



Designation: B1014 – 20

Standard Specification for Welded Copper and Copper Alloy Condenser and Heat Exchanger Tubes with a Textured Surface(s)¹

This standard is issued under the fixed designation B1014; 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 the production of welded copper and copper alloy tubes with a longitudinal seam free of filler metal produced from sheet or strip up to 1.5 in. (38.1 mm), in diameter for use in surface condensers, evaporators, heat exchangers, and general engineering applications. The following coppers or copper alloys are involved:

Copper UNS Nos.	Type of Copper
C10100 ^A	Oxygen-Free-Electronic (OFE)
C10200 ^A	Oxygen-Free, without residual deoxidants (OF)
C10300 ^A	Oxygen-Free, low phosphorus (OFXLP)
C10800 ^A	Oxygen-Free Copper, low phosphorus (OFLP)
C12000 ^A	Phosphorus-Deoxidized, low residual phosphorus (DLP)
C12200 ^A	Phosphorus-Deoxidized, high residual phosphorus (DHP)
C14200	Phosphorus-Deoxidized, arsenical (DPA)
C15630	Nickel Phosphorus
C19200	Phosphorized, 1 % iron
C23000	Red Brass, 85 %
C44300	Admiralty, Arsenical
C44400	Admiralty, Antimonial
C44500	Admiralty, Phosphorized
C60800	Aluminum Bronze
C68700	Aluminum Brass, Arsenical
C70400	Copper-Nickel, 5 %
C70600	Copper-Nickel, 10 %
C70620	Copper-Nickel, 10 % (modified for welding)
C71000	Copper-Nickel, 20 %
C71500	Copper-Nickel, 30 %
C71520	Copper-Nickel, 30 % (modified for welding)
C72200	...

^A Designations listed in Classification B224.

1.1.1 The (1) external tube surface, (2) internal tube surface, or (3) both internal and external tube surfaces of these tubes shall have a textured surface for improved heat transfer or fluid flow, or both. The strip material used to produce the textured surface tubes have been modified to form a textured surface strip material from a smooth surface strip material by a cold-forming process or series of processes. The produced welded textured tubes may be used in condensers, evaporators, heat exchangers, and other similar heat transfer apparatus in

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diameters up to and including 1.5 in. (38.1 mm) for various wall thicknesses up to and including 0.07 in. (1.78 mm).

1.2 The tubing sizes and thicknesses usually furnished to this specification are 1/8 in. (3.2 mm) in inside diameter to 1.5 in. (38.1 mm) in outside diameter and 0.015 in. to 0.070 in. (0.4 mm to 1.78 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 Mechanical property requirements do not apply to tubing smaller than 1/8 in. (3.2 mm) in inside diameter or for a wall thickness smaller than 0.015 in. (0.4 mm).

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

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5.1 *Exception*—Values given in inch-pound units are the standard except for grain size, which is stated in SI units.

1.6 The following safety hazards caveat pertains to the test method described in 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.*

1.7 *Mercury has been designated by many regulatory agencies as a hazardous substance that can cause serious medical issues. Mercury, or its vapor, has been demonstrated to be hazardous to health and corrosive to materials. Use caution when handling mercury and mercury-containing products. See the applicable product Safety Data Sheet (SDS) for additional information. The potential exists that selling mercury or mercury-containing products, or both, is prohibited by local or national law. Users must determine legality of sales in their location.*

