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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 5569A

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Superseding AMS 5569

Steel, Corrosion and Heat Resistant, Seamless and Welded Hydraulic Tubing 19Cr - 9.5Ni - 0.03C max Cold Drawn, 1/8 Hard Temper

(Composition similar to 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 may be supplied.

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 canceled and no superseding document has been specified, the last published issue of that document shall apply.

QUESTIONS REGARDING THIS DOCUMENT: (724) 772-7161 FAX: (724) 776-0243
TO PLACE A DOCUMENT ORDER: (724) 776-4970 FAX: (724) 776-0790
SAE WEB ADDRESS: http://www.sae.org

2.1 SAE Publications:

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

AMS 2248	Chemical Check Analysis Limits, 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, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM A 262	Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels
ASTM A 370	Mechanical Testing of Steel Products
ASTM E 112	Determining 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) Examination of Seamless and Welded Tubular Products, Austenitic Stainless Steel and Similar Alloys
ASTM E 1417	Liquid Penetrant Examination

2.3 U.S. Government Publications:

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

MIL-STD-753	Corrosion-Resistant Steel Parts, Sampling, Inspection, and Testing for Surface Passivation

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	18.0	20.0
Nickel	8.0	11.0
Molybdenum	--	0.50
Copper	--	0.75

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

3.2 Condition:

Solution heat treated, 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 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 be performed in accordance with ASTM A 370:

3.4.1 Tensile properties shall be as shown 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 - 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 44.5, incl	4
Over 1.75 to 2.00, incl	Over 44.5 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. Samples shall be taken from tubing after final annealing prior to cold working.

3.4.4 Average Grain Size: Shall be ASTM No. 6 or finer, determined in accordance with ASTM E 112. 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, an internal hydrostatic pressure (P) as defined below, or 15.0 ksi, whichever is less. There shall not be any leaking or developing bulges, pinholes, cracks, or other defects except that a diametric permanent set not exceeding 0.002 inch/inch (0.002 mm/mm) is permissible. 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 = 75 ksi (517 MPa) yield strength

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 shown in Table 4.

TABLE 4A - Minimum Flarability, Inch/Pound Units

Nominal OD Inches	Expanded OD Inches	Nominal OD Inches	Expanded OD Inches
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	0.781	1.750	2.106
		2.000	2.356

TABLE 4B - Minimum Flarability, SI Units

Nominal OD Millimeters	Expanded OD Millimeters	Nominal OD Millimeters	Expanded OD Millimeters
6.35	9.12	19.05	23.80
7.92	10.69	25.40	30.15
9.52	12.29	31.75	38.10
12.50	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:

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, or other imperfections detrimental to usage of the tubing.

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

TABLE 5A - Maximum Depth of Discontinuity, Inch/Pound Units

Nominal Wall Thickness Inch	Depth of Discontinuity Inch
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, SI Units

Nominal Wall Thickness Millimeters	Depth of Discontinuity Millimeter
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

3.5.1.1 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.

3.5.2 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.

3.5.3 When standards for acceptance are specified by purchaser, tubing shall be subjected to fluorescent penetrant inspection in accordance with AMS 2645 or ASTM E 1417.

3.5.4 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 of this specification.

3.5.5 Class 2 tubing shall be subjected to ultrasonic inspection in accordance with AMS 2634, Class A1.

3.6 Tolerances:

Shall conform to all applicable requirements of AMS 2243 or MAM 2243, as applicable to half tolerances.

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 the performance of all required tests. Purchaser reserves the right to sample and to perform any confirmation testing deemed necessary to ensure that the tubing conforms to specified requirements.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Composition (3.1), surface finish (3.3.4), tensile properties (3.4.1), bending (3.4.2), average grain size (3.4.4), flarability (3.4.7), quality (3.5), eddy current inspection (3.5.4), ultrasonic inspection (3.5.5), and tolerances (3.6) are acceptance tests and shall be performed on each heat, lot, or tube as applicable.

4.2.2 Periodic Tests: Susceptibility to intergranular attack (3.4.3), passivity (3.4.5), and pressure resistance (3.4.6) are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.3 Sampling and Testing:

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

4.3.1 Each tube shall be tested for flarability. The end of the tube shall be cut square with the tube end smooth and free from burrs, but not rounded. Flared ends need not be removed after test.

4.3.2 When a pressure resistance test is specified, the unsupported length shall be not less than 2 feet (0.6 m) or six times the nominal OD, whichever is greater.

4.3.3 Each length of tubing shall be visually examined for compliance to surface condition (3.2) and quality (3.5).

4.3.4 Sampling for dimensional tolerances shall be as shown in Table 6. The tubing shall be measured at three orientations, 60 degrees apart, at one end of each tube.