



# AEROSPACE MATERIAL

Society of Automotive Engineers, Inc.

TWO PENNSYLVANIA PLAZA, NEW YORK, N.Y. 10001

## SPECIFICATION

# AMS 6424

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Revised

STEEL BARS, FORGINGS, AND TUBING  
0.80Cr - 1.8Ni - 0.25Mo (0.49 - 0.55C)

### 1. SCOPE:

- 1.1 Form: This specification covers an aircraft-quality, low-alloy steel in the form of bars, forgings, mechanical tubing, and forging stock.
- 1.2 Application: Primarily for parts with section 3.5 in. (89 mm) or less in thickness at the time of heat treatment which require a through-hardening steel capable of developing a hardness as high as 40 HRC and also parts with thinner section thickness which require proportionately higher hardness.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications (AMS) and Aerospace Standards (AS) shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

- 2.1 SAE Publications: Available from Society of Automotive Engineers, Inc., Two Pennsylvania Plaza, New York, New York 10001.

#### 2.1.1 Aerospace Material Specifications:

AMS 2251 - Tolerances, Alloy Steel Bars  
AMS 2253 - Tolerances, Carbon and Alloy Steel Tubing  
AMS 2259 - Chemical Check Analysis Limits, Wrought Low-Alloy and Carbon Steels  
AMS 2301 - Aircraft Quality Steel Cleanliness, Magnetic Particle Inspection Procedure  
AMS 2350 - Standards and Test Methods  
AMS 2370 - Quality Assurance Sampling of Carbon and Low-Alloy Steels, Wrought Products Except Forgings  
AMS 2372 - Quality Assurance Sampling of Carbon and Low-Alloy Steels, Forgings and Forging Stock  
AMS 2375 - Approval and Control of Critical Forgings  
AMS 2808 - Identification, Forgings

#### 2.1.2 Aerospace Standards:

AS 1182 - Standard Machining Allowance, Aircraft Quality and Premium Quality Steel Products

- 2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

ASTM A255 - End-Quench Test for Hardenability of Steels  
ASTM A370 - Mechanical Testing of Steel Products  
ASTM E112 - Estimating Average Grain Size of Metals  
ASTM E350 - Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron  
ASTM E381 - Rating Macroetched Steel

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- 2.3 Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.

2.3.1 Federal Standards:

Federal Test Method Standard No. 151 - Metals; Test Methods

3. TECHNICAL REQUIREMENTS:

- 3.1 Composition: Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E350, by spectrographic methods in accordance with Federal Test Method Standard No. 151, Method 112, or by other approved analytical methods:

|            | min  | max   |
|------------|------|-------|
| Carbon     | 0.49 | 0.55  |
| Manganese  | 0.65 | 0.85  |
| Silicon    | 0.20 | 0.35  |
| Phosphorus | --   | 0.025 |
| Sulfur     | --   | 0.025 |
| Chromium   | 0.70 | 0.90  |
| Nickel     | 1.65 | 2.00  |
| Molybdenum | 0.20 | 0.30  |
| Copper     | --   | 0.35  |

- 3.1.1 Check Analysis: Composition variations shall meet the requirements of AMS 2259, paragraph titled "Low Alloy Steels", except that check analysis limit for carbon shall apply to over max only.

- 3.2 Condition: The product shall be supplied in the following condition; hardness and tensile strength shall be determined in accordance with ASTM A370:

3.2.1 Bars:

- 3.2.1.1 Bars 0.500 In. (12.70 mm) and Under in Diameter or Distance Between Parallel Sides: Cold finished having tensile strength not higher than 135,000 psi (931 MPa) or equivalent hardness.

- 3.2.1.2 Bars Over 0.500 In. (12.70 mm) in Diameter or Distance Between Parallel Sides: Hot finished having hardness not higher than 255 HB or equivalent except that bars ordered cold finished may have hardness as high as 277 HB or equivalent.

- 3.2.2 Forgings: As ordered.

- 3.2.3 Mechanical Tubing: Cold finished having hardness not higher than 28 HRC or equivalent except that tubing ordered hot finished shall have hardness not higher than 23 HRC or equivalent.

- 3.2.4 Forging Stock: As ordered by the forging manufacturer.

- 3.3 Properties: The product shall conform to the following requirements; hardness testing shall be performed in accordance with ASTM A370:

- 3.3.1 Hardenability: Shall be J62=2 min and J55=12 min, determined on the standard end-quench test specimen in accordance with ASTM A255 except that the steel shall be normalized at  $1700^{\circ}\text{F} \pm 10^{\circ}$  ( $926.7^{\circ}\text{C} \pm 6^{\circ}$ ) and the test specimen austenitized at  $1525^{\circ}\text{F} \pm 10^{\circ}$  ( $829.4^{\circ}\text{C} \pm 5.6^{\circ}$ ). The hardenability test is not required on product which will not yield a suitable specimen but the steel from which the product is made shall conform to the hardenability specified in this paragraph.

- 3.3.2 Grain Size: Predominantly 5 or finer with occasional grains as large as 3 permissible, ASTM E112, McQuaid-Ehn test.

