

MIL-S-5000E  
12 November 1982  
~~SUPERSEDING~~  
MIL-S-5000D  
8 March 1971

## MILITARY SPECIFICATION

### STEEL, CHROME-NICKEL-MOLYBDENUM (E4340) BARS AND REFORGING STOCK

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

#### 1. SCOPE

1.1 Scope. This specification covers electric furnace steel bars and reforging stock of aircraft quality.

1.2 Classification.

1.2.1 Physical condition. Bars 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) Hardened and tempered, 130,000 psi minimum yield strength

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Engineering Specifications and Standards Department (Code 93), Naval Air Engineering Center, Lakehurst, NJ 08733, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

## MIL-S-5000E

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

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

1.3 Sizes and shapes. Bars and re forging stock shall be furnished in the sizes and shapes specified (see 6.2).

## 2. APPLICABLE DOCUMENTS

### 2.1 Government documents.

2.1.1 Specifications and standards. Unless otherwise specified, the following specifications and standards of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation, form a part of this specification to the extent specified herein.

#### SPECIFICATIONS

##### MILITARY

MIL-I-6868	Inspection Process, Magnetic Particle
MIL-I-8950	Inspection, Ultrasonic, Wrought Metals, Process for

#### STANDARDS

##### FEDERAL

FED-TEST METHOD-STD 151	Metals; Test Methods
FED-STD-183	Continuous Identification Marking of Iron and Steel Products

#### STANDARDS

##### MILITARY

MIL-STD-163	Steel Mill Products Preparation for Shipment and Storage
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MIL-S-5000E

(Copies of specifications and standards required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. The issues of the documents which are indicated as DoD adopted shall be the issue listed in the current DoDISS and the supplement thereto, if applicable.

SOCIETY OF AUTOMOTIVE ENGINEERS, INC.

AMS 2301 Aircraft Quality Steel Cleanliness, Magnetic Particle Inspection Procedure

(Applications for copies should be addressed to: Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 29 General Requirements for Hot-rolled and Cold Finished Carbon and Alloy Steel Bars

ASTM A 255 End Quench Test for Hardenability of Steels, Method of

ASTM E 8 Tension Testing of Metallic Materials, Methods of

ASTM E 10 Brinell Hardness of Metallic Materials, Test Method for

ASTM E 18 Rockwell Hardness and Rockwell Superficial Hardness of of Metallic Materials, Test Methods for

ASTM E 112 Estimating Average Grain Size of Metals, Methods for

ASTM E 381 Macroetch Testing, Inspection, and Rating Steel Products, Comprising Bars, Billets, Blooms and Forgings

(Applications for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103).

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies).

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence.

## MIL-S-5000E

## 3. REQUIREMENTS

3.1 Material quality. The steel shall be produced by electric furnace practice and shall be of aircraft quality conforming to AMS 2301 except that a maximum average frequency (F) rating of 0.34 and a maximum average severity (S) rating of 0.25 shall apply for all sizes and products. In addition, AMS 2301 specimens which contain indications representing non-metallic inclusions over 1.00 inch in length shall be subject to rejection.

3.1.1 Ultrasonic inspection. When specified, bars or intermediate mill products and reforging stock shall be ultrasonically inspected in accordance with MIL-I-8950. The minimum quality level shall be as specified below (see 4.6):

<u>Dimensions (inches)</u>	<u>Ultrasonic Classification</u>
1-1/2 to 9 thickness	A
Larger than 9	B

3.2 Chemical composition. The chemical composition shall be as specified in Table I.

TABLE I. Chemical Composition.

<u>Element</u>	<u>Analysis (percent)</u>	<u>Check Analysis Tolerance (percent) 1/</u>
Carbon	0.38 - 0.43	+ 0.02
Manganese	0.65 - 0.85	± 0.03
Phosphorus	0.025 (max)	± 0.005, -0.00
Sulfur	0.025 (max)	+ 0.005, -0.00
Silicon	0.15 - 0.35	+ 0.02
Nickel	1.65 - 2.00	± 0.05
Chromium	0.70 - 0.90	± 0.03
Molybdenum	0.20 - 0.30	± 0.02
Copper	0.35 (max)	± 0.03, -0.00

1/ Individual determinations may vary from the specified range to the extent shown in the check analysis column, except that the 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.

3.3 Hardenability. End-quench hardenability values for the steel in all specified conditions shall be Rockwell C-50 minimum at 20/16 inch and Rockwell C-45 minimum at 32/16 inch.

3.4 Grain size. The austenite grain size shall be predominantly No. 5 or finer with grains as large as No. 3 permissible.

