Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AEROSPACE MATERIAL SPECIFICATION

AMS 5633B
Superseding AMS 5633A
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ALLOY BARS AND FORGINGS, CORROSION AND HEAT RESISTANT
38Fe - 13.2Cr - 38Ni - 5.5Mo - 0.85Cb - 2.5Ti - 1.6Al - 0.009B
Solution Heat Treated

1. SCOPE:

1.1 Form: This specification covers a corrosion and heat resistant, iron-nickel alloy in the form of bars, wire, forgings, and forging stock.

1.2 Application: Primarily for parts, such as turbine discs, shafts, spacers, dowels, and fittings requiring high strength up to 1400° F (760° C) and oxidation resistance up to 1600° F (871° C).

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

2.1 SAE Publications: Available from Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, Pennsylvania 15096.

2.1.1 Aerospace Material Specifications:

AMS 2241 - Tolerances, Corrosion and Heat Resistant Steel Bars and Wire and Titanium and Titanium Alloy Bars and Wire
AMS 2248 - Chemical Check Analysis Limits, Wrought Heat and Corrosion Resistant Steels and Alloys
AMS 2350 - Standards and Test Methods
AMS 2371 - Quality Assurance Sampling of Corrosion and Heat Resistant Alloys, Wrought Products Except Forgings
AMS 2375 - Approval and Control of Critical Forgings
AMS 2808 - Identification, Forgings

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

ASTM E8 - Tension Testing of Metallic Materials
ASTM E10 - Brinell Hardness of Metallic Materials
ASTM E21 - Short-Time Elevated Temperature Tension Tests of Materials
ASTM E112 - Estimating the Average Grain Size of Metals
ASTM E139 - Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials
ASTM E292 - Conducting Time-for-Rupture Notch Tension Tests of Materials
ASTM E354 - Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt-Base Alloys

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

2.3.1 Federal Standards:

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

Printed in U.S.A.

3. TECHNICAL REQUIREMENTS:

3.1 Composition: Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E354, by spectrographic methods in accordance with Federal Test Method Standard No. 151, Method 112, or by other approved analytical methods:

	min	max
Carbon	0.02	0.08
Manganese	--	0.25
Silicon	--	0.25
Phosphorus	--	0.015
Sulfur	--	0.015
Chromium	12.50	14.00
Nickel	36.50	39.50
Molybdenum	5.00	6.00
Columbium	0.60	1.10
Titanium	2.30	2.70
Aluminum	1.45	1.75
Boron	0.003	0.015
Iron	remainder	

3.1.1 Check Analysis: Composition variations shall meet the requirements of AMS 2248.

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

Ø 3.2.1 Bars, Wire, and Forgings: Solution heat treated.

3.2.1.1 Bars and wire 2.750 in. (69.85 mm) and under in diameter or distance between parallel sides shall be cold finished. Larger size bars shall be hot finished and descaled.

3.2.1.2 Forgings: Shall be descaled.

3.2.2 Forging Stock: As ordered by the forging manufacturer.

3.3 Heat Treatment: Bars, wire, and forgings shall be solution heat treated by heating to 1875° F ± 25 (1023.9° C ± 14), holding at heat for 60 min. ± 5, and quenching in oil or water.

3.4 Properties:

3.4.1 Bars, Wire, and Forgings:

3.4.1.1 As Solution Heat Treated: The product shall conform to the following requirements:

3.4.1.1.1 Hardness: Not higher than 275 HB or equivalent, determined in accordance with ASTM E10.

3.4.1.1.2 Grain Size: Predominantly 4 or finer with no grains larger than 2, determined by comparison of a polished and etched specimen with the chart in ASTM E112 or, in case of disagreement, by the intercept (Heyn) method.

3.4.1.2 After Precipitation Heat Treatment: The product shall conform to the requirements of 3.4.1.2.1.1, 3.4.1.2.2, and 3.4.1.2.3 and shall be capable of meeting the requirements of 3.4.1.2.1.2 after heating to 1450° F ± 25 (787.8° C ± 14), holding at heat for 16 hr ± 1, cooling in air, reheating to 1200° F ± 25 (648.9° C ± 14), holding at heat for 16 hr ± 1, and cooling in air. Furnace cooling from 1450° F (787.8° C) to 1200° F (648.9° C) may be substituted for cooling in air and reheating.