- 3.3.3 Macrostructure: Visual examination of transverse sections from bars, billets, forging stock, and tube rounds, etched in accordance with ASTM E381 in hot hydrochloric acid (1:1) at 160 - 180° F (71.1 - 82.2° C) for sufficient time to develop a well-defined macrostructure, shall show no injurious imperfections such as pipe, cracks, porosity, segregation, and inclusions detrimental to fabrication or to performance of parts. Macrostructure shall be equal to or better than the following macrographs of ASTM E381:

| Section Size         |                         | Macrographs    |
|----------------------|-------------------------|----------------|
| Square Inches        | (Square Centimeters)    |                |
| Up to 36, incl       | (Up to 232, incl)       | S2 - R1 - C2   |
| Over 36 to 100, incl | (Over 232 to 645, incl) | S2 - R2 - C3   |
| Over 100             | (Over 645)              | As agreed upon |

3.3.4 Decarburization:

- 3.3.4.1 Bars and tubing ordered ground, turned, or polished shall be free from decarburization on the ground, turned, or polished surfaces. Decarburization on tubing ID shall not exceed the maximum depth specified in Table II.
- 3.3.4.2 Allowable decarburization of bars, billets, and tube rounds ordered for redrawing or forging or to specified microstructural requirements shall be as agreed upon by purchaser and vendor.
- 3.3.4.3 Decarburization of bars to which 3.3.4.1 or 3.3.4.2 is not applicable shall be not greater than shown in Table I.

TABLE I

| Nominal Diameter or Distance<br>Between Parallel Sides<br>Inches | Depth of<br>Decarburization<br>Inch |
|------------------------------------------------------------------|-------------------------------------|
| 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 1.000 to 1.500, incl                                        | 0.020                               |
| Over 1.500 to 2.000, incl                                        | 0.025                               |
| Over 2.000 to 2.500, incl                                        | 0.030                               |
| Over 2.500 to 3.000, incl                                        | 0.035                               |
| Over 3.000 to 4.000, incl                                        | 0.045                               |

TABLE I (SI)

| Nominal Diameter or Distance<br>Between Parallel Sides<br>Millimeters | Depth of<br>Decarburization<br>Millimeters |
|-----------------------------------------------------------------------|--------------------------------------------|
| Up to 9.52, incl                                                      | 0.25                                       |
| Over 9.52 to 12.70, incl                                              | 0.30                                       |
| Over 12.70 to 15.88, incl                                             | 0.36                                       |
| Over 15.88 to 25.40, incl                                             | 0.43                                       |
| Over 25.40 to 38.10, incl                                             | 0.51                                       |
| Over 38.10 to 50.80, incl                                             | 0.64                                       |
| Over 50.80 to 63.50, incl                                             | 0.76                                       |
| Over 63.50 to 76.20, incl                                             | 0.89                                       |
| Over 76.20 to 101.60, incl                                            | 1.14                                       |

- 3.3.4.3.1 Limits for depth of decarburization of bars over 4.000 in. (101.60 mm) in nominal diameter or distance between parallel sides shall be as agreed upon by purchaser and vendor.
- 3.3.4.4 Decarburization of tubing to which 3.3.4.1 or 3.3.4.2 is not applicable shall be not greater than shown in Table II:

TABLE II

| Nominal Wall Thickness<br>Inches | Depth of<br>Decarburization<br>Inch |       |
|----------------------------------|-------------------------------------|-------|
|                                  | ID                                  | OD    |
| Up to 0.109, incl                | 0.008                               | 0.015 |
| Over 0.109 to 0.203, incl        | 0.010                               | 0.020 |
| Over 0.203 to 0.400, incl        | 0.012                               | 0.025 |
| Over 0.400 to 0.600, incl        | 0.015                               | 0.030 |
| Over 0.600 to 1.000, incl        | 0.017                               | 0.035 |
| Over 1.000                       | 0.020                               | 0.040 |

TABLE II (SI)

| Nominal Wall Thickness<br>Millimeters | Depth of<br>Decarburization<br>Millimeters |      |
|---------------------------------------|--------------------------------------------|------|
|                                       | ID                                         | OD   |
| Up to 2.77, incl                      | 0.20                                       | 0.38 |
| Over 2.77 to 5.16, incl               | 0.25                                       | 0.51 |
| Over 5.16 to 10.16, incl              | 0.30                                       | 0.64 |
| Over 10.16 to 15.24, incl             | 0.38                                       | 0.76 |
| Over 15.24 to 25.40, incl             | 0.43                                       | 0.89 |
| Over 25.40                            | 0.51                                       | 1.02 |

- 3.3.4.5 Decarburization shall be measured by the microscopic method or by Rockwell Superficial 30-N scale or equivalent hardness testing method on hardened but untempered specimens protected during heat treatment to prevent changes in surface carbon content. Depth of decarburization, when measured by a hardness method, is defined as the perpendicular distance from the surface to the depth under that surface below which there is no further increase in hardness. Such measurements shall be far enough away from any adjacent surface to be uninfluenced by any decarburization or lack of decarburization thereon.
- 3.3.4.5.1 When determining the depth of decarburization, it is permissible to disregard local areas provided the decarburization of such areas does not exceed the above limits by more than 0.005 in. (0.13 mm) and the width is 0.065 in. (1.65 mm) or less.
- 3.4 Quality: Steel shall be aircraft quality conforming to AMS 2301. The product shall be uniform in quality and condition, clean, sound, and free from foreign materials and from internal and external imperfections detrimental to fabrication or to performance of parts.
- 3.4.1 Bars and tubing ordered ground, turned, or polished shall be free from seams, laps, tears, and cracks open to the ground, turned, or polished surfaces.
- 3.4.2 Product ordered to surface conditions other than ground, turned, or polished shall, after removal of the standard machining allowance, be free from seams, laps, tears, cracks, and other defects exposed to the machined surfaces. Standard machining allowance shall be in accordance with AS 1182.