AEROSPACE MATERIAL SPECIFICATION

AMS5581™	REV. G
Issued 1977-01 Revised 2022-06 Superseding AMS5581F	

Nickel Alloy, Corrosion- and Heat-Resistant, Seamless or Welded Tubing
62Ni - 21.5Cr - 9.0Mo - 3.7Cb (Nb)
Annealed
(Composition similar to UNS N06625)

RATIONALE

AMS5581G is the result of a Five-Year Review and update of the specification. The revision prohibits unauthorized exceptions (3.7, 4.4.1, 5.2.1, 8.4), updates reporting requirements for composition (3.1.3), revises Condition (3.2) and Fabrication (3.3), updates the requirements for tensile testing including setting a minimum size (3.4.1), updates the Hydrostatic Test to standard method (3.4.3), updates grain size requirement (3.4.5) adds quality and non-destructive test provisions (3.5, 4.2.1, 4.4), requires melter identification (4.4), and allows prior revisions (8.3).

1. SCOPE

1.1 Form

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

1.2 Application

This tubing has been used typically for fluid lines requiring high strength and corrosion resistance at temperatures from cryogenic to 1800 °F (982 °C), but usage is not limited to such applications.

1.3 Classification

The 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 specified, either Type 1 or Type 2 may be supplied.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

For more information on this standard, visit
https://www.sae.org/standards/content/AMS5581G/

2. REFERENCES

2.1 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.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS2263	Tolerances, Nickel, Nickel Alloy, and Cobalt Alloy Tubing
AMS2269	Chemical Check Analysis Limits, Nickel, Nickel Alloys, and Cobalt Alloys
AMS2371	Quality Assurance Sampling and Testing, Corrosion and-Heat Resistant Steels and Alloys, Wrought Products and Forging Stock
AMS2634	Ultrasonic Inspection of Thin Wall Metal Tubing
AMS2700	Passivation of Corrosion Resistant Steels
AMS2807	Identification, Carbon and Low-Alloy Steels, Corrosion- and Heat-Resistant Steels and Alloys, Sheet, Strip, Plate, and Aircraft Tubing
AS7766	Terms Used in Aerospace Metals Specifications

2.1.2 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 B751	General Requirements for Nickel and Nickel Alloy Welded Tube
ASTM B829	General Requirements for Nickel and Nickel Alloys Seamless Pipe and Tube
ASTM E8/E8M	Tension Testing of Metallic Materials
ASTM E112	Determining Average Grain Size
ASTM E354	Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys
ASTM E1417/E1417M	Liquid Penetrant Testing

2.2 Definitions

Terms used in AMS are defined in AS7766 and the following:

BORE CONDITIONING: Any mechanical cleaning method that is used in the bore of tubing to improve the final surface appearance, with no resultant change in tubing size beyond the allowable tolerances.

3. TECHNICAL REQUIREMENTS

3.1 Composition

Shall conform to the percentages by weight shown in Table 1, determined in accordance with ASTM E354 or by other analytical methods acceptable to purchaser.

Table 1 - Composition

Element	Min	Max
Carbon	--	0.10
Manganese	--	0.50
Silicon	--	0.50
Phosphorus	--	0.015
Sulfur	--	0.015
Chromium	20.00	23.00
Molybdenum	8.00	10.00
Columbium (Niobium)	3.15	4.15
Titanium (3.1.1)	--	0.40
Aluminum (3.1.1)	--	0.40
Cobalt (3.1.2)	--	1.00
Iron	--	5.00
Nickel	remainder	

3.1.1 Shall be present but not in excess of specified maximum.

3.1.2 Determination not required for routine acceptance.

3.1.3 Producer may test for any element not listed in Table 1 and include this analysis in the report of 4.4. Reporting of any element not listed in the composition table is not a basis for rejection, unless limits of acceptability are specified by the purchaser.

3.1.4 Check Analysis

Composition variations shall meet the applicable requirements of AMS2269.

3.2 Condition

Annealed. Annealing heat treatment shall be performed in an atmosphere yielding a bright finish. Alternately, product shall be chemically cleaned to produce a uniform finish. It is permissible to pickle prior to final cleaning treatment. Final chemical cleaning may take place after any final finishing (see 3.3.3). After final chemical cleaning, tube cleanliness shall be verified using the corrosion resistance test methods specified in AMS2700 for class 2 parts, or alternate method acceptable to the purchaser.

3.3 Fabrication

3.3.1 Tubing shall be produced by a seamless and drawn or a welded and drawn process. Finishing operations shall be performed prior to final annealing heat treatment. Tubing shall not be centerless ground. A light polish to improve external surface appearance or meet surface finish requirements may be employed after anneal and, if performed, the product shall be subsequently chemically cleaned.

