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SUPERSEDING
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MILITARY SPECIFICATION

STEEL, CHROME-MOLYBDENUM-ALUMINUM; BARS, RODS, BILLETS AND FORGING STOCK (FOR NITRIDING) (AIRCRAFT QUALITY)

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

1. SCOPE

1.1 Scope. This specification covers steel of aircraft quality for use in the manufacture of nitrided parts (see 6.1).

1.2 Classification. The steel shall be furnished in the following conditions, as specified (see 6.2):

Physical condition:

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

Surface condition.

(1) Black, as forged or as rolled
(2) Pickled or blast cleaned
(3) Rough turned
(4) Cold finished and stress relieved
(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:

SPECIFICATIONS

MILITARY

MIL-I-6868—Inspection Process, Magnetic Particle

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

MILITARY

MIL-STD-163—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

AMS2640—Magnetic Particle Inspection

(Copies of Aerospace Material Specifications may be obtained from the Society of Automotive Engineers, Inc., 485 Lexington Avenue, New York, N.Y., 10017.)

3. REQUIREMENTS

3.1 Material. The steel shall be of aircraft quality. The material shall be magnetically inspected in accordance with the procedures of AMS2301, and shall not exceed the size and frequency rating limits indicated in the paragraph entitled "Disposition" of AMS2301 (see 4.10).

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

3.3 Hardness limits for conditions (C) and (E) material. The hardness for materials 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), and shall be not more than Brinell 248 (Rockwell C–24) when furnished in surface condition (4)

3.4 Hardenability. End-quench hardenability values for the steel in all conditions shall be not less than J50 at 8/16 inch and J45 at 12/16 inch

TABLE I *Chemical composition*

Element	Composition [1] (percent)	Check analysis tolerance [2] (percent)
Carbon	0 38 to 0 43	±0 02
Manganese	50 to 0 70	±0 03
Phosphorus	025 (max)	+0 005
Sulfur	025 (max)	+0 005
Silicon	20 to 0 40	±0 02
Chromium	1 40 to 1 80	±0 05
Aluminum	95 to 1 35	±0 10
Molybdenum	30 to 0 40	±0 02

[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 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 tolerances shall be negotiated

3.5 Macrostructure and Microstructure.

3.5.1 *Macrostructure.* Inclusions disclosed by visual examination of deep-acid-etched bars in sizes up to 36 square inches, inclusive, shall be not greater than indicated by plates A4, B2, and C4 of MIL–STD–430 Bars in sizes over 36 to 100 square inches, inclusive, shall be not greater than A5, B2, and C4. Plates D1 through D8 are unacceptable in any bar size.

3.5.2 *Microstructure.* The material shall reveal no excessive segregation of ferrite nor excessive banding when examined as specified in 4.7

3.6 Decarburization. Unless otherwise specified, the depth of decarburization for bars and rods furnished in surface conditions (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

3.6.2 When bars are intended for reforging purposes, the decarburization limits of table II 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 specified in table II by more than 0 005 inch and the width is 0 065 inch or less

TABLE II *Decarburization limits*

Nominal diameter or distance between opposite faces (inches)	Maximum permissible depth of decarburization (inches) [1]
0 5 and under	0 030
Over 0 5 to 1 0, incl	035
Over 1 0 to 1 5, incl	040
Over 1 5 to 2 0, incl	050
Over 2 0 to 2 5, incl	060
Over 2 5 to 3 0 incl	070

[1] The value specified as the maximum depth of decarburization is the sum of the complete plus the partial decarburization

3.7 Mechanical properties of condition (F) steel. The mechanical properties of material supplied in condition (F) shall be as specified in table III for rounds and squares 3 inches and under in diameter or cross section For sizes over 3 inches, the mechanical properties shall be as negotiated.

TABLE III *Mechanical properties of condition (F) steel*

Tensile strength, minimum (psi)	Yield strength at 0 2 percent offset or at extension indicated		Elongation in 2 inches, minimum (percent)	Reduction of area, minimum (percent)
	Minimum (psi)	Extension under load (inches in 2 inches)		
112, 000	90, 000	0 0101	16	50

3.8 Dimensions and tolerances.

3.8.1 *Width and thickness* Unless otherwise specified, the permissible variation in

dimensions of bars and rods shall be as specified in Fed. Std. No. 48 (see 6.2)

3.8.2 *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 tolerances as specified in paragraph 1d4 entitled "Stainless and Heat Resisting Steels" of Fed. Std. No. 48.

