Designation: B543/B543M – 12

Standard Specification for Welded Copper and Copper-Alloy Heat Exchanger Tube[1]

This standard is issued under the fixed designation B543/B543M; 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 established the requirements for welded tube of copper and various copper alloys up to 3⅛ in., inclusive, in diameter, for use in surface condensers, evaporators, heat exchangers, and general engineering applications. The following coppers or copper alloys are involved:[2]

Copper or Copper Alloy UNS No.[2]	Previously Used Designation	Type of Metal
C10800[A]	...	oxygen-free, low phosphorus
C12200[A]	...	DHP phosphorized, high residual phosphorus
C19400	...	copper-iron alloy
C23000	...	red brass
C44300	...	arsenical admiralty
C44400	...	antimonial admiralty
C44500	...	phosphorized admiralty
C68700	...	arsenical aluminum brass
C70400	...	95-5 copper-nickel
C70600	...	90-10 copper-nickel
C70620	...	90-10 copper-nickel (Modified for Welding)
C71000	...	80-20 copper-nickel
C71500	...	70-30 copper-nickel
C71520	...	70–30 copper-nickel (Modified for Welding)
C71640	...	copper-nickel-iron-manganese
C72200	...	...

[A] Copper UNS Nos. C10800 and C12200 are classified in Classification B224.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. 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 standard.

1.3 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

Warning—Mercury has been designated by EPA and many state agencies as a hazardous material that can cause central nervous system, kidney, and liver damage. Mercury, or its vapor, may be hazardous to health and corrosive to materials. Caution should be taken when handling mercury and mercury-containing products. See the applicable product Material Safety Data Sheet (MSDS) for details and EPA's website (http://www.epa.gov/mercury/faq.htm) for additional information. Users should be aware that selling mercury or mercury-containing products, or both, in your state may be prohibited by state law. (Mercury is a definite health hazard in use and disposal. (See 12.1.1.))

2. Referenced Documents

2.1 *ASTM Standards:*[3]

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

B224 Classification of Coppers

B846 Terminology for Copper and Copper Alloys

B858 Test Method for Ammonia Vapor Test for Determining Susceptibility to Stress Corrosion Cracking in Copper Alloys

B900 Practice for Packaging of Copper and Copper Alloy Mill Products for U.S. Government Agencies

B968/B968M Test Method for Flattening of Copper and Copper-Alloy Pipe and Tube

E3 Guide for Preparation of Metallographic Specimens

E8 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

E54 Test Methods for Chemical Analysis of Special Brasses and Bronzes (Withdrawn 2002)[4]

[1] This specification is under the jurisdiction of ASTM Committee B05 on Copper and Copper Alloys and is the direct responsibility of Subcommittee B05.04 on Pipe and Tube.

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[2] New designation established in accordance with Practice E527. In the new UNS system, the designations for copper alloys are simply expansions of the present standard designations by a prefix "C" and a suffix "00."

[3] 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.

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

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

E62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods) (Withdrawn 2010)[4]
E112 Test Methods for Determining Average Grain Size
E118 Test Methods for Chemical Analysis of Copper-Chromium Alloys (Withdrawn 2010)[4]
E243 Practice for Electromagnetic (Eddy Current) Examination of Copper and Copper-Alloy Tubes
E478 Test Methods for Chemical Analysis of Copper Alloys
E255 Practice for Sampling Copper and Copper Alloys for the Determination of Chemical Composition
E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

3. Terminology

3.1 For the definitions of the terms related to copper and copper alloys, refer to Terminology B846

4. Types of Welded Tube

4.1 *Forge-Welded Tube* manufactured as described in 6.2.2.1, 6.2.2.2, and 6.2.2.3.

4.1.1 *As-Welded Tube*—Forge-welded tube with internal and external flash removed and no further refinement of grain structure.

4.1.2 *Welded and Annealed Tube*—Forge-welded tube with internal and external flash removed, that has been annealed to produce a uniform grain size appropriate to the specified annealed temper.

4.1.3 *Welded and Cold-Reduced Tube*—Forge-welded tube with internal and external flash removed and subsequently cold reduced to conform to the specified size and temper.

4.1.4 *Welded and Cold-Drawn Tube*—Forge-welded tube with internal and external flash removed and subsequently cold drawn over a plug or mandrel to the specified size and temper.

