

MIL-S-6098A  
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MILITARY SPECIFICATION

STEEL, CHROME-NICKEL-MOLYBDENUM (8735)  
BARS AND REFORGING STOCK (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 bars and reforcing stock  
of aircraft quality.

1.2 Classification.—

1.2.1 Physical condition.— Material shall be in one of the following physical  
conditions, as specified (see 6.2):

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

1.2.2 Surface condition.— Material shall be in one of the following physical  
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

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## 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:

SPECIFICATIONMilitary

MIL-I-6868	Inspection Process, Magnetic Particle
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STANDARDSFederal

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.

AMS 2251	Tolerances, Alloy Steel Bars
AMS 2301	Aircraft Quality Steel Cleanliness-- Magnetic Particle Inspection Procedure
AMS 2640	Magnetic Particle Inspection

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

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## 3. REQUIREMENTS

3.1 Material.— The steel shall be of aircraft quality. The material shall be magnetically inspected in accordance with the procedures of AMS 2301, and shall not exceed the size and frequency rating limits indicated in the paragraph entitled "Disposition" of AMS 2301 (see 4.4).

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

Table I. Chemical composition

Element	Analysis (percent)	Check analysis tolerance <sup>1/</sup> (percent)
Carbon	0.33 - 0.38	± 0.02
Manganese	0.75 - 1.00	± 0.04
Phosphorus	0.025 (max)	+ 0.005
Sulfur	0.025 (max)	+ 0.005
Silicon	0.20 - 0.35	± 0.02
Nickel	0.40 - 0.70	± 0.03
Chromium	0.40 - 0.60	± 0.03
Molybdenum	0.20 - 0.30	± 0.03
Copper	0.35 (max)	+ 0.02

<sup>1/</sup> 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.

3.3 Hardenability.— End-quench hardenability values for the steel in all specified conditions shall be Rockwell C-45 minimum at 5/16 inch and Rockwell C-35 minimum at 8/16 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 reforging bars in sizes up to 36 square inches, inclusive, shall be equal to or better than S-2, R-1 and C-2 of MIL-STD-430. Bars in sizes over 36 to 100 square inches, inclusive, should be equal to or better than S-2, R-2 and C-3 of MIL-STD-430.

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3.6 Decarburization.— Unless otherwise specified (see 6.2.2), the depth of decarburization of products in surface conditions (2) and (4) shall be not greater than the following limits:

<u>Nominal diameter or distance between opposite faces (inches)</u>	<u>Maximum depth of decarburization (inches) 1/</u>
Up to 0.375 incl.	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

1/ 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 0.065 inch or less.

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

3.6.3 When material is intended for reforging purposes, the decarburization limits specified herein are waived.

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 condition (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), or (3).

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).

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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 1-1/2 inches in the least dimension shall be as specified in table II.

Table II. Mechanical properties of condition (F) steel

Tensile strength (min psi)	Yield strength at 0.2 percent offset or extension indicated		Elongation in 2 inches or 4 times diameter (min %)	Reduction of area (min %)
	(min psi)	Extension under load inches in 2 inches		
125,000	100,000	0.0107	17	55

3.9.1 When products in condition (F) are ordered with mechanical properties differing from those specified in table II or when products in condition (F) are ordered in sizes larger than 1-1/2 inches in the least dimension, the mechanical properties shall be as agreed upon between the supplier and the purchaser.

3.10 Identification of product.— Each bar shall be identified in accordance with Fed Std. No. 183. The markings shall include the heat number of the metal and the number of this specification.

3.11 Tolerances.— Tolerances shall conform to the limits of AMS 2251 applicable to hot rolled or cold rolled, respectively, alloy steel bars.

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.

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

#### 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.

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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.

4.2.1 Inspection lot.— An inspection lot shall consist of 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 in accordance with table III shall be examined for compliance with surface condition, identification, dimensional, and preparation for delivery requirements.

Table III. Sampling for examination of product

Lot size	Sample size	Acceptance number
1 to 15	All	0
16 to 180	15	0
181 to 300	35	0
301 to 500	50	1
Over 500	75	2

4.4 Magnetic inspection quality.— Specimens shall be selected and rated in accordance with the procedures of AMS 2301. Inspection shall be in accordance with MIL-I-6868 or AMS 2640.

4.5 Chemical analysis.—

4.5.1 Sampling.— At least one sample shall be selected to represent each heat of steel in accordance with Fed. Test Method Std. No. 151. The sample shall consist of not less than 2 ounces.

4.5.1.1 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.

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

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.

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4.6.2 Preparation of specimens.— Specimens for the end-quench-hardening test shall conform to method 711, Fed. Test Method Std. No. 151. The steel shall be normalized prior to machining the test specimen by heating to  $1600^{\circ} \pm 25^{\circ}$  F, holding at this temperature for 1 hour and cooling in still air.

