NOTICE OF ADOPTION

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AMS 5584

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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 5584

Issued 1 JUL 1993

Submitted for recognition as an American National Standard

STEEL, CORROSION AND HEAT RESISTANT, SEAMLESS AND WELDED HYDRAULIC TUBING
17Cr - 12Ni - 1.5Mo C max
Cold Drawn, One Eighth-Hard Temper

UNS S30403

1. SCOPE:

1.1 Form:

This specification covers a corrosion and heat resistant steel in the form of two types of thin-wall, close-tolerance tubing 0.125 to 2.00 inches (3.18 to 50.8 mm), inclusive, in nominal OD.

1.2 Application:

This tubing has been used typically in high pressure hydraulic or pneumatic systems assembled with brazed joints, but usage is not limited to such applications.

1.3 Classification:

The tubing covered by this specification is classified as follows:

Class 1 - Seamless and Drawn
Class 2 - Welded and Drawn

1.3.1 Unless a specific class is ordered, either Class 1 or Class 2 may be supplied.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2248 Chemical Check Analysis Limits, Wrought Corrosion and Heat Resistant Steels and Alloys, Maraging and Other Highly-Alloyed Steels, and Iron Alloys
AMS 2371 Quality Assurance Sampling and Testing, Corrosion and Heat Resistant Steels and Alloys, Wrought Products and Forging Stock
AMS 2645 Fluorescent Penetrant Inspection
AMS 2807 Identification, Carbon and Low-Alloy Steels, Corrosion and Heat Resistant Steels and Alloys, Sheet, Strip, Plate, and Aircraft Tubing

2.2 ASTM Publications:

Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM A 262 Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels
ASTM A 370 Mechanical Testing of Steel Products
ASTM A 450 General Requirements for Carbon, Ferritic Alloy, and Austenitic Alloy Steel Tubes
ASTM A 450M General Requirements for Carbon, Ferritic Alloy, and Austenitic Alloy Steel Tubes (Metric)
ASTM E 112 Determining the Average Grain Size
ASTM E 353 Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys
ASTM E 426 Electromagnetic (Eddy Current) Testing of Seamless and Welded Tubular Products, Austenitic Stainless Steel and Similar Alloys

2.3 U.S. Government Publications:

Available from DODSSP Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage
MIL-STD-753 Corrosion-Resistant Steel Parts, Sampling, Inspection, and Testing for Surface Passivation
MIL-STD-6866 Inspection, Liquid Penetrant

2.4 ANSI Publications:

Available from American National Standards Institute, Inc., 11 West 42nd Street, New York, NY 10036.

ANSI B46.1 Surface Texture

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 353, by spectrochemical methods, or by other analytical methods acceptable to purchaser.

TABLE 1 - Composition

Element	min	max
Carbon	--	0.03
Manganese	--	2.00
Silicon	--	1.00
Phosphorus	--	0.04
Sulfur	--	0.03
Chromium	16.0	18.0
Nickel	10.0	14.0
Molybdenum	2.0	3.0
Copper	--	0.75

3.1.1 Check Analysis: Composition variations shall meet the requirements of AMS 2248.

3.2 Condition:

Solution heat treated free from continuous carbide network, cold drawn, pickled as required, and passivated.

3.3 Fabrication:

3.3.1 Class 1: Tubing shall be produced by a seamless process.

3.3.2 Class 2: Tubing shall be produced by the gas-metal-arc, gas-tungsten-arc, or plasma arc process and subsequently drawn. Tubing shall contain no more than one longitudinal weld and no circumferential welds. Tubing shall be processed to remove any dimensional indication of the presence of welds.

3.3.3 Tensile properties shall be obtained by cold working and not by heat treatment. A minimum reduction of 30% is recommended for Class 2 tubing.

3.3.4 Surface Finish: The external and internal surface finishes shall not be rougher than 32 microinches (0.8 μm) and 63 microinches (1.6 μm) respectively, determined in accordance with ANSI B 46.1 and may be produced by any method yielding the specified surface condition that will not affect limits of wall thickness or corrosion resistance, with the exception that grinding is not acceptable. A light polish to improve surface appearance may be employed.

3.4 Properties:

Tubing shall conform to the following requirements; tensile and bend testing shall conform to ASTM A 370:

3.4.1 Tensile properties shall be as specified in Table 2 and 3.4.1.1.

TABLE 2 - Tensile Properties

Property	Value
Tensile Strength	105 - 140 ksi (724 - 965 MPa)
Yield Strength at 0.2% offset	75.0 - 100 ksi (517 - 689 MPa)
Elongation, minimum	
Full Section	20%
Strip	15%

3.4.1.1 Tubing under 0.50 inch (12.7 mm) in nominal OD and having wall thickness of 0.02 inch (0.5 mm) or under may have elongation as low as 16% when tested in full section.