4.2 *Fusion-Welded Tube* manufactured as described in section 6.3.

4.2.1 *As-Welded Tube*—Fusion-welded tube with no further refinement of grain structure.

4.2.2 *Welded and Annealed Tube*—Fusion-welded tube that has been annealed to produce a uniform grain size appropriate to the specified annealed temper. The structure of the weld zone shall be that which is typical of a fusion weld.

4.2.3 *Welded and Cold-Reduced Tube*—Fusion-welded tube subsequently cold-reduced to conform to the specified size and temper.

4.2.4 *Welded and Cold-Drawn Tube*—Fusion-welded tube subsequently cold-drawn over a plug or mandrel to the specified size and temper.

4.3 *Fully Finished Tube*—Welded tube with internal and external flash removed, if present, and subsequently cold-drawn over a plug or mandrel and annealed, and redrawn when necessary to conform to the specified temper.

5. Ordering Information

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

5.1.1 ASTM designation and year of issue,

5.1.2 Copper or Copper Alloy UNS No. designation (for example, UNS No. C10800),

5.1.3 Tube type (Section 4),

5.1.4 Temper (Section 8),

5.1.5 Dimensions, the diameter, wall thickness, whether minimum or nominal wall, and length, (Section 14),

5.1.6 Quantity of each size (number of pieces and length, in inches or feet and inches),

5.2 The following options are available and shall be specified at the time placing the order, when required:

5.2.1 When heat identification or traceability is required,

5.2.2 Whether a pressure test is to be used instead of the eddy-current test (Section 13.1),

5.2.3 Whether cut ends of the tube are to be deburred, chamfered, or otherwise treated (Section 15),

5.2.4 If the product is to be subsequently welded, (see Table 1, Footnote F)

5.2.5 Certification, if required (Section 23), and

5.2.6 Mill test report, if required (Section 24).

5.3 In addition, when material is purchased for agencies of the U.S. Government, it shall conform to the Supplementary Requirements as defined herein when specified in the contract or purchase order.

6. Materials and Manufacture

6.1 *Material:*

6.1.1 The material of manufacture shall be strip of one of the Copper Alloy UNS Nos. listed in section 1.1 of such purity and soundness as to be suitable for processing into the products prescribed herein.

6.1.2 In the event heat identification or traceability is required, the purchaser shall specify the details desired.

6.2 *Manufacture:*

6.2.1 The product shall be manufactured by forming the material into a tubular shape on a suitable forming mill.

6.2.2 Welding shall be accomplished by any process that produces a forge weld leaving no crevice in the weld seam visible to the unaided eye.

6.2.2.1 *Forge-Welded Tube*—The edges of the strip shall be heated to the required welding temperature, usually by high frequency electric current, and be pressed firmly together causing a forge-type joint to be formed with internal and external flash or bead.

6.2.2.2 The external flash (that portion of the weld which extends beyond the normal wall) shall always be removed.

6.2.2.3 The internal flash shall be removed to the extent that it shall not exceed 0.006 in. [0.152 mm] in height or 10 % of the nominal wall thickness, whichever is greater.

6.3 *Fusion-Welded Tube*—The edges of the strip shall be brought together and welded, usually by a GTAW welding process, without the addition of filler metal, causing a fusion-type joint to be formed with no internal or external flash or bead removal necessary.

6.4 *Fully Finished Tube*—May be welded and subsequently processed by any method that would produce a tube suitable for subsequent cold-drawing and annealing.