3.4.1.2.1 Tensile Properties:

3.4.1.2.1.1 At Room Temperature: Shall be as follows, determined in accordance with ASTM E8:

Tensile Strength, min	183,000 psi (1262 MPa)
Yield Strength at 0.2% Offset, min	127,000 psi (876 MPa)
Elongation in 2 in. (50.8 mm) or 4D, min	11%
Reduction of Area, min	15%

3.4.1.2.1.2 At 1200° F (648.9° C): Shall be as follows, determined in accordance with ASTM E21 on test specimens heated to 1200° F ± 5 (648.9°C ± 2.8), held at heat for 30 min. ± 3 before testing, and tested at 1200° F ± 5 (648.9° C ± 2.8) at a strain rate of 0.003 - 0.007 in. per in. per min. (0.003 - 0.007 mm/mm/min.) to the yield strength and at a rate of 0.03 - 0.07 in. per in. per min. (0.03 - 0.07 mm/mm/min.) above the yield strength:

Tensile Strength, min	155,000 psi (1069 MPa)
Yield Strength at 0.2% Offset, min	127,000 psi (876 MPa)
Elongation in 2 in. (50.8 mm) or 4D, min	11%
Reduction of Area, min	15%

3.4.1.2.2 Hardness: Should be 320 - 403 HB or equivalent, determined in accordance with ASTM E10, but the product shall not be rejected on the basis of hardness if the tensile property requirements of 3.4.1.2.1.1 are met.

3.4.1.2.3 Stress-Rupture Test at 1400° F (760° C): Shall be as follows; testing of notched specimens and of combination smooth and notched specimens shall be performed in accordance with ASTM E292 and of smooth specimens in accordance with ASTM E139:

3.4.1.2.3.1 A combination smooth and notched test specimen machined to the dimensions shown in Fig. 1 and Table I, maintained at 1400° F ± 3 (760° C ± 1.7) while a load sufficient to produce an initial axial stress of 55,000 psi (379 MPa) is applied continuously, shall not rupture in less than 25 hours. The test shall be continued to rupture, without change of load, with rupture occurring in the smooth section.

3.4.1.2.3.2 As an alternate procedure, separate smooth and notched test specimens, machined from adjacent sections of the same piece, with gage sections conforming to the respective dimensions of Table I may be tested individually under the above conditions. The smooth specimen shall not rupture in less than 25 hours. The notched specimen shall not rupture in less time than the companion smooth specimen but need not be tested to rupture.

3.4.1.2.3.3 The tests of 3.4.1.2.3.1 and 3.4.1.2.3.2 may be conducted using a load higher than required to produce an initial axial stress of 55,000 psi (379 MPa) but load shall not be changed while test is in progress. Time to rupture and rupture location requirements shall be as specified in 3.4.1.2.3.1.

3.4.1.2.3.4 When permitted by purchaser, the tests of 3.4.1.2.3.1 and 3.4.1.2.3.2 may be conducted using incremental loading. In such case, the load required to produce an initial axial stress of 55,000 psi (379 MPa) shall be used to rupture or for 25 hr, whichever occurs first. After 25 hr and at intervals of 8 - 16 hr, preferably 8 - 10 hr, thereafter, the stress shall be increased in increments of 5000 psi (34.5 MPa). Time to rupture and rupture location requirements shall be as specified in 3.4.1.2.3.1.

3.4.2 Forging Stock: When a sample of stock is forged to a test coupon and heat treated as in 3.3 and 3.4.1.2, specimens taken from the heat treated coupon shall conform to the requirements of 3.4.1.2.1.1, 3.4.1.2.2, and 3.4.1.2.3 and be capable of meeting the requirements of 3.4.1.2.1.2. If specimens taken from stock after heat treatment as in 3.3 and 3.4.1.2 conform to the requirements of 3.4.1.2.1.1, 3.4.1.2.1.2, 3.4.1.2.2 and 3.4.1.2.3, the tests shall be accepted as equivalent to tests of a forged coupon.

