

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

Steel, Alloy (Manganese-Silicon-Nickel), Bars and Forging Stock (Aircraft Quality)

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1. SCOPE:

1.1 Scope:

This specification covers manganese-silicon-nickel alloy steel bars and forging stock of aircraft quality and suitable for heat treatment to 220,000 psi minimum tensile strength.

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1.2 Classification:

Bars shall be furnished in one of the following physical and surface conditions as specified (see 6.3):

- (A) As forged
- (B) As rolled
- (C) Annealed
- (D) Normalized
- (E) Normalized and tempered
- (F) Hardened and tempered

Surface conditions:

- (1) Black, as forged or rolled
- (2) Pickled or blast cleaned
- (3) Rough turned
- (4) Cold finished
- (5) Turned, ground, and polished

2. APPLICABLE DOCUMENTS:

The following publications, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

2.1 ASTM Publications:

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

E23-47T Tentative Methods of Impact Testing of Metallic Materials

2.2 U.S. Government Publications:

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

P-S-661 Solvent; Dry-Cleaning

QQ-M-151 Metals; General Specification for Inspection of

MIL-I-6868 Inspection Process, Magnetic Particle

FED-STD-48 Tolerances for Steel and Iron Wrought Products

MIL-STD-129 Marking for Shipment and Storage

MIL-STD-163 Preparation of Steel Products for Domestic Shipment (Storage) and Overseas Shipment

3. REQUIREMENTS:

3.1 Material:

The steel shall be of aircraft quality, satisfactory for the fabrication of parts which may be subject to magnetic particle inspection by the methods described in Specification MIL-I-6868.

3.1.1 Manufacturing process: The steel shall be manufactured by the open-hearth or electric-furnace process, unless a single process is specified in the contract or purchase order.

3.1.1.1 Sufficient discard shall be taken from each ingot to insure freedom from piping and undue segregation.

3.2 Chemical composition:

The chemical composition shall be as specified in table I.

TABLE I - Chemical Composition 1/

Element	Analysis, percent	Check analysis tolerance 2/, percent
Carbon	0.23 - 0.28	±0.01
Manganese	1.20 - 1.50	±0.04
Phosphorus	3/0.040 (max)	+0.005
Sulfur	3/0.040 (max)	+0.005
Silicon	1.30 - 1.70	±0.05
Nickel	1.65 - 2.00	±0.05
Chromium	0.40 (max)	+0.03
Molybdenum	0.35 - 0.45	±0.03

1/ For sizes over 200 square inches in cross-sectional area, or 18 inches in width, or 10,000 pounds in weight per piece, the chemical composition shall be negotiated.

2/ Individual determinations may vary from the specified range to the extent shown in the check analysis column, except that elements in any heat shall not vary both above and below the specified range. For sizes over 100 square inches in cross-sectional area, the check analysis shall be negotiated.

3/ 0.025 (max) when basic electric-furnace steel is specified.

3.3 Hardenability:

End-quench-hardness values for the steel in all specified conditions shall be Rockwell C-47 minimum at 8/16 inch and C-45 minimum at 24/16 inch.

3.4 Grain size:

The austenitic grain size shall be predominately No. 5 or finer with grains as large as No. 3 permissible.

3.5 Macrostructure:

Visual examination of deep acid etched specimens shall show no evidence of pipes, internal cracks, excessive segregation, or other injurious defects.

3.6 Surface decarburization:

Unless otherwise specified, the depth of decarburization for bars furnished in surface conditions (2) and (4) shall be not greater than the limits specified in table II.

TABLE II - Decarburization

Nominal diameter or distance between opposite faces, inches	Maximum depth of decarburization, inches ^{1/}
Up to 0.375, incl	0.010
Over 0.375 to 0.500, incl	0.012
Over 0.500 to 0.625, incl	0.014
Over 0.625 to 1.000, incl	0.017
Over 1.00 to 1.50, incl	0.020
Over 1.50 to 2.00, incl	0.025
Over 2.00 to 2.50, incl	0.030
Over 2.50 to 3.00, incl	0.035
Over 3.00	0.040

^{1/} The value specified as the maximum depth of decarburization is the sum of the complete plus the partial decarburization.

3.6.1 Bars furnished in surface conditions (3) and (5) shall be free from decarburization.

3.6.2 When bars are intended for reforging purposes, the above decarburization limits shall not apply.

3.6.3 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 3.6 by more than 0.005 inch and the width is 0.065 inch, or less.

3.7 Surface and physical condition:

Unless otherwise specified, bars 1-1/2 inches or less in diameter or thickness shall be furnished in condition (C) (4), and bars over 1-1/2 inches in diameter or thickness shall be furnished in condition (C) (2).

