AEROSPACE MATERIAL SPECIFICATION

AMS5896™	REV. B

Issued 1994-06
Revised 2010-08
Reaffirmed 2015-12

Superseding AMS5896A

Steel, Corrosion and Heat-Resistant, Seamless or Welded Hydraulic Tubing 18.5Cr - 10.5Ni - 0.55Ti (321) Solution Heat Treated and Cold Drawn, 1/8 Hard Temper (Composition similar to UNS S32100)

RATIONALE

AMS5896B has been reaffirmed to comply with the SAE five-year review policy.

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 aircraft hydraulic tubing.

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

Tubing covered by this specification is classified as follows:

Type 1: Seamless and drawn
Type 2: Welded and drawn

1.3.1 Unless a specific type is ordered, either type 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 cancelled and no superseding document has been specified, the last published issue of that document shall apply.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMS5896B

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), www.sae.org.

AMS2243	Tolerances, Corrosion and Heat-Resistant Steel Tubing
AMS2248	Chemical Check Analysis Limits, Corrosion and Heat-Resistant Steels and Alloys, Maraging and Other Highly-Alloyed Steels, and Iron Alloys
AMS2371	Quality Assurance Sampling and Testing, Corrosion and Heat-Resistant Steels and Alloys, Wrought Products and Forging Stock
AMS2634	Ultrasonic Inspection, Thin Wall Metal Tubing
AMS2807	Identification, Carbon and Low-Alloy Steels, Corrosion and Heat-Resistant Steels and Alloys, Sheet, Strip, Plate, and Aircraft Tubing
AMS-STD-753	Corrosion-Resistant Steel Parts: Sampling, Inspection, and Testing for Surface Passivation

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, www.astm.org.

ASTM A 262	Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels
ASTM A 370	Mechanical Testing of Steel Products
ASTM A 450/A 450M	General Requirements for Carbon, Ferritic Alloy, and Austenitic Alloy Steel Tubes (Metric)
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 Testing

2.3 ANSI Publications

Available from American National Standards Institute, Inc., 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

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	--	0.08
Manganese	--	2.00
Silicon	--	1.00
Phosphorus	--	0.040
Sulfur	--	0.030
Chromium	17.00	20.00
Nickel	9.00	12.00
Titanium	5x(C+N)	0.75
Molybdenum	--	0.75
Copper	--	0.75
Nitrogen	--	0.10

3.1.1 Check Analysis

Composition variations shall meet the applicable requirements of AMS2248.

3.2 Condition

Solution heat treated, cold drawn, pickled as required, and passivated. Tensile properties shall be obtained by cold working and not by heat treatment.

3.3 Fabrication

3.3.1 Type 1

Tubing shall be produced by a seamless process.

3.3.2 Type 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. A minimum reduction of 30 percent is recommended for Type 2 tubing.

3.3.3 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, except centerless 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 specified in 3.4.1.1.

TABLE 2 - TENSILE PROPERTIES

Property	Value
Tensile Strength	105 to 140 ksi (724 to 965 MPa)
Yield Strength at 0.2% Offset	75.0 to 110 ksi (517 to 758 MPa)
Elongation in 2 Inches (50.8 mm), min	
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

Tubing shall show no evidence of cracking or splitting when bent cold around a suitable mandrel of a diameter equal to the bend factor shown in Table 3 times the nominal OD. During test, flattening shall not exceed 5 percent of the minimum OD. An appropriate internal mandrel may be used. For Type 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
Up to 1.00, incl	Up 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 the following equation:

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

3.4.3 Susceptibility to Intergranular Attack

Specimens from tubing, after sensitizing treatment, shall pass the intergranular corrosion test performed in accordance with ASTM A 262, Practice E. After exposure, tubing shall be tested in accordance with the flattening test requirements of ASTM A 450/ASTM A 450M. Samples shall be taken from tubing after final annealing but may be taken 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 AMS-STD-753.

3.4.6 Pressure Resistance

When specified, 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 inch/inch (0.002 mm/mm) of diameter is acceptable. Hydrostatic pressure (P) shall be determined by the following equation:

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

where:

P = Hydrostatic pressure in ksi (MPa)
S = 75.0 ksi (517 MPa) yield strength
D = Nominal OD (nominal OD plus tolerance)
d = Nominal ID (nominal OD minus twice minimum wall thickness)

3.4.7 Flarability

Specimens as in 4.3.1 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-degree included angle to produce a flare having the permanent expanded OD not less than shown in Table 4.

TABLE 4A - FLARABILITY, INCH/POUND UNITS

Nominal OD Inches	Expanded OD Inches
0.125	0.200
0.188	0.302
0.250	0.359
0.312	0.421
0.375	0.484
0.500	0.656
0.625	0.781
0.750	0.937
1.000	1.187
1.250	1.500
1.500	1.721
1.750	2.106
2.000	2.356

TABLE 4B - FLARABILITY, SI UNITS

Nominal OD Millimeters	Expanded OD Millimeters
3.18	5.08
4.78	7.67
6.35	9.12
7.92	10.69
9.52	12.29
12.70	16.66
15.88	19.84
19.05	23.80
25.40	30.15
31.75	38.10
38.10	43.71
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 or 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 on a clean white cloth drawn through the length of the bore of a test sample. Discoloration of the cloth, 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 testing in accordance with ASTM E 1417.

3.5.4 Type 1 tubing shall be subjected to eddy current inspection in accordance with ASTM E 426 using calibration notches specified in ASTM A 450 or ASTM A 450M except that the standard used shall contain simulated flaws not greater than those shown in Table 5.

3.5.5 Type 2 tubing shall be subjected to ultrasonic inspection in accordance with AMS2634, Class A1.

3.6 Tolerances

Shall conform to all applicable requirements of AMS2243 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 confirmatory testing deemed necessary to ensure that the tubing conforms to specified requirements.