1.8 *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

- B153** Test Method for Expansion (Pin Test) of Copper and Copper-Alloy Pipe and Tubing
 - B154** Test Method for Mercurous Nitrate Test for Copper Alloys
 - B170** Specification for Oxygen-Free Electrolytic Copper—Refinery Shapes
 - B224** Classification of Coppers
 - B577** Test Methods for Detection of Cuprous Oxide (Hydrogen Embrittlement Susceptibility) in Copper
 - B601** Classification for Temper Designations for Copper and Copper Alloys—Wrought and Cast
 - B846** Terminology for Copper and Copper Alloys
 - B858** Test Method for Ammonia Vapor Test for Determining Susceptibility to Stress Corrosion Cracking in Copper Alloys
 - B950** Guide for Editorial Procedures and Form of Product Specifications for Copper and Copper Alloys
 - B968/B968M** Test Method for Flattening of Copper and Copper-Alloy Pipe and Tube
 - E3** Guide for Preparation of Metallographic Specimens
 - E8/E8M** Test Methods for Tension Testing of Metallic Materials
 - E29** Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
 - E53** Test Method for Determination of Copper in Unalloyed Copper by Gravimetry
 - E62** Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods) (Withdrawn 2010)³
 - E112** Test Methods for Determining Average Grain Size
 - E118** Test Methods for Chemical Analysis of Copper-Chromium Alloys (Withdrawn 2010)³
 - E243** Practice for Electromagnetic (Eddy Current) Examination of Copper and Copper-Alloy Tubes
 - E255** Practice for Sampling Copper and Copper Alloys for the Determination of Chemical Composition
 - E478** Test Methods for Chemical Analysis of Copper Alloys
 - E527** Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)
 - E2575** Test Method for Determination of Oxygen in Copper and Copper Alloys by Inert Gas Fusion
- ### 2.2 ASME Code:⁴
- ASME Boiler and Pressure Vessel Code Application**

3. Terminology

3.1 *Definitions*—For definitions of terms related to copper and copper alloys, refer to Terminology **B846**.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *lengths, mill, n*—straight lengths, including ends that are conveniently manufactured in the mills.

3.2.1.1 *Discussion*—Full-length pieces are usually 10 ft, 12 ft, or 20 ft (3 m, 3.7 m, or 6.1 m) and subject to established length tolerances.

3.2.2 *lengths, stock, n*—straight lengths that are mill cut and stored in advance of orders.

3.2.2.1 *Discussion*—Stock lengths are usually 6 ft to 20 ft (1.8 m to 6.1 m) and subject to established tolerances.

3.2.3 *% of secondary pattern, n*—combination of secondary characters.

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

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

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

3.2.7 *secondary characters, n*—fadeout texture impressed on material.

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

3.3 *Symbols (Textured Tube Nomenclature):*

3.3.1 *D*—outside tube diameter-nominal

3.3.2 *D_i*—inside tube diameter

3.3.3 *ID1*—top of primary to bottom of secondary

3.3.4 *ID2*—top of primary to top of secondary

3.3.5 *ID3*—top of secondary to top of secondary

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

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

3.3.8 *ID6*—top of secondary to bottom of secondary

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

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

3.3.11 *Pc*—primary pattern center spacing

3.3.12 *Pd*—primary pattern character diameter

3.3.13 *Phi*—primary pattern height (inside)

3.3.14 *Pho*—primary pattern height (outside)

3.3.15 *Sc*—secondary pattern center spacing

3.3.16 *Sd*—secondary pattern character diameter

3.3.17 *Shi*—secondary pattern character (inside)

3.3.18 *Sho*—secondary pattern height (outside)

3.3.19 *W*—wall thickness (no pattern)

3.3.20 *WI*—wall thickness peak inside to valley outside (secondary pattern)

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 The last approved version of this historical standard is referenced on www.astm.org.

⁴ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

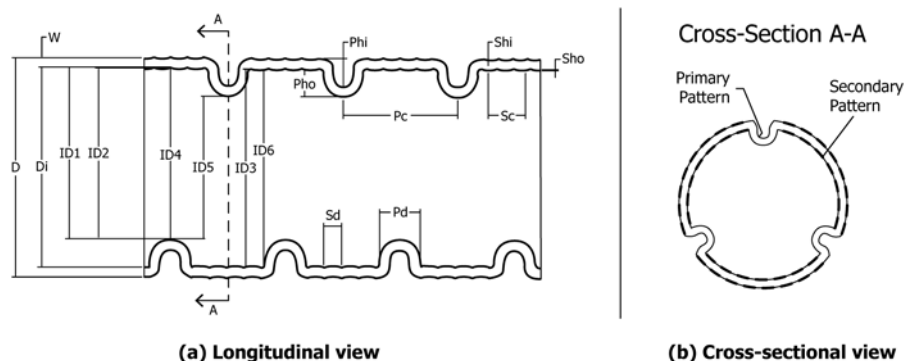


FIG. 1 Views of Representative Textured Tube Showing Variables that Describe Possible Primary and Secondary Texturizations that may be Applied to Inside Surface of Tube, Outside Surface of Tube, or Both Inside and Outside Surfaces of Tube

