Designation: A 632 – 04

Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing (Small-Diameter) for General Service[1]

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 reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This specification covers grades of stainless steel tubing in sizes under ½ 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°F (−200°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:* [2]

A 262 Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels

A 380 Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems

A 1016/A 1016M Specification for General Requirements for Ferritic Alloy Steel, Austenitic Alloy Steel, and Stainless Steel Tubes

E 165 Test Method for Liquid Penetrant Examination

E 527 Practice for Numbering Metals and Alloys (UNS)

2.2 *SAE Standard:*

SAE J 1086 Practice for Numbering Metals and Alloys (UNS)[3]

3. Ordering Information

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

3.1.1 Quantity (feet or number of lengths),

3.1.2 Name of product (seamless or welded tubes),

3.1.3 Grade (see Table 1),

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

3.1.5 Length (specific or random),

3.1.6 Optional requirements (check analysis, see Section 7; hydrostatic, air underwater pressure test, or nondestructive electric test, see Section 13),

3.1.7 Test report required,

3.1.8 Specification designation, and

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

4. General Requirements

4.1 Tubing furnished under this specification shall conform to the applicable requirements of the current edition of Specification A 1016/A 1016M, unless otherwise provided herein.

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°F (980°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.

[1] 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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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001.

***A Summary of Changes section appears at the end of this standard.**

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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[A]	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[B]	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[C]	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	...	...	...	...	...	...	...[D]	...	...
Columbium + tantalum	...	...	...	...	...	...	...	...[E]	...[E]
Tantalum, max	...	...	...	...	...	...	...	...	0.10

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

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. The chemical composition thus determined shall conform to the specified requirements.

7.2 If the analysis made in accordance with 7.1 does not conform to the specified requirements, an analysis of each 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 ⅛ 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.

TABLE 2 Tensile Requirements

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

[A] 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).
[B] Yield strength is not generally determined on tubing sizes smaller than ⅛ 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, ½ (0.500) in. (12.70 mm)	+0.004 (0.10) −0.000	+0.000 −0.004 (0.10)	10

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).

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 12.1 shall apply to each heat.

11.4 Each tube shall be subjected to a pressure test or the nondestructive test described in Section 13.

12. Flaring Test

12.1 *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.

13. Hydrostatic, Air Underwater Pressure Test, or Nondestructive Electric Test

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

13.2 *Hydrostatic Test*:

Each tube shall be subjected to a hydrostatic test at a test pressure not exceeding 1000 psi (6.89 MPa).

13.3 *Air Underwater Pressure Test*:

Each tube shall be subjected to an air underwater pressure test, at a test pressure as given by the following equation or 500 psi (3.4 MPa), whichever is less:

$$P = 2St / D \quad (1)$$

where:

P = air 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.

13.4 *Nondestructive Electric Test*:

13.5 Each tube shall be subjected to a nondestructive electric test that is capable of detecting imperfections 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.

14. Keywords

14.1 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 When specified, tubing shall be supplied *thermocouple clean* on the inside surface. *Thermocouple clean* is defined as being free of all drawing compounds, carbon, dirt, dust, visible surface oxides, scale, and other contaminants.

S3.1.1 Verify the freedom from inside visible surface oxides and scale by cutting two short lengths of tubing as specimens and longitudinally sectioning both. Pickle one of the specimens in accordance with Specification A 380 and then wash both. Visually, without magnification, compare the pickled and unpickled specimens to confirm that neither exhibits surface oxides or scale on their inside surfaces.

S3.1.2 Verify cleanliness and freedom from contaminants, such as drawing compounds, carbon, dirt, and dust, by passing a solvent-saturated swatch of lint-free yarn or cloth, or a felt plug through the tube. Isopropyl alcohol, methanol, ethanol, denatured alcohol, or acetone followed by alcohol are acceptable solvents. Because acetone leaves a residual film, cleaning with acetone alone is not acceptable. While a heavy discoloration of the swatch or plug is unacceptable, a light discoloration is acceptable unless particles of grit or metallic flakes are visually detectable without the use of magnification.

S3.2 After verifying that the inside surface is thermocouple clean, the tubing shall be capped or otherwise protected to ensure cleanliness upon arrival at its destination. The producer and purchaser shall agree on the method of protection.

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.).

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this specification since the last issue, A 632 – 02a, that may impact the use of this specification. (Approved March 1, 2004)

(1) Added reference to Specification A 380 in Referenced Documents and Supplementary Requirement S3.

Committee A01 has identified the location of selected changes to this specification since the last issue, A 632 – 02, that may impact the use of this specification. (Approved September 10, 2002)

(1) Reference to Specification A 1016/A 1016M has been added.
(2) References to Test Methods and Definitions A 370, Terminology A 941, and Test Methods A 751 have been deleted from Section 2 and throughout the standard.
(3) Section 12 was renamed from "Manipulation Test" to "Flaring Test."
(4) Section on Terminology was deleted.
(5) Section on General Requirements was added.
(6) Paragraphs 7.1 and 7.2 were revised.
(7) Sections on Retests, Retreatment, Test Specimens and Test Methods, Inspection, Rejection, Certification, and Product Marking were deleted.
(8) Section 13 was revised.

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