

# MIL-S-8699A

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Superseding  
MIL-S-8699(ASG)  
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## MILITARY SPECIFICATION

### STEEL BARS AND FORGING STOCK (4330) VANADIUM MODIFIED, AIRCRAFT QUALITY

This specification has been approved by the Department of Defense and is mandatory for use by the Departments of the Army, the Navy, and the Air Force.

#### 1. SCOPE

1.1 Scope.- This specification covers aircraft quality bars and forging stock of composition similar to that commercially designated as 4330 vanadium modified, and suitable for use for parts to be heat-treated to 220,000-psi tensile strength.

1.2 Classification.- Bars and forging stock shall be furnished in one of the following physical and surface conditions, as specified (see 6.2):

##### Physical conditions:

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

##### Surface conditions:

- (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 specifications and standards, of the issue in effect on date of invitation for bids, form a part of this specification to the extent specified herein:

##### SPECIFICATIONS

##### Military

MIL-I-6868

Inspection Process, Magnetic Particle

FSC 5510

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STANDARDSFederal

FED. STD. No. 48	Tolerances for Steel and Iron Wrought Products
FED. TEST METHOD STD. NO. 151	Metals; Test Methods

Military

MIL-STD-163	Preparation of Steel Products for Domestic Shipment (Storage) and Overseas Shipment
MIL-STD-183	Continuous Identification Marking of Iron and Steel Products

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

**3. REQUIREMENTS**

**3.1 Material**.- The steel shall be of aircraft quality, satisfactory for the fabrication of parts which may be subject to magnetic particle inspection by the methods described in Specification MIL-I-6868.

**3.1.1 Manufacturing process**.- The steel shall be manufactured by the open-hearth or electric-furnace process, unless a single process is specified in the contract or purchase order.

**3.1.1.1** Sufficient discard shall be taken from each ingot to insure freedom from piping and undue segregation.

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

**3.3 Hardenability**.- End-quench-hardenability values for the steel in all specified conditions shall be Rockwell C-49 minimum at 1 1/16 inch and C-45 minimum at 2 1/16 inch.

**3.4 Grain size**.- The austenitic grain size shall be predominantly No. 5 or finer, with grains as large as No. 3 permissible.

**3.5 Macrostructure**.- Visual examination of deep-acid-etched specimens shall show no evidence of pipes, internal cracks, excessive segregation, or other injurious defects.

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

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

**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.

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TABLE I

Chemical composition <sup>1/</sup>

Element	Analysis percent	Check analysis tolerance <sup>2/</sup> percent
Carbon	0.28 - 0.33	±0.02
Manganese	0.80 - 1.00	±0.04
Phosphorous	<sup>3/</sup> 0.025 (max)	+0.005
Sulfur	<sup>3/</sup> 0.025 (max)	+0.005
Silicon	0.20 - 0.35	±0.02
Nickel	1.65 - 2.00	±0.05
Chromium	0.75 - 0.95	±0.05
Molybdenum	0.35 - 0.50	±0.03
Vanadium	0.05 - 0.10	±0.01
Iron	Remainder	

<sup>1/</sup> 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.

<sup>2/</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.

<sup>3/</sup> 0.040 (max) when open-hearth steel is specified.

TABLE II

Decarburization

Nominal diameter or distance between opposite faces, inches	Maximum depth of decarburization, inch <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
Over 3.00	0.040

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

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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 conditions (C) and (E) material.-

3.8.1 The hardness for material in physical conditions (C) and (E) shall be not more than Brinell 241 (Rockwell C-23) or Brinell 255 (Rockwell C-25), respectively. These hardness limitations apply when the material is furnished in surface conditions (1), (2), (3), and (5).

3.8.2 The hardness for material in physical conditions (C) and (E) shall be not more than Brinell 248 (Rockwell C-24) or Brinell 277 (Rockwell C-29) respectively, when furnished in surface condition (4).

3.9 Mechanical properties of condition (F) steel.- Unless otherwise specified, the mechanical properties of material supplied in condition (F) in sizes up to and including 2 inches in the least dimension, shall be as specified in table III.

TABLE III

Mechanical properties of condition (F) steel

Tensile strength (min)	Yield strength at 0.2 percent set or extension indicated (min)		Elongation (min)	Reduction of area (min)	Charpy V-notch impact strength at 70°F (min)
psi	psi	Extension under load; inches per inch	percent	percent	ft lb
220,000	190,000	0.0082	10	40	15

3.9.1 When bars in condition (F) are ordered with mechanical properties differing from those specified in table III, or when bars in condition (F) are ordered in sizes larger than 2 inches in the least dimensions, the mechanical properties shall be as is agreed upon between the contractor and the procuring activity.

3.10 Impact strength.- The V-notch Charpy impact strength, at approximately 70°F (room temperature), of specimens prepared in accordance with 4.10 herein, shall be not less than 15 ft lb. The Rockwell C hardness of specimens tested shall be not less than Rockwell C-45.

3.11 Tolerances.-

3.11.1 Diameter or thickness.- The permissible variation from nominal dimensions shall be as shown on Standard FED. STD. No. 48, except that when bars are intended for reforging purposes, the requirements of Standard FED. STD. No. 48 are waived.