3.3.21 W2—wall thickness valley inside to peak outside (secondary pattern)

3.3.22 W3—wall thickness base of primary pattern

3.3.23 W4—wall thickness in wall of the primary character

3.4 Fig. 1 illustrates a representative textured tube showing variables that describe the possible primary and secondary enhancements 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 (a) longitudinal view (b) cross-sectional view.

3.5 Fig. 2 details are regarding the sample representative geometry of the patterns used to enhance the flat strip material before it is used to create a welded tube. One, both, or more patterns may be used and combined. Each pattern is made up of a variety of possible shapes. See Fig. 2(a) Sample secondary (background) surface and Fig. 2(b) Sample primary surface.

3.6 In Fig. 3, details are given regarding the wall thickness of the representative sample geometry of the patterns used to enhance the flat strip material before it is used to create a welded tube.

4. Types of Welded Tubes

4.1 The following types of welded tubes are manufactured under this specification:

4.1.1 *As-Welded Tube*—A condition created as a result of forming sheet or plate into tubular form and welding without subsequent heat treatment or cold work.

4.1.2 Welded and annealed tube annealed to produce a uniform grain size appropriate to the specified annealed temper.

5. Ordering Information

5.1 Include the following specified choices when placing orders for product under this specification, as applicable:

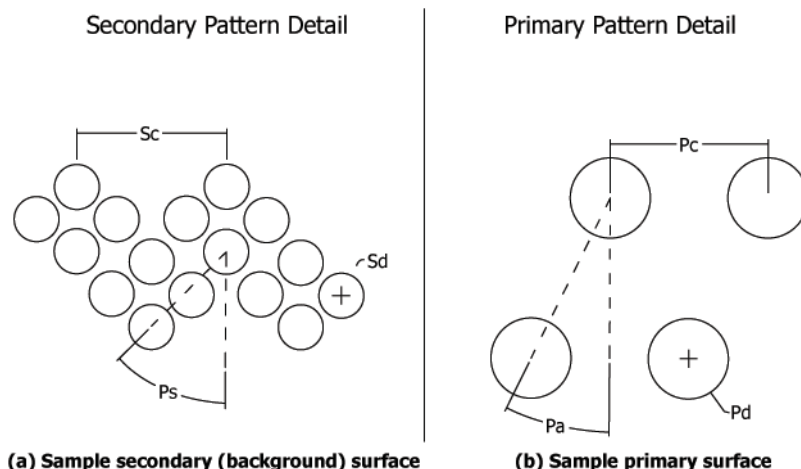
5.1.1 ASTM designations and year of issue.

5.1.2 Copper [Alloy] UNS No. (or other internationally recognized copper [alloy]) designation.

5.1.3 *Heat Treatment*—Annealing may be performed in-line, post-production, or customer-specified.

5.1.4 Temper (Section 8).

5.1.5 *Dimensions*—Specified in English or SI units with one-unit system used throughout.



NOTE 1—One, both, or more patterns may be used and combined; each pattern made up of a variety of possible shapes.

FIG. 2 Details regarding Sample Representative Geometry of Patterns Used to Texture Flat Strip Material before it is Used to Create Welded Tube

