

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

Steel: Chrome-Molybdenum (4140) Bars, Rods, and Forging Stock (For Aircraft Applications)

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1. SCOPE:

1.1 Scope:

This specification covers chrome-molybdenum (4140) steel bars, rods, and forging stock of aircraft quality.

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1.2 Classification:

1.2.1 Physical conditions: Bars and rods shall be furnished in one of the following physical conditions, as specified (see 6.2):

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

1.2.2 Surface conditions: Bars and rods shall be furnished in one of the following surface conditions, as specified (see 6.2):

- (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 SAE Publication:

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

AMS 2301 Aircraft Quality Steel Cleanliness - Magnetic Particle Inspection Procedure

2.2 U.S. Government Publications:

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

FED-STD-48	Tolerances for Steel and Iron Wrought Products
FED-STD-151	Metals, Test Methods
FED-STD-183	Continuous Identification Marking of Iron and Steel Products
MIL-STD-163	Steel Mill Products, Preparation for Shipment and Storage
MIL-STD-430	Macrograph Standards for Steel Bars, Billets, and Blooms

3. REQUIREMENTS:

3.1 Chemical composition:

The material shall conform to the chemical composition and shall be within the check analysis tolerances shown in table I.

3.2 Hardenability:

End-quench-hardening values for the steel in all specified conditions shall be Rockwell C-50 minimum at 6/16 inch and Rockwell C-44 minimum at 9/16 inch.

3.3 Grain size:

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

3.4 Quality:

The size and frequency of inclusions shall not exceed the size and frequency limits indicated by the paragraph entitled "Disposition" of AMS 2301 (see 4.11).

3.5 Macrostructure:

Inclusions disclosed by visual examination of deep acid etched bars in sizes to and including 36 square inches, shall not be more severe than S2, R1, and C2 of MIL-STD-430. Bars in sizes over 36 to 100 square inches, inclusive, shall not be more severe than S2, R2, and C3.

3.6 Decarburization:

Unless otherwise specified, the depth of decarburization for bars and rods furnished in surface conditions (1), (2), and (4) shall be not greater than the limits specified in table II.

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

TABLE I. Chemical composition

Element	Composition (percent) ^{1/}	Check analysis tolerance (percent) ^{2/}
Carbon	0.38 - 0.43	+0.02
Manganese	.75 - 1.00	+ .04
Phosphorus	.025 (max.)	+ .005
Sulfur	.025 (max.)	+ .005
Silicon	.20 - 0.35	+ .02
Chromium	.80 - 1.10	+ .05
Molybdenum	.15 - 0.25	+ .02
Copper	.35 (max.)	+ .03
Nickel	.25 (max.)	+ .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 individual determinations of any one element 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.

TABLE II. Depth of decarburization

Nominal diameter or distance between opposite faces (inches)	Maximum depth of decarburization ^{1/} (inches)
Up to 0.375 inclusive	0.010
Over 0.375 to 0.500, incl.	.012
Over 0.500 to 0.625, incl.	.014
Over 0.625 to 1.000, incl.	.017
Over 1.00 to 1.50, incl.	.020
Over 1.50 to 2.00, incl.	.025
Over 2.00 to 2.50, incl.	.030
Over 2.50 to 3.00, incl.	.035
Over 3.00 to 4.00, incl.	.045
Over 4.00	^{2/}

- ^{1/} The value specified as the maximum depth of decarburization is the sum of the complete plus the partial decarburization.
- ^{2/} Decarburization of bars over 4.0 inches shall be as negotiated or specified (see 6,2(f)).

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. Measurements shall be far enough away from any adjacent surface to be not influenced by decarburization or lack of decarburization thereon.

3.7 Surface and physical condition:

Unless otherwise specified (see 6.2), bars and rods 1-1/2 inches or less in diameter or thickness shall be furnished in condition (E) (4), and bars over 1-1/2 inches in diameter or thickness shall be furnished in condition (E) (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 229 (Rockwell C-21) when furnished in surface conditions (1), (2), (3), or (5).

3.8.2 The hardness for material in physical conditions (C) and (E) shall be not more than Brinell 241 (Rockwell C-23) when furnished, in surface condition (4).

3.9 Mechanical properties of condition (F) steel:

The mechanical properties of material supplied in condition (F) shall be as specified in the contract or order (see 6.2).

3.10 Identification of product:

Each piece shall be identified in accordance with FED-STD-183. The markings shall include the heat number of the metal and the designation of this specification.

3.11 Tolerances:

3.11.1 Diameter or thickness: The permissible variation in dimensions of the bars and rods shall be as shown on FED-STD-48, except that when bars are intended for reforming purposes the requirements of FED-STD-48 are waived.

3.11.2 Exact lengths: Bars and rods of all sizes may be ordered to exact lengths or in lengths expressed as a multiple of a definite unit, with length tolerances as specified in the contract or purchase order (see 6.2).

3.11.3 Mill lengths: When exact or multiple lengths are not ordered, bars and rods 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 Workmanship:

Material 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.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for inspection:

Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirement.

4.2 Quality conformance inspection:

All the examinations and tests of steel are classified as quality conformance inspection, for which necessary sampling techniques and methods of testing are specified in this section.

