SAE Aerospace
An SAE International Group

# AEROSPACE MATERIAL SPECIFICATION

AMS 6413K

Issued DEC 1942
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Superseding AMS 6413J

## Steel, Mechanical Tubing
## 0.80Cr - 1.8Ni - 0.25Mo (0.35 - 0.40C) (SAE 4337)

(Composition similar to UNS G43370)

RATIONALE

AMS 6413K is a Five Year Review and update of this specification.

## 1. SCOPE

### 1.1 Form

This specification covers an aircraft-quality, low-alloy steel in the form of mechanical tubing.

### 1.2 Application

This product has been used typically for parts, 0.875 inch (22.22 mm) and under in section thickness at time of heat treatment, requiring a through-hardening steel capable of developing hardness as high as 50 HRC, and also parts of greater thickness but requiring proportionately lower hardness, 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.

### 2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), or www.sae.org.

| | |
|---|---|
| AMS 2253 | Tolerances, Carbon and Alloy Steel Tubing |
| AMS 2259 | Chemical Check Analysis Limits, Wrought Low-Alloy and Carbon Steels |
| AMS 2301 | Steel Cleanliness, Aircraft-Quality Magnetic Particle Inspection Procedure |
| AMS 2370 | Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel Wrought Products and Forging Stock |
| AMS 2806 | Identification, Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels and Corrosion and Heat-Resistant Steels and Alloys |
| AS1182 | Standard Machining Allowance, Aircraft-Quality and Premium Aircraft-Quality Steel Bars and Mechanical Tubing |





**TO PLACE A DOCUMENT ORDER:** **Tel: 877-606-7323 (inside USA and Canada)**
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**Fax: 724-776-0790**
**Email: CustomerService@sae.org**
**SAE WEB ADDRESS:** **http://www.sae.org**

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, or www.astm.org.

| | |
|---|---|
| ASTM A 255 | Determining Hardenability of Steel |
| ASTM A 370 | Mechanical Testing of Steel Products |
| ASTM E 112 | Determining Average Grain Size |
| ASTM E 350 | Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron |
| ASTM E 381 | Macroetch Testing Steel Bars, Billets, Blooms, and Forgings |
| ASTM E 384 | Microindentation Hardness of Materials |

3. TECHNICAL REQUIREMENTS

3.1 Composition

Shall conform to the percentages by weight shown in Table 1, determined by wet chemical methods in accordance with ASTM E 350, by spectrochemical methods, or by other analytical methods acceptable to purchaser.

TABLE 1 - COMPOSITION

| Element | 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, unless otherwise ordered, having hardness not higher than 25 HRC, or equivalent (See 8.2). Tubing ordered hot finished and annealed shall have hardness not higher than 99 HRB, or equivalent (See 8.2). Hardness shall be determined in accordance with ASTM A 370.

3.3 Properties

Tubing shall conform to the following requirements; hardness testing shall be performed in accordance with ASTM A 370:

3.3.1 Macrostructure

Visual examination of transverse full cross-sections from billets or tube rounds, etched in hot hydrochloric acid in accordance with ASTM E 381, shall show no pipe or cracks. Porosity, segregation, inclusions, and other imperfections shall be no worse than the macrographs of ASTM E 381 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 100, incl | Over 232 to 645, incl | S2 - R2 - C3 |

3.3.2 Average Grain Size

Shall be ASTM No. 5 or finer, determined in accordance with ASTM E 112.

3.3.3 Hardenability

Shall be J 10/16 inch (15.9 mm) = 50 HRC minimum and J 18/16 inch (28.6 mm) = 18 HRC minimum, determined on the standard end-quench test specimen in accordance with ASTM A 255 except that the steel shall be normalized at 1700 °F ± 10 (927 °C ± 6) and the test specimen austenitized at 1500 °F ± 10 (816 °C ± 6).

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 3.

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 3.

TABLE 3A - MAXIMUM DECARBURIZATION, INCH/POUND UNITS

| Nominal Wall Thickness Inches | Total Depth of Decarburization Inch ID | Total Depth of Decarburization Inch 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 3B - MAXIMUM DECARBURIZATION, SI UNITS

| Nominal Wall Thickness Millimeters | Total Depth of Decarburization Millimeters ID | Total Depth of Decarburization Millimeters 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 metallographic method, by HR 30N scale hardness testing method, or by a traverse method using microhardness testing in accordance with ASTM E 384. The hardness method(s) shall be conducted on a hardened but untempered specimen 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 on the adjacent surface. In case of dispute, the depth of decarburization determined using the microhardness traverse method shall govern.

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 inch (0.13 mm) and the width is 0.065 inch (1.65 mm) or less.

3.4 Quality

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.

3.4.1 Steel shall be aircraft-quality conforming to AMS 2301.

3.4.2 Mechanical tubing ordered hot rolled or cold drawn, or ground, turned, or polished shall, after removal of the standard machining allowance in accordance with AS1182, be free from seams, laps, tears, and cracks open to the ground, turned, or polished surface.

3.5 Tolerances

Shall conform to all applicable requirements of AMS 2253.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The vendor of the tubing shall supply all samples for vendor's tests and shall be responsible for the performance of all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the tubing conforms to specified requirements.

4.2 Classification of Tests

All technical requirements are acceptance tests and shall be performed on each heat or lot as applicable.

4.3 Sampling and Testing

Shall be in accordance with AMS 2370.

4.4 Reports

The vendor shall furnish with each shipment a report showing the results of tests for composition, macrostructure, hardenability, and frequency-severity cleanliness rating of each heat and for hardness 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, AMS 6413K, size, and quantity.

4.5 Resampling and Retesting

Shall be in accordance with AMS 2370.

5. PREPARATION FOR DELIVERY

5.1 Sizes

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

5.2 Identification

Shall be in accordance with AMS 2806.

5.3 Protective Treatment

Tubing ordered cold drawn, cold rolled, ground, turned, or polished shall be protected from corrosion prior to shipment.