3.8.3 *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.

3.9 Identification marking. Each bar and rod shall be identified in accordance with Fed. Std. No. 183. The markings shall include the heat number of the metal and the designation of this specification.

3.9.1 *Billets and forgings.* Billets and forgings shall be individually marked with markings specified in 3.8, or shall have attached metal tags impression stamped with the information.

3.10 Workmanship. The bars, rods, billets, and forgings shall be straight, of uniform quality and condition, free from pipes, laps, cracks, twists, seams, damaged ends, or other harmful defects, and shall have a finish of the best quality. Surface imperfections such as handling marks, light seams, straightening marks, light die or roll marks, shallow pits and scale pattern, will not be considered as harmful defects, provided the imperfections are removable within the tolerances specified for the diameter or across flats. The removal of surface imperfections is not required.

3.10.1 *Cold finishing.* Cold finishing shall be accomplished subsequent to heat treating operations. The surfaces of cold finished bars shall be free from scale.

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, the supplier may utilize his own facilities or any commercial laboratory acceptable to 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 Classification of tests. All the examinations and tests of steel are classified as quality conformance tests.

4.2.1 *Inspection lot.* An inspection lot shall consist of mill forms of one heat, shape, condition, and size presented for acceptance at one time.

4.3 Examinations.

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

4.3.2 *Examination of 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 or more samples shall be selected and prepared in accordance with Method 111 or 112 of Fed. Test Method Std. No. 151 to represent each heat of steel. Samples shall be taken in a zone midway between the center and surface except that material less than 1¼ inch thick shall be sampled through the entire cross section.

4.4.2 Samples for check chemical analysis may be waived at the discretion of the procuring activity, provided that all material under inspection can be identified as being made from a heat previously analyzed and found to conform to the chemical composition specified herein.

4.4.3 *Analysis.* Chemical analysis shall be by the wet chemical or spectrochemical analysis in accordance with Method 111 or 112 of Fed. Test Method Std. No. 151, or other analytical methods. In the event of dispute, analysis shall be by wet chemical methods.

4.5 Hardness.

4.5.1 *Sampling.* Five samples, or 5 percent of the lot, whichever is greater, shall be selected at random from each lot of material. When a lot consists of less than five, each bar or rod shall be tested.

4.5.2 *Method of test.* Hardness testing shall conform to Method 242 or 243 of Fed. Test Method Std. No. 151 to insure compliance with 3.3.

4.6 Hardenability.

4.6.1 *Sampling* One or more samples shall be selected from each heat of steel from which material is presented for acceptance. Cast, forged, or rolled samples are acceptable

4.6.2 *Preparation of specimens* Specimens for the end-quench hardenability test shall conform to Method 711 of Fed Test Method Std No. 151 Specimens shall be normalized from 1,800° ± 10° F prior to machining the test specimen.

4.6.3 *Method of test.* End-quench-hardenability tests shall be conducted in accordance with Method 711 of Fed Test Method Std No 151 to insure compliance with 3 4 Specimens shall be austenitized at 1,700° ± 10° F.

4.7 Macrostructure and microstructure.

4.7.1 *Sampling* Two or more samples shall be selected at random from each lot of material (see 4 2 1)

4.7.2 *Preparation of specimens*

4.7.2.1 *Macrostructure specimens.* Samples shall be machined or ground, or both, as required, in such manner that the specimen test surface shall represent an entire cross section of the bar, rod, billet, or forging The specimen shall be ground to appropriate fineness, etched with an aqueous solution containing 50 percent hydrochloric acid by volume and maintained at a temperature of approximately 71° C (160° F) to reveal the grain structure and the presence of defects

4.7.2.2 *Microstructure specimens.* Samples shall be austenitized at 1,700° F, oil quenched, and tempered at 1,100° F, and prepared for examination as specified in 4 7 2.1

4.7.3 *Method of test.*

4.7.3.1 *Macrostructure* Specimens shall be prepared and examined by a competent metallographist in accordance with Method 321 of Fed. Test Method Std. No 151 for compliance with 3.5 1 and 3 10

4.7.3.2 *Microstructure* Specimens shall be prepared and examined by a competent metallographist to determine compliance with 3 5 2

4.8 Decarburization.

4.8.1 *Sampling.* One or more samples from each lot (see 4 2 1) shall be selected for determination of the depth of decarburization

