# AEROSPACE MATERIAL SPECIFICATION

| AMS6526™ | REV. J |
|---|---|

Issued 1968-05
Revised 2022-03

Superseding AMS6526H

# Steel, Bars, Forgings, Mechanical Tubing, Rings, and Stock for Forgings and Rings 1.0Cr - 7.5Ni - 4.5Co - 1.0Mo - 0.09V (0.29 - 0.34C) Consumable Electrode Vacuum Remelted, Annealed (Composition similar to UNS K91283)

RATIONALE

AMS6526J is the result of a Five-Year Review and update of the specification. The revision updates the title to match the scope, updates composition test method (3.1), updates macrostructure (3.5.1, 8.9), updates decarburization (3.5.4.5), revises the hardening procedure (3.5.5.1.2), adds strain rate to tensile testing (3.5.5.2.1), removes size limits for fracture toughness specimens (3.5.5.3), updates reporting (4.4.2), prohibits unauthorized exceptions (3.8, 4.4.4, 5.2.1.1, 8.6), updates definitions (8.4), adds note on AS1182 (8.5), and allows prior revisions (8.7).

## 1. SCOPE

### 1.1 Form

This specification covers a premium aircraft-quality, high-strength, low-alloy steel in the form of bars, forgings, mechanical tubing, flash welded rings, and stock for forging or flash welded rings.

### 1.2 Application

These products have been used typically for parts requiring toughness and through hardening to high strength levels and where such parts may require welding during fabrication, but usage is not limited to such applications.

1.2.1 Certain processing procedures and service conditions may cause these products to become subject to stress-corrosion cracking; ARP1110 recommends practices to minimize such conditions.

## 2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

### 2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS2251 Tolerances, Low-Alloy Steel Bars

AMS2253 Tolerances, Carbon and Alloy Steel Tubing



**TO PLACE A DOCUMENT ORDER:** **Tel: 877-606-7323 (inside USA and Canada)**
**Tel: +1 724-776-4970 (outside USA)**
**Fax: 724-776-0790**
**Email: CustomerService@sae.org**
**SAE WEB ADDRESS:** **http://www.sae.org**

**For more information on this standard, visit**
https://www.sae.org/standards/content/AMS6526J

AMS2259 Chemical Check Analysis Limits, Wrought Low-Alloy and Carbon Steels

AMS2300 Steel Cleanliness, Premium Aircraft-Quality, Magnetic Particle Inspection Procedure

AMS2370 Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel Wrought Products and Forging Stock

AMS2372 Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel Forgings

AMS2750 Pyrometry

AMS2806 Identification, Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels and Corrosion and Heat-Resistant Steels and Alloys

AMS2808 Identification, Forgings

AMS7496 Rings, Flash Welded, Carbon and Low-Alloy Steels

ARP1110 Minimizing Stress Corrosion Cracking in Wrought Forms of Steels and Corrosion Resistant Steels and Alloys

AS7766 Clarification of Terms Used in Aerospace Metals Specifications

AS1182 Standard Stock Removal Allowance, Aircraft-Quality and Premium Aircraft-Quality, Steel Bars and Mechanical Tubing

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM A370 Mechanical Testing of Steel Products

ASTM A604 Macroetch Testing of Consumable Electrode Remelted Steel Bars and Billets

ASTM A751 Chemical Analysis of Steel Products

ASTM E45 Determining the Inclusion Content of Steel

ASTM E112 Determining Average Grain Size

ASTM E140 Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness

ASTM E399 Plane-Strain Fracture Toughness of Metallic Materials

ASTM E1077 Estimating the Depth of Decarburization of Steel Specimens

3. TECHNICAL REQUIREMENTS

3.1 Composition

Shall conform to the percentages by weight shown in Table 1, determined in accordance with ASTM A751 or by other analytical methods acceptable to purchaser.

***Table 1 - Composition***

| Element | Min | Max |
|---|---|---|
| Carbon | 0.29 | 0.34 |
| Manganese | 0.10 | 0.35 |
| Silicon | -- | 0.20 |
| Phosphorus | -- | 0.010 |
| Sulfur | -- | 0.010 |
| Chromium | 0.90 | 1.10 |
| Nickel | 7.00 | 8.00 |
| Cobalt | 4.25 | 4.75 |
| Molybdenum | 0.90 | 1.10 |
| Vanadium | 0.06 | 0.12 |
| Copper | -- | 0.35 |

3.1.1 Check Analysis

Composition variations shall meet the applicable requirements of AMS2259.

