SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

AMS 5589E

Issued SEP 1996
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Superseding AMS 5589D

Nickel Alloy, Corrosion and Heat-Resistant, Seamless Tubing
52.5Ni - 19Cr - 3.0Mo - 5.1Cb (Nb) - 0.90Ti - 0.50Al - 18Fe
Consumable Electrode Remelted or Vacuum Induction Melted
1775 °F (968 °C) Solution Heat Treated

(Composition similar to UNS N07718)

RATIONALE

AMS 5589E eliminates the requirement for passivation after polishing, and is a Five Year Review and update of this specification.

1. SCOPE

1.1 Form

This specification covers a corrosion and heat-resistant nickel alloy in the form of seamless tubing.

1.2 Application

This tubing has been used typically for fluid lines and components requiring resistance to creep and stress-rupture up to 1300 °F (704 °C) and oxidation resistance up to 1800 °F (982 °C), particularly those parts which are formed or welded and then heat treated to develop desired properties, but usage is not limited to such applications.

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.

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.

AMS 2263	Tolerances, Nickel, Nickel Alloy, and Cobalt Alloy Tubing
AMS 2269	Chemical Check Analysis Limits, Nickel, Nickel Alloys and Cobalt Alloys
AMS 2371	Quality Assurance Sampling and Testing, Corrosion and Heat-Resistant Steels and Alloys, Wrought Products and Forging Stock
AMS 2750	Pyrometry
AMS 2807	Identification, Carbon and Low-Alloy Steels, Corrosion and Heat-Resistant Steels and Alloys, Sheet, Strip, Plate, and Aircraft Tubing.

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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 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 8	Tension Testing of Metallic Materials
ASTM E 8M	Tension Testing of Metallic Materials (Metric)
ASTM E 18	Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
ASTM E 112	Determining Average Grain Size
ASTM E 139	Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials
ASTM E 354	Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys
ASTM E 426	Electromagnetic (Eddy Current) Examination of Seamless and Welded Tubular Products, Austenitic Stainless Steel and Similar Alloys

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

TABLE 1 - COMPOSITION

Element	min	max
Carbon	--	0.08
Manganese	--	0.35
Silicon	--	0.35
Phosphorus	--	0.015
Sulfur	--	0.015
Chromium	17.00	21.00
Nickel	50.00	55.00
Molybdenum	2.80	3.30
Columbium (Niobium)	4.75	5.50
Titanium	0.65	1.15
Aluminum	0.20	0.80
Cobalt	--	1.00
Tantalum	--	0.05
Boron	--	0.006
Copper	--	0.30
Iron	remainder	

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3.1.1 Check Analysis

Composition variations shall meet the applicable requirements of AMS 2269.

3.2 Melting Practice

Alloy shall be produced by multiple melting using consumable electrode practice in the remelt cycle or shall be induction melted under vacuum. If consumable electrode remelting is not performed in vacuum, electrodes which have been produced by vacuum induction melting shall be used for remelting.

3.3 Condition

Cold drawn or pilgered, solution heat treated, and descaled.

3.4 Fabrication

Tubing shall be produced by a seamless process. The external and internal surface finishes may be produced by pickling, bright annealing, or 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 a centerless-ground finish is not acceptable. A light polish to improve external surface appearance may be employed after solution heat treatment.

3.5 Solution Heat Treatment

Solution heat treat by heating in a protective atmosphere within the range 1725 to 1825 °F (941 to 996 °C), holding at the selected temperature within ± 25 °F (± 14 °C) for a time commensurate with cross-sectional thickness, and cooling at a rate equivalent to an air cool or faster. Pyrometry shall be in accordance with AMS 2750.

3.6 Properties

Tubing shall conform to the following requirements:

3.6.1 As Solution Heat Treated

3.6.1.1 Tensile Properties

Tubing, 0.125 inch (3.18 mm) and over in nominal OD with nominal wall thickness 0.015 inch (0.38 mm) and over, shall have the properties shown in Table 2, determined in accordance with ASTM E 8 or ASTM E 8M.