4.6.3 Test method.— End-quench-hardening tests shall be conducted in accordance with method 711 of Fed. Test Method Std. No. 151 to ensure compliance with 3.3. Specimens shall be austenitized at  $1550^{\circ} \pm 25^{\circ}$  F.

#### 4.7 Grain size.—

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

4.7.2 Test 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, method 311 of Fed. Test Method Std. No. 151.

#### 4.8 Macrostructure.—

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

4.8.2 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 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  $71^{\circ}$  C ( $160^{\circ}$  F).

4.8.3 Test method.— Specimens shall be examined by a metallographist to determine compliance with 3.5 and 3.12.

#### 4.9 Decarburization.—

4.9.1 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.

4.9.2 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 over 1 inch in diameter, the section shall exhibit not less than 1 linear inch of the original surface of the bar.

4.9.2.1 Measurement of case depth.— Decarburization depth may be measured by making a microhardness transversal at intervals of 0.001 inch on a line

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perpendicular to the surface in question and noting the depth at which successive hardness readings do not vary from a mean by more than the equivalent of one Rockwell "C" hardness unit.

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

4.10.1 Sampling.- At least 5 bars of each temper and size shall be tested to ascertain conformance to the permissible hardness values. When a lot consists of less than 5 bars, each bar shall be tested.

4.10.2 Test method.- Hardness testing shall conform to method 242 or 243 of Fed. Test Method Std. No. 151 to ensure compliance with 3.8.

4.11 Mechanical properties of condition (F) steel.-

4.11.1 One or more samples shall be selected from the lot.

4.11.2 Specimens.- Tensile test specimens shall conform to the round type specimens of method 211 of Fed. Test Method Std. No. 151. 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; 1-1/2 inches and over, the axis shall be located midway between the center and the surface of the bar. The axis of tensile test specimens shall be parallel to the direction of rolling or drawing.

4.11.3 Test method.- 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.

4.12 Certified heats.- Heats that have been tested and found to comply with the specified requirements shall be considered acceptable.

4.12.1 Test reports.- Each shipment from certified heats shall be accompanied by test reports, in duplicate, showing compliance with requirements for chemical and grain size, hardenability, macroetch, mechanical properties and cleanliness, as applicable, including F/S ratings.

4.13 Rejection and retest.- If any specimen fails to conform to the requirements of this specification, it shall be cause for rejection of the material represented by this specimen, subject to the retest provisions of Fed. Test Method Std. No. 151, except that five test specimens shall be selected for retest.

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.

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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 material covered by this specification is intended for general use in the manufacture of various aircraft parts.

6.2 Ordering data.- Procurement documents should specify:

- (a) Title, number, and date of this specification.
- (b) Size and shape.
- (c) Physical and surface conditions (see 1.2).
- (d) Exact lengths and length tolerances, if mill lengths are not acceptable.
- (e) Levels of packaging and packing desired (see section 5).

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

6.2.2 When decarburization limits closer than those specified in 3.6 are desired, these limits should be specified in the contract or purchase order.

Custodians:  
 Air Force - (11)  
 Navy - AS  
 Army - MR

Preparing activity  
 Air Force - (11)

Project No. 9510-0092

Review activities:  
 Air Force - (11), (69)  
 Navy - AS  
 Army - MR, MI

User activities:  
 Army - AV, MU  
 Navy - OS

## SPECIFICATION ANALYSIS SHEET

Form Approved Budget  
Bureau No. 119-ROO4INSTRUCTIONS

This sheet is to be filled out by personnel either Government or contractor, involved in the use of the specification in procurement of products for ultimate use by the Department of Defense. This sheet is provided for obtaining information on the use of this specification which will insure that suitable products can be procured with a minimum amount of delay and at the least cost. Comments and the return of this form will be appreciated. Fold on lines on reverse side, staple in corner, and send to preparing activity.

## SPECIFICATION

MLL-S-6098A Steel, Chrome-Nickel- Molyb. (8735), etc., AC Quality

## ORGANIZATION

CITY AND STATE

## CONTRACT NO.

QUANTITY OF ITEMS PROCURED

DOLLAR AMOUNT

\$

## MATERIAL PROCURED UNDER A

 Direct Government Contract Subcontract

1. HAS ANY PART OF THE SPECIFICATION CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?

A. GIVE PARAGRAPH NUMBER AND WORDING

B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES

2. COMMENTS ON ANY SPECIFICATION REQUIREMENT CONSIDERED TOO RIGID

3. IS THE SPECIFICATION RESTRICTIVE?

 YES NO

IF "YES" IN WHAT WAY?

4. REMARKS (Attach any pertinent data which may be of use in improving this specification. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity.)

SUBMITTED BY (Printed or typed name and activity)

DATE

DD Form 1426

FOLD

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