

AEROSPACE
MATERIAL
SPECIFICATION

AMS 5629C
Superseding AMS 5629B

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STEEL BARS, FORGINGS, RINGS, AND EXTRUSIONS, CORROSION RESISTANT
13Cr - 8.0Ni - 2.2Mo - 1.1Al

Vacuum Induction Plus Vacuum Consumable Electrode Melted
Solution Heat Treated, Precipitation Hardenable UNS S13800

1. SCOPE:

1.1 Form: This specification covers a corrosion-resistant steel in the form of bars, wire, forgings, flash welded rings, extrusions, and stock for forging, flash welded rings, or extrusion.

1.2 Application: Primarily for parts requiring corrosion resistance, stress-corrosion resistance, high strength up to 600°F (315°C), and good ductility and strength in the transverse direction in large section sizes. Certain design and processing procedures may cause these products to become susceptible to stress-corrosion cracking; ARP 1110 recommends practices to minimize such conditions.

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 Recommended Practices 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.

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2.1.1 Aerospace Materials 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 2315 - Determination of Free Ferrite Content
- AMS 2350 - Standards and Test Methods
- 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 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 7490 - Rings, Flash Welded, Corrosion and Heat Resistant Austenitic Steels and Austenitic-Type Alloys

2.1.2 Aerospace Recommended Practices:

- ARP 1110 - Minimizing Stress Corrosion Cracking in Heat Treatable Wrought Low Alloy and Martensitic Corrosion Resistant Steels

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

- ASTM A370 - Mechanical Testing of Steel Products
- ASTM A604 - Macroetch Testing of Consumable Electrode Remelted Steel Bars and Billets
- ASTM E112 - Determining Average Grain Size
- 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 Federal Standards:

- Federal Test Method Standard No. 151 - Metals; Test Methods

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, determined by wet chemical methods in accordance with ASTM E353, by spectrographic methods in accordance with Federal Test Method Standard No. 151, Method 112, or by other analytical methods approved by purchaser:

	min	max
Carbon	--	0.05
Manganese	--	0.10
Silicon	--	0.10
Phosphorus	--	0.010
Sulfur	--	0.008
Chromium	12.25 - 13.25	
Nickel	7.50 - 8.50	
Molybdenum	2.00 - 2.50	
Aluminum	0.90 - 1.35	
Nitrogen	--	0.010

3.1.1 Check Analysis: Composition variations shall meet the requirements of AMS 2248 except that no variation over max is permitted for nitrogen.

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

3.2.1 Bars and Wire:

3.2.1.1 Rounds: Centerless ground or turned after solution heat treatment.

3.2.1.2 Hexagons, Squares, and Flats: Cold finished, solution heat treated, straightened, and descaled or hot finished, solution heat treated, and descaled, as ordered.

3.2.2 Forgings and Flash Welded Rings: Solution heat treated and descaled.

3.2.2.1 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 7490.

3.2.3 Extrusions: Solution heat treated, straightened, and descaled.

3.2.4 Stock for Forging, Flash Welded Rings, or Extrusion: As ordered by the forging, flash welded ring, or extrusion manufacturer.

3.3 Heat Treatment: Bars, wire, forgings, flash welded rings, and extrusions shall be solution heat treated by heating to 1700°F + 25 (925°C + 15), holding at heat for not less than 30 min., and cooling as required to below 60°F (15°C).

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 All Products:

3.4.1.1 Macrostructure: Visual examination of transverse sections as in 4.3.3
 Ø from bars, billets, extrusions, and stock for forging, flash welded rings, or extrusions, etched in accordance with ASTM A604 in hot hydrochloric acid (1:1) at 160° - 180°F (70° - 80°C) for sufficient time to develop a well-defined macrostructure shall show no pipe or cracks. Porosity, segregation, inclusions, and other imperfections for product 81 sq in. (525 cm²) and under in nominal cross-sectional area shall be no worse than the following macrographs of ASTM A604; macrostructure standards for product over 81 sq in. (525 cm²) in nominal cross-sectional area shall be as agreed upon by purchaser and vendor:

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

3.4.1.2 Microstructure: The product shall contain not more than 2% free
 Ø ferrite, determined in accordance with AMS 2315.

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

3.4.2.1 As Solution Treated:

3.4.2.1.1 Tensile Strength: Wire shall have tensile strength not higher than 175,000 psi (1205 Mpa) or equivalent hardness.

3.4.2.1.2 Hardness:

3.4.2.1.2.1 Bars: Not higher than 363 HB or equivalent, determined at midradius or quarter thickness.

3.4.2.1.2.2 Forgings, Flash Welded Rings, and Extrusions: Not higher than 363 HB or equivalent.

3.4.2.1.3 Grain Size: Shall be 5 or finer for product up to 3.00 in. (75 mm) in
 Ø nominal cross-sectional thickness with occasional grains as large as 3, and shall be 4 or finer for product 3.00 in. (75 mm) and over in nominal cross-sectional thickness with occasional grains as large as 3; determined by comparison of a polished and etched specimen with the chart in ASTM E112.

3.4.2.2 After Precipitation Heat Treatment: The solution heat treated product 12 in. (300 mm) and under in nominal diameter or maximum cross-section dimension, when precipitation heat treated for 4 hr \pm 0.25 to a particular condition at the temperatures shown in Table I and cooled in air shall have the properties specified in 3.4.2.2.1 and 3.4.2.2.2 for that particular condition. Tensile and hardness tests shall be made in only one precipitation heat treated condition; that precipitation heat treated condition shall be H1000, unless otherwise specified by purchaser.

