



AEROSPACE MATERIAL SPECIFICATION

AMS5609™**REV. F**

Issued 1964-01
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Revised 2024-09

Superseding AMS5609E

Steel, Corrosion and Heat Resistant, Bars, Wire,
Forgings, Mechanical Tubing, Rings and Stock for Forging and Rings
12Cr - 0.12Cb (Nb) (410 Modified)
Ferrite Controlled, Annealed
(Composition similar to UNS S41040)

RATIONALE

AMS5609F is the result of a Five-Year Review and update of the specification. The revision updates the Title to match the Scope, updates composition testing and reporting (see 3.1 and 3.1.1), clarifies wire condition (see 3.2.2), revises decarburization requirements (see 3.3.3), adds grain size requirements (see 3.3.4.1), adds pyrometry controls (see 3.3.6), adds tensile testing strain rate control (see 3.3.6.3), revises ferrite content and response to heat-treatment test frequency (see 4.4.1), updates exception requirements (see 4.4.3 and 8.7), and adds additional forging stock options (see 4.4.4 and 8.8).

1. SCOPE

1.1 Form

This specification covers an 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 parts requiring a combination of high room-temperature tensile properties with oxidation resistance up to 1000 °F (538 °C) and where control of ferrite content 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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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.

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
AMS2303	Steel Cleanliness, Aircraft Quality, Martensitic Corrosion-Resistant Steels, 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
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
AMS7493	Rings, Flash Welded, Ferritic and Martensitic Corrosion-Resistant Steels
ARP1110	Minimizing Stress Corrosion Cracking in Wrought Forms of Steels and Corrosion Resistant Steels and Alloys
AS1182	Standard Stock Removal Allowance, Aircraft-Quality and Premium Aircraft-Quality Steel, Bars and Mechanical Tubing
AS7766	Terms Used in Aerospace Metals Specifications

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 A751	Chemical Analysis of Steel Products
ASTM E112	Determining the Average Grain Size
ASTM E140	Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness
ASTM E340	Macroetching Metals and Alloys
ASTM E1077	Standard Test Methods for Estimating the Depth of Decarburization of Steel Specimens

2.3 Definitions

Terms used in AMS are defined in AS7766.

3. TECHNICAL REQUIREMENTS

3.1 Composition

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 the 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
Columbium (Niobium)	0.05	0.20
Nickel	--	0.75
Molybdenum	--	0.20
Aluminum	--	0.05
Copper	--	0.50
Tin	--	0.05
Nitrogen	--	0.08

3.1.1 The producer may test for any element not listed in Table 1 and include this analysis in the report of 4.4. Reporting of any element not listed in the composition table is not a basis for rejection unless limits of acceptability are specified by the purchaser.

3.1.2 Check Analysis

Composition variations shall meet the requirements of AMS2248 except that check analysis limits for columbium shall be 0.02 under minimum and 0.05 over maximum.

3.2 Condition

The product shall be supplied in the following condition:

3.2.1 Bars

Bars shall be annealed.

3.2.1.1 Round Bar

Round bars shall be ground or turned.

3.2.1.2 Bars, other than rounds, over 0.500 to 2.750 inches (12.70 to 69.85 mm), inclusive, in nominal distance between parallel sides and all hexagons shall be cold finished.

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

3.2.1.4 Bars shall not be cut from plate (see 4.4.2).

3.2.2 Wire

Wire shall be cold drawn and annealed.

3.2.3 Forgings and Flash-Welded Rings

Forgings and flash-welded rings shall be annealed.

3.2.3.1 Flash-welded rings shall not be supplied unless specified or permitted on the purchaser's part drawing. When supplied, rings shall be manufactured in accordance with AMS7493.

3.2.4 Mechanical Tubing

Mechanical tubing shall be annealed and cold finished.

3.2.5 Stock for Forging or Flash-Welded Rings

Stock for forging or flash-welded rings shall be as ordered by the forging or flash-welded ring manufacturer.

3.3 Properties

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

3.3.1 Tensile Properties and Hardness as Received

3.3.1.1 Bars, Forgings, Mechanical Tubing, and Flash-Welded Rings

Hardness for bars, forgings, mechanical tubing, and flash-welded rings shall not be higher than 241 HB or equivalent (see 8.2).

3.3.1.2 Wire

Tensile strength for wire shall not be higher than 115 ksi (793 MPa) or equivalent hardness (see 8.3).