6.5 There shall be no crevice in the weld seam visible to the unaided eye.

TABLE 1 Chemical Requirements

Copper or Copper Alloy UNS No.	Composition, %											
	Copper[A]	Nickel incl Cobalt	Lead, max	Iron	Zinc	Manganese	Aluminum	Phosphorus	Tin	Antimony	Arsenic	Other Elements
C10800	99.95[B] min	...	...	...	...	...	...	0.005–0.012	...	...	...	...
C12200	99.9 min	...	...	...	...	...	...	0.015–0.040	...	...	...	...
C19400	97.0[C] min	...	0.03	2.1–2.6	0.05–0.20	...	...	0.015–0.15	...	...	...	...
C23000	84.0–86.0	...	0.05	0.05 max	remainder	...	...	...	...	...	...	...
C44300	70.0–73.0[D]	...	0.07	0.06 max	remainder	...	...	...	0.8–1.2	...	0.02–0.06	...
C44400	70.0–73.0[D]	...	0.07	0.06 max	remainder	...	...	...	0.8–1.2	0.02–0.10	...	...
C44500	70.0–73.0[D]	...	0.07	0.06 max	remainder	...	...	0.02–0.10	0.8–1.2	...	...	...
C68700	76.0–79.0[AE]	...	0.07	0.06 max	remainder	...	1.8–2.5	...	...	...	0.02–0.06	...
C70400	remainder[AE]	4.8–6.2	0.05	1.3–1.7	1.0 max	0.30–0.8	...	...	...	...	...	...
C70600	remainder[AE]	9.0–11.0	0.05	1.0–1.8	1.0 max	1.0 max	...	...	...	...	...	...
C70620	86.5 min[AE]	9.0–11.0	0.02	1.0–1.8	0.50 max	1.0	...	.02 max	...	...	...	C 0.05 max s 0.02 max
C71000	remainder[AEF]	19.0–23.0	0.05	0.50–1.0	1.0 max[F]	1.0 max	...	[F]	...	...	...	[F]
C71500	remainder[AE]	29.0–33.0	0.05	0.40–1.0	1.0 max	1.0 max	...		...	...	...	...
C71520	65.0 min[AE]	29.0–33.0	.02	0.40–1.0	0.50 max	1.0 max	...	0.02 max	...	...	...	C 0.05 max S 0.02 max
C71640	remainder[F]	29.0–32.0	0.05[F]	1.7–2.3	1.0 max[F]	1.5–2.5	...	[F]	...	...	...	C.06[F] max S.03 max
C72200	remainder[AFCG]	15.0–18.0	0.05[F]	.50–1.0	1.0 max[F]	1.0 max	...	[F]	...	...	...	[F] Si.03 max Ti.03 max[G]

[A] Silver counting as copper.
[B] Copper + silver + phosphorus.
[C] Cu + Sum of Named Elements, 99.8 % min.
[D] For tubular products, the minimum Sn content may be 0.9 %
[E] Cu + Sum of Named Elements, 99.5 % min.
[F] When the product is for subsequent welding applications and so specified by the purchaser, zinc shall be 0.50 % max, lead 0.02 % max, phosphorus 0.02 % max, sulfur 0.02 % max, and carbon 0.05 % max.
[G] Chromium 0.30 to 0.7

7. Chemical Composition

7.1 The material shall conform to the chemical compositional requirements in Table 1 for Copper or Copper Alloy UNS No. designation specified in the ordering information.

7.2 The composition limits do not preclude the presence of other elements. By agreement between the manufacturer and purchaser, limits may be established and analysis required for unnamed elements.

7.3 For Copper Alloy UNS No. C19400, copper may be taken as the difference between the sum of all the elements analyzed and 100 % %. When all the elements in Table 1 are analyzed, their sum shall be 99.8 % minimum.

7.3.1 For copper alloys in which copper is specified as the remainder, copper may be taken as the difference between the sum of all the elements analyzed and 100 %.

7.3.1.1 *Copper Alloy UNS Nos. C70400, C70600, C70620, C71000, C71500, C71520, and C71640*—When all the elements in Table 1 are analyzed, their sum shall be 99.5 % minimum.

7.3.1.2 *Copper Alloy UNS No. C72200*—When all the elements in Table 1 are analyzed, their sum shall be 99.8 % minimum.

7.3.2 For copper alloys in which zinc is specified as the remainder, either copper or zinc may be taken as the difference between the sum of all the elements analyzed and 100 %.

7.3.2.1 *Copper Alloy UNS No. C23000*—When all the elements in Table 1 are analyzed, their sum shall be 99.8 % minimum.

7.3.2.2 *Copper Alloy UNS Nos. C44300, C44400, and C44500*—When all the elements in Table 1 are analyzed, their sum shall be 99.6 % minimum.

7.3.2.3 *Copper Alloy UNS No. C68700*—When all the elements in Table 1 are analyzed, their sum shall be 99.5 % minimum.

