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INTERNATIONAL
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 5589C

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Superseding AMS 5589B

Submitted for recognition as an American National Standard

NICKEL ALLOY, CORROSION AND HEAT RESISTANT, SEAMLESS TUBING
52.5Ni - 19Cr - 3.0Mo - 5.1Cb - 0.90Ti - 0.50Al - 18Fe
Consumable Electrode or Vacuum Induction Melted
1775 °F (968 °C) Solution Heat Treated

UNS N07718

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 following publications form a part of this publication 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 2263 Tolerances, Nickel, Nickel Alloy, and Cobalt Alloy Tubing
MAM 2263 Tolerances, Metric, Nickel, Nickel Alloy, and Cobalt Alloy Tubing
AMS 2269 Chemical Check Analysis Limits, Wrought Nickel Alloys and Cobalt Alloys
AMS 2371 Quality Assurance Sampling and Testing, Corrosion and Heat Resistant Steels and Alloys, Wrought Products and Forging Stock

2.1 (Continued):

AMS 2750 Pyrometry
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 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 the 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) 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 Av nue, Philadelphia, PA 19111-5094.

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage

3. TECHNICAL REQUIREMENTS:

3.1 Composition:
(R)

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	4.75	5.50
Titanium	0.65	1.15
Aluminum	0.20	0.80
Cobalt	--	1.00
Tantalum (3.1.1)	--	0.05
Boron	--	0.006
Copper	--	0.30
Iron	remainder	

3.1.1 Determination not required for routine acceptance.

3.1.2 Check Analysis: Composition variations shall meet the requirements of AMS 2269.

3.1.2 Determination not required for routine acceptance.

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:
(R)

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 surface appearance may be employed.

3.5 Solution Heat Treatment:
(R)

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	95.0 ksi (655 MPa)
Elongation in 2 Inches (50.8 mm), min	30%

3.6.1.2 Average Grain Size: Shall be ASTM No. 5 or finer, determined in
(R) accordance with ASTM E 112 (see 8.2).

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 (R) Hardness: Should be not lower than 36 HRC, or equivalent (see 8.3), 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 met.

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 to 16 hours, preferably 8 to 10 hours, 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 (R) 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.

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.

3.8 (R) Tolerances:

Shall conform to all applicable requirements of AMS 2263 or MAM 2263. Tolerances for tubing 1.50 to 4.50 inches (38.1 to 114.3 mm) OD shall be as shown in Table 4.

TABLE 4A - Large Tubing Tolerances, Inch/Pound Units

Nominal OD Inches	Tolerance Plus and Minus Inch
1.50 to 3.50, incl	0.015
Over 3.50 to 4.50, incl	0.020

TABLE 4B - Large Tubing Tolerances, SI Units

Nominal OD Inches	Tolerance Plus and Minus mm
38.1 to 88.9, incl	0.38
Over 88.9 to 114.3, incl	0.51

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:
(R)

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.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests for the following requirements are acceptance tests and shall be performed on each heat or lot as applicable:

4.2.1.1 Composition (3.1), quality (3.7), and tolerances (3.8).

4.2.1.2 Tensile properties (3.6.1.1) and average grain size (3.6.1.2) of each lot as solution heat treated.

4.2.1.3 Tensile properties (3.6.2.1) and hardness (3.6.2.2) of each lot after precipitation heat treatment.

4.2.2 Periodic Tests: Tests for the following requirements are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser:

4.2.2.1 Flarability (3.6.1.3) as solution heat treated.
(R)

4.2.2.2 Stress-rupture properties (3.6.2.3) after precipitation heat treatment.

4.2.2.3 Tensile properties (3.6.2.1), hardness (3.6.2.2), and stress-rupture properties (3.6.2.3) after re-solution and precipitation heat treatment.

4.3 Sampling and Testing:
(R)

Shall be in accordance with AMS 2371 and the following:

4.3.1 Specimens for flarability test (3.6.1.3) shall be full tubes or sections cut from a tube. 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:

The vendor of tubing shall furnish with each shipment a report showing the results of tests for chemical composition of each heat and the results of tests on each lot to determine conformance to the other acceptance test requirements and, when performed, to the periodic test requirements. This report shall include the purchase order number, heat and lot number, AMS 5589C, size, and quantity.