## MIL-S-5000E

3.5 Macrostructure. Visual examination of deep-acid-etched reforcing stock in sizes up to and including 36 square inches shall be equal to or better than S-2, R-1 and C-2; sizes over 36 to and including 100 square inches shall be equal to or better than S-2, R-2, and C-2 of ASTM E 381. Product forms other than reforcing stock shall be macroscopic examined at a section thickness not less than 3 inches and shall be equal to or better than S-2, R-1, and C-2 of ASTM E 381.

3.6 Decarburization. Unless otherwise specified, the depth of decarburization of products in surface condition (2) or (4) shall be not greater than the following limits (see 6.2):

Nominal Diameter or Distance Between Opposite Faces (Inches)	Maximum Depth of Decarburization (Inches) <sup>1/</sup>
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

<sup>1/</sup> The value specified as the maximum depth of decarburization is the sum of the complete plus the partial decarburization.

3.6.1 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 3.6 by more than 0.005 inch and the width is 0.064 inch or less.

3.6.2 Products furnished in surface conditions (3), (5), and (6) shall be free from decarburization.

3.6.3 When intended for reforcing purposes, the above decarburization limits shall not apply.

3.7 Surface and physical conditions. 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.

3.8.1 The hardness for material in physical conditions (C) and (E) shall be not more than Brinell 235 (Rockwell C 22) when furnished in surface conditions (1), (2), or (3).

## MIL-S-5000E

3.8.2 The hardness for material in physical conditions (C) and (E) shall be not more than Brinell 265 (Rockwell C-27) when furnished in surface condition (4).

3.9 Mechanical properties of condition (F) steel. Unless otherwise specified, the mechanical properties of products supplied in condition (F) in sizes up to and including 3 inches in the least dimension shall conform to the limits specified in Table II (see 6.2).

TABLE II. Mechanical properties of condition (F) steel.<sup>1/</sup>

Tensile Strength (min)	Yield Strength at 0.2 percent offset or extension indicated (min) Extension under load	Elongation in 2 inch. (min)	Reduction in area (min)
psi	psi      inches in 2 inches	percent	percent
150,000	130,000      0.0127	14	53

<sup>1/</sup> When products in condition (F) are ordered with mechanical properties differing from those specified in 3.9 or when products in condition (F) are offered in sizes larger than 3 inches in the least dimension, the mechanical properties shall be as agreed upon the supplier and the purchaser.

3.10 Identification of product. Each bar shall be identified in accordance with FED-STD-183. The markings shall include the heat number of the metal and number of this specification.

3.11 Tolerances. Tolerances shall conform to the limits of ASTM A 29.

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. Steel melting practice shall produce metal complying with all requirements of this specification.

3.12.1 Cold drawn bars. Cold drawn bars shall be free from scale. Drawing shall be accomplished after all heat-treating operations have been completed; however, stress relieving should be accomplished after drawing.

## MIL-S-5000E

## 4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the contractor 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 tests required for the testing of the product are classified as acceptance tests, for which necessary sampling techniques and methods of testing are specified in this section.

4.2.1 Inspection conditions. Unless otherwise specified, all inspections shall be performed in accordance with the test conditions specified in the applicable test method document or applicable paragraph(s) in the specification.

4.2.2 Inspection lot. An inspection lot shall include all mill forms of one heat, condition and size presented for acceptance at one time, and when heat treated, from the same process and the same batch.

4.3 Examination of product. Samples selected at random in accordance with Table III shall be examined for compliance with surface condition, identification, dimensional, marking, workmanship, and preparation for delivery requirements.

TABLE III. Sampling for examination of product.

Lot Size	Sample Size	Acceptance number
1 to 65	4	0
66 to 110	5	0
111 to 300	7	0
301 to 500	10	0
501 to 800	15	0
Over 800	25	0

4.4 Chemical analysis.

4.4.1 Sampling. Samples for check chemical analysis shall be selected to represent each heat of steel in accordance with requirements of method 111.2 of Federal Test Method Standard No. 151.

4.4.2 Specimens. Samples for check chemical analysis shall be taken parallel to the axis of the billet 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.

## MIL-S-5000E

4.4.3 Test method. Samples shall be prepared in accordance with Method 111.2 of Federal Test Method Standard No. 151, and shall be tested by wet chemical, spectrographic, or other analytical methods. In the event of dispute, analysis shall be wet chemical methods.

4.5 Steel cleanliness inspection. The material shall be magnetic particle inspected in accordance with MIL-I-6868 to comply with the steel cleanliness requirements of AMS 2301.

4.6 Ultrasonic inspection. Inspection shall be in accordance with MIL-I-8950. Surface roughness shall not exceed 125 roughness height rating (RHR) at 5 megahertz (mhz) and 250 RHR at 2.25 mhz and lower frequencies. The surface roughness of the reference standards shall not vary more than plus or minus 25 RHR from the surface roughness of material being tested.