3.11.2 Exact lengths.- Bars 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 the contract or purchase order.

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3.11.3 Mill lengths.- When exact or multiple lengths are not ordered, bars 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 Identification of product.- Bars shall be marked for identification in accordance with Standard MIL-STD-183. The following marking shall be shown:

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Physical condition  
Heat number

3.12.1 Bars smaller than 1/2 inch in diameter or 3/8 inch in width of flat shall be marked as above or bundled and tagged at each end, with an extra tag included in the bundle.

3.13 Workmanship.- Materials 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.

3.13.1 Cold finishing.- Cold-finished bars shall be free from scale or surface defects. Stress relieving may be accomplished after cold finishing.

#### 4. QUALITY ASSURANCE PROVISIONS

4.1 General.- All the tests required herein for the testing of steel bars are classified as Acceptance tests, for which necessary sampling techniques and methods of testing are specified in this section.

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

#### 4.3 Chemical analysis.-

4.3.1 Sampling.- One or more samples for check chemical analysis shall be selected to represent each heat of steel.

4.3.1.1 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. The sample shall consist of not less than 2 ounces of material.

4.3.1.2 Waiver.- Samples for check chemical analysis may be waived at the discretion of the Inspector, provided that all of the material under inspection can be identified as being made from a heat previously analyzed and found to be in conformance with the chemical composition specified herein.

4.3.1.3 Additional samples.- Where the material is not identifiable as to heat and method of manufacture, or where the identity of any portion of the shipment is obscure in any respect, the Inspector shall select the necessary additional samples to determine conformance of all portions of the shipment to this specification.

4.3.2 Method.- Specimens shall be prepared in accordance with Fed. 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 by wet chemical methods.

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**4.4 Hardenability.-**

**4.4.1 Sampling.-** Two or more samples for end-quench-hardness test shall be selected from each heat of steel from which material is presented for acceptance. Cast, forged, or rolled samples are acceptable.

**4.4.2 Preparation of specimens.-** Specimens for the end-quench-hardness test shall conform to the requirements of Method 711 of Fed. Test Method Standard No. 151. The steel shall be normalized, prior to machining the test specimen, by heating to 1,700°F, holding at this temperature for 1 hour, and cooling in still air.

**4.4.3 Method.-** End-quench-hardness tests shall be conducted in accordance with Method 711 of Fed. Test Method Standard No. 151. Specimens shall be austenitized at 1,550° ±10°F.

**4.5 Grain size.-**

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

**4.5.2 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 Method 311 of Fed. Test Method Standard No. 151.

**4.6 Macrostructure (deep acid etch).-**

**4.6.1 Sampling.-** Two or more sample bars shall be selected to represent each heat of steel from which material is submitted for acceptance.

**4.6.2 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 of the bar 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.

**4.6.3 Method.-** Specimens shall be examined for the presence of defects.

**4.7 Decarburization.-**

**4.7.1 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.

**4.7.2 Method.-**

**4.7.2.1 Microscopic.-** The depth of the zone of decarburization below a surface of a bar shall be determined by examination of a metallographic specimen, or specimens, representing the entire cross section of bars having diameters or maximum widths not greater than 1/2 inch. For bars over 1/2 inch in diameter, or maximum width, the section shall exhibit not less than 1 linear inch of the original surface. Specimens from rectangular bars or shapes shall contain at least one corner. Specimens shall be polished, etched with 5 percent nital, and examined at 100 diameters magnification.

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4.7.2.2 Hardness traverse.- Unless otherwise specified, an alternate acceptable method for determining depth of decarburization shall be a hardness traverse of a cross-sectional surface of the samples selected for test. The specimen shall include a representative portion of the outer surface of the sample selected for test. The specimen shall be hardened by quenching in oil after austenitizing for 1/2 hour at the temperature specified in 4.4.3. The hardness traverse shall be accomplished on a surface representing the cross section of the sample, with individual hardness determinations at close enough intervals from the original outer surface of the bar, to determine compliance with the applicable requirements of 3.6. Acceptable hardness test methods include Rockwell superficial 15N, Knoop, and Vickers. The depth of decarburization shall be considered the distance from the original surface of the sample to the point where hardness does not increase on further hardness traverse testing.

#### 4.8 Hardness of bars in physical condition (C) and (E).-

4.8.1 Sampling.- At least five bars of each temper and size shall be tested to ascertain conformance with the permissible hardness values. When less than five bars are ordered, each bar shall be tested.

4.8.2 Method.- Hardness testing shall conform to Method 243 of Fed. Test Method Standard No. 151.

#### 4.9 Mechanical properties of steel in physical condition (F).-

4.9.1 Sampling.- For material furnished in condition F, one or more tensile-test samples shall be selected from bars produced under the same processing conditions, from the same heat, of the same physical condition, of the same size, essentially uniform in all respects, and submitted for inspection at one time.

4.9.2 Specimens.- Tensile-test specimens shall conform to type R1 or R3, Method 211 of Fed. Test Method Standard No. 151.