3.2 Melting Practice

Steel shall be multiple melted using consumable electrode vacuum practice in the remelt cycle.

3.3 Condition

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

3.3.1 Bars

Bar shall not be cut from plate (also see 4.4.2).

3.3.1.1 Bars 0.500 Inch (12.70 mm) and Under in Nominal Diameter or Least Distance Between Parallel Sides

Annealed and cold finished having tensile strength not higher than 165 ksi (1138 MPa) or equivalent hardness (see 8.2).

3.3.1.2 Bars Over 0.500 Inch (12.70 mm) in Nominal Diameter or Least Distance Between Parallel Sides and Forgings, Flash Welded Rings, and Mechanical Tubing

Hot finished, annealed, and descaled having hardness not higher than 341 HBW, or equivalent (see 8.3).

3.3.2 Forgings and Flash Welded Rings

Hot finished, annealed, and descaled having hardness not higher than 341 HBW, or equivalent (see 8.3).

3.3.2.1 Flash welded rings shall not be supplied unless specified or permitted on purchaser's part drawing. When supplied, rings shall be manufactured in accordance with AMS7496.

3.3.3 Stock for Forging or Flash Welded Rings

As ordered by the forging or flash welded ring manufacturer.

3.4 Heat Treatment

Bars, forgings, mechanical tubing, and flash welded rings shall be duplex annealed by heating to 1250 °F ± 25 °F (677 °C ± 14 °C), holding at heat for 4 hours ± 0.25 hour, cooling to room temperature in air or other atmosphere at a rate equivalent to an air cool, reheating to 1150 °F ± 25 °F (621 °C ± 14 °C), holding at heat for 4 hours ± 0.25 hour, and cooling to room temperature in air or other atmosphere at a rate equivalent to an air cool. Pyrometry shall be in accordance with AMS2750.

3.5 Properties

The product shall conform to the following requirements; hardness, tensile, and impact testing shall be performed in accordance with ASTM A370:

3.5.1 Macrostructure

Visual examination of transverse full cross-sections from bars, billets, tube rounds (solid, not hollow), and stock for forging or flash welded rings, etched in hot hydrochloric acid in accordance with ASTM A604, shall show no pipe or cracks. Porosity, segregation, inclusions, and other imperfections shall be no worse than the macrographs of ASTM A604 shown in Table 2.

***Table 2 - Macrostructure limits***

| Class | Condition | Severity |
|---|---|---|
| 1 | Freckles | A |
| 2 | White Spots | A |
| 3 | Radial Segregation | B |
| 4 | Ring Pattern | B |

3.5.1.1 Macrostructure examination is not required for bored/hollow forgings (including ring forgings) and mechanical tubing that is produced directly from ingots or large blooms unless agreed upon by purchaser and producer (see 8.9).

3.5.1.2 If mechanical tubing is produced directly from ingots or large blooms, transverse sections may be taken from the tubing. Macrostructure standards for such tubes shall be as agreed upon by purchaser and producer (see 8.9).

3.5.2 Micro-Inclusion Rating of Each Heat

No specimen shall exceed the limits shown in Table 3, determined in accordance with ASTM E45, Method D.

***Table 3 - Micro-inclusion limits***

| Type | A Thin | A Heavy | B Thin | B Heavy | C Thin | C Heavy | D Thin | D Heavy |
|---|---|---|---|---|---|---|---|---|
| Worst Field Severity | 1.5 | 1.0 | 1.5 | 1.0 | 1.5 | 1.0 | 1.5 | 1.0 |
| Worst Field Frequency, maximum | a | 1 | a | 1 | a | 1 | 3 | 1 |
| Total Rateable Fields, Frequency, maximum | b | 1 | b | 1 | b | 1 | 8 | 1 |

a - Combined A+B+C, not more than three fields.
b - Combined A+B+C, not more than eight fields.

3.5.2.1 A rateable field is defined as one that has a type A, B, C, or D inclusion rating of at least 1.0 thin or heavy in accordance with ASTM E45.

3.5.3 Average Grain Size of Bars, Forgings, Tubing, and Flash Welded Rings

Shall be ASTM No. 5 or finer, determined in accordance with ASTM E112.

3.5.4 Decarburization

3.5.4.1 Bars, tubing, and flash welded rings 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 5.

3.5.4.2 Allowable decarburization of bars, billets, and tube rounds ordered for redrawing, forging, or flash welding or to specified microstructural requirements shall be as agreed upon by purchaser and producer.

