



AEROSPACE MATERIAL SPECIFICATION

AMS6512™**REV. J**Issued 1970-05
Revised 2022-09

Superseding AMS6512H

Steel, Maraging, Bars, Forgings, Mechanical Tubing, Rings, and Forging Stock
18Ni - 7.8Co - 4.9Mo - 0.40Ti - 0.10Al
Consumable Electrode Vacuum Melted, Annealed
(Composition similar to UNS K92890)

RATIONALE

AMS6512 is the result of a Five-Year Review and update of the specification. The revision prohibits unauthorized exceptions (3.5.5.1.5, 3.8, 4.4.3, 5.2.1.1, 8.7, 8.8), aligns the size and quenchant with similar specification (1.1, 1.2), updates composition requirements (3.1), updates heat treatment (3.4), addresses hollow forgings (3.5.1.1, 3.5.1.2, 8.8), revises micro-inclusion rating method (3.5.2), aligns aging time with similar specifications (3.5.5), adds strain rate control (3.5.5.1.4), updates reporting for bar (4.2.1.2), and allows prior revisions (8.3).

1. SCOPE

1.1 Form

This specification covers a premium aircraft-quality, maraging alloy steel in the form of bars, forgings, mechanical tubing, flash welded rings up through 10.000 inches (254.00 mm), inclusive, in diameter or least distance between parallel sides and stock of any size for forging or flash welded rings.

1.2 Application

These products have been used typically for parts requiring through hardening, without liquid quenching, to a minimum yield strength of 240 ksi (1655 MPa) and where such parts may require welding during fabrication, 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.

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
http://www.sae.org

For more information on this standard, visit
<https://www.sae.org/standards/content/AMS6512J/>

SAE WEB ADDRESS:

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
AMS2251	Tolerances, Low-Alloy Steel Bars
AMS2253	Tolerances, Carbon and Alloy Steel Tubing
AMS2300	Steel Cleanliness, Premium Aircraft-Quality Magnetic Particle Inspection Procedure
AMS2370	Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel Wrought Products and Forging Stock
AMS2372	Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel Forgings
AMS2750	Pyrometry
AMS2761	Heat Treatment of Steel Raw Materials
AMS2806	Identification Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels and Corrosion- and Heat-Resistant Steels and Alloys
AMS2808	Identification Forgings
AMS7496	Rings, Flash Welded, Carbon and Low-Alloy Steels
AS1182	Standard Stock Removal Allowance Aircraft-Quality and Premium Aircraft-Quality Steel Bars and Mechanical Tubing
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 A370	Mechanical Testing of Steel Products
ASTM A604	Macroetch Testing of Consumable Electrode Remelted Steel Bars and Billets
ASTM A751	Chemical Analysis of Steel Products
ASTM E45	Determining the Inclusion Content of Steel
ASTM E112	Determining Average Grain Size
ASTM E140	Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness
ASTM E399	Plane-Strain Fracture Toughness of Metallic Materials

3. TECHNICAL REQUIREMENTS

3.1 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

Element	Min	Max
Carbon	--	0.03
Manganese	--	0.10
Silicon	--	0.10
Phosphorus	--	0.010
Sulfur	--	0.010
Nickel	17.00	19.00
Cobalt	7.00	8.50
Molybdenum	4.60	5.20
Titanium	0.30	0.50
Aluminum	0.05	0.15
Chromium	--	0.50
Copper	--	0.50

3.1.1 Additives

Any additions of calcium, zirconium, and boron shall be made prior to pouring the first melt into electrodes; these elements shall not exceed 0.05% calcium, 0.02% zirconium, and 0.004% boron and shall be analyzed and reported in the final heat analysis.

3.1.2 Check Analysis

Composition variations shall meet the applicable requirements of AMS2248.

3.2 Melting Practice

Steel shall be produced by multiple melting using consumable electrode vacuum remelt (VAR) practice in the remelt cycle.

3.3 Condition

3.3.1 Bars

Annealed and descaled. Bar shall not be cut from plate (also see 4.4.2).

3.3.2 Forgings, Mechanical Tubing, and Flash Welded Rings

Annealed and descaled.

3.3.2.1 Flash welded rings shall not be supplied unless specified or permitted on purchaser's part drawing. When supplied, rings shall be manufactured in accordance with AMS7496.

3.3.3 Stock for Forging or Flash Welded Rings

As ordered by the forging or flash welded ring manufacturer.

3.4 Annealing

Bars, forgings, mechanical tubing, and flash-welded rings shall be annealed in accordance with AMS2761 by heating to a temperature within the range 1500 to 1700 °F (816 to 927 °C), holding at the selected temperature within ± 25 °F (± 14 °C) for a minimum of 1 hour and cooling to room temperature in air or other atmosphere at a rate equivalent to an air cool or faster.

