

AEROSPACE MATERIAL SPECIFICATION



AMS 5586F

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Superseding AMS 5586E

Nickel Alloy, Corrosion and Heat Resistant, Welded Tubing
57Ni - 19.5Cr - 13.5Co - 4.2Mo - 2.9Ti - 1.4Al - 0.006B - 0.08Zr
Consumable Electrode or Vacuum Induction Melted, Annealed
(Composition similar to UNS N07001)

1. SCOPE:

1.1 Form:

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

1.2 Application:

This tubing has been used typically for parts requiring high strength up to 1500 °F (816 °C) and oxidation resistance up to 1750 °F (954 °C), 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 canceled and no superseding document has been specified, the last published issue of that document shall apply.

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, 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 2634	Ultrasonic Inspection, Thin Wall Metal Tubing
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, 100 Barr Harbor, West Conshohocken, PA 19428-2959.

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
ASTM E 1417	Liquid Penetrant Examination

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	0.02	0.10
Manganese	--	0.10
Silicon	--	0.15
Phosphorus	--	0.015
Sulfur	--	0.015
Chromium	18.00	21.00
Cobalt	12.00	15.00
Molybdenum	3.50	5.00
Titanium	2.50	3.25
Aluminum	1.20	1.60
Boron (3.1.1)	0.003	0.010
Zirconium	0.02	0.15
Iron	--	2.00
Copper	--	0.10
Nickel	remainder	

- 3.1.1 Boron may be less than 0.003% by weight, determined on tubing having nominal wall thickness under 0.050inch (1.27 mm), provided the specified requirement is met on the stock from which sheet or strip for making tubing is rolled.

3.1.2 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:

Annealed, and unless annealing is performed in an atmosphere yielding a bright finish, pickled as required. Cooling from the annealing temperature shall be at a rate equivalent to an air cool or faster. Tubing 2.00 inches (50.8 mm) and under shall have been cold worked sufficiently to ensure proper weld reinforcement height and roundness in the weld reinforcement area.

3.4 Fabrication:

Tubing 2.00 inches (50.8 mm) and under in nominal OD shall be produced by a welded and drawn process. Any surface finishing operation applied to remove objectionable pits and surface blemishes shall be performed prior to final solution heat treatment. A light polish to improve external surface appearance may be employed after annealing.

3.5 Properties:

Tubing 0.125 inch (3.18 mm) and over in nominal OD and 0.015 inch (0.38 mm) and over in nominal wall thickness shall conform to the following requirements:

3.5.1 As Annealed:

3.5.1.1 Tensile Properties: Shall be as shown in Table 2, determined in accordance with ASTM E 8 or ASTM E 8M.

TABLE 2 - Tensile Properties

Property	Value
Tensile Strength, max	145 ksi (1000 MPa)
Yield Strength at 0.2% Offset, max	80 ksi (552 MPa)
Elongation in 2 Inches (50.8 mm) or 4D, min	35%

3.5.1.2 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 a permanent expanded OD not less than 1.2 times the nominal OD.

3.5.1.3 Average Grain Size: Shall be ASTM No. 5 or finer, determined in accordance with ASTM E 112.

3.5.2 After Solution, Stabilization, and Precipitation Heat Treatment: Tubing shall meet the requirements of 3.5.2.1, 3.5.2.2, and 3.5.2.3 after being solution heat treated by heating in a suitable atmosphere to $1825^{\circ}\text{F} \pm 25$ ($996^{\circ}\text{C} \pm 14$), holding at heat for $2\text{ hours} \pm 0.25$, and cooling at a rate equivalent to an air cool or faster; stabilization treated by heating to $1550^{\circ}\text{F} \pm 15$ ($843^{\circ}\text{C} \pm 8$), holding at heat for $4\text{ hours} \pm 0.25$, and cooling at a rate equivalent to air cooling; and precipitation treated by heating to $1400^{\circ}\text{F} \pm 15$ ($760^{\circ}\text{C} \pm 8$), holding at heat for $16\text{ hours} \pm 1$, and cooling at a rate equivalent to air cooling.

