represented and no additional testing shall be permitted. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY

5.1 Wire shall be supplied either on spools in one continuous length for machine welding or in cut lengths for manual welding as ordered. Wire on each spool or in each package of cut lengths shall be from the same lot of material.

5.2 Alloy Verification

Wire from each spool or in each package of cut lengths shall be alloy verified by a method acceptable to purchaser. The alloy verification procedures of ARP4926 are recommended.

5.3 Identification

Shall be in accordance with AMS2816 unless AMS2819 or other method is specified by purchaser. When technical exceptions are taken (see 4.4.1), the material shall be identified with AMS4951(EXC).

5.3.1 An 8 inch (203 mm) length of wire shall be made accessible at both ends of each spool for alloy verification.

5.4 Packaging and Marking

Shall be in accordance with AMS2814.

6. ACKNOWLEDGMENT

A producer shall mention this specification number and its revision letter in all quotations and when acknowledging purchase orders.

7. REJECTIONS

Wire not conforming to this specification, or to modifications authorized by purchaser, will be subject to rejection.

8. NOTES

8.1 Revision Indicator

A change bar (l) 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 Terms used in AMS are defined in AS7766.

8.3 Dimensions and properties in inch/pound units and the Fahrenheit temperatures are primary; dimensions and properties in SI units and the Celsius temperatures are shown as the approximate equivalents of the primary units and are presented only for information.

8.4 Unless otherwise specified, the material producer shall work to the revision of this specification (AMS4951) in effect on the date of order placement. Unless otherwise specified, material manufactured and certified to the immediately previous revision of this specification (AMS4951) may be procured and used until inventory is depleted.

8.5 It is the purchaser's obligation to ensure that product they procure or resell as AMS4951 has any exceptions approved by their subsequent purchaser.

8.6 Purchase documents should specify not less than the following:

AMS4951K

Size and form (spools or cut lengths) of wire desired

Length of cut lengths or weight of spools desired

Quantity of wire desired

8.7 Similar Specification

AWS ERTi-2.

PREPARED BY SAE AMS G TITANIUM AND REFRACTORY METALS COMMITTEE