Designation: A1012 – 10 (Reapproved 2021)

Standard Specification for Seamless and Welded Ferritic, Austenitic and Duplex Alloy Steel Condenser and Heat Exchanger Tubes With Integral Fins[1]

This standard is issued under the fixed designation A1012; 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 describes seamless and welded ferritic, austenitic and duplex alloy steel tubing on which the external or internal surface, or both, has been modified by a cold forming process to produce an integral enhanced surface for improved heat transfer. The tubes are used in surface condensers, evaporators, heat exchangers and similar heat transfer apparatus in unfinned end diameters up to and including 1 in. (25.4 mm). Boiler tubes are excluded.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 The following precautionary statement pertains to the test method portion only, Section 12, of this specification: *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.*

1.4 *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]

A213/A213M Specification for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes

A249/A249M Specification for Welded Austenitic Steel Boiler, Superheater, Heat-Exchanger, and Condenser Tubes

A268/A268M Specification for Seamless and Welded Ferritic and Martensitic Stainless Steel Tubing for General Service

A269 Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service

A688/A688M Specification for Seamless and Welded Austenitic Stainless Steel Feedwater Heater Tubes

A789/A789M Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service

A803/A803M Specification for Seamless and Welded Ferritic Stainless Steel Feedwater Heater Tubes

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

3. Terminology

3.1 *Definitions*—For definition of general terms used in this specification, refer to Specification A941.

3.2 *Symbols (Integral Fin Tube Nomenclature):*

D = outside diameter of unenhanced section
D_i = inside diameter of unenhanced section
d_r = root diameter of enhanced section outside of tube
d_o = outside diameter of enhanced section
d_i = inside diameter of enhanced section
W = wall thickness of unenhanced section
W_f = wall thickness of enhanced section
F_h = height of fin—enhanced section outside of tube
F_m = mean fin thickness—enhanced section outside of tube
P = mean rib pitch—enhanced section inside of tube
R_h = height of rib—enhanced section inside of tube
H_a = rib helix angle—enhanced section inside of tube

[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.

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

T_t = transition taper

4. Ordering Information

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

4.1.1 ASTM designation and year of issue (this specification);

4.1.2 ASTM designation and year of issue (plain tube specification);

4.1.3 Welded or seamless;

4.1.4 Alloy grade and UNS designation;

4.1.5 Dimensions; plain tube outside diameter, plain tube wall thickness (average or minimum specified), length and location of unenhanced surfaces and the total tube length. Configuration of enhanced surfaces (fins per unit length, fin height, wall thickness under fin, rib pitch, rib height, etc.) shall be as agreed upon between the manufacturer and purchaser (see Fig. 1 and Fig. 2).

4.1.6 Temper (as-finned or stress relief annealed);

4.1.7 Quantity;

4.1.8 Packaging;

4.1.9 Nondestructive tests;

4.1.10 Customer inspection;

4.1.11 Mill test report;

4.1.12 Certification.

5. General Requirements

5.1 Material furnished under this specification shall conform to the applicable requirements of Specification A1016/A1016M unless otherwise provided herein.

5.2 Enhanced (integrally finned) sections of the tube shall be produced by cold forming the tubing in such a manner that exterior fins, wall under the fin and inside ribs (when specified) are homogeneous.

5.3 Tubes described by this specification shall be furnished with unenhanced (plain) ends.

5.4 Enhanced sections of the tube are normally supplied in the "as finned" temper (cold worked condition produced by the enhancing operation). The unenhanced sections of the tube shall be in the annealed condition and shall be suitable for rolling-in operations.

6. Materials and Manufacture

6.1 The integrally enhanced (finned) tubes shall be manufactured from seamless, welded, or welded/cold worked plain tubes that conform to one of the following ASTM specifications: A213/A213M, A249/A249M, A268/A268M, A269, A688/A688M, A789/A789M, A803/A803M.