8. Temper

8.1 Tube tempers shall be designated as follows:
8.1.1 Welded and annealed WO61.
8.1.1.1 Welded and light cold worked WC55.

8.2 Other tempers shall be produced to the mechanical properties as agreed upon between the manufacturer or supplier and the purchaser.

8.3 Tubes of Copper Alloy UNS Nos. C23000, C44300, C44400, C44500, and C68700 shall be furnished in the annealed temper or the stress relieved condition as specified in the purchase order unless otherwise agreed upon between the purchaser and the manufacturer or supplier.

8.4 Tubes of Copper Alloy UNS Nos. C12200, C19400, C70400, C70600, C70620, C71000, C71500, C71520, C71640, and C72200 are normally supplied in the temper specified in the purchase order without stress relief treatment.

NOTE 1—Some tubes, when subjected to aggressive environments, may be subject to stress-corrosion cracking failure because of the residual tensile stresses developed in straightening. For such applications, it is suggested that tubes of Copper Alloy UNS Nos. C23000, C44300, C44400, C44500, and C68700 be subjected to a stress relieving thermal

treatment subsequent to straightening. If required, this must be specified on the purchase order or contract. Tolerances for roundness and length, and the condition of straightness, for tube so ordered, shall be to the requirements agreed upon between the manufacturer and the purchaser.

9. Grain Size for Annealed Tempers

9.1 Samples of annealed temper tubes shall be examined at a magnification of 75 diameters. The grain size shall be determined in the wall beneath the internal enhancement. While there is not grain size range, the microstructure shall show complete recrystallization and the weld zone shall have a structure typical of hot-forged welds.

10. Mechanical Property Requirements

10.1 *Tensile Strength and Yield Strength Requirements:*

10.2 Product furnished under this specification shall conform to the tensile and yield strength requirements prescribed in Table 2 or Table 3 when tested in accordance with Test Method E8.

10.2.1 Acceptance or rejection based upon mechanical properties shall depend only on tensile strength and yield strength.

11. Performance Requirements

11.1 *Expansion Test Requirements:*

11.1.1 Product in the annealed tempers and the light cold-worked temper shall withstand expansion in accordance with Test Method B153 to the degree specified in Table 4.

11.1.2 The expanded tube area shall be free of defects, but blemishes of a nature that do not interfere with the intended application are acceptable.

11.2 *Flattening Test:*

11.2.1 The flattening test shall be performed in accordance with Test Method section in B968/B968M.

11.3 *Reverse Bend Test:*

11.3.1 When specified in the contract or purchase order, the reverse bend test described in the Test Method section in 19.2.8 shall be performed.

11.3.2 The sample shall be free of defects, but blemishes of a nature that do not interfere with the intended application are acceptable.

12. Other Requirements

12.1 *Mercurous Nitrate Test or Ammonia Vapor Test:*

12.1.1 The mercurous nitrate or ammonia vapor test is required only for Copper Alloys UNS Nos. C23000; C44300; C44400; C44500; C60800; and C68700; when purchased if not supplied in an annealed temper (**Warning—**Mercury is a definite health hazard and therefore equipment for the detection and removal of mercury vapor produced in volitization is recommended. The use of rubber gloves in testing is advisable.)

12.1.2 The test specimens, cut 6 in. [152 mm] in length from the enhanced section shall withstand, without cracking, an immersion in the standard mercurous nitrate solution in Test

TABLE 2 Tensile Requirements — Inch-Pound Values

NOTE 1—See Table 3 for tensile requirements — SI values.

Copper or Copper Alloy UNS No.	Temper		Tensile Strength, min, ksi[A]	Yield Strength at 0.5 % Extension Under Load, min, ksi[A]
	Designation	Name		
C10800, C12200	W061	annealed	30	9[B]
	WC55	light cold-worked	32	15
C19400	W061	annealed	45	15
	WC55	light cold-worked	45	22
C23000	W061	annealed	40	12
	WC55	light cold-worked	42	20
C44300, C44400, C44500	W061	annealed	45	15
	WC55	light cold-worked	50	35
C68700	W061	annealed	50	18
	WC55	light cold-worked	[C]	[C]
C70400	W061	annealed	38	12
	WC55	light cold-worked	40	30
C70600	W061	annealed	40	15
	WC55	light cold-worked	45	35
C70620	WO61	annealed	40	15
	WC55	light cold-worked	45	35
C71000	W061	annealed	45	16
	WC55	light cold-worked	50	35
C71500	W061	annealed	52	18
	WC55	light cold-worked	54	35
C71520	WO61	annealed	52	18
	WC55	light cold-worked	54	35
C71640	W061	annealed	63	25
	WC55	light cold-worked	75	40
C72200	W061	annealed	45	16
	WC55	light cold-worked	50	30