3.8 Hardness limits for conditions (C) and (E) material:

3.8.1 The hardness for material in physical conditions (C) and (E) shall be not more than Brinell 241 (Rockwell C-23), or Brinell 255 (Rockwell C-25), respectively. These hardness limits apply when material is furnished in surface conditions (1), (2), and (3), and (5).

3.8.2 The hardness for material in physical conditions (C) and (E) shall be not more than Brinell 248 (Rockwell C-24), or Brinell 277 (Rockwell C-29), respectively, when furnished in surface condition (4).

3.9 Mechanical properties of condition (F) steel:

Unless otherwise specified, the mechanical properties of material supplied in condition (F) in sizes up to and including 2 inches in the least dimension, shall be as specified in table III.

TABLE III - Mechanical properties of condition (F) steel

Tensile strength (min)	Yield strength at 0.2 percent set or at 0.0082 inch per inch extension under load (min)	Elongation in 2 inches (min)	Reduction of area (min)	Charpy V-notch impact strength at 70 °F
psi	psi	percent	percent	ft lb
220,000	190,000	10	40	20

3.9.1 When bars in condition (F) are ordered with mechanical properties differing from those specified in table III, or when bars in condition (F) are ordered in sizes larger than 2 inches in the least dimensions, the mechanical properties shall be as is agreed upon between the contractor and the procuring activity.

3.10 Impact strength:

The Charpy impact strength, at approximately 70 °F (room temperature), of specimens prepared in accordance with 4.10 herein, shall be not less than 20 ft lb. The Rockwell C hardness of specimens shall be not less than Rockwell C-45.

3.11 Tolerances:

3.11.1 Diameter or thickness: The permissible variation from nominal dimensions shall be as specified in Standard FED-STD-48, except that when bars are intended for reforging purposes the requirements of Standard FED-STD-48 are waived.

3.11.2 Exact lengths: Bars of all sizes may be ordered to exact lengths or in lengths expressed as a multiple of a definite unit, with tolerances as specified in the contract or purchase order.

3.11.3 Mill lengths: When exact or multiple lengths are not ordered, bars will be acceptable in mill lengths of 6 to 20 feet, but not more than 10 percent of any order shall be furnished in lengths shorter than 10 feet.

3.12 Identification of product:

When specified by contract or purchase order, or for direct shipment to a Government activity, each bar 1/2 inch or more in diameter, or 3/8 inch or greater in width of flat, shall be legibly marked throughout its length with a row of continuously recurring symbols. The symbols shall be applied with a marking fluid which is not affected by water or the solvents conforming to Specification P-S-661. The gap between recurring legends shall not exceed 3 feet. The marking used shall not rub off or be smeared by contact incident to normal handling during shipment or storage. The following information shall be included:

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Physical condition

Surface condition

Manufacturer's name or trade-mark

3.12.1 Bars smaller than 1/2 in diameter or 3/8 inch in width of flat shall be marked as above or bundled and tagged at each end with an extra tag included in the bundle.

3.13 Workmanship:

Materials shall be sound, of uniform quality and condition, free from pipes, and shall not contain laps, cracks, twists, seams, or other defects detrimental to the fabrication or performance of parts.

3.13.1 Cold finishing: Cold finished bars shall be free from injurious scale and surface defects. Stress relieving may be accomplished after cold finishing.

4. QUALITY ASSURANCE PROVISIONS:

4.1 General:

All the tests required herein for the testing of steel bars are classified as Acceptance tests, for which necessary sampling techniques and methods of testing are specified in this section.

4.2 Examination of product:

Sufficient spot checks shall be made to assure compliance with the surface condition, identification, dimensional, and workmanship requirements.

4.3 Chemical analysis:

4.3.1 Sampling: One or more samples for check chemical analysis shall be selected to represent each heat of steel in accordance with the requirements of Specification QQ-M-151.

4.3.1.1 Location: Samples for check chemical analysis shall be taken parallel to the axis of the bar selected, at a point midway between the center and surface, except that material less than 1-1/4 inches thick shall be sampled through the entire cross section. The sample shall consist of not less than 2 ounces of material.

4.3.1.2 Waiver: Samples for check chemical analysis may be waived at the discretion of the Inspector, provided that all of the material under inspection can be identified as being made from a heat previously analyzed and found to be in conformance with the chemical composition specified herein.

4.3.1.3 Additional samples: Where the material is not identifiable as to heat and method of manufacture, or where the identity of any portion of the shipment is obscure in any respect, the Inspector shall select the necessary additional samples to determine conformance of all portions of the shipment to this specification.

4.3.2 Method: Specimens shall be prepared in accordance with Specification QQ-M-151 and shall be tested by wet chemical, spectrographic, or other analytical methods. In the event of dispute, analysis shall be by wet chemical methods.

