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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 6527C

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Superseding AMS 6527B

Steel, Bars and Forgings
2.0Cr - 10Ni - 14Co - 1.0Mo (0.15 - 0.19C)
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:

These products have been used typically for heat treated parts requiring a combination of high strength, toughness, and weldability, but usage is not limited to such applications.

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 publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2251	Tolerances, Low-Alloy Steel Bars
MAM 2251	Tolerances, Metric, Low-Alloy Steel Bars
AMS 2259	Chemical Check Analysis Limits, Wrought Low-Alloy and Carbon Steels
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 2310	Qualification Sampling and Testing of Steels, Transverse Tensile Properties
AMS 2370	Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel Wrought Products and Forging Stock

QUESTIONS REGARDING THIS DOCUMENT: (724) 772-7161 FAX: (724) 776-0243
TO PLACE A DOCUMENT ORDER: (724) 776-4970 FAX: (724) 776-0790
SAE WEB ADDRESS: http://www.sae.org

2.1 (Continued):

AMS 2372	Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel Forgings
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
AS1182	Standard Machining Allowance, Aircraft-Quality and Premium Aircraft-Quality Steel Bars and Mechanical Tubing

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM A 604	Macroetch Testing of Consumable Electrode Remelted Steel Bars and Billets
ASTM E 8	Tension Testing of Metallic Materials
ASTM E 8M	Tension Testing of Metallic Materials (Metric)
ASTM E 18	Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
ASTM E 23	Notched Bar Impact Testing of Metallic Materials
ASTM E 45	Determining the Inclusion Content of Steel
ASTM E 112	Determining the Average Grain Size
ASTM E 353	Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys
ASTM E 399	Plane-Strain Fracture Toughness of Metallic Materials

2.3 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

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

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.

TABLE 1 - Composition

Element	min	max
Carbon	0.15	0.19
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 2259, except that carbon shall be not lower than the minimum and cobalt shall be not more than 0.05 under minimum or over maximum. No variation is permitted for oxygen and nitrogen.

3.2 Melting Practice:

Steel shall be multiple melted using vacuum induction melting followed by vacuum arc remelting.

3.3 Condition:

The product shall be supplied in the following condition:

3.3.1 Bars and Forgings: Normalized and overaged with hardness not higher than 36 HRC, or equivalent (See 8.2), determined in accordance with ASTM E 18.

3.3.2 Forging Stock: As ordered by the forging manufacturer.

3.4 Heat Treatment:

Shall conform to the following:

3.4.1 Bars and Forgings: Shall be normalized by heating to 1650 °F ± 25 (899 °C ± 14), holding at heat for 60 minutes ± 5, and cooling to room temperature at a rate equivalent to a still air cool or faster, and overaged by heating to 1250 °F ± 25 (677 °C ± 14), holding at heat for not less than six hours, and fan-air cooling. Pyrometry shall be in accordance with AMS 2750.

3.5 Properties:

The product shall conform to the following requirements:

3.5.1 Macrostructure: Visual examination of transverse full cross-sections from bars, billets, and forging stock, etched in hot hydrochloric acid in accordance with ASTM A 604, shall show no pipe or cracks. Porosity, segregation, inclusions, and other imperfections for product 144 square inches (929 cm^2) and under in nominal cross-sectional area 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

3.5.2 Micro-Inclusion Rating: No specimen shall exceed the limits shown in Table 3, determined in accordance with ASTM E 45, Method D, except that the length of any inclusion shall be not greater than 0.015 inch (0.38 mm).

TABLE 3 - Micro-Inclusion Rating Limits

Field	A Thin	A Heavy	B Thin	B Heavy	C Thin	C Heavy	D Thin	D Heavy
Worst Field Severity	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Worst Field Frequency, maximum	[a]	1	[a]	1	[a]	1	3	1
Total Rateable Fields Frequency, maximum	[b]	1	[b]	1	[b]	1	8	1

[a] Combined A+B+C, not more than 3 fields
[b] Combined A+B+C, not more than 8 fields

3.5.2.1 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 E 45.

3.5.3 Decarburization:

3.5.3.1 Bars ordered ground, turned, or polished shall be free from decarburization on the ground, turned, or polished surfaces.

3.5.3.2 Allowable decarburization of bars and billets ordered for redrawing or forging or to specified microstructural requirements shall be as agreed upon by purchaser and vendor.

3.5.3.3 Decarburization of bars to which 3.5.3.1 or 3.5.3.2 is not applicable shall be no greater than shown in Table 4.

TABLE 4A - Maximum Decarburization, Bars, Inch/Pound Units

Nominal Diameter or Distance Between Parallel Sides Inches	Depth of Decarburization Inch
Up to 0.375, incl	0.015
Over 0.375 to 0.500, incl	0.017
Over 0.500 to 0.625, incl	0.019
Over 0.625 to 1.000, incl	0.022
Over 1.000 to 1.500, incl	0.025
Over 1.500 to 2.000, incl	0.030
Over 2.000 to 2.500, incl	0.035
Over 2.500 to 4.000, incl	0.040

TABLE 4B - Maximum Decarburization, Bars, SI Units

Nominal Diameter or Distance Between Parallel Sides Millimeters	Depth of Decarburization Millimeters
Up to 9.52, incl	0.38
Over 9.52 to 12.70, incl	0.43
Over 12.70 to 15.88, incl	0.48
Over 15.88 to 25.40, incl	0.56
Over 25.40 to 38.10, incl	0.64
Over 38.10 to 50.80, incl	0.76
Over 50.80 to 63.50, incl	0.89
Over 63.50 to 101.60, incl	1.02

3.5.3.4 Decarburization shall be measured by the microscopic method or by HR30N scale or equivalent hardness testing method on hardened but untempered specimens protected during heat treatment to prevent changes in surface carbon content. Depth of decarburization, when measured by a hardness method, is defined as the perpendicular distance from the surface to the depth under that surface below which there is no further increase in hardness. Such measurements shall be far enough away from any adjacent surface to be uninfluenced by decarburization thereon.