TABLE I

Condition	Temperature
H950	950°F \pm 10 (510°C \pm 5)
H1000	1000°F \pm 10 (540°C \pm 5)
H1025	1025°F \pm 10 (550°C \pm 5)
H1050	1050°F \pm 10 (565°C \pm 5)
H1100	1100°F \pm 10 (595°C \pm 5)
H1150	1150°F \pm 10 (620°C \pm 5)

3.4.2.2.1 Tensile Properties:

TABLE II

Condition	Specimen Orientation	Tensile Strength psi, min	Yield Strength at 0.2% Offset psi, min	Elongation in 4D %, min	Reduction of Area %, min
H950	Longitudinal	220,000	205,000	10	45
	Transverse	220,000	205,000	10	35
H1000	Longitudinal	205,000	190,000	10	50
	Transverse	205,000	190,000	10	40
H1025	Longitudinal	185,000	175,000	11	50
	Transverse	185,000	175,000	11	45
H1050	Longitudinal	175,000	165,000	12	50
	Transverse	175,000	165,000	12	45
H1100	Longitudinal	150,000	135,000	14	50
	Transverse	150,000	135,000	14	50
H1150	Longitudinal	135,000	90,000	14	50
	Transverse	135,000	90,000	14	50

TABLE II (SI)

Condition	Specimen Orientation	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa, min	Elongation in 4D %, min	Reduction of Area %, min
H950	Longitudinal	1515	1415	10	45
	Transverse	1515	1415	10	35
H1000	Longitudinal	1415	1310	10	50
	Transverse	1415	1310	10	40
H1025	Longitudinal	1275	1205	11	50
	Transverse	1275	1205	11	45
H1050	Longitudinal	1205	1140	12	50
	Transverse	1205	1140	12	45
H1100	Longitudinal	1035	930	14	50
	Transverse	1035	930	14	50
H1150	Longitudinal	930	620	14	50
	Transverse	930	620	14	50

- 3.4.2.2.1.1 Longitudinal tensile property requirements apply to specimens taken in the longitudinal direction from bars, wire, and extrusions, to specimens taken from forgings with axis of specimen in the area of gage length varying not more than 15 deg from parallel to the forging flow lines, and to specimens taken in the circumferential direction from flash welded rings.
- 3.4.2.2.1.2 Transverse tensile property requirements apply to specimens taken approximately perpendicular to the longitudinal direction of bars and extrusions, to specimens taken from forgings with axis of specimen in the area of gage length varying not more than 15 deg from perpendicular to the forging flow lines, and to specimens taken in either the radial or axial direction from flash welded rings.
- 3.4.2.2.1.3 Transverse tensile property requirements apply only to products from which a test specimen not less than 2-1/2 in. (62.5 mm) long or 1/2 in. (12.5 mm) x 1/2 in. (12.5 mm) cross-section can be taken.
- 3.4.2.2.1.4 Products tested in the transverse direction need not be tested in the longitudinal direction.
- 3.4.2.2.1.5 Tensile property requirements for product over 12 in. (300 mm) in nominal diameter or maximum cross-section dimension shall be as agreed upon by purchaser and vendor.

- 3.4.2.2.2 Hardness: Should be not lower than shown in Table III, or equivalent, for the corresponding precipitation heat treated condition but the product shall not be rejected on the basis of hardness if the applicable tensile property requirements are met.

TABLE III

Condition	Hardness, HRC
H950	45
H1000	43
H1025	41
H1050	40
H1100	34
H1150	30

- 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 3.4.2.2.1 and 3.4.2.2.2. 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, the tests shall be accepted as equivalent to tests of a forged coupon.
- 3.4.4 Stock for Flash Welded Rings or Extrusion: 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 and 3.4.2.2.2.
- 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 followed by vacuum consumable electrode remelting, unless otherwise permitted by purchaser.
- 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.
- 3.6 Sizes: Except when exact lengths or multiples of exact lengths are ordered, straight bars and wire 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: Unless otherwise specified, tolerances for bars and wire shall conform to all applicable requirements of AMS 2241 or MAM 2241. Tolerances for extrusions shall be as specified on the extrusion drawing.

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 (3.4.1.1), and grain size (3.4.2.1.3) of each heat.

4.2.1.2 Hardness (3.4.2.1.2) of each lot of bars, forgings, flash welded rings, and extrusions as solution heat-treated.

4.2.1.3 Tensile properties (3.4.2.1.1) of each lot of wire as solution heat-treated.

4.2.1.4 Tensile properties (3.4.2.2.1) and hardness (3.4.2.2.2) of each lot of bars, wire, forgings, flash welded rings, and extrusions after precipitation heat treatment.

4.2.1.5 Tolerances (3.7) of bars, wire, and extrusions.

4.2.2 Periodic Tests: Tests of forging stock (3.4.3) and of stock for flash welded rings or extrusion (3.4.4) to demonstrate ability to develop required properties, microstructure (3.4.1.2) of the product, and frequency/severity cleanliness rating (3.5.1) are classified as periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.2.3 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 on the first-article shipment of a forging to a purchaser, when a change in material or processing, or both, 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, the contracting officer, or the request for procurement.