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**AEROSPACE
MATERIAL
SPECIFICATION**

Submitted for recognition as an American National Standard

AMS 6413G
Superseding AMS 6413F

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STEEL TUBING, MECHANICAL
0.80Cr - 1.8Ni - 0.25Mo (0.35 - 0.40C) (SAE 4337)

UNS G43370

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 sections 0.875 in. (22 mm) and under in nominal thickness at time of heat treatment which require a through-hardening steel capable of developing hardness as high as 50 HRC when properly hardened and tempered and also parts of greater thickness but 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 and Aerospace Standards shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2253 - Tolerances, Carbon and Alloy Steel Tubing

MAM 2253 - Tolerances, Metric, 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 Procedure

AMS 2350 - Standards and Test Methods

AMS 2370 - Quality Assurance Sampling of Carbon and Low-Alloy Steels, Wrought Products Except Forgings and Forging Stock

AMS 2806 - Identification, Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels and Corrosion and Heat Resistant Steels and Alloys

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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 - Determining Average Grain Size

ASTM E350 - Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron

ASTM E381 - Macroetch Testing, Inspection, and Rating Steel Products Comprising Bars, Billets, Blooms, and Forgings

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

2.3.1 Military Standards:

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

3. TECHNICAL REQUIREMENTS:

3.1 Composition: Shall conform to the following percentages by weight, \emptyset determined by wet chemical methods in accordance with ASTM E350 or by spectrographic or other analytical methods approved by purchaser:

	min	max
Carbon	0.35	0.40
Manganese	0.65	0.85
Silicon	0.15	0.35
Phosphorus	--	0.025
Sulfur	--	0.025
Chromium	0.70	0.90
Nickel	1.65	2.00
Molybdenum	0.20	0.30
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 \emptyset equivalent except that tubing ordered hot finished and annealed shall have hardness not higher than 99 HRB or equivalent; hardness shall be determined in accordance with ASTM A370.

3.3 Properties: Tubing shall conform to the following requirements; hardness testing shall be performed in accordance with ASTM A370:

3.3.1 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° - 180°F (70° - 80°C) for sufficient time to develop a well-defined macrostructure, shall show no pipe or cracks. Except as specified in 3.3.1.1, porosity, segregation, inclusions, and other imperfections shall be no worse than the following macrographs of ASTM E381.

Section Size		Macrographs
Square Inches	Square Centimetres	
Up to 36, incl	Up to 230, incl	S2 - R1 - C2
Over 36 to 100, incl	Over 230 to 645, incl	S2 - R2 - C3
Over 100	Over 645	As agreed upon

- 3.3.1.1 If tubes are produced directly from ingots or large blooms, transverse sections may be taken from tubes rather than tube rounds. Macrostructure standards for such tubes shall be as agreed upon by purchaser and vendor.
- 3.3.2 Grain Size: Predominantly 5 or finer with occasional grains as large as 3 permissible, determined in accordance with ASTM E112.
- 3.3.3 Hardenability: Shall be J50=10 min and J44=18 min, determined on the standard end-quench test specimen in accordance with ASTM A255 except that the steel shall be normalized at 1700°F + 10 (925°C + 5) and the test specimen austenitized at 1500°F + 10 (815°C + 5). 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.
- 3.3.4 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 tube rounds and 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.

3.3.4.3 (Continued):

TABLE I

Nominal Wall Thickness Inch	Depth of Decarburization Inch	
	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	Depth of Decarburization Millimetre	
	ID	OD
Up to 2.75, incl	0.20	0.38
Over 2.75 to 5.00, incl	0.25	0.50
Over 5.00 to 10.00, incl	0.30	0.62
Over 10.00 to 15.00, incl	0.38	0.75
Over 15.00 to 25.00, incl	0.42	0.88
Over 25.00	0.50	1.00

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 above limits by more than 0.005 in. (0.12 mm) and the width is 0.065 in. (1.65 mm) or less.

3.4 Quality:

3.4.1 Steel shall be aircraft quality conforming to AMS 2301.

3.4.2 Tubing, 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 tubing.

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 (2 - 6 m) but not more than 10% of any shipment shall be supplied in lengths shorter than 10 ft (3 m).
- 3.6 Tolerances: Shall conform to all applicable requirements of AMS 2253 or MAM 2253.
4. QUALITY ASSURANCE PROVISIONS:
- 4.1 Responsibility for Inspection: The vendor of tubing shall supply all samples for vendor's tests 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 sample and to perform any confirmatory testing deemed 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 tests and shall be performed on each heat or lot as applicable.
- 4.3 Sampling: Shall be in accordance with AMS 2370.
- 4.3.1 Samples for macrostructure (3.3.1) rating shall be full cross-sectional specimens obtained from the finished billet or suitable rerolled product representing the top and bottom of at least the first, middle, and last usable ingots of each heat.
- 4.4 Reports:
- 4.4.1 The vendor of tubing shall furnish with each shipment a report showing the results of tests for chemical composition, macrostructure, grain size, hardenability, and frequency-severity cleanliness rating of each heat. This report shall include the purchase order number, heat number, AMS 6413G, size, and quantity from each heat.
- 4.4.2 The vendor of finished or semi-finished parts shall furnish with each shipment a report showing the purchase order number, AMS 6413G, contractor or other direct supplier of tubing, part number, and quantity. When tubing for making parts is produced or purchased by the parts vendor, that vendor shall inspect each lot of tubing to determine conformance to the requirements of this specification and shall include in the report either a statement that the tubing conforms or copies of laboratory reports showing the results of tests to determine conformance.
- 4.5 Resampling and Retesting: Shall be in accordance with AMS 2370.