3.3.2 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 E340, shall show no pipe or cracks. Porosity, segregation, inclusions, and other imperfections shall be no worse than macrostructure standards acceptable to the purchaser.

3.3.3 Decarburization

Bars, wire, and tubing ordered ground, turned, or polished shall be free from decarburization on the ground, turned, or polished surfaces, determined microscopically at a magnification not exceeding 200X in accordance with ASTM E1077. Optical indications of decarburization shall not show a layer of complete (ferrite) or partial decarburization.

3.3.4 Average Grain Size

Average grain size shall be ASTM No. 5 or finer, determined in accordance with ASTM E112.

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

3.3.5 Ferrite Content

Ferrite content shall be not more than 5%, determined in accordance with AMS2315.

3.3.6 Response to Heat Treatment

Response to heat-treatment tensile specimens shall be taken from the product (for forgings, see 3.3.6.1) if the product nominal diameter is 0.250 inch (6.35 mm) or larger or taken from the starting stock if the product's nominal diameter is less than 0.250 inch (6.35 mm). Specimens shall be heat treated in accordance with 3.3.6.2 and tested in accordance with ASTM A370 and shall meet the requirements shown in Table 2 and 3.3.6.4. Pyrometry shall be in accordance with AMS2750.

3.3.6.1 To test forgings, specimens may be taken from forgings or forged test material with the same or less reduction than the least reduced section of the forgings.

3.3.6.2 Heat to 1700 °F $\pm$ 10 °F (927 °C $\pm$ 6 °C), hold at heat for not less than 1 hour $\pm$ 0.1 hour, and cool in still air and double temper by heating to 600 °F $\pm$ 10 °F (316 °C $\pm$ 6 °C), holding at heat for 2 hours $\pm$ 0.25 hour, and cooling at a rate equivalent to a still air cool.

Table 2 - Minimum longitudinal tensile properties - response to heat treatment

Properties	Value
Tensile Strength	185 ksi (1276 MPa)
Yield Strength at 0.2% Offset	152 ksi (1048 MPa)
Elongation in 4D	10%
Reduction of Area	30%

3.3.6.3 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 $\pm$ 0.002 in/in/min ($\pm$ 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 and 0.5 in/in (0.05 and 0.5 mm/mm) of the length of the reduced parallel 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 and 0.5 in/in/min (0.05 and 0.5 mm/mm/min). The requirement for compliance becomes effective for material produced 1 year after the publication date of this specification.

3.3.6.4 Long-Transverse Tensile Tests

Long-transverse tensile tests may be used instead of longitudinal tests if suitable specimens are obtainable from the product and shall meet the longitudinal tensile properties of Table 2.

3.3.6.5 Hardness

Response to heat-treatment hardness shall be 40 to 45 HRC, or equivalent (see 8.2). Product shall not be rejected on the basis of hardness if the tensile properties of 3.3.6, determined on specimens taken from the same sample as that with nonconforming hardness or from another sample with similar nonconforming hardness, are acceptable.

3.3.7 Stock for Flash-Welded Rings

Specimens taken from the stock after heat treatment as in 3.3.6.2 shall conform to the requirements of Table 2 and 3.3.6.4.

3.4 Quality

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

3.4.1 Steel shall be aircraft quality conforming to AMS2303.

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

3.4.3 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.

3.5 Tolerances

3.5.1 Bars and Wire

Bar and wire tolerances shall be in accordance with AMS2241.

3.5.2 Mechanical Tubing

Mechanical tubing tolerances shall be in accordance with AMS2243.

3.6 Exceptions

Any exceptions shall be authorized by the purchaser and reported as in 4.4.3.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The producer of the product shall supply all samples for the producer's tests and shall be responsible for the performance of all required tests. The 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

Composition (see 3.1), tensile properties and hardness as received (see 3.3.1), macrostructure (see 3.3.2), decarburization (see 3.3.3), average grain size (see 3.3.4), ferrite content (see 3.3.5), response to heat treatment (see 3.3.6), and frequency-severity cleanliness rating (see 3.4.1) are acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Periodic Tests

Tests of forging stock (see 3.3.6.1) and stock for flash-welded rings (see 3.3.7), to demonstrate the ability to develop required properties, and grain flow of die forgings are periodic tests and shall be performed at a frequency selected by the producer unless frequency of testing is specified by the purchaser.

4.3 Sampling and Testing

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 shall be in accordance with AMS2371.

4.3.2 Forgings shall be in accordance with AMS2374.