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MILITARY SPECIFICATION

STEEL: CHROME-MOLYBDENUM (4140) BARS, RODS, AND FORGING STOCK (FOR AIRCRAFT APPLICATIONS)

This specification is mandatory for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

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

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

2.1 The following documents, 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:

STANDARDS

Federal

| | |
|-------------------|--|
| Fed. Std. No. 48 | Tolerances for Steel and Iron Wrought Products |
| Fed. Test Method | |
| Std. No. 151 | Metals; Test Methods |
| Fed. Std. No. 183 | Continuous Identification Marking of Iron and Steel Products |

/FSC 9510/

MIL-S-5626C

Military

| | |
|-------------|--|
| MIL-STI-1c3 | Steel Mill Products, Preparation for Shipment and Storage |
| MIL-STD-430 | Macrograph Standards for Steel Bars, Billets, and Blooms |

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications.- The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply:

Society of Automotive Engineers, Inc.

| | |
|---------|--|
| AMS2301 | Aircraft Quality Steel Cleanliness - Magnetic Particle Inspection Procedure |
|---------|--|

(Copies of Aerospace Material Specifications may be obtained from the Society of Automotive Engineers, Inc., Two Pennsylvania Plaza, New York, N. Y. 10001.)

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-hardenability 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 predominantly 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 AMS2301 (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-SM-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.

MIL-S-5626C

TABLE I. Chemical composition

| Element | Composition (percent) <u>1/</u> | Check analysis tolerance (percent) <u>2/</u> |
|------------|---------------------------------|--|
| 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 <u>1/</u> (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 | <u>2/</u> |

- 1/ The value specified as the maximum depth of decarburization is the sum of the surface 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.

MIL-S-5626C

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 (X) (4), and bars over 1-1/2 inches in diameter or thickness shall be furnished in condition (X) (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 Federal Standard No. 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 Federal Standard No. 48, except that when bars are intended for reforging purposes the requirements of Federal Standard No. 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 requirements.

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.

MIL-S-5626C

4.3 Examinations.-

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 Federal Test Method Standard No. 151 to represent each heat of steel.

4.4.2 Method.- Specimens shall be prepared in accordance with Federal Test Method Standard No. 151. Analysis shall be made by spectrochemical method or by Method 111 or 112 of Federal Test Method Standard No. 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 Federal Test Method Standard No. 151. The steel shall be normalized, prior to machining the test specimen, by heating to $1,600^{\circ} \pm 10^{\circ}$ 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 Federal Test Method Standard No. 151. Specimens shall be austenitized at $1,550^{\circ} \pm 10^{\circ}$ F.

4.6 Austenitic grain size.-

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

MIL-8-5626C

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 III of Federal Test Method Standard No. 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.

4.7.2 Preparation of specimens.- Specimens for deep acid etch shall be cut from the ends of the bars or rods selected as test pieces 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 by a method 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 methods. Depth of decarburization is defined as the perpendicular distance from the undecarburized 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 provided 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 Federal Test Method Standard No. 151.

MIL-S-5626C

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 specimens shall conform to the round type specimens of Method 211 of Federal Test Method Standard No. 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 Federal Test Method Standard No. 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 AMS2301.

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.

TABLE IV. Sampling of material, not identifiable

| Lot size | Sample size | Acceptance number (sample defects) |
|------------|-------------|---------------------------------------|
| 1 to 7 | All | 0 |
| 8 to 40 | 7 | 0 |
| 41 to 110 | 15 | 1 |
| 111 to 180 | 25 | 2 |
| 181 to 301 | 35 | 3 |
| Over 301 | 50 | 4 |

4.13 Rejection and retest.- Failure of a specimen to meet the test requirements shall be cause for rejection of the materials represented. At the discretion of the contractor, retest will be permitted. A retest sample of five specimens selected in accordance with table V shall be tested to replace each failed specimen of the original sample. If one of the retest specimens fails, the materials represented shall be rejected with no further retesting permitted.

MIL-S-5626C

TABLE V. Sampling for retest

| | |
|---|---|
| Chemical analysis Hard-ness Grain size Quality | One sample from each of five product items from the same heat of steel. |
| Decarburisation Visual inspection Hardness | One from each of five items of the respective size, configuration, and processing condition from the same heat. |

5. PREPARATION FOR DELIVERY**5.1 Preservation and packaging.-**

5.1.1 Level A.- Materials shall be prepared for shipment in accordance with the methods prescribed by MIL-STD-163. Materials in surface conditions (2) through (5) shall be coated with preservative as prescribed for condition (4).

5.1.2 Level C.- The material shall be preserved and packaged in accordance with commercial practice.

5.2 Packaging.-

5.2.1 Level A.- The material shall be packed in accordance with MIL-STD-163.

5.2.2 Level C.- The material shall be prepared for shipment in accordance with commercial practice to assure carrier acceptance and safe transportation at the lowest rate to the point of delivery and shall meet, as a minimum, the requirements of carrier rules and regulations applicable to the mode of transportation.

5.3 Marking of shipment.- Marking and labeling shall be in accordance with MIL-STD-163.

6. NOTES

6.1 Intended use.- The steel is intended for general use in the manufacture of various aircraft parts. It is used for fittings and for forgings. The material is frequently used in applications for which material conforming to MIL S 6049 is specified.

- (a) Title, number, and date of this specification.
- (b) Size and shape.
- (c) Surface and physical condition, if other than specified in 3.7.
- (d) Exact lengths and length tolerances, if mill lengths are not acceptable (see 3.11).
- (e) If bars are intended for rebar, specify.
- (f) When decarburization limits closer than those specified in table II are desired.
- (g) If mechanical properties of condition (F) steel different than those specified in 3.9 are desired.
- (h) Applicable levels of preservation, packaging, and packing (see 5.1 and 5.2).
- (i) When it is desirable to order materials in the quenched and tempered condition, the properties shall be as specified in the contract or order.

Project No. 9510-0107

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