



Designation: A1098/A1098M – 18 (Reapproved 2022)

Standard Specification for Welded Austenitic, Ferritic, Martensitic and Duplex Stainless Steel Boiler, Superheater, Condenser, and Heat Exchanger Tubes with Textured Surface(s)¹

This standard is issued under the fixed designation A1098/A1098M; 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 approval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers average or minimum-wall thickness welded tubes made from various grades of austenitic, ferritic, martensitic and duplex stainless steel materials in which the (1) external tube surface, (2) internal tube surface, or (3) both internal and external tube surfaces have a textured configuration for improved heat transfer or fluid flow or both. Texture surface(s) are produced by cold forming a specified configuration on the surface(s) of base strip material, prior to welding. The produced welded textured tubes may be used in boilers, superheaters, condensers, evaporators, heat exchangers, and other similar heat transfer apparatus in diameters up to and including 1.5 in. [38 mm] for various wall thicknesses up to and including 0.079 in. [2 mm].

1.2 The tubing sizes and thicknesses usually furnished to this specification are 0.375 in. [10 mm] inside diameter (ID) to 1.5 in. [38 mm] outside diameter and 0.020 to 0.079 in. [0.5 to 2 mm], inclusive, in wall thickness. Tubing having other dimensions may be furnished provided such tubes comply with all other requirements of this specification.

1.3 Optional supplementary requirements are provided and, when one or more of these are desired, each shall be so stated in the order.

1.4 Several grades of austenitic, ferritic, martensitic and duplex stainless steels are included in this specification. Not all alloys are suitable for all conditions. Selection will depend upon design and service requirements.

1.5 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the

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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standard. The inch-pound units shall apply unless the “M” designation of this specification is specified in the order.

1.6 The following safety hazards statement pertains only to the test method and the Supplementary Requirements of this specification. A specific warning statement is given in the Supplementary Requirements. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:²

[A249/A249M Specification for Welded Austenitic Steel Boiler, Superheater, Heat-Exchanger, and Condenser Tubes](#)

[A262 Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels](#)

[A268/A268M Specification for Seamless and Welded Ferritic and Martensitic Stainless Steel Tubing for General Service](#)

[A370 Test Methods and Definitions for Mechanical Testing of Steel Products](#)

[A480/A480M Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip](#)

[A763 Practices for Detecting Susceptibility to Intergranular Attack in Ferritic Stainless Steels](#)

[A789/A789M Specification for Seamless and Welded](#)

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.

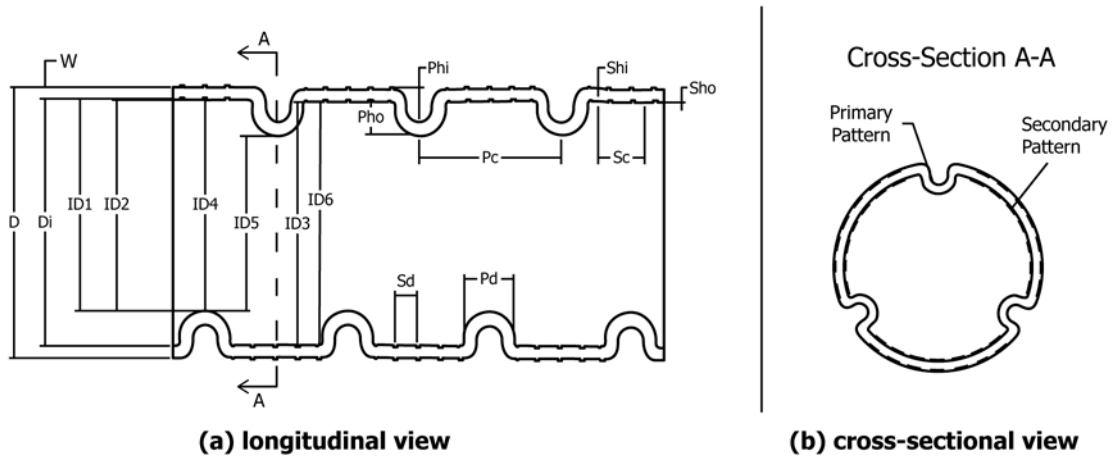


FIG. 1 Views of a Representative Textured Tube Showing Variables that Describe the Possible Primary and Secondary Texturizations that May be Applied to the Inside Surface of a Tube, Outside Surface of the Tube, or Both the Inside and Outside Surfaces of the Tube

Ferritic/Austenitic Stainless Steel Tubing for General Service

A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys

A1016/A1016M Specification for General Requirements for Ferritic Alloy Steel, Austenitic Alloy Steel, and Stainless Steel Tubes

E384 Test Method for Microindentation Hardness of Materials

E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

2.2 ASME Standard.³

Boiler and Pressure Vessel Code Section VIII Para UW-51

2.3 SAE Standards.⁴

SAE J1086 Practice for Numbering Metals and Alloys (UNS)

3. Terminology

3.1 For definitions of general terms used in this specification, refer to Terminology A941.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *plain cylindrical ring gauges, n*—a cylindrical metal ring whose inside diameter is furnished to gauge tolerance.

3.2.2 *plain ending, n*—portion of the tube that has no surface texture.

3.2.3 *primary character, n*—largest texture impressed on material.

3.2.4 *primary pattern, n*—combination of primary characters.

3.2.5 *secondary character, n*—finecut texture impressed on material.

3.2.6 *secondary pattern, n*—combination of secondary characters.

³ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

⁴ Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, <http://www.sae.org>.

3.2.7 *textured surface, n*—impressing a series of characters or textures into the material with the intent of improving heat transfer and fluid flow characteristics in the final welded tube.

