



AEROSPACE MATERIAL SPECIFICATION

AMS5588™**REV. H**Issued 1965-02
Revised 2022-06

Superseding AMS5588G

Nickel Alloy, Corrosion- and Heat-Resistant, Welded Tubing
47.5Ni - 22Cr - 1.5Co - 9.0Mo - 0.60W - 18.5Fe
Solution Heat Treated
(Composition similar to UNS N06002)

RATIONALE

AMS5588H is the result of a Five-Year Review and update of the specification. This revision prohibits unauthorized exceptions (3.7, 4.4.1, 5.2.1, 8.4); updates composition reporting (3.1.1); revises condition (3.2) and fabrication (3.3); updates tensile testing (3.4.1, 8.5); revises the hydrostatic test procedure (3.4.4); updates and adds quality and non-destructive test provisions (3.5.2, 3.5.3, 3.5.4, 4.2.1.1); 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 welded and drawn tubing.

1.2 Application

This tubing has been used typically for fluid lines operating in service under appreciable stresses at elevated temperatures, but usage is not limited to such applications. This alloy has good strength up to 1800 °F (982 °C) and oxidation resistance up to 2200 °F (1204 °C).

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

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AMS2371	Quality Assurance Sampling and Testing, Corrosion- and Heat-Resistant Steels and Alloys, Wrought Products and Forging Stock
AMS2632	Inspection, Ultrasonic, of Thin Materials, 0.50 Inch (12.7 mm) and Under in Cross-Sectional Thickness
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 E571	Electromagnetic (Eddy Current) Examination of Nickel and Nickel Alloy Tubular Products
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	0.05	0.15
Manganese	--	1.00
Silicon	--	1.00
Phosphorus	--	0.040
Sulfur	--	0.030
Chromium	20.50	23.00
Cobalt	0.50	2.50
Molybdenum	8.00	10.00
Tungsten	0.20	1.00
Iron	17.00	20.00
Aluminum	--	0.50
Titanium	--	0.15
Boron	--	0.010
Copper	--	0.50
Nickel	remainder	

3.1.1 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.

3.1.2 Check Analysis

Composition variations shall meet the applicable requirements of AMS2269.

3.2 Condition

Solution heat treated. Solution 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 3.3.4). 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. No specific solution heat treating instructions are specified but it is recommended that the tubing be solution heat treated by heating in a suitable protective atmosphere to $2150^{\circ}\text{F} \pm 25^{\circ}\text{F}$ ($1177^{\circ}\text{C} \pm 14^{\circ}\text{C}$), holding at heat for a time commensurate with section thickness, and cooling rapidly. In no case shall the solution heat treatment temperature be lower than 2100°F (1149°C).

3.3 Fabrication

3.3.1 Tubing shall be fabricated from hot or cold rolled strip, fusion welded without addition of filler metal, cold drawn, and solution heat treated. The cold drawing operation on tubing 3.0 inches (76 mm) and under in nominal OD shall result in not less than 15% reduction in wall thickness; the amount of wall thickness reduction on tubing over 3.0 inches (76 mm) in nominal OD shall be as agreed upon by purchaser and producer.

3.3.2 Finishing operations shall be performed prior to final solution 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 solution heat treatment and, if performed, the product shall be subsequently chemically cleaned.

3.3.3 Bore conditioning is permitted after final solution heat treatment provided the tubing is not sized by metal removal methods beyond the allowable tolerances (see 2.2). 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.

3.3.4 Tubing shall be chemically cleaned after any ID or OD finishing that occurs after solution heat treatment.

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 room temperature, tensile properties

Property	Value
Tensile Strength	100 ksi (689 MPa)
Yield Strength at 0.2% Offset	45.0 ksi (310 MPa)
Elongation in 2 Inches (50 mm)	
Strip Specimens	20%
Full-Section Specimens	25%

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 0.5 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 Average Grain Size

Shall be ASTM No. 4 or finer, determined in accordance with ASTM E112, for tubing 0.125 inch (3.18 mm) and under in nominal wall thickness.

3.4.3 Flareability

Specimens as in 4.3.1 shall withstand, without formation of cracks or other visible defects, flaring at room temperature 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 original nominal diameter.

3.4.4 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 = minimum yield strength from 3.4.1

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.

3.5 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 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.

- 3.5.1 If beads are present at the weld on the inner surface of tubing over 3.0 inches (76 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 3.0 inches (76 mm) and under in nominal OD shall be free from weld reinforcement.
- 3.5.2 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.
- 3.5.3 When no inspection is specified by the purchaser, tubing shall be subjected to either ultrasonic or eddy current inspection in accordance with ASTM B751 or ASTM B829 as applicable, 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 performed when approved by the cognizant engineering organization for tube 0.25 inch (0.64 cm) and under in nominal diameter.
- 3.5.4 When specified by purchaser, tubing shall be subjected to fluorescent penetrant inspection in accordance with ASTM E1417/E1417M, to ultrasonic inspection in accordance with AMS2632, to electromagnetic (eddy-current) inspection in accordance with ASTM E571, or to any combination thereof. Standards for acceptance shall be as agreed upon by purchaser and producer (see 8.5).

3.6 Tolerances

Shall conform to all applicable requirements of AMS2263.

3.7 Exceptions

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

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The producer of tubing shall supply all samples for producer'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

Composition (3.1), tensile properties (3.4.1), average grain size (3.4.2), quality (3.5), and tolerances (3.6) are acceptance tests and shall be performed on each heat or lot as applicable.

- 4.2.1.1 Nondestructive testing (3.5.3 or 3.5.4, when specified) shall be performed on each finished tube. The requirements of 3.5.3 shall become effective 1 year after the publication date of this document.

4.2.2 Periodic Tests

Flareability (3.4.3) and hydrostatic test (3.4.4) are periodic tests and shall be performed at a frequency selected by the producer unless frequency of testing is specified by purchaser.