AEROSPACE MATERIAL SPECIFICATION

AMS6378™	REV. J

Issued 1961-07
Reaffirmed 2010-05
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Superseding AMS6378H

(R) Steel Bars
1.0Cr - 0.20Mo - 0.45Se (0.39 - 0.48C) (4142H Modified)
Die-Drawn, 130 ksi (896 MPa) Yield Strength
Free Machining
(Composition similar to UNS K11542)

RATIONALE

AMS6378J is the result of a Five-Year Review and update of the specification. The revision addresses grain refiners (see 3.1.1, 3.3.2, 4.2.1, 4.2.2, and 8.8), updates composition reporting (see 3.1.2), updates die discussion and microstructure requirements (see 3.2 and 3.2.1), updates macroetch to clarify that both billet and bar do not require test (and/or evaluation) (see 3.3.1), revises decarburization evaluation method (see 3.3.3.3), adds ordering guidance (see 8.6), and updates the prohibition of exceptions requirements (see Table 2, 3.3.4.2, 4.4.2, and 8.7).

1. SCOPE

1.1 Form

This specification covers a free-machining, low-alloy steel in the form of round bars 3.50 inches (88.9 mm) and under in nominal diameter produced by a die-drawing process.

1.2 Application

These bars have been used typically for parts, such as shafts, axles, pins, fasteners, gears, and screw machine parts, 0.50 inch (12.7 mm) and under in nominal section thickness at time of heat treatment, which are normally used at hardness of 30 to 36 HRC and do not require a high degree of ductility, but usage is not limited to such applications.

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.

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
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For more information on this standard, visit
https://www.sae.org/standards/content/AMS6378J/

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

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

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

AMS2806 Identification, Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels, and Corrosion and Heat-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 Standard Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

ASTM E112 Determining 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 E381 Macroetch Testing Steel Bars, Billets, Blooms, and Forgings

ASTM E1077 Estimating the Depth of Decarburization of Steel Specimens

2.3 ISO Publications

Copies of these documents are available online at https://webstore.ansi.org/.

ISO 14001 Environmental management systems

2.4 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	0.39	0.48
Manganese	0.70	1.10
Silicon	0.15	0.35
Phosphorus	--	0.040
Sulfur	--	0.040
Chromium	0.75	1.20
Molybdenum	0.15	0.25
Selenium	0.03	0.06
Nickel	--	0.25
Copper	--	0.35

3.1.1 Aluminum, vanadium, and columbium (niobium) are optional grain refining elements and need not be determined or reported unless used to satisfy the average grain size requirements of 3.3.2.

3.1.2 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.

3.1.3 Check Analysis

Composition variations shall meet the applicable requirements of AMS2259.

3.2 Condition

Bars shall be drawn shapes.

3.2.1 Die-drawing shall be used to assure the mechanical properties and uniform structure of primarily upper bainite with aggregates of lower bainite and pearlite providing good machinability (see 8.4). Microstructural characterization is not required to be evaluated.

3.3 Properties

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

3.3.1 Macrostructure

Visual examination of transverse full cross sections from bars or billets, etched in hot hydrochloric acid in accordance with ASTM E381, shall show no pipe or cracks. Porosity, segregation, inclusions, and other imperfections shall be no worse than the macrographs of ASTM E381 shown in Table 2.

Table 2 - Macrostructure limits

Section Size Square Inches	Section Size Square Centimeters	Macrographs
Up to 36, incl	Up to 232, incl	S2 - R1 - C2
Over 36 to 133, incl	Over 232 to 858, incl	S2 - R2 - C3
Over 133	Over 858	(1)

(1) Limits for larger sizes shall be agreed upon by the producer and purchaser.