3.5 Properties

The product shall conform to the following requirements; hardness and tensile testing shall be performed in accordance with ASTM A370:

3.5.1 Macrostructure

Visual examination of transverse full cross-sections from bars, billets, tube rounds (solid, not hollow), and stock for forgings or flash welded rings, etched in hot hydrochloric acid in accordance with ASTM A604, shall show no pipe or cracks. Porosity, segregation, inclusions, and other imperfections shall be no worse than the macrographs of ASTM A604 shown in Table 2.

Table 2 - Macrostructure limits

Class	Condition	Severity
1	Freckles	A
2	White Spots	A
3	Radial Segregation	B
4	Ring Pattern	B

3.5.1.1 Macrostructure examination is not required for bored/hollow forgings (including ring forgings) and mechanical tubing that are produced directly from ingots or blooms unless otherwise agreed upon by purchaser and producer (see 8.8).

3.5.1.2 If mechanical tubing is produced directly from ingots or large blooms, transverse sections may be taken from the tubing. Macrostructure standards for such tubes shall be as agreed upon by purchaser and producer (see 8.8).

3.5.2 Micro-Inclusion Rating of Each Heat

No specimen shall exceed the limits shown in Table 3, determined in accordance with ASTM E45, Method A.

Table 3 - Micro-inclusion rating

Type	A	B	C	D	E
Thin	1.5	1.5	1.5	2.0	3.0
Heavy	1.0	1.0	1.0	1.5	1.5

3.5.2.1 Type E is titanium nitride and shall be rated in the same manner as Type B.

3.5.3 Hardness of Bars, Forgings, Tubing, and Rings

3.5.3.1 Bars over 0.500 inch (12.70 mm) in nominal diameter or least distance between parallel sides, forgings, tubing, and flash welded rings shall have hardness not higher than 34 HRC, or equivalent (see 8.2).

3.5.3.2 Bars 0.500 inch (12.70 mm) and under in nominal diameter or least distance between parallel sides shall have tensile strength not higher than 160 ksi (1103 MPa) or hardness not higher than 34 HRC, or equivalent (see 8.2).

3.5.4 Average Grain Size of Bars, Forgings, Tubing, and Rings

Shall be as follows, determined in accordance with ASTM E112.

3.5.4.1 Product Under 2.50 Inches (63.5 mm) in Nominal Section Thickness

ASTM No. 6 or finer.

3.5.4.2 Product 2.50 to 10.00 Inches (63.5 to 254.0 mm), Incl, in Nominal Section Thickness

ASTM No. 4 or finer.

3.5.5 After Maraging Heat Treatment

Specimens shall have the following properties after being maraged by heating to 900 °F ± 10 °F (482 °C ± 6 °C), holding at heat for 4 to 6 hours, and cooling to room temperature:

3.5.5.1 Tensile Properties

Shall be as shown in Table 4.

Table 4A - Minimum tensile properties, inch/pound units

Nominal Section Thickness Inches	Specimen Orientation	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 4D %	Reduction of Area %
Up to 4.000, excl	Longitudinal	255	250	6	45
	Transverse	255	250	4	35
4.000 to 10.000, incl	Longitudinal	245	240	5	30
	Transverse	245	240	3	20

Table 4B - Minimum tensile properties, SI units

Nominal Section Thickness Millimeters	Specimen Orientation	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 4D %	Reduction of Area %
Up to 101.60, excl	Longitudinal	1758	1724	6	45
	Transverse	1758	1724	4	35
101.60 to 254.00, incl	Longitudinal	1689	1655	5	30
	Transverse	1689	1655	3	20

3.5.5.1.1 Longitudinal requirements apply to specimens taken with axis of specimens approximately parallel to the grain flow and to specimens taken in the radial direction and in the tangential direction at the rim of disc forgings. All other specimens shall be considered to be in the transverse direction.

3.5.5.1.2 Transverse test requirements apply only to product that tensile specimens not less than 2.50 inches (63.5 mm) in length can be taken.

3.5.5.1.3 Tensile properties in the longitudinal direction need not be determined on product tested in the transverse direction.

3.5.5.1.4 Unless otherwise specified, the strain rate for both longitudinal and transverse tensile tests shall be set at 0.005 in/in/min (0.005 mm/mm/min) and maintained within a tolerance of ±0.002 in/in/min (0.002 mm/mm/min) through 0.2% offset yield strain. After the yield strain, the speed of the testing machine shall be set between 0.05 and 0.5 in/in (0.05 and 0.5 mm/mm) of the length of the reduced section (or distance between the grips for specimens not having a reduced section) per minute. Alternatively, an extensometer and strain rate indicator may be used to set the strain rate between 0.05 and 0.5 in/in/min (0.05 and 0.5 mm/mm/min).