3.4.2 Bending: Tubes shall show no evidence of cracking or splitting when bent cold around a suitable mandrel of diameter equal to the bend factor shown in Table 3 times the nominal OD. During test, flattening shall not exceed 5% of the minimum OD. An appropriate internal mandrel may be used. For Class 2 tubing, the weld shall be at the outside of the bend. A suitable etchant may be used to locate the weld.

TABLE 3 - Bending Parameters

Nominal OD Inches	Nominal OD Millimeters	Bend Factor
0.25 to 1.00, incl	6.4 to 25.4, incl	3
Over 1.00 to 1.75, incl	Over 25.4 to 44.4, incl	4
Over 1.75 to 2.00, incl	Over 44.4 to 50.8, incl	5

3.4.2.1 Flattening during testing is defined in Equation 1:

$$\% \text{ Flattening} = \frac{(\text{max OD} - \text{min OD})}{\text{nominal OD}} \times 100 \qquad \text{(Eq. 1)}$$

3.4.3 Susceptibility to Intergranular Attack: Tubing shall pass the copper-copper sulfate-sulfuric acid test of ASTM A 262, Practice E, except that after exposure, tubing shall be tested in accordance with the flattening test requirements of ASTM A 450. Samples shall be taken from tubing after final annealing but may be taken prior to cold working.

3.4.4 Grain Size: Shall be ASTM No. 6 or finer, determined in accordance with ASTM E 112, except that in case of dispute, the Heyn Intercept method of ASTM E 112 shall be used.

3.4.5 Passivity: Surfaces shall show no reactions indicating active surfaces when subjected to either the copper sulfate test or the potassium ferrocyanide-nitric acid test defined in MIL-STD-753.

3.4.6 Pressure Resistance: When specified, tubing shall withstand for not less than one minute without leaking or developing bulges, pinholes, cracks, or other defects except that a diametric permanent set not exceeding 0.002 inch/inch (0.51 mm/mm) is permissible, an internal hydrostatic pressure (P) or 15.0 ksi (103 MPa), whichever is less. P shall be determined from Equation 2:

$$P = S \frac{(D^2 - d^2)}{(D^2 + d^2)} \qquad \text{(Eq. 2)}$$

where: P = Test pressure in ksi (MPa)
S - Minimum specified yield strength in ksi (MPa)
D - Nominal OD (nominal OD plus tolerance)
d - nominal ID (D minus twice minimum wall thickness)

3.4.7 Flarability: Tubing shall withstand flaring at room temperature, without the formation of cracks or other visible defects, by being forced axially with steady pressure over a hardened and polished tapered steel pin having a 74-degree included angle to produce a flare having a permanent expanded OD not less than specified in Table 4.

TABLE 4A - Minimum Flarability, Inches

Nominal OD	Expanded OD	Nominal OD	Expanded OD
0.250	0.359	0.750	0.937
0.312	0.421	1.000	1.187
0.375	0.484	1.250	1.500
0.500	0.656	1.500	1.721
0.625	0.871	1.750	2.106
		2.000	2.356

TABLE 4B - Minimum Flarability, Millimeters

Nominal OD	Expanded OD	Nominal OD	Expanded OD
6.35	9.12	19.05	23.80
7.92	10.69	25.40	30.15
9.52	12.29	31.75	38.10
12.70	16.66	38.10	43.71
15.88	19.84	44.45	53.49
		50.80	59.84

3.4.7.1 Tubing with nominal OD between any two standard sizes given in Table 4 shall take the same percentage flare as shown for the larger of the two sizes.

3.5 Quality:

3.5.1 Tubing, as received by purchaser, shall be uniform in quality and condition and shall have a finish conforming to the best practice for high quality aircraft tubing. It shall be smooth and free from surface films, discoloration, scale, grease, oil, or other foreign matter. It shall be free from burrs, seams, tears, grooves, cracks, laminations, dents, crimps, slivers, pits, and other imperfections detrimental to usage of the tubing.

3.5.2 Mechanically induced isolated minor surface imperfections, such as handling marks, straightening marks, light mandrel or die marks, shall not exceed the values specified in Table 5.