3.5.4.3 Decarburization of bars and flash welded rings, for which 3.5.4.1 or 3.5.4.2 are not applicable, shall not exceed the values shown in Table 4.

***Table 4A - Maximum total depth of decarburization, inch/pound units***

| Nominal Diameter or Distance Between Parallel Sides Inches | Total Depth of Decarburization Inches |
|---|---|
| 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 |

***Table 4B - Maximum total depth of decarburization, SI units***

| Nominal Diameter or Distance Between Parallel Sides Millimeters | Total Depth of Decarburization 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 127.00, incl | 1.14 |

3.5.4.4 Decarburization of tubing, for which 3.5.4.1 or 3.5.4.2 are not applicable, shall not exceed the values shown in Table 5.

***Table 5A - Maximum total depth of decarburization, inch/pound units***

| Nominal Wall Thickness Inches | Total Depth ID Inches | Total Depth OD Inches |
|---|---|---|
| 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 5B - Maximum total depth of decarburization, SI units***

| Nominal Wall Thickness Millimeters | Total Depth ID Millimeters | Total Depth OD Millimeters |
|---|---|---|
| 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 |

3.5.4.5 Decarburization shall be evaluated by one of the two methods of 3.5.4.5.1 or 3.5.4.5.2.

3.5.4.5.1 Metallographic (Microscopic) Method

A cross section taken perpendicular to the surface shall be prepared in accordance with ASTM E1077, etched, and examined metallographically at a magnification not to exceed 100X. The product shall not show a layer of complete decarburization (ferrite) or partial decarburization exceeding the limits of Tables 4 or 5.

3.5.4.5.2 Hardness Traverse (Microindentation) Method

The total depth of decarburization shall be determined by a traverse method using microindentation hardness testing in accordance with ASTM E1077, hardened, but untempered and protected during heat treatment to prevent changes in surface carbon content. Measurements shall be far enough away from any adjacent surface to be uninfluenced by any decarburization on the adjacent surface. Acceptance shall be as listed in Tables 4 or 5.

3.5.4.6 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 inch (0.13 mm) and the width is 0.065 inch (1.65 mm) or less.

3.5.4.7 In case of dispute, the total depth of decarburization determined using the microindentation hardness traverse method shall govern.

3.5.5 Response to Heat Treatment

Specimens taken from bars, forgings, mechanical tubing, and parent metal of flash welded rings, heat treated as in 3.5.5.1, shall conform to the requirements of 3.5.5.2 and, when specified, 3.5.5.3. Product need not be annealed as in 3.3 before heat treatment to determine conformance to these requirements.

3.5.5.1 Heat Treatment

3.5.5.1.1 Normalizing

Heat to 1675 °F ± 25 °F (913 °C ± 14 °C), hold at heat for not less than 1 hour per inch (25 mm) of maximum section thickness, and cool at a rate equivalent to air cooling to room temperature.

3.5.5.1.2 Hardening

Heat to 1550 °F ± 25 °F (843 °C ± 14 °C), hold at heat for 1 hour per inch (25 mm) of maximum section thickness, but not less than 1 hour, quench sections 4.0 inches (102 mm) and under in nominal thickness into room temperature oil or water and sections over 4.0 inches (102 mm) in nominal thickness into room temperature oil. Within 2 hours after quenching, start to subzero cool to -90 °F (-68 °C) or below, hold at -90 °F (-68 °C) for not less than 2 hours, and warm in air to room temperature.

3.5.5.1.3 Tempering

Heat to 1000 °F ± 10 °F (538 °C ± 6 °C), hold at heat for not less than 2 hours, cool to below 125 °F (52 °C), reheat to 1000 °F ± 10 °F (538 °C ± 6 °C), hold at heat for not less than 2 hours, and cool in air to room temperature.

3.5.5.2 Tensile Properties

Shall be as shown in Table 6.

3.5.5.2.1 Unless otherwise specified, the strain rate shall be set at 0.005 in/in/min (0.005 mm/mm/min) and maintained within a tolerance of ±0.002 in/in/min (0.002 mm/mm/min) through 0.2% offset yield strain. After the yield strain, the speed of the testing machine shall be set between 0.05 in/in and 0.5 in/in (0.05 mm/mm and 0.5 mm/mm) of the length of the reduced section (or distance between the grips for specimens not having a reduced section) per minute. Alternatively, an extensometer and strain rate indicator may be used to set the strain rate between 0.05 in/in/min and 0.5 in/in/min (0.05 mm/mm/min and 0.5 mm/mm/min).

