



# Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing (Small-Diameter) for General Service<sup>1</sup>

This standard is issued under the fixed designation A 632; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

## 1. Scope

1.1 This specification covers grades of stainless steel tubing in sizes under  $\frac{1}{2}$  down to 0.050 in. (12.7 to 1.27 mm) in outside diameter and wall thicknesses less than 0.065 in. down to 0.005 in. (1.65 to 0.13 mm) for general corrosion-resisting and low- or high-temperature service, as designated in Table 1.

NOTE 1—The grades of austenitic stainless steel tubing furnished in accordance with this specification have been found suitable for low-temperature service down to  $-325^{\circ}\text{F}$  ( $-200^{\circ}\text{C}$ ) in which Charpy notched-bar impact values of 15 ft-lbf (20 J), minimum, are required and these grades need not be impact tested.

1.2 Optional supplementary requirements are provided and, when desired, shall be so stated in the order.

1.3 The values stated in inch-pound units are to be regarded as the standard.

## 2. Referenced Documents

### 2.1 ASTM Standards:

A 262 Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels<sup>2</sup>

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products<sup>3</sup>

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products<sup>3</sup>

A 941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys<sup>4</sup>

E 165 Test Method for Liquid Penetrant Examination<sup>5</sup>

E 527 Practice for Numbering Metals and Alloys (UNS)<sup>4</sup>

### 2.2 SAE Standard:

SAE J 1086 Practice for Numbering Metals and Alloys (UNS)<sup>6</sup>

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel, and Related Alloys, and is the direct responsibility of Subcommittee A01.10 on Stainless and Alloy Steel Tubular Products.

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 01.03.

<sup>3</sup> *Annual Book of ASTM Standards*, Vols 01.01, 01.02, 01.03, 01.04, and 01.05.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 01.01.

<sup>5</sup> *Annual Book of ASTM Standards*, Vol 03.03.

<sup>6</sup> Available from Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

## 3. Terminology

3.1 *Definitions*—For definitions of terms used in this specification, refer to Terminology A 941.

## 4. Ordering Information

4.1 Orders for material under this specification should include the following, as required, to describe the desired material adequately:

4.1.1 Quantity (feet or number of lengths),

4.1.2 Name of material (seamless or welded tubes),

4.1.3 Grade (see Table 1),

4.1.4 Size (only two of the following: outside diameter, inside diameter, and average wall),

4.1.5 Length (specific or random),

4.1.6 Optional requirements (check analysis, see Section 15; hydrostatic or nondestructive electric test, see Section 16),

4.1.7 Test report required,

4.1.8 Specification designation, and

4.1.9 Special requirements or any supplementary requirements selected, or both.

## 5. Manufacture

5.1 *Manufacture*—The tubes shall be cold finished and shall be made by the seamless or welded process.

5.2 *Heat Treatment*—All material shall be furnished in the heat-treated condition. The heat-treatment procedure shall consist of heating the material to a minimum temperature of  $1800^{\circ}\text{F}$  ( $980^{\circ}\text{C}$ ) and quenching in water or rapidly cooling by other means.

## 6. Chemical Composition

6.1 The steel shall conform to the requirements as to chemical composition as specified in Table 1.

## 7. Product Analysis

7.1 When specified on the purchase order, an analysis of either one billet or one length of flat-rolled stock or one tube shall be made from each heat. Samples for chemical analysis, except spectrochemical analysis, shall be taken in accordance with Test Methods A 751. The chemical composition thus determined shall conform to the requirements specified.

7.2 If the analysis made in accordance with 7.1 does not conform to the requirements specified, an analysis of each

TABLE 1 Chemical Requirements

Element	Composition, %									
	Grade	TP 304	TP 304L	TP 310	TP 316	TP 316L	TP 317	TP 321	TP 347	TP 348
UNS Designation <sup>A</sup>	S30400	S30403	S31000	S31600	S31603	S31700	S32100	S34700	S34800	
Carbon, max	0.08	0.030	0.15	0.08	0.030	0.08	0.08	0.08	0.08	
Manganese max	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	
Phosphorus, max	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	
Sulfur, max	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	
Silicon, max	0.75	0.75	0.75	0.75	0.75 <sup>B</sup>	0.75	0.75	0.75	0.75	
Nickel	8.0–11.0	8.0–13.0	19.0–22.0	11.0–14.0 <sup>C</sup>	10.0–15.0	11.0–14.0	9.0–13.0	9.0–13.0	9.0–13.0	
Chromium	18.0–20.0	18.0–20.0	24.0–26.0	16.0–18.0	16.0–18.0	18.0–20.0	17.0–20.0	17.0–20.0	17.0–20.0	
Molybdenum	...	...	...	2.00–3.00	2.00–3.00	3.00–4.00	...	...	...	
Titanium	...	...	...	...	...	...	<sup>D</sup>	...	...	
Columbium + tantalum	...	...	...	...	...	...	...	<sup>E</sup>	<sup>E</sup>	
Tantalum, max	...	...	...	...	...	...	...	...	0.10	

<sup>A</sup> New designation established in accordance with Practice E 527 and SAE J 1086, Practice for Numbering Metals and Alloys (UNS).  
<sup>B</sup> For seamless TP316L tubes, the silicon maximum shall be 1.00 %.  
<sup>C</sup> For welded TP 316 tubes, the nickel range shall be 10.0–14.0 %.  
<sup>D</sup> Grade TP 321 shall have a titanium content of not less than five times the carbon content and not more than 0.60 %.  
<sup>E</sup> Grades TP 347 and TP 348 shall have a columbium plus tantalum content of not less than ten times the carbon content and not more than 1.0 %.

billet or length of flat-rolled stock or tube from the same heat may be made and all billets, stock, or tubes thus conforming to the requirements shall be accepted so far as chemical composition is concerned.

