ADOPTION NOTICE

SAE-AMS6519, "STEEL BARS, FORGINGS, TUBING, AND RINGS, MARAGING 19NI - 3.0MO - 1.4TI - 0.10AL DOUBLE VACUUM MELTED, ANNEALED", was adopted on 01-AUG-86 for use by the Department of Defense (DoD). Proposed changes by DoD activities must be submitted to the DoD Adopting Activity: Commander, Defense Supply Center Philadelphia, ATTN: DSCP-ITAA, 700 Robbins Avenue, Philadelphia, PA 19111-5096. Copies of this document may be purchased from the Society of Automotive Engineers 400 Commonwealth Drive Warrendale, Pennsylvania, United States, 15096-0001. http://www.sae.org/

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400 COMMONWEALTH DRIVE, WARRENDALE, PA 15096

AEROSPACE MATERIAL SPECIFICATION

An American National Standard

AMS 6519A

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Superseding AMS 6519

STEEL BARS, FORGINGS, TUBING, AND RINGS, MARAGING 19Ni - 3.0Mo - 1.4Ti - 0.10Al Double Vacuum Melted, Annealed

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: Primarily for parts, such as pressure vessels, requiring through hardening, without quenching, to a minimum yield strength of 240,000 psi (1655 HPa) and where such parts may require welding during fabrication.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications and Aerospace Standards shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2248 - Chemical Check Analysis Limits, Wrought Corrosion and Heat Resistant Steels and Alloys, Maraging, and Other Highly-Alloyed Steels, and Iron Alloys
AMS 2251 - Tolerances, Low-Alloy Steel Bars
MAM 2251 - Tolerances, Metric, Low-Alloy Steel Bars
AMS 2253 - Tolerances, Carbon and Alloy Steel Tubing
AMS 2253 - Tolerances, Metric, Carbon and Alloy Steel Tubing
AMS 2300 - Premium Aircraft-Quality Steel Cleanliness, Magnetic Particle Inspection Procedure
MAM 2300 - Premium Aircraft-Quality Steel Cleanliness, Magnetic Particle Inspection Procedure, Metric (SI) Measurement
AMS 2350 - Standards and Test Methods

2.1.1 (Continued):

AMS 2370 - Quality Assurance Sampling of Carbon and Low-Alloy Steels, Wrought Products Except Forgings and Forging Stock
AMS 2372 - Quality Assurance Sampling of Carbon and Low-Alloy Steels, Forgings and Forging Stock
AMS 2375 - Control of Forgings Requiring First-Article Approval
AMS 2806 - Identification, Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels and Heat and Corrosion Resistant Steels and Alloys
AMS 2808 - Identification, Forgings
AMS 7496 - Rings, Flash Welded, Carbon and Low-Alloy Steels

2.1.2 Aerospace Standards:

AS 1182 - Standard Machining Allowance, Aircraft Quality and Premium Quality Steel Products

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 ce Street, Philadelphia, PA 19103.

ASTM A370 - Mechanical Testing of Steel Products
ASTM A604 - Macroetch Testing of Consumable Electrode Remelted Steel Bars and Billets
ASTM E45 - Determining the Inclusion Content of Steel
ASTM E112 - Determining Average Grain Size
ASTM E353 - Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys
ASTM E399 - Plane-Strain Fracture Toughness of Metallic Materials

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Military Specifications:

MIL-H-6875 - Heat Treatment of Steel, Process for

2.3.2 Military Standards:

MIL-STD-163 - Steel Mill Products, Preparation for Shipment and Storage

3. TECHNICAL REQUIREMENTS:

3.1 Composition: Shall conform to tile following percentages by weight, Ø determined by wet chemical methods in accordance with ASTM E353 or by spectrographic or other analytical methods approved by purchaser:

	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 requirements of AMS 2248.

3.2 Condition: The product shall be supplied in the following condition:

3.2.1 Bars, Forgings, Mechanical Tubing, and Flash Welded Rings: Annealed and descaled.

3.2.1.1 Flash welded rings shall not be supplied unless specified or permitted on purchaser's part drawing. When supplied, they shall be manufactured in accordance with AMS 7496.

3.2.2 Stock for Forgings or Flash Welded Rings: As ordered by the forging or flash welded ring manufacturer.

3.3 Heat Treatment: Bars, forgings, mechanical tubing, and flash welded rings shall be annealed by heating to a temperature within the range 1500° - 1700°F (815° - 925°C), holding at the selected temperature within ±25°F (±15°C) for 1 - 2 hr, and cooling in air to room temperature. Furnace surveys and calibration of temperature controllers and recorders shall be in accordance with MIL-H-6875.

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

3.4.1 Heat of Steel:

3.4.1.1 Macrostructure: Visual examination of transverse sections as in 4.3.3 from bars, billets, tube rounds or tubes, and stock for forging or flash welded rings, etched in accordance with ASTM A604 in a suitable etchant for sufficient time to develop a well-defined macrostructure, shall show no pipe or cracks. Except as specified in 3.4.1.1.1, porosity, segregation, inclusions, and other imperfections detrimental to fabrication or to performance of parts shall be no worse than the following macrographs of ASTM A604:

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

3.4.1.1.1 If tubes are produced directly from ingots or large blooms, transverse sections may be taken from tubes rather than tube rounds. Macrostructure standards for such tubes shall be as agreed upon by purchaser and vendor.

3.4.1.2 Micro-Inclusion Rating: No specimen as in 4.3.4 shall exceed the following limits, determined in accordance with ASTM E45, Method D.

