# AEROSPACE MATERIAL SPECIFICATION

| AMS5611 | REV. F |
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Issued 1970-05
Revised 2006-09
Reaffirmed 2013-08

Superseding AMS5611E

## Steel, Corrosion and Heat-Resistant, Bars, Wire, Forgings, Tubing, and Rings
## 12Cr
## Ferrite Controlled, Consumable Electrode Melted
## (Composition similar to UNS S41001)

RATIONALE

AMS5611F has been reaffirmed to comply with the SAE 5-year review policy.

1. SCOPE

1.1 Form

This specification covers a premium aircraft-quality, corrosion and heat-resistant steel in the form of bars, wire, forgings, mechanical tubing, flash welded rings, and stock for forging or flash welded rings.

1.2 Application

These products have been used typically for pressure vessels or structural parts requiring uniformly high room-temperature tensile properties with oxidation resistance up to 1000 °F (538 °C), where control of ferrite is necessary, but usage is not limited to such applications.

1.2.1 Certain design and processing procedures may cause these products to become susceptible 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.





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**http://www.sae.org/technical/standards/AMS5611F**

2.1 SAE Publications

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

AMS2241 Tolerances, Corrosion and Heat-Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Bars and Wire

AMS2243 Tolerances, Corrosion and Heat-Resistant Steel Tubing

AMS2248 Chemical Check Analysis Limits, Corrosion and Heat-Resistant Steels and Alloys, Maraging and Other Highly-Alloyed Steels, and Iron Alloys

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

AMS2315 Determination of Delta Ferrite Content

AMS2371 Quality Assurance Sampling and Testing, Corrosion and Heat-Resistant Steels and Alloys, Wrought Products and Forging Stock

AMS2374 Quality Assurance Sampling and Testing, Corrosion and Heat-Resistant Steel and Alloy Forgings

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

AMS2808 Identification, Forgings

AMS7493 Rings, Flash Welded, Ferritic and Martensitic Corrosion-Resistant Steels

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

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

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 A 370 Mechanical Testing of Steel Products

ASTM A 604 Macroetch Testing of Consumable Electrode Remelted Steel Bars and Billets

ASTM E 112 Determining Average Grain Size

ASTM E 353 Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys

## 3. TECHNICAL REQUIREMENTS

### 3.1 Composition

Shall conform to the percentages by weight shown in Table 1, determined by wet chemical methods in accordance with ASTM E 353, by spectrochemical methods, or by other analytical methods acceptable to purchaser.

TABLE 1 - COMPOSITION

| Element | min | max |
|---|---|---|
| Carbon | 0.12 | 0.15 |
| Manganese | -- | 0.60 |
| Silicon | -- | 0.50 |
| Phosphorus | -- | 0.025 |
| Sulfur | -- | 0.025 |
| Chromium | 11.50 | 12.50 |
| Nickel | -- | 0.75 |
| Molybdenum | -- | 0.20 |
| Aluminum | -- | 0.05 |
| Copper | -- | 0.50 |
| Tin | -- | 0.05 |
| Nitrogen | -- | 0.18 |

#### 3.1.1 Check Analysis

Composition variations shall meet the applicable requirements of AMS2248.

### 3.2 Melting Practice

Shall be multiple melted using vacuum consumable electrode 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 A 370:

#### 3.3.1 Bars

Annealed having hardness not higher than 241 HB, or equivalent (See 8.2).

3.3.1.1 Bars over 0.500 to 2.750 inches (12.70 to 69.85 mm), inclusive, in nominal diameter or least distance between parallel sides, and all hexagons shall be cold finished.

3.3.1.2 Bars, other than hexagons, over 2.750 inches (69.85 mm) in nominal diameter or least distance between parallel sides shall be hot finished.

#### 3.3.2 Wire

Cold drawn and annealed having tensile strength not higher than 115 ksi (793 MPa), or equivalent hardness (See 8.3).

#### 3.3.3 Forgings and Flash Welded Rings

Normalized and tempered having hardness not higher than 241 HB, or equivalent (See 8.2).

3.3.3.1 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 AMS7493.

3.3.4 Mechanical Tubing

Annealed and cold finished having hardness not higher than 241 HB, or equivalent (See 8.2).

3.3.5 Stock for Forging or Flash Welded Rings

As ordered by the forging or flash welded ring manufacturer.

3.4 Properties

The product shall conform to the following requirements; tensile and hardness testing shall be performed in accordance with ASTM A 370:

3.4.1 Bars, Wire, Forgings, Tubing, and Flash Welded Rings

3.4.1.1 Macrostructure

Visual examination of transverse sections from bars, wire, billets, tube rounds, and stock for forging or flash welded rings, etched in hot hydrochloric acid in accordance with ASTM A 604, shall show no pipe or cracks. Porosity, segregation, inclusions, and other imperfections for product 36 square inches (232 $cm^2$) and under in nominal cross-sectional area shall be no worse than the macrographs of ASTM A 604 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 |



3.4.1.2 Decarburization

Bars, wire, tubing, and flash welded rings ordered ground, turned, or polished shall be free from decarburization on the ground, turned, or polished surfaces, determined metallographically at a magnification not exceeding 100X.