4.9.3 Method.- Tensile tests shall be conducted in accordance with Method 211 of Fed. Test Method Standard No. 151. Yield strength shall be determined by the offset or extension-under-load methods. Impact strength shall be determined in compliance with 4.10 herein.

#### 4.10 Impact strength.-

4.10.1 Sampling.- At least two bars from each heat shall be tested to determine conformance with the specified minimum impact strength.

4.10.2 Waiver.- Samples for Charpy impact tests may be waived at the discretion of the Inspector, provided that all of the material under inspection can be identified as being made from a heat previously tested for and found to be in compliance with the impact strength requirements specified herein.

4.10.3 Preparation of specimens.- V-notched Charpy impact specimens shall be taken from the ends of the sample bars in accordance with Fed. Test Method Standard No. 151. Sections over 2 inches in diameter or thickness may be rolled or forged to size before selection of specimens. Specimens shall be machined or forged approximately to size without notch, before heat treatment. Heat treatment shall comprise austenitizing at 1,550° ±10°F for 1/2 hour, quenching in oil, and tempering at 600° ±10°F for 1 hour. Following heat treatment, the specimens shall be finish-machined and notched to size in accordance with figure 3 "V-Notched Charpy Specimen," Method 221 of Fed. Test Method Standard No. 151. Condition (F) material shall be machined and notched without reheat-treating.

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**4.10.4 Method.-** Tests shall be made in accordance with Fed. Test Method Standard No. 151. The Rockwell C hardness of specimens tested may be measured before or after impact tests. Hardness testing shall conform to the requirements of Method 243 of Fed. Test Method Standard No. 151.

**4.11 Rejection and retest.-** When failure of a specimen is definitely ascribed to faulty material or failure to meet the applicable test requirements, the entire lot shall be rejected. When failure of any lot of material to meet the requirements of this specification is due to inadequate heat treatment, the material may be reheated and resubmitted for tests. Only one reheat treatment will be permitted.

**5. PREPARATION FOR DELIVERY**

**5.1 Application.-** The requirements of section 5 apply only to direct purchases by or direct shipments to the Government.

**5.2 Preservation, packaging and packing.-** Materials shall be prepared for shipment in accordance with the methods prescribed by Standard MIL-STD-163. Materials in surface conditions (2) through (5) shall be coated with preservative.

**5.3 Marking of shipments.-** Interior packages and exterior shipping containers shall be marked in accordance with Standard MIL-STD-163. The identification shall be posed of the following information listed in the order shown:

Stock No. or other identification number as specified in the purchase document\*  
 STEEL BARS (4330) VANADIUM MODIFIED  
 Specification MIL-S-8699A  
 Cross-sectional shape and dimensions (as applicable)\*\*  
 Heat No.\*\*  
 Physical and surface conditions\*\*  
 Quantity contained (as defined in the contract or order for each size)  
 Name of manufacturer\*\*  
 Name of contractor (if different from manufacturer)\*\*  
 Contract or Order No.

\* The contractor shall enter the Federal Stock No. specified in the purchase document or as furnished by the procuring activity. When the Federal Stock No. is not provided or available from the procuring activity, leave space therefor and enter the Stock No. or other identification when provided by the procuring activity.

\*\* Applicable data to be entered by contractor.

**6. NOTES**

**6.1 Intended use.-** The materials covered by this specification are intended for use in the manufacture of aircraft parts and components which are to be heat-treated to a tensile strength of 220,000 to 240,000 psi. These steels combine high tensile strength and good ductility with relatively good impact strength at room and lower temperatures.



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6.2 Ordering data.- Procurement documents should state the following:

- (a) Title, number, and date of this specification.
- (b) Cross-sectional shape and dimensions.
- (c) Physical and surface conditions, when other than conditions (C) (4) and (C) (2) for bars over 1-1/2 inches are desired. (See L.2.)
- (d) Exact lengths and length tolerances, if mill lengths are not acceptable. (See 3.11.)
- (e) Whether domestic or overseas packing is desired. (See 5.2.)

6.2.1 When bars are intended for reforging purposes, it should 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.

NOTICE: When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

**Custodians:**

Army - Ordnance Corps  
Navy - Bureau of Aeronautics  
Air Force

**Preparing activity:**

Navy - Bureau of Aeronautics

**Other interest:**

Army - ET  
Navy - Or

**STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL***(See Instructions - Reverse Side)*

1. DOCUMENT NUMBER	2. DOCUMENT TITLE		
3a. NAME OF SUBMITTING ORGANIZATION		4. TYPE OF ORGANIZATION (Mark one)	
b. ADDRESS (Street, City, State, ZIP Code)		<input type="checkbox"/> VENDOR	<input type="checkbox"/> USER
		<input type="checkbox"/> MANUFACTURER	<input type="checkbox"/> OTHER (Specify): _____
<b>5. PROBLEM AREAS</b>			
a. Paragraph Number and Wording:			
b. Recommended Wording:			
c. Reason/Rationale for Recommendation:			
<b>6. REMARKS</b>			
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)	