Society of Automotive Engineers, Inc.
TWO PENNSYLVANIA PLAZA, NEW YORK, N.Y. 10001

AEROSPACE MATERIAL SPECIFICATION

AMS 6512

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Revised

STEEL BARS, FORGINGS, TUBING, AND RINGS
18Ni - 7.8Co - 4.9Mo - 0.40Ti - 0.10Al
Consumable Electrode Melted, Annealed

1. ACKNOWLEDGMENT: A vendor shall mention this specification number in all quotations and when acknowledging purchase orders.

2. FORM: Bars, wire, forgings, mechanical tubing, flash welded rings, and stock for forging or flash welded rings.

3. APPLICATION: Primarily for heat treated parts, such as pressure vessels, requiring through hardening, without quenching, to a yield strength of 240,000 psi and where such parts may require welding during fabrication.

4. COMPOSITION:

	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

4.1 Additives: Prior to pouring, up to 0.05% calcium, 0.02% zirconium, and 0.003% boron shall be added to the air melted heat; analysis for these elements need not be made.

4.2 Check Analysis: Composition variations shall meet the requirements of the latest issue of AMS 2248.

5. CONDITION: Unless otherwise ordered, the product shall be supplied in the following condition:

5.1 Bars, Wire, Forgings, Mechanical Tubing, and Flash Welded Rings: Annealed as in 6.2.1 and descaled.

5.1.1 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 the latest issue of AMS 7496, unless otherwise specified.

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

6. TECHNICAL REQUIREMENTS: When ASTM methods are specified for determining conformance to the following requirements, tests shall be conducted in accordance with the issue of the ASTM method listed in the latest issue of AMS 2350.

6.1 Properties of the Heat (See 10.1) of Steel:

6.1.1 Inclusion Rating: When determined in accordance with ASTM E45, Method D, and using not less than 9 specimens per heat selected parallel to the direction of rolling and representing the worst area of inclusions in the inspection samples, the inclusion rating shall be as specified below. The method of selection of specimens shall be such that a suitable rating of the heat of steel is assured. Two-thirds of all specimens, as well as the average of all specimens, shall not exceed the following limits except that the length of any inclusion shall be not greater than 0.015 inch.

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

6.1.1.1 Type E is titanium nitrides and shall be rated the same as Type B or Type D.

6.1.2 Macrostructure: Full cross-sectional specimens, representing the top and bottom of the first, middle, and last usable ingots and obtained from the finished billet or a suitable rerolled product, shall be etched in hot hydrochloric acid (1:1) at 160-180 F (71.1-82.2 C) for sufficient time to develop a well defined macrostructure. The macroetched specimen, when examined visually, shall show no pipe, porosity, segregation, inclusions, or other injurious imperfections detrimental to fabrication or to performance of the steel.

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

6.2.1 Annealing Heat Treatment: The product, as received, shall have been annealed by heating to 1500 - 1700 F (815.6 - 926.7 C), holding at the selected temperature within ±25 F (±14 C) for 1 - 2 hr, and cooling in air to room temperature.

6.2.2 Properties As Annealed:

6.2.2.1 Hardness: Bars, forgings, tubing, and flash welded rings shall have hardness not higher than Brinell 321 or equivalent.

6.2.2.2 Tensile Strength: Wire shall have tensile strength not higher than 160,000 psi.

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

6.2.2.3.1 Product Less than 2.5 In. in Section Thickness: Shall be predominantly 6 or finer with occasional grains as large as 4 permissible.

6.2.2.3.2 Product 2.5 to 10.0 In., incl, in Section Thickness: Shall be predominantly 4 or finer with occasional grains as large as 2 permissible.

6.2.2.3.3 Product Over 10.0 In. in Section Thickness: Shall be as agreed upon by purchaser and vendor.

6.2.3 Properties After Maraging Heat Treatment: Specimens taken from the product shall conform to the following requirements after being heated to 900 F ± 10 (482.2 C ±5.6), held at heat for 3 - 6 hr, and cooled in air to room temperature.

6.2.3.1 Tensile Properties: The size and location of tensile test specimens from forgings and flash welded rings shall be as agreed upon by purchaser and vendor. Longitudinal requirements apply to specimens taken with the axis 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. Transverse test requirements are applicable only to product having a section thickness sufficiently large to yield tensile test specimens not less than 2.5 in. in length. Tensile properties in the longitudinal direction need not be determined on product tested in the transverse direction.

