



AEROSPACE MATERIAL SPECIFICATION

Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AMS 6281E
Superseding AMS 6281D

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UNS G86300

STEEL TUBING, MECHANICAL

0.50Cr - 0.55Ni - 0.20Mo (0.28 - 0.33C) (SAE 8630)

1. SCOPE:

- 1.1 Form: This specification covers an aircraft-quality, low-alloy steel in the form of mechanical tubing.
- 1.2 Application: Primarily for parts with section thickness of 0.50 in. (12.7 mm) or less at the time of heat treatment which require a through-hardening steel capable of developing hardness as high as 35 HRC when properly hardened and tempered and for parts of greater thickness requiring proportionately lower hardness.
2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications (AMS) and Aerospace Standards (AS) shall apply. The applicable issue of other documents shall be as specified in AMS2350.

- 2.1 SAE Publications: Available from Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2253 - Tolerances, Carbon and Alloy Steel Tubing
AMS 2259 - Chemical Check Analysis Limits, Wrought Low-Alloy and Carbon Steels
AMS 2301 - Aircraft Quality Steel Cleanliness, Magnetic Particle Inspection Procedures
AMS 2350 - Standards and Test Methods
AMS 2370 - Quality Assurance Sampling of Carbon and Low-Alloy Steels, Wrought Products
Except Forgings and Forging Stock

2.1.2 Aerospace Standards:

AS 1182 - Standard Machining Allowance, Aircraft-Quality and Premium-Quality Steel Products

- 2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM A255 - End-Quench Test for Hardenability of Steel
ASTM A370 - Mechanical Testing of Steel Products
ASTM E112 - Estimating the Average Grain Size of Metals
ASTM E350 - Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron
ASTM E381 - Rating Macroetched Steel

- 2.3 Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Federal Standards:

Federal Test Method Standard No. 151 - Metals; Test Methods

2.3.2 Military Standards:

MIL-STD-163 - Steel Mill Products, Preparation for Shipment and Storage

3. TECHNICAL REQUIREMENTS:

SAE Technical Board rules provide that: "All technical reports, including standards approved and practices recommended, are advisory only. Their use by anyone engaged in industry or trade is entirely voluntary. There is no agreement to adhere to any SAE standard or recommended practice, and no commitment to conform to or be guided by any technical report. In formulating and approving technical reports, the Board and its Committees will not investigate or consider patents which may apply to the subject matter. Prospective users of the report are responsible for protecting themselves against infringement of patents."

- 3.1 **Composition:** Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E350, by spectrographic methods in accordance with Federal Test Method Standard No. 151, Method 112, or by other approved analytical methods:

	min	max
Carbon	0.28	0.33
Manganese	0.70	0.90
Silicon	0.20	0.35
Phosphorus	--	0.025
Sulfur	--	0.025
Chromium	0.40	0.60
Nickel	0.40	0.70
Molybdenum	0.15	0.25
Copper	--	0.35

- 3.1.1 **Check Analysis:** Composition variations shall meet the applicable requirements of AMS 2259.
- 3.2 **Condition:** Cold finished having hardness not higher than 25 HRC or equivalent except that tubing ordered hot finished shall have hardness not higher than 99 HRB or equivalent; hardness shall be determined in accordance with ASTM A370.
- 3.3 **Properties:** The product shall conform to the following requirements; hardness testing shall be performed in accordance with ASTM A370:
- 3.3.1 **Hardenability:** Shall be J35=5 min and J28=8 min, determined on the standard end-quench test specimen in accordance with ASTM A255 except that the steel shall be normalized at $1700^{\circ}\text{F} \pm 10$ ($829.4^{\circ}\text{C} \pm 5.6$) and the test specimen austenitized at $1525^{\circ}\text{F} \pm 25$ ($829.4^{\circ}\text{C} \pm 5.6$). The hardenability test is not required on tubing which will not yield a suitable specimen but the steel from which the tubing is made shall conform to the hardenability specified.
- 3.3.2 **Grain Size:** Predominantly 5 or finer with occasional grains as large as 3 permissible, ASTM E112, McQuaid-Ehn test.
- 3.3.3 **Macrostructure:** Visual examination of transverse sections from billets, tube rounds, or tubes etched in accordance with ASTM E381 in hot hydrochloric acid (1.1) at $160^{\circ} - 180^{\circ}\text{F}$ ($71.1^{\circ} - 82.2^{\circ}\text{C}$) for sufficient time to develop a well-defined macrostructure, shall show no imperfections, such as pipe, cracks, porosity, segregation, and inclusions, detrimental to fabrication or to performance of parts. Except as specified in 3.3.3.1, macrostructure shall be equal to or better than the following macrographs of ASTM E381:

Section Size		Macrographs
Square Inches	(Square Centimetres)	
Up to 36, incl	(Up to 232, incl)	S2 - R1 - C2
Over 36 to 100, incl	(Over 232 to 645, incl)	S2 - R1 - C3
Over 100	(Over 645)	As agreed upon

- 3.3.3.1 If tubes are produced directly from ingots or large blooms, transverse sections may be taken from tubes rather than tube rounds and macrostructure standards shall be as agreed upon by purchaser and vendor.
- 3.3.4 **Decarburization:**
- 3.3.4.1 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 Table I.