TABLE 5A - Maximum Depth of Discontinuity, Inches

Nominal Wall Thickness	Depth of Discontinuity
Up to 0.020, incl	10% of nominal wall thickness
Over 0.020 to 0.030, incl	0.002
Over 0.030 to 0.040, incl	0.0025
Over 0.040 to 0.074, incl	0.003

TABLE 5B - Maximum Depth of Discontinuity, Millimeters

Nominal Wall Thickness	Depth of Discontinuity
Up to 0.51, incl	10% of nominal wall thickness
Over 0.51 to 0.76, incl	0.05
Over 0.76 to 1.02, incl	0.064
Over 1.02 to 1.88, incl	0.08

3.5.2.1 Discontinuities having large root radii plainly visible to the unaided eye, whose surfaces blend into the nominal tubing surfaces, and whose depths do not exceed the maximum depth of acceptable discontinuity or violate wall thickness tolerances, are acceptable. Other surface discontinuities shall be removed by polishing or buffing within the limits of wall thickness tolerances or maximum depth of acceptable discontinuity.

3.5.3 Tubing shall be free from grease or other foreign matter. Metallic flakes or particles shall not be collected by a clean white cloth or wad of cotton drawn through the length of the bore of a test sample. Discoloration of the cloth or wad of cotton, without the presence of flakes or particles, is acceptable.

3.5.4 When standards for acceptance are specified by purchaser, tubing shall be subjected to fluorescent penetrant inspection in accordance with AMS 2645 or MIL-STD-6866.

3.5.5 Class 1 tubing shall be eddy current inspected in accordance with ASTM E 426 using calibration notches specified in ASTM A 450 except that the standard used shall contain simulated flaws not greater than those shown in Table 5.

3.5.6 Class 2 tubing shall be subjected to ultrasonic inspection. Ultrasonic inspection indications for Class 2 tubing shall not be greater than those from the calibration notch when the signal amplitude from the calibration notch is set at not less than 50% of full scale. The noise amplitude during inspection of tubes shall not be greater than 25% of full scale. Ultrasonic inspection shall be conducted as follows:

3.5.6.1 Tubing shall be inspected by ultrasonic, immersion, pulse-echo methods. A calibration shall be performed at the start of operations and periodically reestablished at least once each hour of continuous operation. Separate calibration standards as in 3.5.6.2 shall be used for each tubing size. The arrangement of transducers shall be such that no cross talk is encountered. Tube supporting equipment shall provide in-line stability throughout the complete length of each tube. For the disclosure of discontinuities, a shear mode shall be employed. The equipment shall be such that transducers functioning in a clockwise and counterclockwise direction may be separately gated and recorded. The pulse rate of the equipment shall provide 100% coverage at maximum tube rotational rates. The helix feed angle shall be such that a rejectable signal from the longitudinal calibration notch is produced by both transducers.

3.5.6.2 Calibration Standards: Longitudinal calibration notches for the shear mode shall have a depth not greater than 0.002 inch (0.05 mm) or 5% of the nominal wall thickness, whichever is greater. The length of the calibration notches on both ID and OD surfaces parallel to the tube axis shall be 0.125 inches ± 0.002 (3.18 mm ± 0.05).

3.5.6.2.1 The placement of calibration notches in each standard shall be such that water-travel-distance, shear-angle, helix angle, and equipment gain as established during calibration, remain identical during production applications. Calibration notches may be produced by electrodischarge machining.

3.6 Tolerances:

3.6.1 Diameter: The variation between measured outside diameter (OD), including ovality, and nominal dimensions of tubes shall not exceed the values specified in Table 6. Ovality is the difference between the maximum and minimum diameters in any one section of tubing.

TABLE 6A - Tolerances, OD, Inches

	Nominal OD	Tolerance
	0.25 to 1.00, incl	+0.003 -0.000
Over	1.00 to 1.63, incl	+0.006 -0.000

TABLE 6B - Tolerances, OD, Millimeters

	Nominal OD	Tolerance
	6.4 to 25.4, incl	+0.08 -0.000
Over	25.4 to 41.4, incl	+0.15 -0.000

3.6.2 Wall Thickness: Variations shall not exceed +15%, -0 of nominal wall thickness.

3.6.3 Length: Cut to length tubing shall not vary from the length ordered by more than +1/2 inch (+12.7 mm), -0 including flare.

3.6.4 Straightness: Departure from straightness shall not exceed 0.06 inch (1.5 mm) in a length of 3 feet (1 m).

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. Purchaser reserves the right to sample and to perform any confirmation testing deemed necessary to ensure that the tubing conforms to the requirements of this specification.