4.4 Hardenability:

4.4.1 Sampling: Two or more samples for end-quench-hardenability test shall be selected from each heat of steel from which material is presented for acceptance. Cast, forged, or rolled samples are acceptable.

4.4.2 Preparation of specimens: Specimens for the end-quench-hardenability test shall conform to the requirements of Specification QQ-M-151. The steel shall be normalized prior to machining the test specimen by heating to 1,700° ±10 °F, holding at this temperature for 1 hour, and cooling in still air.

- 4.4.3 Method: End-quench-hardening tests shall be conducted in accordance with Specification QQ-M-151. Specimens shall be austenitized at $1,575^{\circ} \pm 10^{\circ}\text{F}$.
- 4.5 Grain size:
- 4.5.1 Sampling: One or more samples shall be selected to represent each heat of steel from which material is submitted for acceptance.
- 4.5.2 Method: Specimens shall be sectioned and polished to appropriate fineness by metallographic methods and suitably etched to reveal the grain structure. The austenitic grain size shall be determined in accordance with Method B, C, or D, of Specification QQ-M-151.
- 4.6 Macrostructure (deep acid etch):
- 4.6.1 Sampling: Two or more samples shall be selected to represent each heat of steel from which material is submitted for acceptance.
- 4.6.2 Preparation of specimens: Deep acid etch specimens shall be cut from the ends of the bars selected as samples and shall represent the entire cross section of the bar. The specimen shall measure 1/2 inch or more in the direction of the axis of the bar. One of the faces of the specimen representing the cross section of the bar shall be finished flat and smooth by a fine machine cut or by grinding. The finished face of the specimen shall be etched in an aqueous solution containing 50 percent hydrochloric acid by volume and maintained at a temperature of approximately 160 °F.
- 4.6.3 Method: Specimens shall be examined by a competent metallographer for the presence of defects.
- 4.7 Decarburization:
- 4.7.1 Sampling: If the Inspector has reason to suspect that the decarburization limits specified herein may have been exceeded, samples shall be selected for determination of the depth of decarburization.
- 4.7.2 Method:
- 4.7.2.1 Microscopic: The depth of the zone of decarburization below a surface of a bar shall be determined by examination of a metallographic specimen, or specimens, representing the entire cross section of bars having diameters or maximum widths not greater than 1/2 inch. With bars over 1/2 inch in diameter or maximum width, the section shall exhibit not less than 1 linear inch of the original surface. Specimens from rectangular bars or shapes shall contain at least one corner. Specimens shall be polished, etched with nital, and examined at 100 diameters magnification.

- 4.7.2.2 Hardness traverse: Unless otherwise specified, an alternate acceptable method for determining depth of decarburization shall be a hardness traverse of a cross-sectional surface of the samples selected for test. The specimen shall include a representative portion of the outer surface of the sample selected for test. The specimen shall be hardened by quenching in oil after austenitizing for 1/2 hour at the temperature specified in 4.4.3. The hardness traverse shall be accomplished on a surface representing the cross section of the sample, with individual hardness determinations at close enough intervals from the original outer surface of the bar to determine compliance with the applicable requirements of 3.6. Acceptable hardness tests include Rockwell Superficial 15N, Knoop, and Vickers. The depth of decarburization shall be considered the distance from the original surface of the sample to the point where hardness does not increase on further hardness traverse testing.
- 4.8 Hardness of bars in physical conditions (C) and (E):
- 4.8.1 Sampling: At least five bars of each temper and size shall be tested to ascertain conformance with the permissible hardness values. When less than five bars are ordered, each bar shall be tested.
- 4.8.2 Method: Hardness testing shall conform to applicable requirements of Specification QQ-M-151.
- 4.9 Mechanical properties of steel in physical condition (F):
- 4.9.1 Sampling: For material furnished in condition (F), one or more tensile-test samples shall be selected from bars produced under the same processing conditions, from the same heat, of the same physical condition, of the same size, essentially uniform in all respects, and submitted for inspection at one time.
- 4.9.2 Specimens: Tensile-test specimens shall conform to type 1 or 4 of Specification QQ-M-151.
- 4.9.3 Method: Tensile tests shall be conducted in accordance with Specification QQ-M-151. Yield strength shall be determined by the offset or extension-under-load methods. Impact strength shall be determined in compliance with 4.10 herein.
- 4.10 Impact strength:
- 4.10.1 Sampling: At least two bars from each heat shall be tested to determine conformance with the specified minimum impact strength.
- 4.10.2 Waiver: Samples for Charpy impact tests may be waived at the discretion of the Inspector, provided that all of the material under inspection can be identified as being made from a heat previously tested for and found to be in compliance with the impact strength requirements specified herein.