



AEROSPACE MATERIAL SPECIFICATION

AMS6501™

REV. E

Issued 1984-10
Revised 2017-11
Reaffirmed 2022-06

Superseding AMS6501D

Steel, Maraging, Welding Wire
18Ni - 8.0Co - 4.9Mo - 0.40Ti - 0.10Al
Vacuum Induction Melted, Environment Controlled Packaging
(Composition similar to UNS K92890)

RATIONALE

AMS6501E results from a Five-Year Review and update of this specification that revises chemical analysis testing methods (3.1), requires hydrogen testing on finished wire (3.1.1.1), revises fabrication (3.4) and tensile testing specification (3.5.1 and 4.3.1), adds winding requirement (3.5.3.3), revises testing requirements (4.2), radiography specification (4.3.1), and ordering (8.4).

AMS6501E has been reaffirmed to comply with the SAE Five-Year Review policy.

1. SCOPE

1.1 Form

This specification covers a maraging steel in the form of welding wire.

1.2 Application

This wire has been used typically as filler metal for inert gas-metal-arc welding of critical weldments of maraging steels requiring a joint capable of being heat treated to 255 ksi (1758 MPa) tensile strength, but usage is not limited to such applications.

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 +1 724-776-4970 (outside USA), www.sae.org.

AMS2248 Chemical Check Analysis Limits, Corrosion and Heat-Resistant Steels and Alloys, Maraging and Other Highly-Alloyed Steels, and Iron Alloys

AMS2371 Quality Assurance Sampling and Testing, Corrosion and Heat-Resistant Steels and Alloys, Wrought Products and Forging Stock

AMS2813 Packaging and Marking of Packages of Welding Wire, Standard Method

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<https://www.sae.org/standards/content/AMS6501E/>

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
AMS6520	Steel, Maraging, Sheet, Strip, and Plate, 18Ni - 7.8Co - 4.9Mo - 0.40Ti - 0.10Al, Consumable Electrode Melted, Solution Heat Treated
ARP1876	Weldability Test for Weld Filler Metal Wire
ARP1917	Clarification of Terms Used in Aerospace Metals Specifications
ARP4926	Alloy Verification and Chemical Composition, Inspection of Welding Wire

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 A370	Mechanical Testing of Steel Products
ASTM A751	Standard Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
ASTM D2650	Chemical Composition of Gases by Mass Spectrometry
ASTM E1032	Radiographic Examination of Weldments

3. TECHNICAL REQUIREMENTS

3.1 Wire Composition

Shall conform to the percentages by weight shown in Table 1, determined in accordance with ASTM A751, or by other analytical methods acceptable to purchaser.

Table 1 - Composition

Elements	Min	Max
Carbon (3.1.1.1)	--	0.03
Manganese	--	0.10
Silicon	--	0.10
Phosphorus	--	0.010
Sulfur	--	0.010
Nickel	17.00	19.00
Cobalt	7.50	8.50
Molybdenum	4.60	5.20
Titanium	0.30	0.50
Aluminum	0.05	0.15
Boron	--	0.003 (30 ppm)
Zirconium	--	0.010
Oxygen (3.1.1.1)	--	0.010 (100 ppm)
Nitrogen (3.1.1.1)	--	0.0050 (50 ppm)
Hydrogen (3.1.1.1)	--	0.0010 (10 ppm)

3.1.1 Chemical analysis of initial ingot, bar, or rod stock before drawing, other than when analyses are required to be performed on the finished wire, 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 Hydrogen shall be determined on each lot of finished wire (see 4.2.1) in accordance with ASTM D2650. Carbon, oxygen, and nitrogen shall also be determined periodically on finished wire (refer to 4.2.2).

3.1.2 Check Analysis

Composition variations shall meet the applicable requirements of AMS2248. No variation over maximum is permitted for oxygen, nitrogen, and hydrogen.

3.2 Melting Practice

Steel shall be vacuum induction melted (VIM); it may be remelted using consumable electrode vacuum practice (VAR) in the remelt cycle, but remelting is not required.

3.3 Condition

Cold worked, bright finish, in a temper and with a surface finish that will provide proper feeding of the wire in machine welding equipment.

3.4 Fabrication

3.4.1 Wire shall be formed 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 do not tear the wire surface are acceptable provided the wire conforms to the tolerances of 3.7.

3.4.2 In-process annealing between cold rolling or drawing operations shall be performed in a protective atmosphere to avoid surface oxidation and adsorption of other extraneous elements.

3.4.3 Butt welding is permissible only at diameters larger than the final 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 is made at the wire processing station. The butt weld shall not interfere with 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 that will neither result in pitting nor cause gas absorption by the wire or deposition of substances harmful to welding operations.

3.4.5 Residual elements, drawing compounds, oxides, dirt, oil, dissolved gases and other foreign materials 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 by cleaning processes that will neither result in pitting nor cause gas adsorption by the wire or deposition of substances harmful to the welding operations.

3.5 Properties

Wire shall conform to the following requirements:

3.5.1 Tensile Properties

When specified (see 8.4), specimens prepared in accordance with 4.3.1 shall meet the requirements shown in Table 2, determined in accordance with ASTM A370, after being solution heat treated by heating in air to $1500\text{ °F} \pm 25\text{ °F}$ ($816\text{ °C} \pm 14\text{ °C}$), holding at heat for not less than 30 minutes, and cooling in air, and maraged by heating to $900\text{ °F} \pm 15\text{ °F}$ ($482\text{ °C} \pm 8\text{ °C}$), holding at heat for 3 to 5 hours, and cooling in air.

Table 2 - Minimum tensile properties

Property	Value
Tensile Strength	255 ksi (1758 MPa)
Yield Strength at 0.2% Offset	245 ksi (1689 MPa)
Elongation in 2 inches (50.8 mm)	4%

3.5.2 Weldability

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

3.5.3 Spooled Wire

Shall conform to 3.5.3.1, 3.5.3.2 and 3.5.3.3.

3.5.3.1 Cast

Wire, wound on standard 12-inch (305-mm) diameter spools, 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 15 to 50 inches (381 to 1270 mm) in diameter.

3.5.3.2 Helix

The specimen on which cast was determined, when laid on a flat surface and measured between adjacent turns, shall show a vertical separation not greater than 1 inch (25 mm).

3.5.3.3 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 on spools shall be level winding.

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 3**Table 3A - Sizes and diameter tolerances, inch/pound units**

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

Table 3B - Sizes and diameter tolerances, SI units

Form	Nominal Diameter Millimeters	Tolerance
		Millimeter Plus and Minus
Cut Lengths	0.76, 0.89, 1.14	0.025
Cut Lengths	1.57, 2.39, 3.18	0.05
Spools	0.18, 0.25, 0.38, 0.51	0.013
Spools	0.76, 0.89, 1.14	0.025
Spools	1.57, 2.39	0.05

3.7.2 Length

Cut lengths shall be furnished in 18, 27, or 36 inch (457, 686, or 914 mm) lengths, as ordered, and shall not vary more than +0, -0.5 inch (+0, -13 mm) from the length ordered.

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 (3.1.1), including hydrogen (3.1.1.1), tensile properties when specified (3.5.1), 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

Determination of carbon, oxygen, and nitrogen on finished wire (3.1.1.1), weldability (3.5.2), cast (3.5.3.1), and helix (3.5.3.2) 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 in accordance with AMS2371 and as specified herein.