8. Mechanical Properties

8.1 *Tensile Requirements*—The material shall conform to the requirements as to tensile properties specified in Table 2. These mechanical properties apply to tubing 1/8 in. (3.2 mm) and larger in outside diameter by 0.015 in. (0.38 mm) in wall thickness and heavier. Smaller sizes are available meeting the minimum tensile strength specified in Table 2; however, yield strength is not generally determined on such sizes, and the minimum elongation shall be 25 %.

9. Permissible Variations in Dimensions

9.1 Variations in diameter and wall thickness from those specified shall not exceed the amounts specified in Table 3.

10. Surface Condition

10.1 The tubes shall be pickled free of scale. When bright annealing is used, pickling is not required.

11. Number of Tests

11.1 For each lot of 100 finished tubes or fraction thereof, two tubes shall be selected at random for the flaring test (see Note 2).

11.2 One tension test shall be made on a specimen for lots of not more than 50 tubes. Tension tests shall be made on specimens from two tubes for lots of more than 50 tubes (see Note 3).

TABLE 2 Tensile Requirements

Tensile strength, min, ksi (MPa)	75 <sup>A</sup> (515) <sup>A</sup>
Yield strength, min, ksi (MPa)	30 <sup>A,B</sup> (205) <sup>A,B</sup>
Elongation in 2 in. or 50 mm, min, %	35 <sup>B</sup>

<sup>A</sup> Grades TP 304L and TP 316L shall have a minimum tensile strength of 70 ksi (485 MPa) and a minimum yield strength of 25 ksi (170 MPa).  
<sup>B</sup> Yield strength is not generally determined on tubing sizes smaller than 1/8 in. (3.2 mm) in outside diameter or thinner than 0.015 in. (0.38 mm) wall, so yield strength is not required on such sizes. Also, the minimum elongation required on these smaller or thinner sizes is 25 %.

TABLE 3 Permissible Variations in Dimensions

Outside Diameter Range	Outside Diameter, in. (mm)	Inside Diameter, in. (mm)	Wall, plus and minus, %
Up to, but not including 3/32 (0.094) in. (2.38 mm)	+0.002 (0.05) -0.000	+0.000 -0.002 (0.05)	10
3/32 (0.094) in. (2.38 mm) but not including 3/16 (0.188) in. (4.76 mm)	+0.003 (0.08) -0.000	+0.000 -0.003 (0.08)	10
3/16 to, but not including, 1/2 (0.500) in. (12.70 mm)	+0.004 (0.10) -0.000	+0.000 -0.004 (0.10)	10

NOTE 2—For flaring requirements, the term *lot* applies to all tubes of the same nominal size and wall thickness that are produced from the same heat of steel and subjected to the same finishing treatment in a continuous furnace; when final heat treatment is in a batch-type furnace, the lot shall include only those tubes that are heat treated in the same furnace charge.

NOTE 3—For tensile requirements, the term *lot* applies to all tubes prior to cutting, of the same nominal diameter and wall thickness that are produced from the same heat of steel. When final heat treatment is in a batch-type furnace, a lot shall include only those tubes of the same size and the same heat that are heat treated in the same furnace charge. When the final heat treatment is in a continuous furnace, a lot shall include all tubes of the same size and heat, heat treated in the same furnace at the same temperature, time at heat and furnace speed.

11.3 When more than one heat is involved, the test requirements prescribed in 15.1 shall apply to each heat.

11.4 Each tube shall be subjected to a pressure test or the nondestructive test described in Section 16.

12. Retests

12.1 If the results of tension or flaring tests do not conform to the specified requirements, retests may be made on additional tubes of double the original number from the same lot, each of which shall conform to the specified requirements.

12.2 If any tension test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted. If the elongation of any tension test specimen is less than that specified, and any part of the fracture is more than 3/4 in. (19.0 mm) from the center of the gage

length as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

### 13. Retreatment

13.1 If the tubes selected to represent any lot fail to conform to the test requirements, the lot represented may be retreated and resubmitted for test.

### 14. Test Specimens and Test Methods

14.1 Test specimens shall be taken from the ends of the finished tubes before being cut to length. They shall be smooth on the ends and free of burrs and flaws and properly identified with the lot from which they are taken.

14.2 Specimens shall be tested at room temperature.

14.3 The specimens and mechanical tests required shall be made in accordance with Supplement II of Test Methods and Definitions A 370.