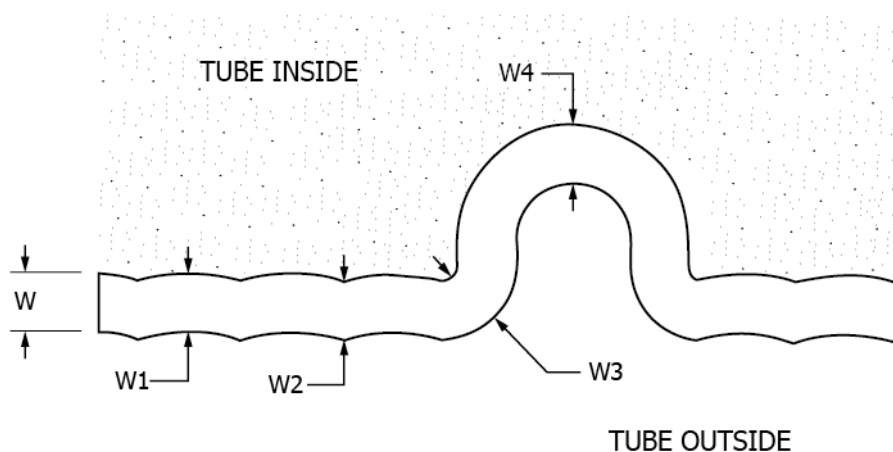


FIG. 3 Details regarding Wall Thickness of Representative Sample Geometry of Patterns Used to Texture Flat Strip Material before it is Used to Create Welded Tube

5.1.5.1 See Fig. 1 for the nominal tube outside diameter and nominal tube wall thickness (wall thickness of the smooth strip material); average effective wall thickness of the finished tube and minimum (specified wall thickness of the tube); wall thickness of the finished tube will be specified; length and location of untextured surfaces (if any); and the total tube length or random lengths.

5.1.5.2 *Configuration of Textured Surfaces*—See Fig. 2 (secondary pattern, secondary pattern depth, secondary pattern height, pitch of the secondary pattern, pitch of the primary pattern depth, and so forth) shall be as agreed upon between the manufacturer and purchaser.

5.1.5.3 Additional specifications may include the various inside or outside diameters (see Fig. 1); textured wall thickness values (see Fig. 3); length and location of untextured sections; tube end finish, if required; effective diameter and wall thickness of the textured section; number of secondary enhancement character units per unit length; number of primary enhancement character units per unit length; and the total tube length.

5.1.6 How furnished: straight lengths or coils.

5.1.7 Quantity—total weight, or total length, or number of pieces of each size.

5.1.8 Packaging.

5.1.9 Intended application.

5.2 The following options are available but may not be included unless specified at the time of placing of the order, when required:

5.2.1 Heat identification or traceability details;

5.2.2 Electromagnetic (eddy current) examination;

5.2.3 Embrittlement test;

5.2.4 Expansion test;

5.2.5 Flattening test;

5.2.6 Certification;

5.2.7 Test Report;

5.2.8 Type of welded tube production and any additional weld requirements;

5.2.9 Flash treatment, if any;

5.2.10 Microscopical examination microphotographs;

5.2.11 Customer inspection;

5.2.12 If product is purchased for agencies of the U.S. government (see the Supplementary Requirements section of Guide B950); and

5.2.13 If product is ordered for ASME Boiler and Pressure Vessel Code Application (see Section 20, Certifications).

6. Materials and Manufacture

6.1 Materials:

6.1.1 The material of manufacture shall be sheet or strip of one of the listed Copper UNS alloys and may be cold worked or annealed to a suitable finish for processing into the products prescribed herein.

6.1.2 When specified in the contract or purchase order that heat identification or traceability is required, the purchaser shall specify the details desired.

6.2 Manufacture:

6.2.1 The textured tubes shall be manufactured from smooth strip material that has been textured by cold working on one or both surfaces before being formed into a tube.

6.2.2 Textured tubes may be furnished with untextured outside surface diameter ends but also may be furnished with textured outside surface diameter ends depending on the specification. Tubes produced with untextured ends may or may not also include untextured sections in areas of the tube other than the ends (landings).

6.2.3 Any tests that are specified and required shall be performed on textured lengths of the tube in accordance with this specification and need not be performed on both the textured and the plain section of the tube.

6.2.4 The enhancements shall be produced by the cold forming of the material strip. To comply with this specification, the enhancement material and smooth tube material shall be considered homogeneous in composition.

6.2.5 The welded (WLD) tubes shall be made from strip material using an automatic welding process with no addition of filler metal.

6.2.5.1 Welding shall be accomplished by any process that produces a fusion weld.

6.2.5.2 *Fusion-Welded Tube*—The edges of the strip shall be brought together and welded, usually by the electric