	Inclusive 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

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

3.4.2 Bars, Wire, Forgings, Tubing, and Flash Welded Rings:

3.4.2.1 As Annealed:

3.4.2.1.1 Hardness: Bars over 0.500 in. (12.50 mm) in nominal diameter or distance between parallel sides, forgings, tubing, and flash welded rings shall have hardness not higher than 321 HB, or equivalent.

3.4.2.1.2 Tensile Strength: Bars 0.500 in. (12.50 mm) and under in nominal diameter or distance between parallel sides shall have tensile strength not higher than 160,000 psi (1105 MPa) or equivalent hardness.

3.4.2.1.3 Grain Size: Shall be as follows, determined in accordance with ASTM E112; the procedure used shall be as agreed upon by purchaser and vendor:

3.4.2.1.3.1 Product Under 2.50 In. (62.5 mm) in Nominal Section Thickness: Predominantly 6 or finer with occasional grains as large as 4 permissible.

3.4.2.1.3.2 Product 2.50 to 10.00 In. (62.5 to 250.0 mm), Incl, in Nominal Section Thickness: Predominantly 4 or finer with occasional grains as large as 2 permissible.

3.4.2.1.3.3 Product Over 10.00 In. (250.0 mm) in Section Thickness: As agreed upon by purchaser and venue.

3.4.2.2 After Maraging: The product shall have the following properties after being maraged heating to 900°F ± 10 (480°C ± 5), holding at heat for 4 - 6 hr, and cooling to room temperature:

3.4.2.2.1 Tensile Properties: Shall be as specified in Table I and 3.4.2.2.1.1.

TABLE I

Nominal Section Thickness Inches	Specimen Orientation	Tensile Strength psi, min	Yield Strength At 0.2% Offset psi, min	Elongation in 4D %, min	Reduction Of Area %, min
Up to 4.000, excl	Longitudinal	255,000	250,000	6	45
	Transverse	255,000	250,000	4	35
4.000 to 10.000, incl	Longitudinal	245,000	240,000	5	30
	Transverse	245,000	240,000	3	20

TABLE I (SI)

Nominal Section Thickness Milimetres	Specimen Orientation	Tensile Strength psi, min	Yield Strength At 0.2% Offset psi, min	Elongation In 4D %, min	Reduction Of Area %, min
Up to 100.00, excl	Longitudinal	1760	1725	6	45
	Transverse	1760	1725	4	35
100.00 to 250.00, incl	Longitudinal	1690	1655	5	30
	Transverse	1690	1655	3	20

3.4.2.2.1.1 Tensile property requirements for product over 10.000 in. (250.00 mm) in nominal section thickness shall be as agreed upon by purchaser and vendor.

3.4.2.2.1.2 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.

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

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

j.4.2.2.2 Hardness: Should be not lower than 48 HRC or equivalent but the product shall not be rejected on the basis of hardness if the tensile property requirements are met.

3.4.2.2.3 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 E399 is a suggested method of test.

3.4.3 Forging Stock: When a sample of stock is forged to a test coupon and heat treated as in 3.3 and 3.4.2.2, specimens taken from the heat treated coupon shall conform to the requirements of 3.4.2.2.1 and 3.4.2.2.2 and, when specified, 3.4.2.2.3. If specimens taken from the stock after heat treatment as in 3.3 and 3.4.2.2 conform to the requirements of 3.4.2.2.1 and 3.4.2.2.2 and, when specified, 3.4.2.2.3, the tests shall be accepted as equivalent to tests of a forged coupon.

3.4.4 Stock for Flash Welded Rings: A sample of stock heat treated as in 3.3 and 3.4.2.2 shall conform to the requirements of 3.4.2.2.1, 3.4.2.2.2, and, when specified, 3.4.2.2.3.

3.5 Quality:

3.5.1 Steel shall be premium aircraft-quality conforming to AMS 2300 or MAM 2300. It shall be produced by multiple melting using vacuum induction process in the initial melt and vacuum consumable electrode practice in the final melt.

3.5.2 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.

3.5.2.1 Bars, tubing, and 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.

3.5.2.2 Product ordered to surface conditions other than ground, turned, or polished shall, after removal of the standard machining allowance, be free from seams, laps, tears, cracks, and other defects exposed to the machined surfaces. Standard machining allowance shall be in accordance with AS 1182.

3.5.3 Grain flow of die forgings, except in areas which contain flash-line end grain, shall follow the general contour of the forging, showing no evidence of re-entrant flow.

3.6 Sizes: Except when exact lengths or multiples of exact lengths are ordered, straight bars, and tubing will be acceptable in mill lengths of 6 - 20 ft (2 - 6 m) but not more than 10% of any shipment shall be supplied in lengths shorter than 10 ft (3 m).

3.7 Tolerances: Shall conform to all applicable requirements of the following:

3.7.1 Bars: AMS 2251 or MAM 2251.

3.7.2 Mechanical Tubing: AMS 2253 or MAM 2253.

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 performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.5. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to all technical requirements of this specification are classified as acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Preproduction Tests: Tests of forgings to determine conformance to all applicable technical requirements of this specification when AMS 2375 is specified are classified as preproduction tests and shall be performed prior to or on the first-article shipment of a forging to a purchaser, when a change in material, processing, or both requires reapproval as in 4.4, and when purchaser deems confirmatory testing to be required.

4.2.2.1 For direct U.S. Military procurement of forgings, substantiating test data, and when requested, preproduction forgings shall be submitted to the cognizant agency as directed bythe procuring activity, the contracting officer, or the request for procurement.