### 15. Manipulation Test

15.1 *Flaring Test*—A section of tube approximately 4 in. (101.6 mm) in length shall stand being flared with a tool having a 60° included angle until the tube at the mouth of the flare has been expanded to the following percentages without cracking or showing flaws:

Ratio of Inside Diameter to Outside Diameter	Minimum Expansion of Inside Diameter, %
0.9	21
0.8	22
0.7	25
0.6	30
0.5	39
0.4	51
0.3	68

NOTE 4—These flare tests shall not be required on sizes under 0.093 in. (2.38 mm) in inside diameter.

### 16. Hydrostatic or Nondestructive Electric Test

16.1 Each tube shall be subjected to the nondestructive electric test or the hydrostatic test. The type of test to be used shall be at the option of the manufacturer, unless otherwise specified in the purchase order.

16.2 *Hydrostatic test:*

Each tube at the final size shall be hydrostatically pressure tested or air pressure tested under water.

16.3 Tubes that are hydrostatically pressure tested shall have the hydrostatic test pressure determined by the following equation, but shall not exceed 1000 psi (6.89 MPa):

$$P = 2St/D$$

where:

- $P$  = hydrostatic test pressure, psi or MPa,
- $S$  = allowable fiber stress of 16 000 psi (110.3 MPa),
- $t$  = specified wall thickness, in. or mm, and
- $D$  = specified outside diameter, in. or mm.

16.4 The air-pressure test under water shall be performed at 500-psi (3.4-MPa) pressure or at a pressure equivalent to a maximum fiber stress of 16 000 psi (110.3 MPa) by the equation shown above, whichever is less.

16.5 The test pressure shall be held for a minimum of 5 s.

16.6 If any tube shows leaks during the hydrostatic test or the air pressure test, it shall be rejected.

16.7 *Nondestructive Electric Test:*

16.8 Each tube shall be tested at the mill by passing it through a nondestructive tester capable of detecting defects with a depth exceeding 10 % of the wall thickness or 0.002 in. (0.05 mm), whichever is greater. Testing will not be required on sizes under 0.125 in. (3.18 mm) in outside diameter. However, at the option of the purchaser, tubing to be drawn to a diameter under 0.125 in. may be tested while in the range from 0.156 in. (3.97 mm) to 0.125 in. outside diameter, and any defects that are found shall be culled out before any further reductions are made.

### 17. Inspection

17.1 The inspector representing the purchaser shall have entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's plant that concern the inspection of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy the inspector that the material is being furnished in accordance with this specification. All tests and inspections shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the plant.

### 18. Rejection

18.1 When inspection at the place of manufacture has been waived by the purchaser, any rejection shall be reported to the manufacturer within 30 working days from receipt of samples by the purchaser.

### 19. Certification

19.1 When inspection at the place of manufacture has been waived by the purchaser, the manufacturer shall furnish, on request, a statement that the material has been tested and has met all requirements of this specification.

### 20. Product Marking

20.1 The name or brand of the manufacturer, the grade of the material from which the tube is made (such as Type 304), the letters ASTM, and the specification designation shall be marked on a tag securely attached to the bundle or box in which the tubes are shipped.

### 21. Keywords

21.1 austenitic stainless steel; seamless tube; small diameter; stainless steel tube; steel tube; welded steel tube

## SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser in the inquiry, contract, or order.

### S1. Dye Penetrant Inspection

S1.1 Each tube shall be submitted to a visible dye or fluorescent dye penetrant examination. The procedure for this specification shall conform to Test Method E 165. The type penetrant and the acceptance level shall be agreed upon between the purchaser and manufacturer.

### S2. Embrittlement Test

S2.1 Tubing shall be capable of meeting the intergranular corrosion test specified in Practice E of Practices A 262 in the as-shipped condition. Stabilized and low-carbon grades shall be capable of meeting the requirements of this test in the sensitized condition (1 h at 1240°F [675°C]).

### S3. Cleanliness

S3.1 The tubing shall be supplied *thermocouple clean* on the inside surface. *Thermocouple clean* is defined as being free of all drawing compounds, carbon, dirt, dust, and other contaminants. A test for this degree of cleanliness is made by

passing a swatch of lint-free yarn or cloth, or felt plug, soaked in alcohol or acetone through the tube. A light discoloration of the swatch is not a cause for rejection unless it contains particles of grit or metallic flakes (no magnification used). In addition, freedom from inside surface oxide shall be determined by sectioning, pickling, and washing short lengths of tubing and comparing with the tubing in the original untested condition. After cleaning, the tubing shall be capped or otherwise protected to ensure cleanliness upon arrival at its destination.

### S4. Unstraightened Tubes

S4.1 When the purchaser specifies tubes unstraightened after final heat treatment (such as coils), the minimum yield strength of Table 2 shall be reduced by 5 ksi.

S4.2 On the certification, and wherever the grade designation for unstraightened tubing appears, it shall be identified with the suffix letter *U* (for example, 304-U, 321-U, and so forth.).

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