4.3 Examination:

- 4.3.1 Sampling for examination for dimensions, surface condition, packaging, and identification marking: Sampling for examination of product for conformance of 4.3.2 shall be selected in accordance with table III to represent materials of one heat, size, and configuration submitted for acceptance at one time.

TABLE III. Sampling for examination of product

Lot size (each class)	Sample size	Acceptance number (sample defects)
1 to 15	All	0
16 to 180	15	0
181 to 300	35	0
301 to 500	50	1
Over 500	75	2

- 4.3.2 Examination of product: Samples shall be examined to assure compliance with the surface condition, identification, dimensional, and workmanship requirements.

- 4.3.3 Preservation, packaging, packing, and marking: Preparation for delivery shall be examined for conformance to section 5.

4.4 Chemical analysis:

- 4.4.1 Sampling: One sample for check chemical analysis shall be selected in accordance with Method 111.1 or 112.1 of FED-STD-151 to represent each heat of steel.

4.4.2 Method: Specimens shall be prepared in accordance with FED-STD-151. Analysis shall be made by spectrochemical method or by Method 111 or 112 of FED-STD-151. In the event of dispute, analysis shall be made by wet chemical methods.

4.5 Hardenability:

4.5.1 Sampling: One sample shall be selected to represent each heat of steel.

4.5.2 Preparation of specimens: Specimens for the end-quench-hardenability test shall conform to FED-STD-151. The steel shall be normalized, prior to machining the test specimen, by heating to $1,600^{\circ} \pm 10^{\circ}\text{F}$, holding at this temperature for 1 hour and cooling in still air.

4.5.3 Method: End-quench-hardenability tests shall be conducted in accordance with Method 711 of FED-STD-151. Specimens shall be austenitized at $1,550^{\circ} \pm 10^{\circ}\text{F}$.

4.6 Austenitic grain size:

4.6.1 Sampling: One sample shall be selected to represent each heat of steel.

4.6.2 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 Procedure B, C, or D of Method 311 of FED-STD-151.

4.7 Macrostructure (deep acid etch):

4.7.1 Sampling: Two samples shall be taken, consisting of transverse sections through billets from locations at the tops of the first and last ingots poured from the heat represented.

4.7.2 Preparation of specimens: Specimens for deep acid etch shall be cut from the ends of the bars or rods selected as samples and shall represent the entire cross section of the bar or rod. The specimen shall measure 1/2 inch or more in the direction of the axis of the bar or rod. One of the faces of the specimen representing the cross section 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 .

4.7.3 Method: Specimens shall be examined by a metallographist for the presence of defects. Macrostructure shall be within limits specified in 3.5.

4.8 Decarburization:

4.8.1 Sampling: If there is reason to suspect that the decarburization limits specified herein may have been exceeded, a sample representing materials of the same heat, size, configuration, and thermal processing shall be selected for determination of the depth of decarburization. Failure to pass this test shall be cause for rejection of the materials represented.

4.8.2 Method: Depth of the zone decarburization below a surface shall be determined by examination of a metallographic specimen or specimens representing the entire cross section of bars 1 inch or less in diameter or width. With bars over 1 inch, the section shall exhibit not less than 1 linear inch of the original surface of the bar. This specimen shall be polished, etched with 5 percent nital and examined at 100 diameters magnification. Decarburization may be determined by microhardness measurements. Depth of decarburization is defined as the perpendicular distance from the nondecarburized depth under that surface below which there is no further increase in hardness.

4.9 Hardness of bars in physical conditions (C) and (E):

4.9.1 Sampling: Not less than five bars shall be selected to represent materials from one heat, physical condition, size, and configuration. When less than five bars are presented for acceptance, each bar shall be tested.

4.9.2 Method: Hardness testing shall conform to the methods and requirements in accordance with Method 243 of FED-STD-151.

4.10 Mechanical properties of steel in physical condition (F):

4.10.1 Sampling: Two samples shall be selected to represent materials of one heat, size, and configuration.

4.10.2 Specimens: Tensile test specimen shall conform to the round type specimens of Method 211 of FED-STD-151.

4.10.2.1 For bars or rods up to 1-1/2 inches in diameter or thickness, the axis of the test specimen shall coincide with the central axis of the bar or rod; 1-1/2 inch and over, the axis shall be located midway between the center and surface of the bar or rod. The axis of the tensile test specimen shall be parallel to the direction of rolling or drawing.

4.10.3 Method: Tensile tests shall be performed in accordance with Method 211 of FED-STD-151. Yield strength shall be determined by the offset or extension-under-load methods.

4.11 Magnetic inspection quality:

The specimens shall be selected, inspected, and rated in accordance with the procedures of AMS 2301.

4.12 Waiver of tests:

Sampling and tests for check chemical analysis, hardenability, and grain size may be waived at the discretion of the procuring activity, provided that all material presented for acceptance is identified as the product of a heat or heats previously analyzed or tested and found to be in compliance with the requirements as specified herein.

4.12.1 Sampling of material not identifiable: Units of product shall be randomly selected to represent each inspection lot in accordance with table IV for the tests referred to in 4.12.