3.3.2 Bore conditioning (see 2.2) is permitted after final anneal provided the tubing is not sized by metal removal methods beyond the allowable tolerances. If bore conditioning is used, 100% visual inspection of each tube shall be performed. The tube ID shall be uniformly shiny with no evidence of remnant material, neither metallic nor nonmetallic in nature.

3.3.3 Tubing shall be chemically cleaned after any ID or OD finishing that occurs after anneal.

3.3.4 Welded (Type 2) tubing shall be cold reduced after welding to remove the bead and any dimensional indication of the presence of welds.

3.4 Properties

Tubing shall conform to the following requirements:

3.4.1 Tensile Properties

Shall be as shown in Table 2, determined in accordance with ASTM E8/E8M.

Table 2 - Minimum tensile properties

Property	Value
Tensile Strength	120 ksi (827 MPa)
Yield Strength at 0.2% Offset	60 ksi (414 MPa)
Elongation in 2 Inches (50 mm) or 4D, Minimum	35%

3.4.1.1 Unless otherwise specified, the strain rate shall be set at 0.005 in/in/min (0.005 mm/mm/min) and maintained within a tolerance of ±0.002 in/in/min (0.002 mm/mm/min) through 0.2% offset yield strain. The strain rate after yield may be increased to any value up to 0.5 in/in/min (or mm/mm/min) or equivalent crosshead speed as a function of gage length. The requirement for compliance becomes effective for material produced 1 year after the publication date of this document.

3.4.1.2 For tubing with an OD less than 1/8 inch (3.2 mm) or wall thickness under 0.015 inch (0.38 mm), alternate testing and acceptance methods may be agreed between the purchaser and the supplier (see 8.5).

3.4.2 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 specified in Table 3.

Table 3A - Flarability, inch/pound units

Nominal OD Inches	Expanded OD Inches	Nominal OD Inches	Expanded OD Inches
0.125	0.200	0.750	0.937
0.188	0.302	1.000	1.187
0.250	0.359	1.250	1.500
0.312	0.421	1.500	1.721
0.375	0.484	1.750	2.106
0.500	0.656	2.000	2.356
0.625	0.781		

Table 3B - Flarability, SI units

Nominal OD Millimeters	Expanded OD Millimeters	Nominal OD Millimeters	Expanded OD Millimeters
3.18	5.08	19.05	23.80
4.78	7.67	25.40	30.15
6.35	9.12	31.75	38.10
7.92	10.69	38.10	43.71
9.52	12.29	44.45	53.49
12.70	16.66	50.80	59.84
15.88	19.84		

3.4.2.1 Tubing with nominal OD between any two standard sizes given in Table 3 shall take the same percentage flare as shown for the larger of the two sizes.

3.4.3 Hydrostatic Test

Tubing shall withstand an internal hydrostatic pressure (P), based on Equation 1, without developing leaks, local bulges, or cracks and without an increase in mean diameter of more than 0.2%.

$$P = S \frac{D^2 - d^2}{D^2 + d^2} \quad \text{(Eq. 1)}$$

where:

P = test pressure in ksi (MPa)
S = 60.0 ksi (414 MPa)
D = maximum OD in inches (mm) (defined as nominal (i.e., order or specified) OD plus tolerance)
d = maximum ID in inches (mm) (maximum OD (D) minus twice the minimum wall thickness)

Mean diameter is the average of two diameters at right angles to each other in the same transverse plane; measurements before and after testing should be taken at substantially the same location.

3.4.4 Microstructure

Tubing shall reveal no continuous intergranular carbide precipitation when suitably etched and examined microscopically at 500X magnification. The presence of some discontinuous intergranular carbide precipitation shall not be considered detrimental if the other technical requirements are met. Standards for acceptance may be as agreed upon by purchaser and producer.

3.4.5 Average Grain Size

Shall be ASTM No. 5 or finer, determined in accordance with ASTM E112.

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 grease, oil and other foreign 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, and scale patterns are acceptable providing the imperfections are removable within the tolerances specified for wall thickness but removal of such imperfections is not required.

3.5.1 A clean white cloth or plug drawn or blown through the length of the bore of a test sample at least 12 inches (30 cm) in length, shall show no visual evidence of metallic flakes or particles. Discoloration of the cloth or plug, without the presence of flakes or particles, is acceptable. Alternate methods for evaluating tube cleanliness may be used for tubing 0.500 inch (12.7 mm) and under ID.

3.5.2 Tubing shall be subjected to either ultrasonic or eddy current inspection in accordance with ASTM B751, ASTM B829 except that suspect indications shall not be accepted based on visual observation (i.e., indications must be either rejected or reconditioned and retested to pass the test). Alternate methods of inspection may be used when approved by the cognizant engineering organization for tube 0.25 inch (0.64 cm) and under in nominal diameter.

3.6 Tolerances

Shall conform to of AMS2263.

3.7 Exceptions

Any exceptions shall be authorized by the purchaser and reported as in 4.4.1.