3.5.5.1.5 Mechanical property requirements for product outside the range covered by 1.1 shall be agreed upon between purchaser and producer and reported per 4.4.3.

3.5.5.2 Hardness

Shall be not lower than 48 HRC, or equivalent (see 8.2), but the product shall not be rejected on the basis of hardness if the tensile property requirements are acceptable, determined on specimens taken from the same sample as that with the nonconforming hardness or from another sample with similar nonconforming hardness.

3.5.5.3 Fracture Toughness

When specified, product shall be subjected to fracture toughness testing in accordance with ASTM E399. Acceptance standards shall be as agreed upon between purchaser and producer (see 8.8).

3.5.6 Forging Stock

Specimens extracted from a forged down test coupon heat treated as in 3.4 and 3.5.5 shall conform to the requirements of 3.5.5.1, 3.5.5.2, and, when specified, 3.5.5.3. If specimens taken from the stock after heat treatment as in 3.4 and 3.5.5 conform to the requirements of 3.5.5.1, 3.5.5.2 and, when specified, 3.5.5.3, the tests shall be accepted as equivalent to tests of a forged coupon.

3.5.6.1 Forging stock from a heat meeting the requirements of 3.5.6 in one size need not be retested for qualification of a smaller size.

3.5.7 Stock for Flash Welded Rings

Specimens taken from the stock after heat treatment as in 3.4 and 3.5.5 shall conform to the requirements of 3.5.5.1, 3.5.5.2, and, when specified, 3.5.5.3.

3.6 Quality

The product, 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 product.

3.6.1 Steel shall be premium aircraft-quality conforming to AMS2300.

3.6.2 Bars and mechanical tubing shall be free from seams, laps, tears, and cracks after removal of the standard stock removal allowance in accordance with AS1182.

3.6.3 Flash welded rings ordered ground, turned, or polished shall be free from seams, laps, tears, and cracks open to the ground, turned, or polished surfaces.

3.6.4 Grain flow of die forgings, except in areas that contain flash-line end grain, shall follow the general contour of the forgings showing no evidence of reentrant grain flow.

3.7 Tolerances

3.7.1 Bars

In accordance with AMS2251.

3.7.2 Mechanical Tubing

In accordance with AMS2253.

3.8 Exceptions

Any exceptions shall be authorized by the purchaser and reported as in 4.4.3.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The producer of the product 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 product conforms to specified requirements.

4.2 Classification of Tests

4.2.1 Acceptance Tests

The following requirements are acceptance tests and shall be performed on each heat or lot as applicable:

4.2.1.1 Composition (3.1), macrostructure (3.5.1), and micro-inclusion rating (3.5.2) of each heat.

4.2.1.2 Hardness (3.5.3) of each lot of bars, forgings, tubing, and flash welded rings as annealed or tensile strength (3.5.3.1) of each lot of bars as annealed.

4.2.1.3 Average grain size (3.5.4) of each lot of bars, forgings, tubing, and flash welded rings as annealed.

4.2.1.4 Tensile properties (3.5.5.1), hardness (3.5.5.2), and, when specified, fracture toughness (3.5.5.3) of each lot of bars, forgings, tubing, and flash welded rings after maraging heat treatment.

4.2.1.5 Tolerances of bars (3.7.1) and mechanical tubing (3.7.2).

4.2.1.6 If stock for forgings or flash welded rings, tests to demonstrate ability to develop required properties (3.5.6 and 3.5.7).

4.2.2 Periodic Tests

Tests for frequency-severity rating (3.6.1), and grain flow of die forgings (3.6.4), 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

4.3.1 Bars, Mechanical Tubing, Flash Welded Rings, and Stock for Forgings and Flash Welded Rings

In accordance with AMS2370.

4.3.2 Forgings

In accordance with AMS2372.

4.4 Reports

4.4.1 The producer of bars, forgings, tubing, and flash welded rings shall furnish with each shipment a report showing the producer identity, country where the metal was melted (e.g., final melt in the case of metal processed by multiple melting operations), results of tests for composition, macrostructure, and micro-inclusion rating, of each heat, and for average grain size and annealed hardness tensile properties, hardness, and, when specified, fracture toughness of each lot after maraging heat treatment, and stating that the product conforms to the other technical requirements. This report shall include the purchase order number, heat and lot numbers, AMS6512J, product form and size (and/or part number, if applicable), and quantity. If forgings are supplied, the size and melt source of stock used to make the forgings shall also be included.

4.4.2 If the ship size/shape is cut from a larger cross section, report the nominal metallurgically worked size (see 3.3.1).