



<b>AEROSPACE MATERIAL SPECIFICATION</b>	<b>AMS5576™</b>	<b>REV. M</b>
	Issued 1952-06 Reaffirmed 2010-10 Revised 2023-10	
Superseding AMS5576L		
(R) Steel, Corrosion- and Heat-Resistant, Welded Tubing 18Cr - 10.5Ni - 0.40Ti (321) Solution Heat Treated (Composition similar to UNS S32100)		

### RATIONALE

AMS5576M is the result of a Five-Year Review and update of the specification. The revision updates composition reporting (see 3.1.1), clarifies heat treatment and fabrication steps (see 3.2 and 3.3), adds strain rate control (see 3.4.1.1), adds tensile properties per industry standard, addresses flarability for small tubing (see 3.4.2.2), adds required inspection requirement and alternate inspection methods for small tubing (see 3.5.1), adds additional details on cleanliness inspection (see 3.5.3), provides for optional inspection methods when specified (see 3.5.4), updates acceptance consistent with changes in 3.5 (see 4.2.1 and 4.2.1.1), adds NDT reporting requirements (see 4.4), allows prior revisions (see 8.3), and prohibits unauthorized exceptions (see 8.4).

## 1. SCOPE

### 1.1 Form

This specification covers a corrosion- and heat-resistant steel in the form of welded tubing.

### 1.2 Application

This tubing has been used typically for parts requiring both corrosion and heat resistance, especially when subjected to welding, brazing, or other exposure to temperatures over 800 °F (427 °C) during fabrication, and also for parts requiring oxidation resistance up to 1500 °F (816 °C) but useful at that temperature only when stresses are low. 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 cancelled and no superseding document has been specified, the last published issue of that document shall apply.

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## 2.1 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](http://www.sae.org).

AMS2243	Tolerances, Corrosion and Heat-Resistant Steel Tubing
AMS2248	Chemical Check Analysis Limits, Corrosion- and Heat-Resistant Steels and Alloys, Maraging and Other Highly Alloyed Steels, and Iron Alloys
AMS2371	Quality Assurance Sampling and Testing, Corrosion and Heat-Resistant Steels and Alloys, Wrought Products and Forging Stock
AMS2634	Ultrasonic Inspection, Thin Wall Metal Tubing
AMS2700	Passivation of Corrosion Resistant Steels
AMS2761	Heat Treatment of Steel Raw Materials
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

## 2.2 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](http://www.astm.org).

ASTM A262	Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels
ASTM A370	Mechanical Testing of Steel Products
ASTM A751	Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
ASTM A1016/A1016M	General Requirements for Ferritic Alloy Steel, Austenitic Alloy Steel, and Stainless Steel Tubes

## 2.3 Definitions

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

**BORE CONDITIONING:** Any mechanical 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.

**SOLUTION HEAT TREATMENT:** Heating of an alloy to a suitable temperature, holding it at that temperature long enough to cause one or more constituents to enter into a solid solution, and then cooling it rapidly enough to keep these constituents in solution. AMS2761 provides guidance but refers to this process as annealing with a quenching treatment.

### 3. TECHNICAL REQUIREMENTS

#### 3.1 Composition

Shall conform to the percentages by weight shown in Table 1, determined in accordance with ASTM A751, or by other analytical methods acceptable to the purchaser.

**Table 1 - Composition**

Element	Min	Max
Carbon	--	0.08
Manganese	--	2.00
Silicon	0.25	1.00
Phosphorus	--	0.040
Sulfur	--	0.030
Chromium	17.00	19.00
Nickel	9.00	12.00
Titanium	5x(C+N)	0.70
Molybdenum	--	0.75
Copper	--	0.75
Nitrogen	--	0.10

3.1.1 The 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 AMS2248.

#### 3.2 Condition

Solution heat treated (see 2.3). Solution heat treatment shall be performed in an atmosphere yielding a bright finish. Alternately, product shall be passivated in accordance with AMS2700 to produce a uniform finish. It is permissible to pickle prior to passivation. Passivation may take place after any final finishing (see 3.3.4).

#### 3.3 Fabrication

Tubing shall be produced by a welded and drawn process.

3.3.1 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 solution heat treatment and, if performed, the product shall be subsequently passivated.

3.3.2 Tubing shall have been cold worked sufficiently, before final solution heat treatment, to ensure proper weld reinforcement (see 3.5.2) and roundness in the weld area (see 3.6).

3.3.3 Bore conditioning (see 2.3) is permitted after final heat treatment 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.

3.3.4 Tubing shall be passivated in accordance with AMS2700 after any ID or OD finishing that occurs after solution heat treatment.

### 3.4 Properties

Tubing shall conform to the following requirements; tensile and bend testing shall be performed in accordance with ASTM A370:

#### 3.4.1 Tensile Properties

Shall be as shown in Table 2.

**Table 2A - Tensile properties, inch/pound units**

Nominal OD Inches	Nominal Wall Thickness Inches	Yield Strength ksi, Min	Tensile Strength ksi, Min	Tensile Strength ksi, Max	Elongation in 2 Inches %, Min Strip	Elongation in 2 Inches %, Min Full Tube
Up to 0.188, incl	Up to 0.016, incl	30.0	75	120	--	33
	Over 0.016			105	--	35
Over 0.188 to 0.500, incl	Up to 0.010, incl	30.0	75	115	30	35
	Over 0.010			105	30	35
Over 0.500	Up to 0.010, incl	30.0	75	120	25	30
	Over 0.010			105	30	35

<sup>1</sup> Minimum tensile and yield strength properties have been taken from ASTM A249 and are not based on AMS statistical methods.