3.5.3.4.1 When determining the depth of decarburization, it is permissible to disregard local areas provided the decarburization of such areas does not exceed the limits of Table 4 by more than 0.005 inch (0.13 mm) and the width is 0.065 inch (1.65 mm) or less.

3.5.4 Average Grain Size: Prior austenitic grain size shall be ASTM No. 6 or finer for product 100 square inches (645 cm^2) and under in cross-sectional area, determined in accordance with ASTM E 112.

3.5.5 Response to Heat Treatment:

3.5.5.1 Bars and Forgings: Test specimens cut from product 100 square inches (645 cm^2) and under in cross-sectional area that have been normalized and overaged as in 3.4 shall have the properties specified in 3.5.5.1.1, 3.5.5.1.2, and 3.5.5.1.3 after being heated to 1575 °F ± 25 (857 °C ± 14), held at heat for 60 minutes ± 5, oil quenched, cooled to -100 °F ± 15 (-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 ± 6), holding at heat for not less than five 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.

3.5.5.1.1 Longitudinal Tensile Properties: Shall be as shown in Table 5, determined in accordance with ASTM E 8 or ASTM E 8M; testing in the longitudinal direction need not be performed on product tested in the transverse direction:

TABLE 5 - Minimum Longitudinal Tensile Properties

Property	Value
Tensile Strength	235 ksi (1620 MPa)
Yield Strength at 0.2% Offset	215 ksi (1482 MPa)
Elongation in 4D	12%
Reduction of Area	60%

3.5.5.1.2 Transverse Tensile Properties: Shall be as shown in Table 6, determined on specimens selected and prepared in accordance with AMS 2310; transverse tensile properties apply only to product from which tensile specimens not less than 2.50 inches (63.5 mm) in length can be taken.

TABLE 6 - Minimum Transverse Tensile Properties

Property	Value
Tensile Strength	235 ksi (1620 MPa)
Yield Strength at 0.2% Offset	215 ksi (1482 MPa)
Elongation in 4D	12%
Reduction of Area	55%

3.5.5.1.3 Fracture Toughness: K_{IC}, shall be not lower than 130 ksi $\sqrt{inch}$ (143 MPa $\sqrt{m}$), determined in accordance with ASTM E 399 on specimens in the L-R or L-C orientation from product 1.50 inches (38.1 mm) and over in nominal section thickness. For product where size precludes testing of fracture toughness, capability shall be demonstrated by Charpy impact testing with specimens taken with longitudinal axis parallel to the grain direction. Specimens shall be Charpy V-notch in accordance with ASTM E 23. Minimum impact value shall be 45 foot pounds (61 J) at room temperature, determined in accordance with ASTM E 23.

3.5.5.2 Forging Stock: When a sample of stock is forged to a test coupon and heat treated as in 3.4 and 3.5.5.1, specimens taken from the heat treated coupon shall conform to the requirements of 3.5.5.1.1 and 3.5.5.1.3. If specimens taken from the stock after heat treatment as in 3.4 and 3.5.5.1 conform to the requirements of 3.5.5.1.1 and/or 3.5.5.1.2, and 3.5.5.1.3, tests shall be accepted as equivalent to tests of a forged coupon.

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 AMS 2300 or MAM 2300, except that a maximum average frequency (F) rating of 0.10 and a maximum average severity (S) rating of 0.20 shall apply.

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

3.6.3 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.

3.7 Tolerances:

Bars shall conform to all applicable requirements of AMS 2251 or MAM 2251.

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: 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), decarburization (3.5.3), average grain size (3.5.4), and frequency severity cleanliness rating (3.6.1) of each heat.

4.2.1.2 Tensile properties (3.5.5.1.1 and/or 3.5.5.1.2) and fracture toughness (3.5.5.1.3) of each lot of bars and forgings after heat treatment.

4.2.1.3 Tolerances (3.7) of bars.

4.2.2 Periodic Tests: The following requirements are 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 Ability of forging stock to develop required properties (3.5.5.2).

4.2.2.2 Grain flow of die forgings (3.6.3).

4.3 Sampling and Testing:

Shall be as follows:

4.3.1 Bars and Forging Stock: In accordance with AMS 2370.

4.3.2 Forgings: In accordance with AMS 2372.

4.4 Reports:

The vendor of the product shall furnish with each shipment a report stating that the product conforms to AMS 6527C and showing the results of tests for chemical composition, macrostructure, micro-inclusion rating, decarburization, average grain size, and frequency-severity cleanliness rating of each heat and for tensile properties and fracture toughness values of each lot after hardening heat treatment, and, when performed, the results of tests to determine conformance to the periodic test requirements. This report shall include the purchase order number, heat and lot numbers, AMS 6527C, 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.