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# AEROSPACE

## MATERIAL SPECIFICATIONS

SOCIETY OF AUTOMOTIVE ENGINEERS, Inc.

485 Lexington Ave., New York, N.Y. 10017

### AMS 6540

Issued 2-15-65

Revised

STEEL BARS AND FORGINGS  
0.48Cr - 8.0Ni - 4.0Co - 0.48Mo - 0.09V (0.24 - 0.30C)  
Annealed

1. **ACKNOWLEDGMENT:** A vendor shall mention this specification number in all quotations and when acknowledging purchase orders.
2. **FORM:** Bars, forgings, and forging stock.
3. **APPLICATION:** Primarily for heat treated parts, such as pressure vessels, requiring through hardening to high strength levels, and where such parts may require welding.
4. **COMPOSITION:**

|            | min  | max   |
|------------|------|-------|
| Carbon     | 0.24 | 0.30  |
| Manganese  | 0.10 | 0.35  |
| Silicon    | 0.10 | 0.35  |
| Phosphorus | —    | 0.010 |
| Sulfur     | —    | 0.010 |
| Chromium   | 0.35 | 0.60  |
| Nickel     | 7.00 | 9.00  |
| Cobalt     | 3.50 | 4.50  |
| Molybdenum | 0.35 | 0.60  |
| Vanadium   | 0.06 | 0.12  |

- 4.1 **Check Analysis:** Composition variations shall meet the requirements of the latest issue of AMS 2259, paragraph titled "Low Alloy Steels"; check analysis limits for cobalt shall be 0.05 under min or over maximum.
5. **CONDITION:**
  - 5.1 **Bars and Forgings:** Unless otherwise ordered, annealed and descaled, having hardness not higher than Brinell 321 or equivalent.
  - 5.2 **Forging Stock:** As ordered by the forging manufacturer.
6. **TECHNICAL REQUIREMENTS:** When ASTM test methods are specified for determining conformance to the following requirements, tests shall be conducted in accordance with the issue of the ASTM method listed in the latest issue of AMS 2350.
  - 6.1 **Grain Size:** Predominantly 5 or finer with occasional grains as large as 3 permissible, determined, unless otherwise specified, in accordance with ASTM E112, McQuaid-Ehn test.
  - 6.2 **Decarburization:**
    - 6.2.1 Bars ordered ground, turned, or polished shall be free from decarburization on such ground, turned, or polished surfaces.
    - 6.2.2 Allowable decarburization of bars ordered for redrawing or forging, or to specified microstructural requirements, shall be as agreed upon by purchaser and vendor.

- 6.2.3 Decarburization of bars to which 6.2.1 or 6.2.2 is not applicable shall be not greater than the following:

| 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 5.000, incl                                        | 0.045                               |

- 6.2.3.1 Bars over 5.000 in. in nominal diameter or distance between parallel sides shall have depth of decarburization limits as agreed upon by purchaser and vendor.
- 6.2.4 Unless otherwise agreed upon by purchaser and vendor, decarburization shall be measured by Rockwell Superficial 30-N scale hardness method, 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 nondecarburized 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.
- 6.2.4.1 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. and the width is 0.065 in. or less.
- 6.3 Inclusion Rating: Unless otherwise specified, the inclusion rating, determined in accordance with ASTM E45, Method A, using not less than 9 specimens per heat or lot selected parallel to the direction of rolling and representing the worst area of inclusions in the inspection sample, shall be as specified below. The method of selection of specimens shall be such that suitable rating of the heat or lot of steel being qualified is assured. Two-thirds of all specimens as well as the average of all specimens shall not exceed the following limits, except that the length of any inclusion shall be not greater than 0.025 inch.

| Type  | Inclusion Rating |     |     |     |
|-------|------------------|-----|-----|-----|
|       | A                | B   | C   | D   |
| Thin  | 2.0              | 2.0 | 2.0 | 2.5 |
| Heavy | 1.5              | 1.5 | 1.5 | 1.5 |

- 6.4 Properties After Heat Treatment: Material heat treated as in 6.4.1, except that annealing (6.4.1.1) is optional, shall conform to the requirements of 6.4.2 and 6.4.3.

6.4.1 Heat Treatment:

- 6.4.1.1 Annealing: Heat to  $1125\text{ F} \pm 25$  ( $607.2\text{ C} \pm 14$ ), hold at heat for 48 hr, and cool in air to room temperature.

- 6.4.1.2 Normalizing: Heat to a temperature within the range of 1600 - 1700 F (871.1 - 926.7 C), hold at the selected temperature within  $\pm 25$  F ( $\pm 14$  C) for 1 hr per inch of section thickness, and cool in air to room temperature.
- 6.4.1.3 Hardening: Heat to a temperature within the range of 1525 - 1575 F (829.4 - 857.2 C), hold at the selected temperature within  $\pm 15$  F ( $\pm 8.3$  C) for 1 hr per inch of section thickness but at least 1 hr, and then from that temperature quench sections up to 4 in. in thickness into room-temperature oil or water, and sections over 4 in. in thickness into room-temperature oil only.
- 6.4.1.4 Tempering: Heat to 1000 F  $\pm 10$  (537.8 C  $\pm 5.6$ ), hold at heat for 2 hr, and cool suitably to approximately 125 F (52 C), and then reheat and recool using the same time and temperature.

6.4.2 Tensile Properties:

|                                                                                                    |             |
|----------------------------------------------------------------------------------------------------|-------------|
| Tensile Strength, psi                                                                              | 185,000 min |
| Yield Strength at 0.2% Offset or at 0.0159 in. in 2 in. Extension Under Load (E = 29,500,000), psi | 175,000 min |
| Elongation, % in 2 in. or 4D                                                                       | 13 min      |
| Reduction of Area, %                                                                               | 50 min      |

- 6.4.3 Fracture Toughness: Shall be determined by a suitable method. Standards shall be as agreed upon by purchaser and vendor.

7. QUALITY: Steel shall be aircraft quality and shall conform to the requirements of the latest issue of 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.

8. TOLERANCES: Unless otherwise specified, tolerances for bars shall conform to all applicable requirements of the latest issue of AMS 2251; for all hexagons, tolerances for cold finished shall apply.

9. REPORTS:

- 9.1 Unless otherwise specified, the vendor of the product shall furnish with each shipment three copies of a report of the results of tests for chemical composition, tensile properties, grain size, and cleanliness rating for each heat in the shipment. This report shall include the purchase order number, heat number, material specification number, size, and quantity from each heat. If forgings are supplied, the part number and the source and size of stock used to make the forgings shall also be included.
- 9.2 Unless otherwise specified, the vendor of finished or semi-finished parts shall furnish with each shipment three copies of a report showing the purchase order number, material specification number, contractor or other direct supplier of material, part number, and quantity. When material for making parts is produced or purchased by the parts vendor, that vendor shall inspect each lot of material to determine conformance to the requirements of this specification, and shall include in the report a statement that the material conforms, or shall include copies of laboratory reports showing the results of tests to determine conformance.

10. IDENTIFICATION:

- 10.1 Bars: Individual pieces or bundles shall have attached a metal or plastic tag embossed with the purchase order number, AMS 6540, nominal size, and heat number, or shall be boxed and the box marked with the same information. In addition to the above identification, flats 2 in. and larger in both dimensions and other bars 2 in. and over in diameter or distance between parallel sides shall be stamped with the heat number within 2 in. of one end.