



AEROSPACE MATERIAL SPECIFICATION

AMS6340™**REV. D**Issued 2006-03
Revised 2023-10

Superseding AMS6340C

Steel Bars, Forgings, Mechanical Tubing
and Forging Stock
0.88Cr - 1.8Ni - 0.42Mo - 0.08V (0.28 - 0.33C) (4330 Mod)
Premium Aircraft Quality
Consumable Electrode Vacuum Remelted
(Composition similar to UNS K23080)

RATIONALE

AMS6340D is the result of a Five-Year Review and update of the specification. The revision includes update of the Title to match the Scope and product quality, update to composition reporting (see 3.1.1), clarification of macrostructure (see 3.4.1 and 8.8), revision of hardenability requirements (see 3.4.4), revision of decarburization testing requirements (see 3.4.5.5), addition of strain rate requirements to all tensile tests (see 3.4.6.3), additional ordering information on forging stock (see 4.4.3 and 8.8), notes on bar stock quality (see 8.4), and updates to the requirements for product exceptions (see 4.4.4 and 8.7).

1. SCOPE

1.1 Form

This specification covers a premium aircraft-quality, low-alloy steel in the form of bars, forgings, mechanical tubing, and forging stock.

1.2 Application

These products have been used typically for parts requiring high tensile strength and good ductility with relatively high impact strength, superior transverse properties, and hardness, but usage is not limited to these applications. Certain design and processing procedures may cause these products to become susceptible to stress-corrosion cracking after heat treatment; 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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For more information on this standard, visit
<https://www.sae.org/standards/content/AMS6340D/>

SAE WEB ADDRESS:

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
AMS2259	Chemical Check Analysis Limits, Wrought Low-Alloy and Carbon Steels
AMS2300	Steel Cleanliness, Premium Aircraft-Quality, Magnetic Particle Inspection Procedure
AMS2310	Qualification Sampling and Testing of Steels for Transverse Tensile Properties
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
AMS2806	Identification Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels, and Corrosion and Heat-Resistant Steels and Alloys
AMS2808	Identification, Forgings
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 A255	Hardenability of Steel
ASTM A370	Mechanical Testing of Steel Products
ASTM A604	Macroetch Testing of Consumable Electrode Remelted Steel Bars and Billets
ASTM A751	Standard Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
ASTM E45	Determining the Inclusion Content of Steel
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 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	0.28	0.33
Manganese	0.65	1.00
Silicon	0.15	0.35
Phosphorus	--	0.015
Sulfur	--	0.015
Chromium	0.75	1.00
Nickel	1.65	2.00
Molybdenum	0.35	0.50
Vanadium	0.05	0.10
Copper	--	0.35

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 applicable requirements of AMS2259.

3.2 Melting Practice

Steel shall be multiple melted using consumable electrode vacuum process 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

3.3.1.1 Bars 0.500 inch (12.70 mm) and under in nominal diameter or least distance between parallel sides shall be cold finished having tensile strength not higher than 130 ksi (896 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 shall be hot finished, and annealed if necessary, unless otherwise ordered, having hardness not higher than 241 HBW, or equivalent (see 8.3). Bars ordered cold finished may have hardness as high as 248 HBW, or equivalent (see 8.3).

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

3.3.2 Forgings

Forgings shall be normalized and tempered having hardness not higher than 269 HBW, or equivalent (see 8.3).

3.3.3 Mechanical Tubing

Mechanical tubing shall be cold finished, unless otherwise ordered, having hardness not higher than 25 HRC, or equivalent (see 8.3). Tubing ordered hot finished and annealed shall have hardness not higher than 99 HRB, or equivalent (see 8.3).

3.3.4 Forging Stock

As ordered by the forging manufacturer.

3.4 Properties

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

3.4.1 Macrostructure

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

3.4.1.1 Macrostructure examination is not required for bored/hollow forgings (including ring forgings) and mechanical tubing that are produced directly from ingots or large blooms, unless otherwise agreed upon by the purchaser and producer (see 8.8).

3.4.1.2 If mechanical tubing is produced directly from ingots or large blooms, transverse sections may be taken from the tubing rather than tube rounds. Macrostructure standards for such tubes shall be as agreed upon by the purchaser and producer (see 8.8).

3.4.2 Micro-Inclusion Rating

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

Table 3 - Micro-inclusion rating limits

Type	A		B		C		D	
	Thin	Heavy	Thin	Heavy	Thin	Heavy	Thin	Heavy
Worst Field Severity	2.0	1.0	1.5	1.0	1.5	1.0	1.5	1.0
Worst Field Frequency, Maximum	a	1	a	1	a	1	5	3
Total Ratable Fields, Frequency, Maximum	b	1	b	1	b	1	c	3

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

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

C - Any number of lower ratable D-type thin fields per specimen is permitted.

3.4.2.1 Thickness of D-type heavy shall not exceed 0.0005 inch (12.7 µm).

3.4.2.2 A ratable 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.

3.4.3 Average grain size of bar, forgings and mechanical tubing shall be ASTM No. 5 or finer, determined in accordance with ASTM E112.

3.4.4 Hardenability of Each Heat

Hardenability shall be J 14/16 inch (22.23 mm) = 49 HRC minimum, and J 24/16 inch (38.10 mm) = 45 HRC minimum, determined on the standard end-quench test specimen in accordance with ASTM A255 except that the steel shall be normalized at 1700 °F ± 10 °F (927 °C ± 6 °C) and the specimen austenitized at 1550 °F ± 10 °F (843 °C ± 6 °C). Cast specimens do not need to be normalized.