3.3 *Symbols:*

3.3.1 D —outside tube diameter-nominal

3.3.2 D_i —inside tube diameter

3.3.3 $ID1$ —top of primary character to bottom of secondary character. See Fig. 1 cross section A-A for view of primary character and secondary character pattern.

3.3.4 $ID2$ —top of primary character to top of secondary character

3.3.5 $ID3$ —top of secondary character to top of secondary character

3.3.6 $ID4$ —top of primary character to bottom of primary character at intersection of the base (each on opposite sides of the tube)

3.3.7 $ID5$ —top of primary character to top of primary character (each on opposite sides of the tube)

3.3.8 $ID6$ —top of secondary character to bottom of secondary character

3.3.9 P_a —angle of the primary character unit (if any)

3.3.10 P_a —angle of the secondary character unit (if any)

3.3.11 P_c —primary character center spacing

3.3.12 P_d —primary character diameter

3.3.13 P_{hi} —primary character height (inside)

3.3.14 P_{ho} —primary character height (outside)

3.3.15 S_c —secondary character center spacing

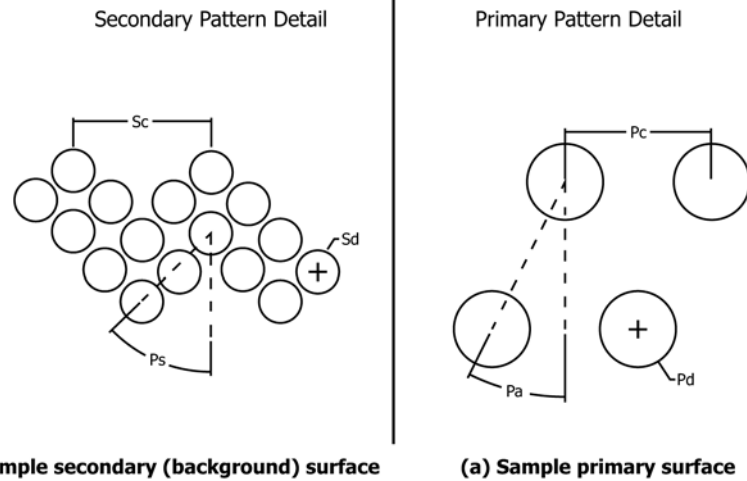
3.3.16 S_d —secondary character diameter

3.3.17 S_{hi} —secondary character height (inside)

3.3.18 S_{ho} —secondary character height (outside)

3.3.19 W —wall thickness (no pattern)

3.3.20 W_I —wall thickness peak inside to valley outside (secondary character)



(a) Sample secondary (background) surface **(a) Sample primary surface**
NOTE — One, both, or more patterns may be used and combined. Each pattern made up of a variety of possible shapes.

FIG. 2 Details Regarding the Sample Representative Geometry of the Patterns Used to Texture the Flat Strip Material before It is Used to Create a Welded Tube

- 3.3.21 W_2 —wall thickness valley inside to peak outside (secondary character)
- 3.3.22 W_3 —wall thickness base of primary character
- 3.3.23 W_4 —wall thickness in wall of the primary character

4. Ordering Information

4.1 It is the responsibility of the purchaser to specify all requirements that are necessary for product ordered under this specification. Such requirements may include, but are not limited to, the following:

- 4.1.1 Quantity (feet, metres, or number of lengths);
- 4.1.2 Name of material welded tubes (WLD);
- 4.1.3 Grade (refer to [Table 1](#));
- 4.1.4 Size (outside diameter and wall thickness);
- 4.1.5 Length (specific or random);
- 4.1.6 Hydrostatic testing or non-destructive electric testing (see [Section 16](#));
- 4.1.7 Test report required (see [Certification Section of Specification A1016/A1016M](#));
- 4.1.8 Specification designation;
- 4.1.9 Special requirements and any supplementary requirements selected.
 - 4.1.9.1 Additional requirements may include the various inside or outside diameters ([Fig. 1](#)), texture wall thickness values (see [Fig. 3](#)), and length of untextured sections if required; effective diameter and wall thickness of the modified section; number of secondary textured character units per unit length; number of primary textured character units per unit length; and the total tube length.

5. General Requirements

5.1 Material furnished under this specification shall conform to the applicable requirements of the current edition of [Specification A1016/A1016M](#) unless otherwise provided herein.

6. Manufacture

- 6.1 The strip used to form welded tubes shall be textured by cold working on one or both surfaces before being formed into a tube.
- 6.2 The tubes may have plain ends or have untextured sections within the tube length as specified in the purchase order.
- 6.3 The tubes shall be made from flat rolled steel using an automatic welding process with no addition of filler metal.
- 6.4 Subsequent to welding and before final heat treatment, the tubes may be worked only in the welded portion. Cold working and the method of cold working shall be at the option of the manufacturer unless specified otherwise in the purchase order.

7. Chemical Composition

7.1 The heat analysis shall conform to the chemical composition requirements given in [Table 1](#).

8. Heat Treatment

- 8.1 Austenitic stainless steel tubes shall be provided in the solution annealed condition as specified in [Table 2](#).
- 8.2 Ferritic stainless steels shall be given a final heat treatment of 1200°F [650°C] or higher and cooled as appropriate for the grade to meet the requirement of this specification.
- 8.3 For Type 44, annealing is done at 1500 to 1550°F [815 to 842°C] for 1 hr per inch [25 mm] of thickness and furnace cool to room temperature.
- 8.4 Martensitic stainless steel tubing shall be given a final heat treatment by reheating to a temperature of 1200°F [650°C] or higher and cooled (as appropriate for the grade) to meet the requirements of this specification.