The Engineering Society For Advancing Mobility Land Sea Air and Space®
400 Commonwealth Dr., Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 6527A

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Superseding AMS 6527

STEEL BARS AND FORGINGS
2.0Cr - 10Ni - 14Co - 1.0Mo (0.13 - 0.17C) (AF 1410)
Vacuum Melted, Normalized and Overaged

UNS K92571

1. SCOPE:

1.1 Form: This specification covers a premium aircraft-quality alloy steel in the form of bars, forgings, and forging stock.

1.2 Application: Primarily for heat treated parts requiring a combination of high strength, high toughness, and weldability.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications 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 2241 - Tolerances, Corrosion and Heat Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Bars and Wire
MAM 2241 - Tolerances, Metric, Corrosion and Heat Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Bars and Wire
AMS 2248 - Chemical Check Analysis Limits, Wrought Corrosion and Heat Resistant Steels and Alloys, Maraging and Other Highly-Alloyed Steels, and Iron Alloys
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 (Cont'd.)

AMS 2371 - Quality Assurance Sampling of Corrosion and Heat Resistant Steels and Alloys, Wrought Products Except Forgings and Forging Stock
AMS 2374 - Quality Assurance Sampling of Corrosion and Heat Resistant Steels and Alloys, Forgings and Forging Stock
AMS 2375 - Control of Forgings Requiring First Article Approval
AMS 2750 - Pyrometry
AMS 2806 - Identification, Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels and Corrosion and Heat Resistant Steels and Alloys
AMS 2808 - Identification, Forgings

2.1.2 Aerospace Standards:

AS1182 - Standard Machining Allowance, Aircraft Quality and Premium Quality Steel

2.2 ASTM Publications: Available from ASTM, 1916 Race Street, Philadelphia, PA 19103.

ASTM A604 - Macroetch Testing of Consumable Electrode Remelted Steel Bars and Billets
ASTM E8 - Tension Testing of Metallic Materials
ASTM E8M - Tension Testing of Metallic Materials (Metric)
ASTM E45 - Determining the Inclusion Content of Steel
ASTM E112 - Determining Average Grain Size
ASTM E339 - Plane-Strain Facture Toughness of Metallic Materials
ASTM E353 - Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys

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 the following percentages by weight, Ø determined by wet chemical methods in accordance with ASTM E353, by spectrochemical methods, or by other analytical methods acceptable to purchaser:

	min	max
Carbon	0.13	0.17
Manganese	--	0.10
Silicon	--	0.10
Phosphorus	--	0.008
Sulfur	--	0.005
Phosphorus + Sulfur	--	0.010
Chromium	1.80	2.20
Nickel	9.50	10.50
Cobalt	13.50	14.50
Molybdenum	0.90	1.10
Titanium	--	0.015
Aluminum	--	0.015
Oxygen	--	0.0020 (20 ppm)
Nitrogen	--	0.0015 (15 ppm)

3.1.1 Check Analysis: Composition variations shall meet the requirements of AMS 2248. No variation is permitted for oxygen and nitrogen.

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

3.2.1 Bars and Forgings: Normalized, overaged, and descaled.

3.2.2 Forging Stock: As ordered by the forging manufacturer.

3.3 Heat Treatment: Shall conform to the following:

3.3.1 Bars: Shall be normalized by heating to 1650°F ± 25 (899°C ± 14), holding Ø at heat for 60 minutes ± 5, air cooling to room temperature, and overaged by heating to 1250°F ± 25 (677°C ± 14), holding at heat for not less than 6 hours, and forced-air cooling. Pyrometry shall be in accordance with AMS 2750.

3.3.2 Forgings: Shall be heat treated in accordance with MIL-H-6875. Ø

3.4 Properties: The product shall conform to the following requirements:

3.4.1 Macrostructure: Visual examination of transverse sections as in 4.3.1.3 Ø from bars, billets, and forging stock, etched in accordance with ASTM A604, shall show no pipe or cracks. Porosity, segregation, inclusions, and other imperfections for product 36 square inches (232 cm^2) and under in nominal cross-sectional area shall be no worse than the following macrographs of ASTM A604; macrostructure standards for product over 36 square inches (232 cm^2) in nominal cross-sectional area shall be as agreed upon by purchaser and vendor.

3.4.1 (Cont'd.)

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

3.4.2 Micro-Inclusion Rating: No specimen as in 4.3.1.4 shall exceed the Ø following limits, determined in accordance with ASTM E45, Method D:

	A		B		C		D	
	Thin	Heavy	Thin	Heavy	Thin	Heavy	Thin	Heavy
Worst Field Severity	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Worst Field Frequency, maximum	*	1	*	1	*	1	3	1
Total Rateable Fields Frequency, maximum	**	1	**	1	**	1	8	1

* Combined A+B+C, not more than 3 fields
** Combined A+B+C, not more than 8 fields

3.4.2.1 A rateable field is defined as one which has a type A, B, C, or D inclusion rating of at least 1.0 thin or heavy in accordance with the Jernkontoret Chart, Plate III, ASTM E45.

3.4.3 Grain Size: Shall be 10 or finer for product 100 square inches (645 cm^2) and under in cross-sectional area, determined by comparison of a polished and etched specimen with the chart in ASTM E112. Grain size for product over 100 square inches (645 cm^2) in cross-sectional area shall be as agreed upon by purchaser and vendor.