3.3.2 Average Grain Size

3.3.2.1 The average austenitic grain size shall be ASTM No. 5 or finer, determined in accordance with ASTM E112.

3.3.2.2 The product of a heat shall be considered to have an ASTM No. 5 or finer austenitic grain size if one or more of the following are determined by heat analysis (see 8.8):

- A total aluminum content of 0.020 to 0.050%.
- An acid soluble aluminum content of 0.015 to 0.050%.
- A vanadium content of 0.02 to 0.08%.
- A columbium (niobium) content of 0.02 to 0.05%.

3.3.3 Decarburization

3.3.3.1 Bars ordered ground, turned, or polished shall be free from decarburization on the ground, turned, or polished surfaces.

3.3.3.2 Where 3.3.3.1 or 3.3.3.2 are not applicable, decarburization of bars shall be not greater than shown in Table 3.

Table 3A - Maximum total depth of decarburization limits, inch/pound units

Nominal Diameter 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 3.500, incl	0.040

Table 3B - Maximum total depth of decarburization limits, SI units

Nominal Diameter 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 88.90, incl	1.02

3.3.3.3 Decarburization shall be evaluated by one of the two methods of 3.3.3.3.1 or 3.3.3.3.2.

3.3.3.3.1 Metallographic (Microscopic) Method

A cross section of the surface shall be prepared in accordance with ASTM E1077 and examined metallographically at a magnification of 200X. The sample shall not show a layer of complete (ferrite) or partial decarburization exceeding the limits of Table 3.

3.3.3.3.2 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. Samples shall be hardened and protected during heat treatment to prevent changes in surface carbon content. Samples may be tempered at the option of the producer. 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 Table 3.

3.3.3.3.3 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.

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

3.3.4 Tensile Properties

Specimens, cut from the center of bars 1.50 inches (38.1 mm) and under in nominal diameter and at mid-radius on sizes larger than 1.50 inches (38.1 mm), shall conform to Table 4.

Table 4 - Minimum tensile properties

Property	Value
Tensile Strength	150 ksi (1034 MPa)
Yield Strength at 0.2% Offset	130 ksi (896 MPa)
Elongation in 4D	5%
Reduction of Area	20%

3.3.4.1 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 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).

3.3.4.2 Mechanical property requirements for product outside the size range covered by 1.1 shall be agreed upon between the producer and purchaser and reported as in 4.4.2.

3.3.5 Hardness

Hardness shall be 302 to 341 HBW, or equivalent (see 8.2), but bars shall not be rejected on the basis of hardness if the tensile properties 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 Quality

Bars, 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 bars.

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

3.5 Tolerances

Bars shall conform to all applicable requirements of AMS2251, except that tolerances for diameter shall be as shown in Table 5.

Table 5A - Diameter tolerances, inch/pound units

Nominal Diameter Inches	Tolerance, Inch Minus Only
Up to 0.375, incl	0.003
Over 0.375 to 1.500, incl	0.005
Over 1.500 to 2.500, incl	0.006
Over 2.500 to 3.500, incl	0.007

Table 5B - Diameter tolerances, SI units

Nominal Diameter Millimeters	Tolerance, Millimeter Minus Only
Up to 9.52, incl	0.08
Over 9.52 to 38.10, incl	0.13
Over 38.10 to 63.50, incl	0.15
Over 63.50 to 88.90, incl	0.18

3.6 Exceptions

Any exceptions shall be authorized by the purchaser and reported as in 4.4.2.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The producer of bars 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 bars conform to specified requirements.

4.2 Classification of Tests

4.2.1 Acceptance Tests

All technical requirements are acceptance tests and shall be performed on each heat or lot as applicable. If grain refining elements (see 3.3.2.2) are not present, the ASTM E112 grain size test (see 3.3.2.1) shall be conducted on each lot.

4.2.2 Periodic Tests

If grain refining elements (see 3.3.2.2) are present, the ASTM E112 grain size test (see 3.3.2.1) shall be conducted on a periodic basis and shall be performed at a frequency selected by the producer (not to exceed 1 year) unless frequency of testing is specified by the purchaser.

4.3 Sampling and Testing

Sampling and testing shall be in accordance with AMS2370.