6.2.3.1.1 Product with Nominal Cross Section Less than 4.0 Inches:

Specimen Orientation	Tensile Strength psi, min	Yield Strength at 0.2% Offset or at Extension Indicated (E = 26,500,000) psi, min	Extension Under Load in. in 2 in.	Elongation % in 2 in. or 4D, min	Reduction of Area %, min
Longitudinal	255,000	250,000	0.0229	6	45
Transverse	255,000	250,000	0.0229	4	35

6.2.3.1.2 Product with Nominal Cross Section 4.0 to 10.0 In., Inclusive:

Specimen Orientation	Tensile Strength psi, min	Yield Strength at 0.2% Offset or at Extension Indicated (E = 26,500,000) psi, min	Extension Under Load in. in 2 in.	Elongation % in 2 in. or 4D, min	Reduction of Area %, min
Longitudinal	245,000	240,000	0.0221	5	30
Transverse	245,000	240,000	0.0221	3	20

6.2.3.1.3 Product with Nominal Cross Section Over 10.0 Inches: Shall have tensile properties as agreed upon by purchaser and vendor.

6.2.3.2 Hardness: Material should have hardness not lower than Rockwell C 48 or equivalent but shall not be rejected on the basis of hardness if the tensile property requirements are met.

6.2.3.3 Impact Strength: Product shall have Charpy V-Notch impact value not lower than the following when determined at room temperature in accordance with ASTM E23:

Nominal Section Thickness Inches	Charpy V-Notch Impact Value, ft - lb, min	
	Longitudinal	Transverse
Up to 2.5, incl	12	--
Over 2.5 to 4.0, incl	10	8
Over 4.0 to 10.0, incl	8	6
Over 10.0	as agreed upon	

6.2.3.4 Fracture Toughness: When specified, product shall be subject to fracture toughness testing. Method of test and standards for acceptance of product shall be as agreed upon by purchaser and vendor. (ASTM Proposed Recommended Practice for Plane-Strain Fracture Toughness Testing of High-Strength Metallic Materials using a Fatigue-Cracked Bend Specimen is a suggested method of test.)

6.3 Stock for Forging or Flash Welded Rings: When a sample of stock is forged to a test coupon and heat treated as in 6.2.1 and 6.2.3, specimens taken from the heat treated coupon shall conform to the requirements of 6.2.3.1, 6.2.3.2, and 6.2.3.3 as applicable to the size of the forged coupon. If specimens taken from the stock after heat treatment as in 6.2.1 and 6.2.3 conform to the requirements of 6.2.3.1, 6.2.3.2, and 6.2.3.3 as applicable, the tests shall be accepted as equivalent to tests of the forged coupon.

6.4 Resampling and Retesting: If any specimen used in the above tests fails to meet the specified requirements, acceptance of the product may be based on the testing of three additional specimens, all of which shall conform to specified requirements. Failure of any retest specimen to conform to specified requirements shall be cause for rejection of the material represented and no additional testing permitted. Results of all tests shall be reported.

7. QUALITY: Steel shall be premium quality and shall conform to the requirements of the latest issue of AMS 2300; it shall be produced by multiple melting using consumable electrode practice in the remelt cycle; at least one of the melting cycles shall be under vacuum. The product shall be uniform in quality and condition, clean, sound, and free from foreign materials and from internal and external imperfections detrimental to fabrication, appearance, or performance of parts.

7.1 Bars, wire, and tubing ordered ground, turned, or polished shall be free from seams, laps, tears, and cracks.

7.2 Product ordered to surface conditions other than ground, turned, or polished shall, after removal of the applicable 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 values shown in the latest issue of AMS 2300.

8. SAMPLING: Bars, wire, and mechanical tubing shall be sampled in accordance with all applicable requirements of the latest issue of AMS 2370 and as specified herein. Forgings, flash welded rings, and stock for forging or flash welded rings shall be sampled as agreed upon by purchaser and vendor.

9. TOLERANCES: Unless otherwise specified, tolerances shall conform to all applicable requirements of the following:

9.1 Bars and Wire: The latest issue of AMS 2251.

9.2 Mechanical Tubing: The latest issue of AMS 2253.

10. REPORTS:

10.1 Unless otherwise specified, the vendor of the product shall furnish with each shipment three copies of a report of the results of tests for chemical composition, grain size, inclusion rating, and AMS 2300 frequency-severity rating of each heat in the shipment and for tensile and impact properties of each size from each heat after maraging heat treatment. A heat shall be the consumable electrode remelted ingots produced from steel originally melted in a single furnace charge. This report shall include the purchase order number, heat number, material specification number, size, and quantity from each heat. If forgings are supplied, the part number and size of stock used to make the forgings shall also be included.

10.2 Unless otherwise specified, the vendor of finished or semi-finished parts shall furnish with each shipment three copies of a report showing the purchase order number, material specification number, contractor or other direct supplier of material, part number, and quantity. When material for making parts is produced or purchased by the parts vendor, that vendor shall inspect each lot of material to determine conformance to the requirements of this specification, and shall include in the report a statement that the material conforms, or shall include copies of laboratory reports showing the results of tests to determine conformance.