ADOPTION NOTICE

AMS 5896, "Steel, Corrosion and Heat Resistant, Seamless or Welded Hydraulic Tubing 18.5Cr – 10.5Ni – 0.55Ti (SAE 30321) Solution Heat Treated and Cold Drawn, One–Eighth Hard Temper" was adopted on 14 September 1994 for use by the Department of Defense (DoD). Proposed changes by DoD activities must be submitted to the DoD Adopting Activity: Air Force, ASC/ENOSD, Building 125, 2335 Seventh Street, Suite 6, Wright–Patterson AFB OH 45433–7809. DoD activities may obtain copies of this standard from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111–5094. The private sector and other Government agencies may purchase copies from the Society of Automotive Engineers Inc., 400 Commonwealth Drive, Warrendale, PA 15096–0001.

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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 5896

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Submitted for recognition as an American National Standard

STEEL, CORROSION AND HEAT RESISTANT, SEAMLESS OR WELDED HYDRAULIC TUBING 18.5Cr - 10.5Ni - 0.55Ti (SAE 30321) Solution Heat Treated and Cold Drawn, One-Eighth Hard Temper

UNS S32100

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 1 or Type 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 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 2371 Quality Assurance Sampling and Testing, Corrosion and Heat Resistant Steels and Alloys, Wrought Products and Forging Stock
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/ A 450M General Requirements for Carbon, Ferritic Alloy, and Austenitic Alloy Steel Tubes
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-2154 Inspection, Ultrasonic, Wrought Metals, Process for
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	--	0.08
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 requirements of AMS 2248.

3.2 Condition:

Solution heat treated free from continuous carbide network, 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% 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, 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 specified in Table 2 and 3.4.1.1 for all nominal outside diameters and wall thicknesses.

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% 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 Equation 1.

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

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/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 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 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 from Equation 2.

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

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 specified 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, straightening marks, light mandrel or die marks, shall not exceed the values specified 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 Millimeter	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 inspection in accordance with MIL-STD-6866.

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/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 MIL-STD-2154 and the following. Ultrasonic inspection indications 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:

3.5.5.1 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 3.5.5.2 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 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.

3.5.5.2 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 inch ± 0.002 (3.18 mm ± 0.05).

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

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 performing all required tests. 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.