4.7 Hardenability.

4.7.1 Sampling. One or more samples for end-quench hardenability test shall be selected from each heat of steel from which material is presented for acceptance.

4.7.2 Preparation of specimens. Specimens for the end-quench hardenability test shall conform to ASTM A 255. The steel shall be normalized prior to machining the test specimen by heating  $1,600^{\circ} \pm 10^{\circ}\text{F}$ , holding at this temperature for 1 hour and cooling in still air.

4.7.3 Test method. End-quench hardenability test shall be conducted in accordance with ASTM A 255. Specimens shall be austenitized at  $1,550^{\circ} \pm 10^{\circ}\text{F}$ . Tests shall establish compliance with 3.3.

4.8 Grain size.

4.8.1 Sampling. One or more samples shall be selected to represent each heat of steel from which material is submitted for acceptance.

4.8.2 Test method. Specimens shall be sectioned and polished to appropriate fineness by metallographic methods and suitably etched to reveal the grain structure. The austenite grain size shall be determined in accordance with ASTM E 112.

4.9 Macrostructure.

4.9.1 Sampling. Two or more sample slices at least 1/4 inch thick shall be selected to represent each heat of steel from which material is submitted for acceptance.

4.9.2 Procedure. The samples shall be prepared in accordance with ASTM E 381. The etched samples shall meet the requirements of 3.5.

4.10 Decarburization.

4.10.1 Sampling. If the purchaser 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.



## MIL-S-5000E

4.10.2 Test method. 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 bars 1 inch or less in diameter or width. With bars of 1 inch in diameter, 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 100X magnification.

4.11 Hardness of bars in physical conditions (C) and (E).

4.11.1 Sampling. At least five bars of each condition and size shall be tested to determine conformance with hardness values of 3.8. When less than five bars are ordered, each bar shall be tested.

4.11.2 Test method. Hardness testing shall conform to ASTM E 10 or ASTM E 18.

4.12 Mechanical properties of condition (F) steel.

4.12.1 Sampling. One or more samples shall be selected from the lot.

4.12.2 Specimens. Tensile test specimens shall conform to the round type specimens of ASTM E 8. For bars 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; for bars 1 1/2 inches and over, the axis shall be located midway between the center and the surface of the bar. The axis of specimens shall be parallel to the direction of rolling or drawing.

4.12.3 Test method. Tensile tests shall be conducted in accordance with ASTM E 8. Yield strength shall be determined by the offset or extension-under-load methods.

4.13 Certified test reports. Heats which have been tested and found to comply with the requirements of this specification shall be acceptable. Each shipment from these heats shall be accompanied by test reports, in duplicate, showing compliance with requirements for chemistry, hardenability, mechanical properties, grain size, ultrasonic properties, macrostructure and magnetic particle frequency/severity ratings.

4.14 Rejection and retest. Failure of a specimen to comply with specified requirements shall cause rejection of the materials represented. However, at the discretion of the contractor/supplier, retest will be permitted. A retest sample of five specimens, one from each of five bars, shall be tested to replace each failed specimen from the original sample. If one retest specimen fails, the materials represented shall be rejected. Rejected material may be reprocessed and resubmitted.

4.15 Packaging. Packaging shall be examined for conformance to section 5.

## MIL-S-5000E

## 5. PACKAGING

5.1 Packaging.

5.1.1 Level A. The materials shall be properly separated by condition and size when prepared for delivery. The bars shall be preserved and packaged in accordance with MIL-STD-163.

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

5.2 Packing.

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

5.2.2 Level C. The materials 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 shipments. Marking and labeling shall be in accordance with MIL-STD-163.

## 6. NOTES

6.1 Intended use. Steel covered by this specification is intended for use in the manufacture of highly stressed aircraft parts requiring high hardenability.

6.2 Ordering data. Procurement documents should specify the following:

- a. Title, number, and date of this specification.
- b. Physical and surface conditions. (See 1.2.1, 1.2.2, and 3.9.1).
- c. Size and shape.
- d. When bars are intended for reforging purposes, it should be so stated.
- e. If decarburization limits closer than those specified in 3.6 are described.
- f. Exact lengths and length tolerances, if mill lengths are not acceptable.
- g. Levels of packaging and packing required (see section 5).
- h. Whether ultrasonic inspection is required (see 3.1.1).

MIL-S-5000E

6.3 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Custodians:  
Army - MR  
Navy - AS  
Air Force - 20

Preparing activity:  
Navy - AS  
(Project No. 9510-0370)

Review activities:  
Army - EA, ER, MI  
Air Force - 99  
DLA - IS

User activities:  
Army - AT

☆U.S. GOVERNMENT PRINTING OFFICE: 1982-605-034/5469



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