***Table 6 - Minimum tensile properties***

| Property | Value |
|---|---|
| Tensile Strength | 220 ksi (1517 MPa) |
| Yield Strength at 0.2% Offset | 190 ksi (1310 MPa) |
| Elongation in 4D | 10% |
| Reduction of Area | 40% |

3.5.5.3 Fracture Toughness

Fracture toughness, when specified, shall be not less than 90.0 ksi $\sqrt{\text{inch}}$ (99 MPa $\sqrt{\text{m}}$) $K_{IC}$, determined in accordance with ASTM E399.

3.5.6 Forging Stock

Specimens extracted from a forged down test coupon heat treated as in 3.5.5.1 shall conform to the requirements of 3.5.5.2, and, when specified, 3.5.5.3. If specimens taken from the stock after heat treatment as in 3.5.5.1 conform to the requirements of 3.5.5.2 and, when specified, 3.5.5.3, the tests shall be accepted as equivalent to tests of a forged coupon.

3.5.6.1 Forging stock from a heat meeting the requirements of 3.5.6 in one size need not be retested for use in a smaller size.

3.5.7 Stock for Flash Welded Rings

Specimens taken from stock after heat treatment as in 3.5.5.1 shall conform to the requirements of 3.5.5.2 and, when specified, 3.5.5.3.

3.6 Quality

The product, as received by purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and from imperfections detrimental to usage of the product.

3.6.1 Steel shall be premium aircraft-quality conforming to AMS2300, except that a maximum average frequency (F) rating of 0.10 and a maximum average severity (S) rating of 0.20 shall apply.

3.6.2 Bars and mechanical tubing shall be free from seams, laps, tears, and cracks after removal of the standard stock removal allowance in accordance with AS1182.

3.6.3 Grain flow of die forgings, except in areas that contain flash-line end grain, shall follow the general contour of the forgings showing no evidence of reentrant grain flow.

3.7 Tolerances

3.7.1 Bars

In accordance with AMS2251.

3.7.2 Mechanical Tubing

In accordance with AMS2253.

3.8 Exceptions

Any exceptions shall be authorized by the purchaser and reported as in 4.4.4.

## 4. QUALITY ASSURANCE PROVISIONS

### 4.1 Responsibility for Inspection

The producer of the product shall supply all samples for producer's tests and shall be responsible for the performance of all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to specified requirements.

### 4.2 Classification of Tests

#### 4.2.1 Acceptance Tests

The following requirements are acceptance tests and shall be performed on each heat or lot as applicable:

4.2.1.1 Composition (3.1), macrostructure (3.5.1), and micro-inclusion rating (3.5.2) of each heat.

4.2.1.2 Condition (3.3), average grain size (3.5.3), and decarburization (3.5.4) of each lot of bars, forgings, mechanical tubing, and flash welded rings.

4.2.1.3 Tensile properties (3.5.5.2) and, when specified, fracture toughness (3.5.5.3) of each lot of bars, forgings, mechanical tubing, and parent metal of flash welded rings after heat treatment.

4.2.1.4 Tolerances (3.7) of bars and mechanical tubing.

4.2.1.5 If forging stock, tests to demonstrate ability to develop required properties (3.5.6).

#### 4.2.2 Periodic Tests

The frequency severity cleanliness rating (3.6.1), and grain flow of die forgings (3.6.3), are periodic tests and shall be performed at a frequency selected by the producer unless frequency of testing is specified by purchaser.

### 4.3 Sampling and Testing

#### 4.3.1 Bars, Mechanical Tubing, Flash Welded Rings, and Stock for Forging or Flash Welded Rings

In accordance with AMS2370.

4.3.1.1 Specimens for tensile tests of bars shall be taken at the mid-thickness location.

#### 4.3.2 Forgings

In accordance with AMS2372.

### 4.4 Reports

4.4.1 The producer of bar, forgings, tubing, and flash welded rings shall furnish with each shipment a report showing the producer identity, country where the metal was melted (e.g., final melt in the case of metal processed by multiple melting operations), results of tests for composition, macrostructure, and micro-inclusion rating of each heat, and for average grain size and response to heat treatment including, when specified, fracture toughness properties of each lot, and stating that the product conforms to the other technical requirements. This report shall include the purchase order number, heat and lot numbers, AMS6526J, product form, size (and/or part number, if applicable), and quantity. If forgings are supplied, the size and melt source of stock used to make the forgings shall also be included.

4.4.2 Report the nominal metallurgically worked cross sectional size and the cut size, if different (also see 3.3.1).