3.4.5 Decarburization

3.4.5.1 Bars and tubing 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 3.4.5.4.

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

3.4.5.3 Where 3.4.5.1 or 3.4.5.2 are not applicable, decarburization of bars shall be not greater than 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	0.015
Over 0.375 to 0.500, incl	0.017
Over 0.500 to 0.625, incl	0.019
Over 0.625 to 1.000, incl	0.022
Over 1.000 to 1.500, incl	0.025
Over 1.500 to 2.000, incl	0.030
Over 2.000 to 2.500, incl	0.035
Over 2.500 to 3.000, incl	0.040
Over 3.000 to 4.000, 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	0.38
Over 9.52 to 12.70, incl	0.43
Over 12.70 to 15.88, incl	0.48
Over 15.88 to 25.40, incl	0.56
Over 25.40 to 38.10, incl	0.64
Over 38.10 to 50.80, incl	0.76
Over 50.80 to 63.50, incl	0.89
Over 63.50 to 76.20, incl	1.02
Over 76.20 to 101.60, incl	1.14

3.4.5.3.1 Limits for depth of decarburization of bars over 4.000 inches (101.60 mm) in nominal diameter or distance between parallel sides shall be as agreed upon by the purchaser and producer.

3.4.5.4 Where 3.4.5.1 or 3.4.5.2 are not applicable, decarburization of tubing shall be not greater than shown in Table 5.

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

Nominal Wall Thickness Inches	Total Depth of Decarburization Inches	Total Depth of Decarburization Inches
	ID	OD
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 of Decarburization Millimeters	Total Depth of Decarburization Millimeters
	ID	OD
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

3.4.5.5 Decarburization shall be evaluated by one of the two methods of 3.4.5.5.1 or 3.4.5.5.2.

3.4.5.5.1 Metallographic (Microscopic) Method

A cross section taken perpendicular to the surface shall be etched and examined metallographically at a magnification not to exceed 200X in accordance with ASTM E1077. The sample shall not show a layer of complete (ferrite) or partial decarburization exceeding the limits of Tables 4 and 5.

3.4.5.5.2 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. 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 Tables 4 and 5.

3.4.5.5.3 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.

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

3.4.6 Response to Heat Treatment for Bars, Forgings, and Mechanical Tubing

Specimens shall meet the following requirements after being normalized by heating to 1700 °F ± 10 °F (927 °C ± 6 °C), holding at heat for not less than 1 hour, and cooling in air; hardened by heating to 1550 °F ± 10 °F (843 °C ± 6 °C), holding at heat for 1 hour ± 0.2 hour, and quenching in oil, and heated to the required tempering temperature, held at heat for not less than 1 hour, and cooled in air.

3.4.6.1 Longitudinal Tensile Properties

Longitudinal tensile properties shall be as shown in Table 6. Testing in the longitudinal direction need not be performed on product tested in the transverse direction.

Table 6 - Minimum longitudinal tensile properties – response to heat treatment

Property	Value
Tensile Strength	220 ksi (1517 MPa)
Yield Strength at 0.2% Offset	185 ksi (1276 MPa)
Elongation in 4D or 2 inches (50 mm)	10%
Reduction of Area	35%

3.4.6.2 Transverse Tensile Properties

Shall be as shown in Table 7, determined on specimens selected and prepared in accordance with AMS2310. Transverse tensile requirements of Table 7 apply only to product that tensile specimens not less than 2.50 inches (63.5 mm) in length can be taken.

Table 7A - Minimum transverse tensile properties, inch/pound units – response to heat treatment

Cross-Sectional Area Square Inches	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Reduction of Area %, Average	Reduction of Area %, Individual
Up to 144, incl	220.0	185.0	35	30
Over 144 to 225, incl	220.0	185.0	30	25
Over 225	220.0	185.0	25	20

Table 7B - Minimum tensile properties, SI units

Cross-Sectional Area Square Centimeters	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Reduction of Area %, Average	Reduction of Area %, Individual
Up to 929, incl	1517	1276	35	30
Over 929 to 1452, incl	1517	1276	30	25
Over 1452	1517	1276	25	20

3.4.6.3 Unless otherwise specified, the strain rate for all tensile tests 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).

3.5 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.

3.5.1 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.

3.5.2 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.

3.5.3 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.

3.6 Tolerances

3.6.1 Bars

Tolerances for bars shall be in accordance with AMS2251.

3.6.2 Mechanical Tubing

Tolerances for mechanical tubing shall be in accordance with AMS2253

3.7 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 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), condition (see 3.3), macrostructure (see 3.4.1), micro-inclusion rating (see 3.4.2), average grain size (see 3.4.3), hardenability (see 3.4.4), decarburization (see 3.4.5), and tolerances (see 3.6) are acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Periodic Tests

Response to heat treatment (see 3.4.6), frequency-severity cleanliness rating (see 3.5.1) and grain flow of die forgings (see 3.5.3) 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

4.3.1 Sampling and testing of Bars, Forging Stock, and Mechanical Tubing shall be in accordance with AMS2370.

4.3.2 Sampling and testing of Forgings shall be in accordance with AMS2372.

4.4 Reports

4.4.1 The producer of bar, forgings, and mechanical tubing shall furnish with each shipment a report showing the producer's identity, country where the metal was melted (e.g., final melt in the case of metal processed by multiple melting operations), the results of tests for composition, macrostructure, micro-inclusion rating, and hardenability of each heat and for condition (hardness or tensile), and average grain size 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, AMS6340D, product form and size or part number, 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 (see 3.3.1.3).

4.4.3 The producer of forging stock 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) and the results of tests for composition, macrostructure, micro-inclusion rating and hardenability of each heat and the results of any additional property requirements imposed by the purchase order (see 8.8). This report shall include the purchase order number, heat number, AMS6340D, size, and quantity.