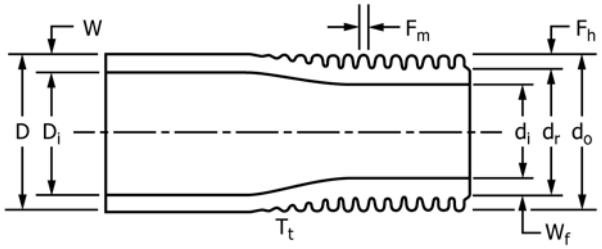

FIG. 1 Outside Enhancement Only

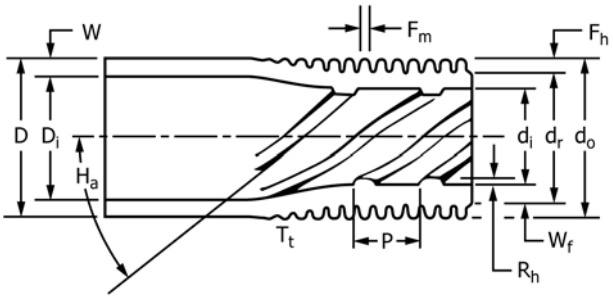

FIG. 2 Outside and Inside Enhancement

7. Temper

7.1 The tube after enhancing shall normally be supplied in the as-finned temper. When specified by the purchaser, for bending, coiling or other fabricating operations, enhanced portions of the tube may be stress relief annealed or solution annealed.

7.2 Heat treatment of enhanced sections, or bend areas, or both, shall be in accordance with the governing plain tube specification.

8. Chemical Composition

8.1 The tubing specified shall conform to the chemical requirements prescribed in the governing plain tube specification.

9. Tensile Requirements

9.1 The tube prior to the finning operation, or unenhanced portions of the finned tube, shall conform to the requirements for tensile properties prescribed in the governing plain tube specification.

10. Permissible Variations in Dimensions

10.1 *Diameter*—The outside diameter of the unenhanced sections shall not exceed the diameter tolerances shown in the governing plain tube specification as measured by micrometers and verified by "go" and "no go" ring gages. The diameter over the enhanced sections shall not exceed the diameter of the plain sections involved, as determined by a "go" ring gage unless otherwise specified. The dimensions of the ring gages shall be as described in 10.1.1 and 10.1.2.

10.1.1 The inside diameter dimension of the "go" ring gage shall be equal to the nominal tube diameter, plus the maximum tolerance, plus 0.002 in. The length of the "go" ring gage shall be 1 in. (25.4 mm) minimum.

10.1.2 The inside diameter dimension of the "no go" ring gage shall be equal to the nominal tube diameter minus the maximum tolerance. The length of the "no go" ring gage shall be 1 in. (25.4 mm) minimum.

10.2 *Wall Thickness*—The wall thickness of enhanced and unenhanced sections shall not exceed the thickness tolerances

shown in the governing plain tube specification unless otherwise agreed to between the manufacture and purchaser. No tube at any point shall be less than the minimum thickness specified in the plain sections or in the enhanced sections.

10.3 *Length*—The length of the tubes shall not be less than that specified, but may exceed the specified value by the amounts given in Table 1.

10.3.1 The length of plain ends, as measured from the tube end to the first tool impression, shall not be less than that specified, but may exceed the specified value by ½ in. (12.7 mm).

10.3.2 The length of fin sections and lands (unenhanced portions) shall be as specified ± ¼ in. (6.35 mm).

10.4 *Squareness of Cut*—The angle of cut of the end of any tube may depart from square by not more than 0.016 in.

10.5 *Straightness*—The tube shall be reasonably straight and free of bends or kinks.

11. Workmanship, Finish, and Appearance

11.1 Finished tubes shall be clean and free of foreign material, shall have smooth ends free of burrs, and shall be free of injurious external and internal imperfections. Minor defects may be removed, provided the dimensional tolerances of Section 10 are not exceeded.

11.2 A slight amount of oxidation on the surface resulting from heat treatment after enhancing or bending is acceptable. When the plain tube specification allows for a slight amount of oxidation on the surface resulting from heat treatment, this also is acceptable.