3.5.2.1 Tensile Properties: Shall be as shown in Table 3, determined in accordance with ASTM E 8 or ASTM E8M.

TABLE 3 - Minimum Tensile Properties

Property	Value
Tensile Strength	160 ksi (1103 MPa)
Yield Strength at 0.2% Offset	105 ksi (724 MPa)
Elongation in 2 Inches (50.8 mm) or 4D	15%

3.5.2.2 Hardness: Shall be 34 to 44 HRC, or equivalent (See 8.2), determined in accordance with ASTM E 18.

3.5.2.3 Stress-Rupture Properties: Shall be as follows, determined in accordance with ASTM E 139; the test at 1500°F (816°C) (3.5.2.3.2) need be run only if the tubing fails to pass the test at 1350°F (732°C). Tubing which passes the test of 3.5.2.3.2 will be acceptable.

3.5.2.3.1 At 1350°F (732°C): A tensile specimen, maintained at $1350^{\circ}\text{F} \pm 3$ ($732^{\circ}\text{C} \pm 2$) while a load sufficient to produce the initial axial stress shown in Table 4 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 shown in Table 4.

TABLE 4A - Stress Rupture Requirements, Inch/Pound Units

Nominal Wall Thickness Inch	Stress ksi	Elongation in 2 Inches or 4D %, min
0.015 to 0.020, incl	62.5	4
Over 0.020 to 0.030, incl	65.0	4
Over 0.030 to 0.050, incl	67.5	4
Over 0.050	70.0	5

TABLE 4B - Stress Rupture Requirements, SI Units

Nominal Wall Thickness Millimeters	Stress MPa	Elongation in 50.8 mm or 4D %, min
0.38 to 0.51, incl	431	4
Over 0.51 to 0.76, incl	448	4
Over 0.76 to 1.27, incl	465	4
Over 1.27	483	5

3.5.2.3.2 At 1500 °F (816 °C): A tensile specimen, maintained at 1500 °F $\pm$ 3 (816 °C $\pm$ 2) while a load sufficient to produce an initial axial stress of 37.5 ksi (259 MPa) or higher is applied continuously, shall not rupture in less than 23 hours. Elongation after rupture, measured at room temperature, shall be not less than 5% in 2 inches (50.8 mm).

3.5.2.3.2.1 The test of 3.5.2.3.2 may be conducted using incremental loading. In such case, the load required to produce an initial axial stress of 37.5 ksi (259 MPa) or higher 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, the stress shall be increased in increments of 2.5 ksi (17 MPa). Time to rupture and elongation requirements shall be as specified in 3.5.2.3.2.

3.6 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 grease, oil and other matter, 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.

3.6.1 If weld reinforcement is present at the weld on the inner surface of tubing over 2.00 inches (50.8 mm) in nominal OD, such weld reinforcement shall be not thicker than 0.010 inch (0.25 mm). The outer surface of all tubing and the inner surface of tubing 2.00 inches (50.8 mm) and under in nominal OD shall be free from weld reinforcement.

3.6.2 When specified by purchaser, tubing shall be subjected to fluorescent penetrant inspection in accordance with ASTM E 1417, to ultrasonic inspection in accordance with AMS 2634, to electromagnetic (eddy-current) inspection in accordance with ASTM E 426, or to any combination thereof. Tubing shall meet the requirements of acceptance criteria established by the cognizant engineering organization.

3.7 Tolerances:

Shall conform to all applicable requirements of AMS 2263 or MAM 2263.

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.

4.2 Classification of Tests:

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

4.2.1.1 Composition (3.1) of each heat.

4.2.1.2 Tensile properties (3.5.1.1) average grain size (3.5.1.3) and tolerances (3.7) of each lot as annealed.

4.2.1.3 Tensile properties (3.5.2.1), hardness (3.5.2.2), and stress-rupture properties (3.5.2.3) of each lot after solution, stabilization, and precipitation heat treatment.

4.2.2 Periodic Tests: Flarability (3.5.1.2) of as-annealed tubing is a periodic test 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:

4.3.1 Specimens for flarability test (3.5.1.2) 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 for tensile properties and average grain size annealed, and for tensile properties, hardness and stress-rupture properties precipitation heat treated of each lot, and stating that the product conforms to the other technical requirements. This report shall include the purchase order number, heat and lot numbers, AMS 5586F, size, and quantity.

4.5 Resampling and Retesting:

Shall be in accordance with AMS 2371.