[A] ksi = 1000 psi.
[B] Light straightening operation is permitted.
[C] Where no properties are shown, strength requirements shall be as agreed upon between the purchaser and the manufacturer or supplier.

TABLE 3 Tensile Requirements — SI Values

NOTE 1—See Table 2 for tensile requirements — inch-pound values.

Copper or Copper Alloy UNS No.	Temper		Tensile Strength, min, MPA	Yield Strength at 0.5 % Extension Under Load, min, MPA
	Designation	Name		
C10800, C12200	W061	annealed	205	60[A]
	WC55	light cold-worked	220	105
C19400	W061	annealed	310	105
	WC55	light cold-worked	310	150
C23000	W061	annealed	275	85
	WC55	light cold-worked	290	140
C44300, C44400, C44500	W061	annealed	310	105
	WC55	light cold-worked	345	240
C68700	W061	annealed	345	125
	WC55	light cold-worked	[B]	[B]
C70400	W061	annealed	260	85
	WC55	light cold-worked	275	205
C70600	W061	annealed	275	105
	WC55	light cold-worked	310	240
C70620	WO61	annealed	275	105
	WC55	light cold-worked	310	240
C71000	W061	annealed	310	110
	WC55	light cold-worked	345	240
C71500	W061	annealed	360	125
	WC55	light cold-worked	370	240
C71520	WO61	annealed	360	125
	WC55	light cold-worked	370	240
C71640	W061	annealed	435	170
	WC55	light cold-worked	515	275
C72200	W061	annealed	310	110
	WC55	light cold-worked	345	205

[A] Light straightening operation is permitted.
[B] Where no properties are shown, strength requirements shall be as agreed upon between the purchaser and the manufacturer or supplier.

TABLE 4 Expansion Requirements

Temper	Copper or Copper Alloy UNS No.	Expansion of Tube Outside Diameter, in Percent of Original Outside Diameter
Annealed	C10800	30
	C12200	30
	C19400	20
	C23000	20
	C44300, C44400, C44500	20
	C68700	20
	C70400	30
	C70600	30
	C70620	30
	C71000	30
	C71500	30
	C71520	30
	C71640	30
	C72200	30
Light cold-worked	C10800	20
	C12200	20
	C19400	20
	C70400	20
	C70600	20
	C70620	20
	C71000	20
	C71500	20
	C71520	20
	C71640	20
	C72200	20
Annealed and light cold-worked, stress relieved	C23000	20
	C44300, C44400, C44500	20
	C68700	20

Method B154 or immersion in the ammonia vapor solution as defined in Test Method B858.

12.1.3 Unless otherwise agreed upon between the manufacturer, or supplier, and the purchaser, the manufacturer shall have the option of using either the mercurous nitrate test or the ammonia vapor test. If agreement cannot be reached, the mercurous nitrate test standard shall be utilized.

12.1.4 If the ammonia vapor test is selected, the appropriate risk level pH value for the test solution shall be agreed upon by the manufacturer and purchaser, or alternately, if the purchaser defers to the manufacturer's expertise for the selection of the test pH value, the minimum value selected shall be 9.8.

13. Nondestructive Testing

13.1 Each tube shall be subjected to an eddy-current test in 13.1.1. Fully finished tube (see 4.3) may be tested in the final drawn, annealed, or heat-treatment temper or in the drawn temper prior to the final anneal or heat treatment, unless otherwise agreed upon between the manufacturer or supplier and the purchaser. Tube supplied welded and annealed (see 4.1.2) may be tested in the welded condition before anneal or heat treatment, unless otherwise agreed upon between the manufacturer or supplier and the purchaser. The purchaser may specify either of the tests in 13.1.2 or 13.1.3 as an alternative to the eddy-current test.

