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400 Commonwealth Dr., Warrendale, PA 15096

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 5564

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Revised

STEEL TUBING, CORROSION RESISTANT
19Cr - 10Ni (SAE 30304)
High Pressure Hydraulic, Welded Plus Ultrasonically Tested or Seamless
UNS S30400

1. SCOPE:

1.1 Form: This specification covers a corrosion-resistant steel in the form of tubing produced by drawing seamless hollows or by drawing welded hollows and ultrasonically testing.

1.2 Application: Primarily for high pressure hydraulic lines requiring corrosion resistance. Maximum service temperature should not exceed 700°F (370°C).

1.3 Classification: The tubing covered by this specification is classified as follows:

Class 1 - Seamless
Class 2 - Welded, drawn, and ultrasonically inspected

1.3.1 Either Class 1 or Class 2 may be supplied unless a specific class is ordered.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications 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 2243 - Tolerances, Corrosion and Heat Resistant Steel Tubing
MAM 2243 - Tolerances, Metric, Corrosion and Heat Resistant Steel Tubing
AMS 2248 - Chemical Check Analysis Limits, Wrought Corrosion and Heat Resistant Steels and Alloys, Maraging and Other Highly-Alloyed Steels, and Iron Alloys
AMS 2350 - Standards and Test Methods
AMS 2371 - Quality Assurance Sampling of Corrosion and Heat Resistant Steels and Alloys, Wrought Products Except Forgings and Forging Stock

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

ASTM A262 - Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels
ASTM A370 - Mechanical Testing of Steel Products
ASTM E112 - Determining Average Grain Size
ASTM E353 - Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys

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

2.4 ANSI Publications: Available from American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.

ANSI B46.1 - Surface Texture

3. TECHNICAL REQUIREMENTS:

3.1 Composition: Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E353 or by spectrographic or other analytical methods approved by purchaser:

	min	max
Carbon	--	0.08
Manganese	--	2.00
Silicon	--	1.00
Phosphorus	--	0.045
Sulfur	--	0.030
Chromium	18.00	20.00
Nickel	8.00	12.00
Molybdenum	--	0.75
Copper	--	0.75

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

3.2 Condition: Cold drawn.

3.3 Fabrication: Tubing shall be produced by a seamless or a welded and drawn process. The specified tensile properties shall be obtained by cold working and not by heat treatment (annealing). Surface finishes shall be not rougher than 32 microin. (0.8 μm) for OD and 63 microin. (1.6 μm) for ID, determined in accordance with ANSI B46.1, and may be produced by any method which will provide the required surface condition and which will not affect limits of wall thickness or corrosion resistance, with the exception that centerless ground finish is not acceptable. A light polish to improve surface appearance may be employed. Passivation shall follow any polishing treatment.

3.3.1 Welded (Class 2) tubing shall be processed to eliminate any dimensional indication of the weld and shall be ultrasonically tested to detect and discard any tubing containing defects exceeding calibration notches (See 3.5.3).

3.4 Properties: Tubing shall conform to the following requirements; tensile and bend testing shall be performed in accordance with ASTM A370:

3.4.1 Tensile Properties: Shall be as specified in Table 1.

TABLE I

Nominal OD Inch	Nominal Wall Thickness Inch	Tensile Strength psi	Yield Strength at 0.2% Offset psi	Elongation in 2 in. (Full Tube) %, min
Up to 0.125, incl	All	95,000 - 130,000	--	--
Over 0.125 to 0.188, incl	Up to 0.016, incl	95,000 - 130,000	60,000 - 90,000	20
	Over 0.016	95,000 - 130,000	60,000 - 90,000	25
Over 0.188	All	105,000 - 140,000	75,000 - 110,000	20

TABLE I(SI)

Nominal OD Millimetre	Nominal Wall Thickness Millimetre	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 50 mm (Full Tube) %, min
Up to 3.00, incl	All	655 - 895	--	--
Over 3.00 to 4.75, incl	Up to 0.40, incl	655 - 895	415 - 620	20
	Over 0.40	655 - 895	415 - 620	25
Over 4.75	All	725 - 965	515 - 760	20

3.4.2 Flarability: Tubing shall withstand flaring at room temperature, without 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 deg included angle to produce a flare having a permanent expanded OD not less than that specified in Table II.

TABLE II

Nominal OD Inches	Expanded OD Inches	Nominal OD Inches	Expanded OD Inches
0.125	0.200	0.750	0.937
0.188	0.290	1.000	1.187
0.250	0.359	1.250	1.500
0.312	0.421	1.500	1.721
0.375	0.484	1.750	2.106
0.500	0.656	2.000	2.356
0.625	0.781	2.500	2.856
		3.000	3.356

TABLE II(SI)

Nominal OD Millimetres	Expanded OD Millimetres	Nominal OD Millimetres	Expanded OD Millimeters
3.18	5.08	19.05	23.80
4.78	7.37	25.40	30.15
6.35	9.12	31.75	38.10
7.92	10.69	38.10	43.71
9.52	12.29	44.45	53.49
12.70	16.66	50.80	59.84
15.88	19.84	63.50	72.54
		76.20	85.24

3.4.2.1 Tubing with nominal OD between any two standard sizes given in 3.4.2 shall be flared to the same percentage increase of OD as shown for the larger of the two sizes.