3.4.1.3 Response to Heat Treatment

Bars, wire, forgings, tubing, and flash welded rings shall have the properties shown in Table 3, determined on full-thickness specimens taken from product 0.500 inch (12.70 mm) and under in nominal diameter or distance between parallel sides, or from samples with a minimum dimension of 0.500 inch ± 0.100 (12.70 mm ± 2.54) cut from larger product except that samples for tensile tests cut from larger product shall have a minimum dimension of 0.500 to 0.750 inch (12.70 to 19.05 mm). The specimens shall be hardened by heating in a neutral atmosphere to 1735 °F ± 10 (946 °C ± 6), holding at heat for 1 hour ± 0.1, and cooling in still air and double tempered by heating to 600 °F ± 10 (316 °C ± 6), holding at heat for 2 hours ± 0.25, and cooling in air, reheating to 600 °F ± 10 (316 °C ± 6), holding at heat for 2 hours ± 0.25, and cooling in air.

3.4.1.3.1 Longitudinal Tensile Properties

TABLE 3 - MINIMUM LONGITUDINAL TENSILE PROPERTIES

| Property | Value |
|---|---|
| Tensile Strength | 180 ksi (1241 MPa) |
| Yield Strength at 0.2% Offset | 145 ksi (1000 MPa) |
| Elongation in 2 inches (50.8 mm) or 4D | 10% |
| Reduction of Area | 30% |

3.4.1.3.1.1 Long-Transverse Tests

May be used instead of longitudinal tests if obtainable from the product.

3.4.1.3.2 Hardness

Should be 39 to 44 HRC, or equivalent (See 8.2). The product shall not be rejected on the basis of hardness if the tensile properties of 3.4.1.3.1 are acceptable, determined on specimens taken from the same sample as that with nonconforming hardness or from another sample with similar nonconforming hardness.

3.4.1.3.3 Average Grain Size

Predominantly 5 or finer, determined in accordance with ASTM E 112 (See 8.4).

3.4.1.3.4 Delta Ferrite Content

Shall be not more than 5%, determined in accordance with AMS2315.

3.4.2 Forging Stock

When a sample of stock is forged to a test coupon and heat treated as in 3.4.1.3, specimens taken from the heat treated coupon shall conform to the requirements of 3.4.1.3.1, 3.4.1.3.2, 3.4.1.3.3, and 3.4.1.3.4. If specimens taken from the stock after heat treatment as in 3.4.1.3 conform to the requirements of 3.4.1.3.1, 3.4.1.3.2, 3.4.1.3.3, and 3.4.1.3.4, the tests shall be acceptable as equivalent to tests of a forged coupon.

3.4.3 Stock for Flash Welded Rings

Specimens taken from the stock after heat treatment as in 3.4.1.3 shall conform to the requirements of 3.4.1.3.1, 3.4.1.3.2, 3.4.1.3.3, and 3.4.1.3.4.

3.5 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.

3.5.1 Steel shall be premium aircraft-quality conforming to AMS2300.

3.5.2 Bars ordered hot rolled or cold drawn, or ground, turned, or polished, shall, after removal of the standard machining allowance in accordance with AS1182, be free from seams, laps, tears, and cracks open to the ground, turned, or polished surface.

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

3.6 Tolerances

Shall be as follows:

3.6.1 Bars and Wire

In accordance with AMS2241.

3.6.2 Mechanical Tubing

In accordance with AMS2243.

## 4. QUALITY ASSURANCE PROVISIONS

### 4.1 Responsibility for Inspection

The vendor of the product shall supply all samples for vendor'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) of each heat.

4.2.1.2 Macrostructure (3.4.1.1) of each heat.

4.2.1.3 Decarburization (3.4.1.2) of each lot of bars, wire, tubing, and flash welded rings ordered ground, turned, or polished.

4.2.1.4 Longitudinal tensile properties (3.4.1.3.1), average grain size (3.4.1.3.3), and ferrite content (3.4.1.3.4) of each lot of bars, wire, forgings, tubing, and flash welded rings after hardening and double tempering.

4.2.1.5 Tolerances of bars and wire (3.6.1) and mechanical tubing (3.6.2).

#### 4.2.2 Periodic Tests

Hardness (3.4.1.3.2) of bars, wire, forgings, tubing, and flash welded rings after heat treatment, frequency-severity cleanliness rating (3.5.1), grain flow of die forgings (3.5.3), and tests of forging stock (3.4.2) and of stock for flash welded rings (3.4.3) to demonstrate ability to develop required properties are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

### 4.3 Sampling and Testing

Shall be as follows:

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

In accordance with AMS2371.

4.3.1.1 Specimens for grain size of flash welded rings shall be cut from parent metal not including the weld-heat-affected zone.

#### 4.3.2 Forgings

In accordance with AMS2374.

### 4.4 Reports

The vendor of the product shall furnish with each shipment a report showing the results of tests for composition, macrostructure, and, when performed, frequency-severity cleanliness rating of each heat and for tensile properties, average grain size, and percent ferrite 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, AMS5611F, size, and quantity. If forgings are supplied, the size and melt source of stock used to make the forgings shall also be included.