12. Nondestructive Tests

12.1 After enhancing operations, subject each tube to a nondestructive electromagnetic test, and either a pneumatic or hydrostatic test as specified in the purchase order. Tubes normally shall be tested in the as-fabricated condition but, at the option of the manufacturer or purchaser, may be tested in the stress relief annealed condition.

12.1.1 *Eddy Current Test*—Eddy current inspect the tube by passing it through an encircling coil designed to test the entire cross section of the tube.

12.1.1.1 The reference standard used to adjust the sensitivity setting of the apparatus shall be sound and of the same nominal alloy, enhanced configuration, condition (temper), and nominal dimensions as the lot of tubes to be tested on a production basis. Drill four holes not larger than 0.031 in. (0.787 mm) in diameter radially through the enhanced wall in each of four successive planes at 0°, 90°, 180°, and 270°. Use a suitable drill jig to guide the drill, taking care to avoid distortion of the adjacent fins. Locate one hole in the weld for welded material. Space artificial discontinuities at least 16 in. (406 mm) apart to provide signal resolution adequate for interpretation. Discard and replace the reference standard when erroneous signals are produced from mechanical, metallurgical, or other damage to the tube.

TABLE 1 Length Tolerances

Specified Length, ft (m)	Tolerance, in. (mm)
Up to 24 (7.3), incl	+ ⅛ (3.2)
Over 24 to 34 (7.3 to 10.4), incl	+ ¼ (6.4)
Over 34 to 44 (10.4 to 13.4), incl	+ ⅜ (9.5)
Over 44 (13.4)	+ ½ (12.7) max

12.1.1.2 Adjust the eddy current test unit to obtain an optimum signal-to-noise ratio with the minimum sensitivity required to detect all four artificial defects in the reference standard on a repeatable basis. Equipment adjustments and tube speed maintained during calibration shall be the same for production tubes.

12.1.1.3 Set aside tubes showing an eddy current indication in excess of any signal obtained from artificial defects in the reference standard and subject them to retest or rejection.

12.1.1.4 Tubes causing irrelevant signals because of debris and like effects shall be considered to conform, should they not cause output signals beyond acceptable limits when retested. Tubes causing irrelevant signals because of visible and identifiable handling marks (rough fin tip, notches in the fin) shall be considered to conform, provided the wall thickness in the enhanced and unenhanced areas is not less than the minimum specified.

12.1.1.5 Tubes causing relevant signals because of injurious defects (incomplete welds, splits, embedded debris, broken tool impressions, ID defects), that reduce the wall thickness below the minimum specified shall be rejected. If, after retest and examination, no source for the reject signal can be discerned, the tube shall be rejected.

12.1.2 *Pneumatic Test*—After finning, each tube shall be subjected to an internal pneumatic leak test for 5 s without showing evidence of leakage. Any evidence of leakage shall be cause for rejection. The test method used shall permit easy visual detection of any leakage, such as using the air under water at a minimum of 250 psi (1.72 MPa) or the pneumatic leak method in accordance with Specification A1016/A1016M.

12.1.2.1 *Air Underwater Pressure Test*—Each tube shall be tested in accordance with Specification A1016/A1016M except using test pressure specified in 12.1.2.

12.1.2.2 *Pressure Differential Test*—Procedure and acceptance criteria shall be agreed upon between the manufacturer and purchaser.

12.1.3 *Hydrostatic Test*—When examined with this test method, each tube shall be tested in accordance with Specification A1016/A1016M, except, the equation for calculating test pressure shall be modified as follows:

$$Inch - Pound\ Units: P = 32\,000\ W_f/d_r \quad (1)$$

$$SI\ Units: P = 220.6\ W_f/d_r$$

where:

P = hydrostatic test pressure, psi (or MPa),
W_f = wall under fin thickness, in. (or mm),
d_r = fin root diameter, in. (or mm),

12.1.3.1 As agreed upon between the manufacturer and purchaser, a minimum hydrostatic test pressure in excess of the requirements of Specification A1016/A1016M may be stated on the order. The tube wall stress shall be determined by the following equation:

$$S = Pd_r/2W_f \quad (2)$$