3.4.4 After Heat Treatment:

3.4.4.1 Bars and Forgings: Test specimens cut from product 100 square inches Ø (645 cm^2) and under in cross-sectional area that have been normalized and overaged as in 3.3 shall have the properties specified in 3.4.4.1.1 and 3.4.4.1.2 after heating to 1525°F ± 25 (829°C ± 14), held at heat for 60 minutes, ± 5, forced-air cooled, cooled to -100°F ± 14 (-73°C ± 8), held at temperature for 60 minutes, ± 5, warmed in air to room temperature, and aged by heating to 950°F ± 10 (510°C ± 5), holding at heat for not less than 5 hours, and forced air cooling. The 1650°F ± 25 (899°C ± 14) normalized portion of the cycle applied to the test samples may be deleted if the parent product has previously been treated as in 3.3. Properties of samples prepared from product over 100 square inches (645 cm) in cross-sectional area shall be as agreed upon by purchaser and vendor.

3.4.4.1.1 Tensile Properties: Shall be as follows, determined in accordance with ASTM E8 or ASTM E8M on specimens taken in the longitudinal direction:

Tensile Strength, minimum	235,000 psi (1620 MPa)
Yield Strength at 0.2% Offset, minimum	215,000 psi (1482 MPa)
Elongation in 4D, minimum	12%
Reduction of area, minimum	60%

3.4.4.1.2 Ø Fracture Toughness: Shall be not lower than 130,000 psi $\sqrt{\text{inch}}$ (143 MPa $\sqrt{\text{m}}$) K_{Ic}, determined in accordance with ASTM E399 on specimens in the TL orientation from product 1.50 inches (38.1 mm) and over in nominal section thickness. Fracture toughness requirements and method of testing shall be as agreed upon by purchaser and vendor for product under 1.50 inches (38.1 mm) in nominal section thickness. If specimens are not capable of yielding a K_{Ic} value, the K_Q value will be acceptable.

3.4.4.2 Forging Stock: When a sample of stock is forged to a test coupon and heat treated as in 3.3 and 3.4.4.1, specimens taken from the heat treated coupon shall conform to the requirements of 3.4.4.1.1 and 3.4.4.1.2. If specimens taken from the stock after heat treatment as in 3.3 and 3.4.4.1 conform to the requirements of 3.4.4.1.1 and 3.4.4.1.2, the tests shall be accepted as equivalent to tests of a forged coupon.

3.5 Quality:

3.5.1 Steel shall be premium aircraft-quality conforming to AMS 2300 or MAM 2300. It shall be multiple melted using vacuum induction melting followed by vacuum arc remelting.

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 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 Bars 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 imperfections exposed to the machined surfaces. Standard machining allowance shall be in accordance with AS1182.

3.5.2.3 Ø Forgings shall have substantially uniform macrostructure. Standards for acceptance shall be as agreed upon by purchaser and vendor.

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

3.6 Sizes: Except when exact lengths or multiples of exact lengths are ordered, straight bars will be acceptable in mill lengths of 6 - 20 feet (1.8 - 6.1 m) but not more than 10% of any shipment shall be supplied in lengths shorter than 10 feet (3 m).

3.7 Tolerances: Bars shall conform to all applicable requirements of AMS 2241 or MAM 2241.

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

4.2.1.1 Composition (3.1), macrostructure (3.4.1), micro-inclusion rating (3.4.2), and grain size (3.4.3) and frequency severity cleanliness rating (3.4.2) of each heat.

4.2.1.2 Tensile properties (3.4.4.1.1) of each lot of bars and forgings after heat treatment.

4.2.1.3 Tolerances (3.7) of bars.

4.2.2 Periodic Tests: Tests to determine conformance to the following requirements are classified as periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser:

4.2.2.1 Fracture toughness (3.4.4.1.2) of bars and forgings after heat treatment.

4.2.2.2 Ability of forging stock to develop required properties (3.4.4.2).

4.2.2.3 Quality (3.5.1).

4.2.3 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 and/or processing requires reapproval as in 4.4, and when purchaser deems confirmatory testing to be required.

4.2.3.1 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 by the procuring activity, contracting officer, or request for procurement.

4.3 Sampling: Shall be in accordance with the following; a heat shall be the consumable electrode remelted ingots produced from steel originally melted as a single furnace charge.

4.3.1 For Acceptance Tests:

4.3.1.1 Bars: AMS 2371.

4.3.1.2 Forgings and Forging Stock: AMS 2374.

4.3.1.3 Samples for macrostructure rating (3.4.1) shall be full cross-sectional specimens obtained from the finished billet or suitable rerolled product representing the top and bottom of at least the first, middle, and last usable ingot of each heat.

4.3.1.4 Samples for micro-inclusion rating (3.4.2) shall be obtained from the finished billet or suitable rerolled product and shall consist of not less than four specimens representing the top and bottom of the first and last ingot from a heat yielding 10 or fewer ingots or not less than six specimens representing the top and bottom of the first, middle, and last usable ingot from a heat yielding more than 10 ingots. Specimens shall be selected so that the surface to be examined will be approximately parallel to the direction of rolling.

4.3.2 For Periodic Tests and Preproduction Tests: As agreed upon by purchaser and vendor.

4.4 Approval: When specified, approval and control of forgings shall be in accordance with AMS 2375.

4.5 Reports:

4.5.1 The vendor of bars and forgings shall furnish with each shipment a report showing the results of tests for chemical composition, macrostructure, micro-inclusion rating, and grain size of each heat and, when performed, the results of tests to determine conformance to the periodic test requirements. This report shall include the purchase order number, lot number, AMS 6527A, size, and quantity. When forgings are supplied, the part number and the size and melt source of stock used to make the forgings shall also be included.

4.5.2 Ø The vendor of forging stock shall furnish with each shipment a report showing the results of tests for chemical composition and frequency-severity cleanliness rating of each heat. This report shall include the purchaser order number, heat number, AMS 6527A, size, and quantity.