SAE The Engineering Resource For Advancing Mobility®
400 COMMONWEALTH DRIVE WARRENDALE PA 15096

AEROSPACE MATERIAL SPECIFICATION

AMS 5586C

Issued 6-30-84
Revised 4-1-85

ALLOY TUBING, WELDED, CORROSION AND HEAT RESISTANT
57Ni - 19.5Cr - 13.5Co - 4.2Mo - 2.9Ti - 1.4Al - 0.08Zr - 0.006B
Consumable Electrode or Vacuum Induction Melted, Annealed

UNS N07001

1. SCOPE:

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

1.2 Application: Primarily for parts requiring high strength up to 1500°F (815°C) and oxidation resistance up to 1750°F (955°C).

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

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 2350 - Standards and Test Methods
AMS 2371 - Quality Assurance Sampling of Corrosion and Heat Resistant Steels and Alloys, Wrought Products Except Forgings and Forging Stock

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM E8 - Tension Testing of Metallic Materials
ASTM E18 - Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
ASTM E112 - Determining Average Grain Size
ASTM E139 - Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials
ASTM E354 - Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Federal Standards:

Federal Test Method Standard No. 151 - Metals; Test Methods

2.3.2 Military Standards:

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

3. TECHNICAL REQUIREMENTS:

3.1 Composition: Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E354, by spectrographic methods in accordance with Federal Test Method Standard No. 151, Method 112, or by other analytical methods approved by purchaser:

	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
Zirconium	0.02	0.15
Boron (3.1.1)	0.003	0.010
Iron	--	2.00
Copper	--	0.10
Nickel	remainder	

3.1.1 Boron may be less than 0.003, determined on tubing having nominal wall thickness less than 0.050 in. (1.25 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 requirements of AMS 2269.

3.2 Condition: Annealed and descaled. Annealing shall be performed in a suitable protective atmosphere at such temperature and for such time as will produce tubing meeting the requirements of 3.4. Cooling from the annealing temperature shall be at a rate equivalent to air cool or faster.

3.3 Fabrication: Tubing 2.00 in. (50 mm) and under in nominal OD shall be cold worked after welding and prior to annealing.

3.4 Properties: Tubing 0.125 in. (3.12 mm) and over in nominal OD and 0.015 in. (0.38 mm) and over in nominal wall thickness shall conform to the following requirements; properties of tubing under 0.125 in. (3.12 mm) in nominal OD or under 0.015 in. (0.38 mm) in nominal wall thickness shall be as agreed upon by purchaser and vendor:

3.4.1 As Annealed:

3.4.1.1 Tensile Properties: Shall be as follows, determined in accordance with ASTM E8:

Tensile Strength, max	145,000 psi (1000 MPa)
Yield Strength at 0.2% Offset, max	80,000 psi (555 MPa)
Elongation in 2 in. (50 mm) or 4D, min	35%

3.4.1.2 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 deg included angle to produce a flare having a permanent expanded OD not less than 1.2 times the nominal OD.

3.4.1.3 Pressure Test: Tubing shall show no bulges, leaks, or other defects when subjected to an internal hydrostatic pressure of 15,000 psig (105 MPag) or pressure sufficient to cause a tensile stress of 40,000 psi (275 MPa) in the tubing wall, whichever is less. The hydrostatic pressure (P) shall be calculated from the following equation:

$$P = \frac{2St}{D}$$

where, S = 40,000 psi (275 MPa) tensile stress
t = Minimum wall thickness (nominal thickness minus maximum negative tolerance)
D = Nominal OD

3.4.1.4 Grain Size: Shall be substantially uniform without pronounced segregation of fine and coarse grain areas, determined in accordance with ASTM E112; standards for acceptance shall be as agreed upon by purchaser and vendor.

3.4.2 After Solution, Stabilization, and Precipitation Heat Treatment: Tubing shall meet the requirements of 3.4.2.1, 3.4.2.2, and 3.4.2.3 after being solution heat treated by heating in a suitable atmosphere to 1825°F ± 25 (995°C ± 15), holding at heat for 2 hr ± 0.25, and cooling at a rate equivalent to air cool or faster; stabilization treated by heating to 1550°F ± 15 (845°C ± 8), holding at heat for 4 hr ± 0.25, and cooling in air; and precipitation treated by heating to 1400°F ± 15 (760°C ± 8), holding at heat for 16 hr ± 1, and cooling in air.