3.5 Quality:

3.5.1 Material shall be produced by multiple melting using consumable electrode practice in the remelt cycle, unless otherwise permitted. If consumable electrode remelting is not performed in vacuum, electrodes which have been produced by vacuum induction melting shall be used.

3.5.2 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 or to performance of parts. Forgings shall have substantially uniform macrostructure and grain flow.

3.6 Sizes: Except when exact lengths or multiples of exact lengths are ordered, bars and straight wire will be acceptable in mill lengths of 6 - 20 ft (1.8 - 6.1 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.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of the product shall supply all samples 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 perform such confirmatory testing as he deems necessary to assure that the product conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: The following tests are classified as acceptance or routine control tests:

4.2.1.1 Tests of the product to determine conformance to composition (3.1) requirements.

4.2.1.2 Tests of bars, wire, and forgings in the solution heat treated condition to determine conformance to hardness (3.4.1.1.1) and grain size (3.4.1.1.2) requirements.

4.2.1.3 Tests of bars, wire, and forgings to determine conformance to room temperature tensile (3.4.1.2.1.1), hardness (3.4.1.2.2), and stress-rupture (3.4.1.2.3) requirements after precipitation heat treatment.

4.2.1.4 Tests of bars and wire to determine conformance to tolerance (3.7) requirements.

4.2.2 Qualification Tests: The following tests are classified as qualification or periodic control tests:

4.2.2.1 Tests of bars, wire, and forgings to demonstrate capability of meeting 1200° F (648.9° C) tensile (3.4.1.2.1.2) requirements.

4.2.2.2 Tests of forging stock to demonstrate capability of developing required properties (3.4.2).

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

4.3.1 Bars and Wire: AMS 2371.

4.3.2 Forgings and Forging Stock: As agreed upon by purchaser and vendor.

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

4.5 Reports:

4.5.1 The vendor of the product shall furnish with each shipment three copies of a report of the results of tests for chemical composition of each heat in the shipment and the results of tests on each size from each heat to determine conformance to the other acceptance test requirements of this specification. This report shall include the purchase order number, heat number, material specification number and its revision letter, size, and quantity from each heat. If 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 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 and its revision letter, 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.

4.6 Resampling and Retesting: If any specimen used in the above tests fails to meet the specified requirements, disposition of the product may be based on the results of testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the product represented and no additional testing shall be permitted. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY:

5.1 Identification: The product shall be identified as follows:

5.1.1 Bars and Wire:

5.1.1.1 Each straight bar and wire over 0.500 in. (12.70 mm) in diameter or least width of flat surface shall be marked in a row of characters recurring at intervals not greater than 3 ft (914 mm) with AMS 5633B, heat number, and manufacturer's identification. The characters shall be of such size
ø as to be clearly legible, shall be applied using a suitable marking fluid, and shall be capable of being removed in hot alkaline cleaning solution without rubbing. The markings shall have no deleterious effect on the material or its performance and shall be sufficiently stable to withstand normal handling.

5.1.1.2 Straight bars and wire 0.500 in. (12.70 mm) and under in diameter or least width of flat surface shall be securely bundled and identified by a durable tag marked with the purchase order number,
ø AMS 5633B, heat number, nominal size, and manufacturer's identification and attached to each bundle or shall be boxed and the box marked with the same information.

5.1.1.3 Coiled bars and wire shall be securely bundled and identified by a durable tag marked with the purchase order number, AMS 5633B, heat number, nominal size, and manufacturer's identification and attached to each coil or shall be boxed and the box marked with the same information.

5.1.2 Forgings: In accordance with AMS 2808.

5.1.3 Forging Stock: As agreed upon by purchaser and vendor.

5.2 Packaging: The product shall be prepared for shipment in accordance with commercial practice to assure carrier acceptance and safe transportation to the point of delivery. Packaging shall conform to carrier rules and regulations applicable to the mode of transportation.