<sup>2</sup> Yield strength is not required to be determined for OD sizes less than 0.125 inch or for wall thicknesses less than 0.015 inch.

**Table 2B - Tensile properties, SI units**

Nominal OD Millimeters	Nominal Wall Thickness Millimeters	Yield Strength MPa, Min	Tensile Strength MPa, Min	Tensile Strength MPa, Max	Elongation in 50 mm %, Min Strip	Elongation in 50 mm %, Min Full Tube
Up to 4.78, incl	Up to 0.41, incl	205	515	827	--	33
	Over 0.41			724	--	35
Over 4.78 to 12.70, incl	Up to 0.25, incl	205	515	793	30	35
	Over 0.25			724	30	35
Over 12.70	Up to 0.25, incl	205	515	827	25	30
	Over 0.25			724	30	35

<sup>1</sup> Minimum tensile and yield strength properties have been taken from ASTM A249 and are not based on AMS statistical methods.

<sup>2</sup> Yield strength is not required to be determined for OD sizes less than 3.2 mm or for wall thicknesses less than 0.38mm.

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  $\pm 0.002$  in/in/min ( $\pm 0.002$  mm/mm/min) through 0.2% offset yield strain. After the yield strain, the speed of the testing machine shall be set between 0.05 in/in and 0.5 in/in (0.05 mm/mm and 0.5 mm/mm) of the length of the reduced parallel section (or distance between the grips for specimens not having a reduced section) per minute. Alternatively, an extensometer and strain rate indicator may be used to set the strain rate between 0.05 in/in/min and 0.5 in/in/min (0.05 mm/mm/min and 0.5 mm/mm/min). The requirement for compliance becomes effective for material produced 1 year after the publication date of this specification.

#### 3.4.2 Flareability

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 that for the larger of the two sizes.

3.4.2.2 Flarability requirements for tubing under 0.125 inch (3.18 mm) or over 2.000 inches (50.80 mm) in nominal OD shall be as agreed upon by the purchaser and producer.

### 3.4.3 Susceptibility to Intergranular Attack

Specimens from tubing, after sensitizing treatment and immersion as required by ASTM A262 Practice E, shall not exhibit intergranular attack or cracks when tested in accordance with the following:

#### 3.4.3.1 Examination of OD Surface

Shall be performed after flattening a 1 inch (25 mm) long specimen to a total thickness under load of three times the wall thickness.

#### 3.4.3.2 Examination of ID Surface

Shall be performed after splitting a 1 inch (25 mm) long specimen and folding the split specimen, with ID surfaces on the outside of fold, around a mandrel having a diameter equal to the nominal wall thickness of the tube.

##### 3.4.3.2.1 Tubing Over 0.625 Inch (15.88 mm) in OD

The axis of the fold shall be parallel to the axis of the tube.

##### 3.4.3.2.2 Tubing 0.625 Inch (15.88 mm) and Under in OD

The axis of the fold shall be either parallel or transverse to the axis of the tube.

3.4.3.3 If a weld is visible, flattening and/or folding parallel to the tube axis shall be oriented so as to apply maximum tension to the weld.

### 3.5 Quality

Tubing, as received by the 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, 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 When no inspection is specified by the purchaser, tubing shall be subjected to either ultrasonic or eddy current inspection in accordance with AMS2634 or ASTM A1016/A1016M 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.
- 3.5.2 If weld reinforcement is present at the welds on the inner surfaces of tubing over 2.00 inches (50.8 mm) in nominal OD, such weld reinforcement shall not be thicker than 0.010 inch (0.25 mm). The outer surfaces of all tubing and the inner surfaces of tubing 2.00 inches (50.8 mm) and under in nominal OD shall be free from beads.
- 3.5.3 Tubing shall be free from grease, oil, and other foreign matter. A clean white cloth or plug drawn or blown through the length of the bore of a test sample at least 12 inches (30cm) 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, as agreed with the purchaser, for evaluating tube cleanliness may be used for tubing 0.500 inch (12.7mm) and under ID.
- 3.5.4 When specified by the purchaser, tubing shall be subjected to fluorescent penetrant inspection in accordance with ASTM E1417/E1417M, to ultrasonic inspection in accordance with AMS2634, to electromagnetic (eddy-current) examination in accordance with ASTM E426, or to any combination thereof. Standards for acceptance shall be as agreed upon by the purchaser and producer.

### 3.6 Tolerances

Shall conform to all applicable requirements of AMS2243 for hydraulic tubing.

### 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 the producer's tests and shall be responsible for the performance of all required tests. The 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 (see 3.1), tensile properties (see 3.4.1), cleanliness (see 3.5.3), and tolerances (see 3.7) are acceptance tests and shall be performed on each heat or lot as applicable.

- 4.2.1.1 Nondestructive inspection (see 3.5.1) shall be performed on each finished length of tube or as specified (see 3.5.4). Inspection per 3.5.1 shall become effective 1 year after publication of this document.