4.8.2 *Method of test.* Depth of the zone of decarburization below a surface shall be determined by examination of a metallographic specimen or specimens representing the entire cross section of the bars or rods 1 inch or less in diameter or width. With bars or rods over 1 inch, the section shall exhibit not less than 1 linear inch of the original surface. This specimen shall be polished, etched with 5 percent nital, and examined at 100 diameters magnification to insure conformance with 3 6 or 3 6 1

4.8.2.1 *Condition (F) steel.* The depth of decarburization of condition (F) steel may be measured to insure conformance with 3 6 or 3 6 1 by the microscopic method specified in 4 8 2 or by a Rockwell superficial 30-N scale hardness traverse across a prepared section through the specimen, in which case, the depth of decarburization is defined as the distance measured from the nearest original surface to the point at which no increase in hardness is found

4.9 Mechanical properties of condition (F) steel.

4.9.1 *Sampling* For material furnished in condition (F), two tensile test samples shall be selected from each lot (see 4 2 1) If one of the two test samples fails the lot shall be rejected

4.9.2 *Specimens* Tensile test specimens shall conform to the round type specimens described in Method 211 of Fed Test Method Std. No 151.

4.9.2.1 For bars or rods up to 1½ inches in diameter or thickness, the axis of the test specimen shall coincide with the central axis of the bar or rod, 1½ inches 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.

4.9.3 *Method of test* Tensile tests shall be performed in accordance with Method 211 of Fed Test Method Std. No 151. Yield strength shall be determined by the offset or extension-under-load methods.

4.10 Magnetic inspection quality. The specimens shall be selected, inspected, and rated in accordance with the procedures of AMS2301 Inspection shall be in accordance with MIL-I-6868 or AMS2640.

4.11 Rejection and retest. Where failure of a specimen is definitely ascribed to faulty steel, or the steel fails to meet the applicable test

requirements, the entire lot shall be rejected At the discretion of the contractor, retest will be permitted A retest sample of five specimens shall be tested to replace each failed specimen of the original sample If one of the retest specimens fail, the lot shall be rejected with no further retesting permitted

4.11.1 Where failure of any lot of material to meet the requirements of this specification is due to inadequate heat treatment, the material may be reheat-treated and resubmitted for test Only two such reheat-treatments will be permitted.

5. PREPARATION FOR DELIVERY

5.1 Preservation, packaging, and packing.

5.1.1 *Level A* Materials shall be properly separated by size and condition when prepared for delivery. Materials shall be preserved, packaged, and packed in accordance with MIL–STD–163

5.1.2 *Level C* Materials shall be prepared for delivery in accordance with the manufacturer's commercial practice

5.2 Marking of shipments. Marking and labeling shall be in accordance with MIL–STD–163

6. NOTES

6.1 Intended use. The steel is suitable for use in aircraft parts and other parts in which a high core strength is required The steel may be case hardened in ammonia gas to give a minimum case hardness of 900 Vickers

6.2 Ordering data. Procurement documents should specify·

(a) Title, number, and date of this specification
(b) Physical and surface conditions (see 1 2)
(c) Size and shape
(d) Permissible dimensional variations, when other than specified, exact lengths and length tolerances, if mill lengths are not acceptable (see 3 8)
(e) Level of packaging and packing required (see section 5)

6.2.1 When bars are intended for reforging purposes, it should be so stated

Custodians:
Army—MR
Navy—WP
Air Force—(11)

Reviewer activities·
Army—MU, SMUFA
Navy—WP
Air Force—(11), (69)

User activities:
Army—
Navy—WP
Air Force—(11)

Preparing activity:
Air Force—(11)

Project No 9510–0042

Review/user information is current as of the date of this document For future coordination of changes to this document, draft circulation should be based on the information in the current Federal Supply Classification Listing of DoD Standardization Documents.

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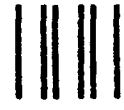

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(See Instructions – Reverse Side)

1. DOCUMENT NUMBER | 2. DOCUMENT TITLE

3a. NAME OF SUBMITTING ORGANIZATION

b. ADDRESS *(Street, City, State, ZIP Code)*

4 TYPE OF ORGANIZATION *(Mark one)*

- ☐ VENDOR
- ☐ USER
- ☐ MANUFACTURER
- ☐ OTHER *(Specify)*

5. PROBLEM AREAS

a. Paragraph Number and Wording.

b. Recommended Wording

c. Reason/Rationale for Recommendation

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional

b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional

c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional

8. DATE OF SUBMISSION *(YYMMDD)*

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