AEROSPACE MATERIAL SPECIFICATION

AMS6519	REV. D

Issued 1986-01
Reaffirmed 2006-02
Revised 2014-07

Superseding AMS6519C

Steel, Maraging, Bars, Forgings, Tubing, and Rings
19Ni - 3.0Mo - 1.4Ti - 0.10Al
Premium Aircraft Quality
Double Vacuum Melted, Annealed
(Composition similar to UNS K92150)

SAENORM.COM : Click to view the full PDF of ams6519d

RATIONALE

AMS6519D results from a Five Year Review and update of this specification that revises cutting restrictions, corrects SI converted dimensions and revises reporting requirements.

1. SCOPE

1.1 Form

This specification covers a premium aircraft-quality, maraging steel in the form of bars, forgings, mechanical tubing, flash welded rings, and stock for forging or flash welded rings.

1.2 Application

These products have been used typically for parts, such as pressure vessels, requiring through hardening, without 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.

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.

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

SAE Technical Standards Board 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 © 2014 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
SAE WEB ADDRESS: **http://www.sae.org**

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMS6519D

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

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

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 A 370 Mechanical Testing of Steel Products

ASTM A 604 Macroetch Testing of Consumable Electrode Remelted Steel Bars and Billets

ASTM E 45 Determining the Inclusion Content of Steel

ASTM E 112 Determining Average Grain Size

ASTM E 353 Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys

ASTM E 399 Linear-Elastic Plane-Strain Fracture Toughness K_{IC} of Metallic Materials

3. TECHNICAL REQUIREMENTS

3.1 Composition

Shall conform to the percentages by weight shown in Table 1, determined by wet chemical methods in accordance with ASTM E 353, by spectrochemical methods, or by other analytical methods acceptable to purchaser.

SAENORM.COM : Click to view the full PDF of ams6519d

TABLE 1 - COMPOSITION

Element	min	max
Carbon	--	0.03
Manganese	--	0.10
Silicon	--	0.10
Phosphorus	--	0.010
Sulfur	--	0.010
Nickel	18.00	20.00
Molybdenum	2.75	3.25
Titanium	1.30	1.45
Aluminum	0.05	0.15
Chromium	--	0.50
Cobalt	--	0.50
Copper	--	0.50

3.1.1 Prior to pouring, up to 0.05% calcium shall be added to the melt but analysis for this element need not be performed.

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 vacuum induction process (VIM) in the initial melt and vacuum consumable electrode remelt practice (VAR) in the final melt.

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 Forgings or Flash Welded Rings

As ordered by the forging or flash welded ring manufacturer.

3.4 Heat Treatment

Bars, forgings, mechanical tubing, and flash-welded rings shall be annealed 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 1 to 2 hours, and cooling to room temperature in air or other atmosphere at a rate equivalent to an air cool. Pyrometry shall be in accordance with AMS2750.

3.5 Properties

The product shall conform to the following requirements; hardness and tensile testing shall be performed in accordance with ASTM A 370:

3.5.1

SAENORM.COM : Click to view the full PDF of ams6519d

3.5.2 Macrostructure

Visual examination of transverse full cross-sections from bars, billets, tube rounds, and stock for forging or flash welded rings, etched in hot hydrochloric acid in accordance with ASTM A 604, shall show no pipe or cracks. Porosity, segregation, inclusions, and other imperfections shall be no worse than the macrographs of ASTM A 604 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

3.5.3 Micro-Inclusion Rating of each heat

No specimen shall exceed the limits shown in Table 3, determined in accordance with ASTM E 45, Method D.

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

3.5.3.1 Type E is titanium nitrides and shall be rated in the same manner as Type B.

3.5.4 Bars, Wire, Forgings, Tubing, and Flash Welded Rings

3.5.4.1 Annealed Condition

3.5.4.1.1 Hardness

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 321 HB, or equivalent (See 8.2).

3.5.4.1.2 Tensile Strength

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 (1105 MPa) or equivalent hardness (See 8.3).

3.5.4.1.3 Average Grain Size

Shall be as follows, determined in accordance with ASTM E 112.

3.5.4.1.3.1 Product Under 2.50 Inches (62.5 mm) in Nominal Section Thickness

ASTM No. 6 or finer.

3.5.4.1.3.2 Product 2.50 to 10.00 Inches (62.5 to 250.0 mm), Inclusive, in Nominal Section Thickness

ASTM No. 4 or finer.

3.5.4.2 After Maraging Heat Treatment

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

SAENORM.COM : Click to view the full PDF of ams6519d

3.5.4.2.1 Tensile Properties

Shall be as shown in Table 4 and 3.5.3.2.1.1.

3.5.4.2.1.1 Longitudinal requirements apply to specimens taken with the 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.

3.5.4.2.1.2 Transverse requirements apply only to product from which tensile specimens not less than 2.50 inches (62.5 mm) in length can be taken.

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

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	1760	1725	6	45
	Transverse	1760	1725	4	35
101.60 to 254.00, incl	Longitudinal	1690	1655	5	30
	Transverse	1690	1655	3	20

SAENORM.COM : Click to view the full PDF of ams6519d

3.5.4.2.2 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 nonconforming hardness or from another sample with similar nonconforming hardness.

3.5.4.2.3 Fracture Toughness

When specified, the product shall be subjected to fracture toughness testing. Method of test and standards for acceptance shall be as agreed upon by purchaser and vendor. ASTM E 399 is a suggested method of test.

3.5.5 Forging Stock

When a sample of stock is forged to a test coupon and heat treated as in 3.4 and 3.5.3.2, specimens taken from the heat treated coupon shall conform to the requirements of 3.5.3.2.1 and 3.5.3.2.2 and, when specified, 3.5.3.2.3. If specimens taken from the stock after heat treatment as in 3.4 and 3.5.3.2 conform to the requirements of 3.5.3.2.1 and 3.5.3.2.2, and, when specified, 3.5.3.2.3, the tests shall be accepted as equivalent to tests of a forged coupon.

3.5.6 Stock for Flash Welded Rings

A sample of stock heat treated as in 3.4 and 3.5.3.2 shall conform to the requirements of 3.5.3.2.1, 3.5.3.2.2, and, when specified, 3.5.3.2.3.

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 tubing ordered hot rolled or cold drawn, or ground, turned, or polished, shall, after removal of the standard stock removal allowance in accordance with AS1182, be free from seams, laps, tears, and cracks open to the ground, turned, or polished surface.

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

3.7 Tolerances

3.7.1 Bars

In accordance with AMS2251.

3.7.2 Mechanical Tubing

In accordance with AMS2253.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The vendor 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

Tests for 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), micro-inclusion rating (3.5.2), and frequency-severity cleanliness rating (3.6.1) of each heat.

4.2.1.2 Hardness (3.5.3.1.1) or tensile properties (3.5.3.1.2), as applicable, of each lot of bars, forgings, tubing, and flash welded rings as annealed.

4.2.1.3 Average grain size (3.5.3.1.3) of each lot of bars, forgings, tubing, and flash welded rings as annealed.

4.2.1.4 Tensile properties (3.5.3.2.1) and hardness (3.5.3.2.2) 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 When specified, fracture toughness (3.5.3.2.3) of the product.

4.2.2 Periodic Tests

Tests for grain flow of die forgings (3.6.3) and ability of forging stock (3.5.4) and of stock for flash welded rings (3.5.5) to develop required properties are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

SAENORM.COM : Click to view the full PDF of ams6519d