Society of Automotive Engineers, Inc.
TWO PENNSYLVANIA PLAZA, NEW YORK, N.Y. 10001

AEROSPACE MATERIAL SPECIFICATION

AMS 6441D
Superseding AMS 6441C
Issued 7-1-45
Revised 11-1-69

STEEL TUBING, MECHANICAL
1.45Cr (0.98 - 1.10C) (SAE 52100)
Bearing Quality

1. ACKNOWLEDGMENT: A vendor shall mention this specification number and its revision letter in all quotations and when acknowledging purchase orders.

2. APPLICATION: Primarily for parts requiring a through-hardening steel usually with hardness of approximately Rockwell C 60 and section thickness less than 0.500 inch.

3. COMPOSITION:

	min	max
Carbon	0.98	1.10
Manganese	0.25	0.45
Silicon	0.20	0.35
Phosphorus	--	0.025
Sulfur	--	0.025
Chromium	1.30	1.60
Nickel	--	0.25
Molybdenum	--	0.06
Copper	--	0.35

3.1 Check Analysis: Composition variations shall meet the requirements of the latest issue of AMS 2259, paragraph titled "Low Alloy Steels".

4. CONDITION: Unless otherwise specified, tubing shall be supplied cold finished. The product shall ø be in a machinable condition with a microstructure of spheroidized cementite in a ferrite matrix. Tubing ordered hot finished shall have hardness not higher than Rockwell B 95 or equivalent.

5. TECHNICAL REQUIREMENTS: When ASTM methods are specified for determining conformance to the following requirements, tests shall be conducted in accordance with the issue of the ASTM method listed in the latest issue of AMS 2350.

5.1 Hardenability: Specimens shall be full sections of the tubing, shall have wall thickness of 0.5 in. or less with wall thicknesses over 0.5 in. being turned to 0.5 in., and shall be ground on both faces normal to the axis so that length is 0.625 inch. The specimens shall be protected by suitable means, or treated in an atmosphere, to minimize scaling and prevent either carburization or decarburization during heat treatment. The specimens shall be placed in a furnace which is at 1525 F ± 10 (829.4 C ± 5.6), allowed to heat to 1525 F ± 10 (829.4 C ± 5.6), held at heat for 20 min., and quenched in commercial paraffin oil (100 SUS at 100 F (37.8 C)) at room temperature. The hardened specimens shall have substantially uniform hardness not lower than Rockwell C 63 at any point below any permissible decarburization.

5.2 Decarburization:

5.2.1 Tubing ordered ground, turned, or polished shall be free from decarburization on the ground, turned, or polished surfaces. Inside decarburization of such tubing shall not exceed the maximum depth specified in 5.2.3.

5.2.2 Allowable decarburization of pierced billets or of tubing for redrawing or forging or tubing ordered to specified microstructural requirements shall be as agreed upon by purchaser and vendor.

5.2.3 Decarburization of tubing to which 5.2.1 or 5.2.2 is not applicable shall be not greater than the following:

Nominal Outside Diameter Inches	Depth of Decarburization Inch per Side	
	Hot Finished	Cold Finished
Up to 1.000, incl	0.012	0.010
Over 1.000 to 2.000, incl	0.020	0.014
Over 2.000 to 3.000, incl	0.030	0.019
Over 3.000 to 4.000, incl	0.035	0.024
Over 4.000 to 5.000, incl	0.040	0.028

5.2.3.1 Limits for depth of decarburization of tubing over 5.000 in. in nominal OD shall be as agreed upon by purchaser and vendor.

5.2.4 Unless otherwise agreed upon by purchaser and vendor, decarburization shall be measured by the microscopic method or by Rockwell Superficial 30-N scale hardness method, 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.

5.3 Inclusion Rating: Steel from which the product is produced shall be subjected to two of the following three methods of inclusion rating. The methods of test to be used and frequency of testing shall be as agreed upon by purchaser and vendor. Specimens shall represent the cross section of billet stock taken from the top and bottom of at least the first ingot, middle ingot, and last usable ingot.

5.3.1 Macroetch: Specimens shall be macroetched in hot hydrochloric acid (1:1) at 160 - 180 F (71.1 - 82.2 C) for sufficient time to develop a well defined macrostructure. Such specimens shall show freedom from pipe, excessive porosity, segregation, and injurious inclusions.

5.3.2 Fracture: Specimens, approximately 0.375 in. in thickness, shall be normalized, annealed, hardened, and fractured. The fractured specimens shall show freedom from pipe, porosity, excessive segregation, and injurious inclusions. No nonmetallic inclusion over 1/8 in. in length and not more than one nonmetallic inclusion 1/16 - 1/8 in. in length shall be evident on the fractured surfaces of two or fewer specimens. If more than two of the specimens exceed these limits, the heat shall be retested after additional discard or shall be rejected.

5.3.3 Micro-Inclusion: Radial specimens, approximately 0.28 sq in. in surface area cut midway between center and surface of hardened fracture samples, shall be polished, on a face longitudinal to the direction of rolling, for micro-inclusion rating in accordance with the Jernkontoret chart in ASTM E45. Two-thirds of all specimens and at least one from each ingot tested, as well as the average of all specimens, shall not exceed the following limits when evaluated in accordance with ASTM E45, Method A.

Type	Inclusion Rating			
	A	B	C	D
Thin	2.0	2.0	2.0	1.5
Heavy	1.5	1.5	1.5	1.5