TABLE 2 - TENSILE PROPERTIES

Property	Value
Tensile Strength, max	155 ksi (1069 MPa)
Yield Strength at 0.2% Offset, max	95 ksi (655 MPa)
Elongation in 2 Inches (50.8 mm), min	30%

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3.6.1.2 Average Grain Size

Shall be ASTM No. 5 or finer, determined in accordance with ASTM E 112.

3.6.1.3 Flarability

Specimens as in 4.3.1 from tubing 0.188 to 2.000 inches (4.78 to 50.80 mm), inclusive, in nominal OD and with OD/wall thickness ratio of 10:1 or less 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 a permanent expanded OD not less than 1.20 times the original nominal outside diameter.

3.6.2 After Precipitation Heat Treatment

Tubing 0.125 inch (3.08 mm) and over in nominal OD with nominal wall thickness 0.015 inch (0.38 mm) and over shall meet the requirements of 3.6.2.1, 3.6.2.2, and 3.6.2.3 after being precipitation heat treated by heating to 1325 °F ± 15 (718 °C ± 8), holding at heat for 8 hours ± 0.5, furnace cooling to 1150 °F ± 15 (621 °C ± 8) holding at 1150 °F + 15 (621 °C ± 8) until a total precipitation time of 18 hours has been reached, and cooling at a rate equivalent to an air cool or faster. Tubing shall also meet the requirements of 3.6.2.1, 3.6.2.2, and 3.6.2.3 after being re-solution heat treated by heating to 1750 °F ± 25 (954 °C ± 14), holding at heat for not less than 30 minutes, and cooling at a rate equivalent to an air cool or faster and precipitation heat treated as above.

3.6.2.1 Tensile Properties

Shall be as shown in Table 3, determined in accordance with ASTM E 8 or ASTM E 8M.

TABLE 3 - MINIMUM TENSILE PROPERTIES

Property	Value
Tensile Strength	185 ksi (1276 MPa)
Yield Strength at 0.2% Offset	150 ksi (1034 MPa)
Elongation in 2 Inches (50.8 mm)	12%

3.6.2.2 Hardness

Should be not lower than 36 HRC, or equivalent (see 8.2), determined in accordance with ASTM E 18, but the tubing shall not be rejected on the basis of hardness if the tensile property requirements of 3.6.2.1 are acceptable, determined on specimens taken from the same sample as that with nonconforming hardness, or from another sample with similar nonconfomring hardness.

3.6.2.3 Stress-Rupture Properties at 1300 °F (704 °C)

A tensile specimen, maintained at 1300 °F ± 3 (704 °C ± 2) while a load sufficient to produce an initial axial stress of 72.5 ksi (500 MPa) is applied continuously, shall not rupture in less than 23 hours. The test shall be continued to rupture without change of load. Elongation after rupture, measured at room temperature, shall be not less than 5% in 4D. Test shall be performed in accordance with ASTM E 139.

3.6.2.3.1 The test of 3.6.2.3 may be conducted using a load higher than required to produce an initial axial stress of 72.5 ksi (500 MPa) but load shall not be changed while test is in progress. Time to rupture and elongation requirements shall be as specified in 3.6.2.3.

3.6.2.3.2 The test of 3.6.2.3 may be conducted using incremental loading. In such case, the load required to produce an initial axial stress of 72.5 ksi (500 MPa) shall be used to rupture or for 23 hours, whichever occurs first. After the 23 hours and at intervals of 8 hours minimum, thereafter, the stress shall be increased in increments of 5000 psi (34.5 MPa). Time to rupture and elongation requirements shall be as specified in 3.6.2.3.

3.6.2.3.3 The stress-rupture test is not required on tubing which will not yield a suitable specimen but the alloy from which the tubing was made shall conform to the requirements of 3.6.2.3.

3.7 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, 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.

3.7.1 When specified by purchaser, tubing shall be subjected to electromagnetic (Eddy Current) testing in accordance with ASTM E 426, using calibration notches in accordance with ASTM A 450 or ASTM A 450M.

3.7.2 Tubing shall be free from grease or other foreign material. Metallic flakes or particles shall not be collected on a clean white cloth drawn through the bore of a test sample. Discoloration of the cloth, without the presence of flakes or particles, is acceptable.

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