- 3.3.4.2 Allowable decarburization of pierced billets, of tubing for redrawing or forging, or of tubing ordered to specified microstructural requirements shall be as agreed upon by purchaser and vendor.
- 3.3.4.3 Decarburization of tubing to which 3.3.4.1 or 3.3.4.2 is not applicable shall be not greater than shown in Table I:

TABLE I

Nominal Wall Thickness Inches	<u>Depth of Decarburization, Inch</u>	
	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 I (SI)

Nominal Wall Thickness Millimetres	<u>Depth of Decarburization, Millimetres</u>	
	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

- 3.3.4.4 Decarburization shall be measured by the microscopic method or by Rockwell Superficial 30-N scale or equivalent hardness testing method on hardened but untempered specimens protected during heat treatment to prevent changes in surface carbon content. Depth of decarburization, when measured by a hardness method, is defined as the perpendicular distance from the surface to the depth under that surface below which there is no further increase in hardness. Such measurements shall be far enough away from any adjacent surface to be uninfluenced by any decarburization or lack of decarburization thereon.
- 3.3.4.4.1 When determining the depth of decarburization, it is permissible to disregard local areas provided the decarburization of such areas does not exceed the limits above by more than 0.005 in. (0.13 mm) and the width is 0.065 in. (1.64 mm) or less.

3.4 Quality:

- 3.4.1 Steel shall be aircraft quality conforming to AMS 2301.
- 3.4.2 Tubing shall be uniform in quality and condition, clean, sound and free from foreign materials and from internal and external imperfections detrimental to fabrication or to performance of parts.
- 3.4.2.1 Tubing ordered ground, turned, or polished shall be free from seams, laps, tears, and cracks open to the ground, turned, or polished surfaces.
- 3.4.2.2 Tubing ordered to surface conditions other than ground, turned, or polished shall, after removal of the standard machining allowance, be free from seams, laps, tears, cracks, and other defects exposed to the machined surfaces. Standard machining allowance shall be in accordance with AS 1182.

3.5 Sizes: Except when exact lengths or multiples of exact lengths are ordered, tubing will be acceptable in mill lengths of 6 - 20 ft (1.8 - 6.1 m) but not more than 10% of any shipment shall be supplied in lengths shorter than 10 ft (3 m).

3.6 Tolerances: Unless otherwise specified, tolerances shall conform to all applicable requirements of AMS 2253.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of tubing shall supply all samples and shall be responsible for performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.4. Purchaser reserves the right to perform such confirmatory testing as he deems necessary to ensure that the tubing conforms to the requirements of this specification.

4.2 Classification of Tests: Tests to determine conformance to all technical requirements of this specification are classified as acceptance or routine control tests.

4.3 Sampling: Shall be in accordance with AMS 2370.

4.4 Reports:

4.4.1 The vendor of tubing shall furnish with each shipment three copies of a report of the results of tests on each heat in the shipment for chemical composition, hardenability, grain size, macro-structure, and AMS 2301 frequency-severity rating. This report shall include the purchase order number, heat number, material specification number and its revision letter, size, and quantity from each heat.

4.4.2 The vendor of finished or semi-finished parts shall furnish with each shipment three copies of a report showing the purchase order number, material specification number and its revision letter, contractor or other direct supplier of material, part number, and quantity. When material for making parts is produced or purchased by the parts vendor, that vendor shall inspect each lot of material to determine conformance to the requirements of this specification, and shall include in the report a statement that the material conforms, or shall include copies of laboratory reports showing the results of tests to determine conformance.

4.5 Resampling and Retesting: Shall be in accordance with AMS 2370.

5. PREPARATION FOR DELIVERY:

5.1 Identification: Tubing shall be identified as follows:

5.1.1 Each tube over 0.500 in. (12.70 mm) in nominal OD or least width of flat surface shall be marked in a row of characters recurring at intervals not greater than 3 ft (914 mm) with AMS 6281E, heat number, and manufacturer's identification. The characters shall be of such size as to be clearly legible, shall be applied using a suitable marking fluid, and shall be capable of being removed in hot alkaline cleaning solution without rubbing. The markings shall have no deleterious effect of the tubing or its performance and shall be sufficiently stable to withstand normal handling.

5.1.2 Straight tubes 0.500 in. (12.70 mm) and under in nominal OD or least width of flat surface shall be securely bundled and identified by a durable tag marked with the purchase order number, AMS 6281E, heat number, nominal size, and manufacturer's identification and attached to each bundle or shall be boxed and the box marked with the same information.

5.2 Protective Treatment: Tubing ordered cold-drawn, cold-rolled, ground, turned, or polished shall be shall be coated with a suitable corrosion-preventive compound prior to shipment.