3.4.2.1 Tensile Properties: Shall be as follows, determined in accordance with ASTM E8:

Tensile Strength, min	160,000 psi (1105 MPa)
Yield Strength at 0.2% Offset, min	105,000 psi (725 MPa)
Elongation in 2 in. (50 mm), min	15%

3.4.2.2 Hardness: Should be 34 - 44 HRC, determined in accordance with ASTM E18, or equivalent, but tubing shall not be rejected on the basis of hardness if the tensile property requirements of 3.4.2.1 are met.

3.4.2.3 Stress-Rupture Properties: Shall be as follows, determined in accordance with ASTM E139; the test at 1500°F (815°C) need be run only if the tubing fails to pass the test at 1350°F (732°C) and tubing which passes the test of 3.4.2.3.2 will be acceptable:

3.4.2.3.1 At 1350°F (730°C): A tensile specimen, maintained at 1350°F ± 3 (732°C ± 2) while a load sufficient to produce the initial axial stress shown in Table I 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 I.

TABLE I

Nominal Wall Thickness Inches	Stress psi	Elongation in 2 in. %, min
0.015 to 0.020, incl	62,500	4
Over 0.020 to 0.030, incl	65,000	4
Over 0.030 to 0.050, incl	67,500	4
Over 0.050	70,000	5

TABLE I (SI)

ø

Nominal Wall Thickness Millimetres	Stress MPa	Elongation in 50 mm %, min
0.38 to 0.50, incl	430	4
Over 0.50 to 0.75, incl	450	4
Over 0.75 to 1.25, incl	465	4
Over 1.25	485	5

3.4.2.3.2 At 1500°F (815°C): A tensile specimen, maintained at 1500°F ± 3 (815°C ± 2) while a load sufficient to produce an initial axial stress of 37,500 psi (260 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 2 in. (50 mm).

3.4.2.3.2.1 The test of 3.4.2.3.2 may be conducted using a load higher than required to produce an initial axial stress of 37,500 psi (260 MPa) but load shall not be changed while test is in progress. Time to rupture and elongation requirements shall be as specified in 3.4.2.3.2.

3.4.2.3.2.2 When permitted by purchaser, the test of 3.4.2.3.2 may be conducted using incremental loading. In such case, the load required to produce an initial axial stress of 37,500 psi (260 MPa) shall be used to rupture or for 23 hr, whichever occurs first. After the 23 hr and at intervals of 8 - 16 hr, preferably 8 - 10 hr, thereafter, the stress shall be increased in increments of 2500 psi (17 MPa). Time to rupture and elongation requirements shall be as specified in 3.4.2.3.2.

3.5 Quality:

3.5.1 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.

3.5.2 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 the 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.

3.5.3 If beads are present at the weld on the inner surface of tubing over 2.00 in. (50 mm) in nominal OD, such beads shall be not thicker than 0.010 in. (0.25 mm). The outer surface of all tubing and the inner surface of tubing 2.00 in. (50 mm) and under in nominal OD shall be free from beads.

3.6 Sizes: Except when exact lengths or multiples of exact lengths are ordered, straight tubing will be acceptable in mill lengths of 6 - 20 ft (2 - 6 m) but not more than 10% of any shipment shall be supplied in lengths shorter than 10 ft (3 m).

3.7 Tolerances: Unless otherwise specified, 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 performing all Ø required tests. Results of such tests shall be reported to the purchaser as required by 4.4. 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 to determine conformance to the following Ø requirements are classified as 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 (3.4.1.1) and grain size (3.4.1.4) of each lot as Ø annealed.

4.2.1.3 Tensile properties (3.4.2.1), hardness (3.4.2.2), and stress-rupture Ø properties (3.4.2.3) of each lot after solution, stabilization, and precipitation heat treatment.

4.2.2 Periodic Tests: Tests to determine conformance to requirements for Ø flarability (3.4.1.2) and pressure test (3.4.1.3) of as annealed tubing are classified as periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.3 Sampling: Shall be in accordance with AMS 2371 and the following; when Ø consumable electrode remelted alloy is supplied, a heat shall be the consumable electrode remelted ingots produced from alloy originally melted as a single furnace charge.