3.4.2.2 Flarability requirements for tubing having nominal OD greater than 3.000 in. (76.20 mm) or less than 0.125 in. (3.18 mm) shall be as agreed upon by purchaser and vendor.

3.4.3 Pressure Resistance: The tubing shall show no bulges, leaks, pinholes, cracks, or other defects when subjected to an internal hydrostatic pressure (P) except that a diametric permanent set of 0.002 in. per in. (0.002 mm/mm) of diameter is acceptable. The hydrostatic pressure (P) shall be determined from the equation:

$$P = S \frac{D^2 - d^2}{D^2 + d^2}$$

where, P = Test pressure in psi (MPa)
S = Minimum yield strength from Table I
D = Nominal OD
d = Nominal ID

3.4.4 Embrittlement: Tubing, as received, shall pass the copper/copper sulfate/sulfuric acid test performed in accordance with ASTM A262, Practice E, without evidence of intergranular attack. After exposure, full cross-sectional specimens of tubing 0.625 in. (15.75 mm) and under in nominal OD shall be flattened to a total thickness under load of three times the wall thickness of the tubing, and 1-in. (25-mm) long specimens of tubing over 0.625 in. (15.75 mm) in nominal OD shall be split and bent 180 deg, with outside surface of tube on inside of bend, around a diameter equal to four times the nominal wall thickness without showing cracks or other defects. In either flattening or bending, the fold shall be made parallel to the axis of the tube and shall coincide with the weld in welded (Class 2) tubing if the weld is visible.

3.4.4.1 Care should be exercised in differentiating between cracks caused by intergranular attack and cracks resulting from superficial yielding or rupturing of the surface of the specimens. Doubt as to whether superficial cracking is caused by intergranular attack should be resolved by metallographic examination.

3.4.5 Microstructure: Tubing shall reveal no continuous carbide precipitation when electrolytically etched in a 10% sodium cyanide solution and examined microscopically at 500X magnification. The presence of some discontinuous intergranular carbide precipitation shall not be considered detrimental if the technical requirements of 3.4.4 and 3.4.7 are met.

3.4.6 Grain Size: Shall be 5 or finer determined by comparison of a specimen, polished and electrolytically etched in a 10% oxalic acid solution, with the chart in ASTM E112, using 100X magnification.

3.4.7 Macro-Etching: Tubing, 0.625 in. (15.75 mm) and under in nominal OD, shall withstand immersion for 1 hr in a solution containing 10% nitric acid and 2% hydrofluoric acid by weight at 140°F ± 5 (60°C ± 3) without formation of a pebbly appearance on either ID or OD surface. In case of question as to the acceptability of the surface appearance produced by etching, the tubing shall be considered satisfactory if the requirements of 3.4.4, 3.4.5, and 3.4.6 are met.

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 heavy scale or oxide, burrs, seams, tears, grooves, laminations, slivers, pits, and other imperfections detrimental to usage of the tubing. Surface imperfections such as handling marks, straightening marks, light mandrel and die marks, shallow pits, and scale pattern will not be considered injurious if the imperfections are removable within the tolerances specified for wall thickness but removal of such imperfections is not required.

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

3.5.3 Ultrasonic inspection indications for Class 2 welded and drawn tubing shall be not 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 be not greater than 25% of full scale. Ultrasonic inspection shall be conducted as follows:

3.5.3.1 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 3.5.3.2 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 on two consecutive powered turns of the tube.

3.5.3.2 Calibration Standards: Longitudinal calibration notches for the shear mode shall have a depth not greater than 0.002 in. (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 0.250 in. ± 0.010 (6.25 mm ± 0.28).

3.5.3.2.1 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 Sizes: Except when exact lengths or multiples of exact lengths are ordered, straight tubing will be acceptable in mill lengths of 5 - 24 ft (1.5 - 7.3 m) but at least 70% of any shipment shall be supplied in lengths longer than 17 ft (5.2 m) and 90% longer than 12 ft (3.7 m).

3.7 Tolerances: Shall conform to all applicable requirements of AMS 2243 or MAM 2243.

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:

4.2.1 Acceptance Tests: Tests to determine conformance to requirements for composition (3.1), tensile properties (3.4.1), microstructure (3.4.5), grain size (3.4.6), ultrasonic quality of Class 2 tubing (3.5.3), and tolerances (3.7) are classified as acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Periodic Tests: Tests to determine conformance to requirements for surface roughness (3.3), flarability (3.4.2), pressure resistance (3.4.3), embrittlement (3.4.4), and macro-etching (3.4.7) are classified as periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.3 Sampling: Shall be in accordance with AMS 2371 and the following; a lot shall be all tubing of one size made from one heat of steel and presented for vendor's inspection at one time.

4.3.1 Specimens for flarability test (3.4.2) shall be full tubes or sections cut from tubes. The end of the specimen to be flared shall be cut square, with the cut end smooth and free from burrs, but not rounded.

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 of each heat and for tensile properties of each lot, and stating that the tubing conforms to the other acceptance test requirements of this specification. This report shall include the purchase order number, heat number, AMS 5564, size, and quantity from each heat.