13.1.1 *Eddy Current Test*—Each tube shall be passed through an eddy-current testing unit adjusted to provide information on the suitability of the tube for the intended application. Testing shall follow the procedures of Practice E243, except as modified in 13.1.1.2.

13.1.1.1 The depth of the round-bottom transverse notches and the diameters of the drilled holes in the calibrating tube used to adjust the sensitivity of the test unit are shown in Table 5 or Table 6 and Table 7 or Table 8 respectively.

13.1.1.2 The discontinuities used to calibrate the test system may be placed in the strip from which the tube will be manufactured. These calibration discontinuities will pass through the continuous operations of forming, welding, and eddy-current testing. The test unit sensitivity required to detect the resultant discontinuities shall be equivalent to or greater than that required to detect the notches or drilled holes of Table 5 or Table 6 and Table 7 or Table 8 respectively, or other calibration discontinuities that may be used by mutual agreement between the manufacturer or supplier and the purchaser. Calibration discontinuities may be on the outside tube surface, the internal tube surface, or through the tube wall and shall be spaced to provide signal resolution adequate for interpretation. Each calibration discontinuity shall be detected by the eddy-current tester.

13.1.1.3 Tubes that do not actuate the signaling device of the eddy-current tester shall be considered as conforming to the requirements of this test. Tubes causing irrelevant signals because of moisture, soil, and like effects may be reconditioned and retested. Such tubes, when retested to the original test parameters, shall be considered to conform if they do not cause output signals beyond the acceptable limits. Tubes causing irrelevant signals because of visible and identifiable handling marks may be retested by the hydrostatic test prescribed in 13.1.2, or the pneumatic test prescribed in 13.1.3. Tubes meeting requirements of either test shall be considered to conform if the tube dimensions are within the prescribed limits, unless otherwise agreed to by the manufacturer or supplier and the purchaser.

13.1.2 *Hydrostatic Test*—When specified, each tube selected in accordance with 13.1 shall withstand, without showing evidence of leakage, an internal hydrostatic pressure sufficient to subject the material to a fiber stress of 7000 psi [48 MPa], determined by the following equation for thin hollow cylinders under tension. The tube need not be tested at a hydrostatic pressure of over 1000 psig [7.0 MPa] unless so specified.

$$P = 2St/(D - 0.8t) \quad (1)$$

where:

P = hydrostatic pressure, psig [MPa],
t = thickness of tube wall, in. [mm],
D = outside diameter of the tube, in. [mm], and
S = allowable stress of the material, psi [MPa].

TABLE 5 Notch Depth — Inch-Pound Values

NOTE 1—See Table 6 for notch depth — SI values.

Tube Wall Thickness, in.	Tube Outside Diameter, in.		
	Over ¼ to ¾ , incl	Over ¾ to 1¼, incl	Over 1¼ to 3⅛, incl
Over 0.017–0.032	0.005	0.006	0.007
Incl 0.032–0.049	0.006	0.006	0.0075
Incl 0.049–0.083	0.007	0.0075	0.008
Incl 0.083–0.109	0.0075	0.0085	0.0095
Incl 0.109–0.120	0.009	0.009	0.011

TABLE 6 Notch Depth — SI Values

NOTE 1—See Table 5 for notch depth — inch-pound values.

Tube Wall Thickness, mm	Tube Outside Diameter, mm		
	Over 6 to 19, incl	Over 19 to 32, incl	Over 32 to 80, incl
Over 0.4–0.8	0.13	0.15	0.18
Incl 0.8–1.3	0.15	0.15	0.19
Incl 1.3–2.1	0.18	0.19	0.20
Incl 2.1–2.8	0.19	0.22	0.24
Incl 2.8–3.0	0.23	0.23	0.28

TABLE 7 Diameter of Drilled Holes — Inch-Pound Values

NOTE 1—See Table 8 for diameter of drilled holes — SI values.

Tube Outside Diameter	Diameter of Drilled Holes	Drill No.
in.	in.	
¼ –¾, incl	0.025	72
Over ¾ –1, incl	0.031	68
Over 1–1¼, incl	0.036	64
Over 1¼ –1½, incl	0.042	58
Over 1½ –1¾, incl	0.046	56
Over 1¾ –2, incl	0.052	55

TABLE 8 Diameter of Drilled Holes — SI Values

NOTE 1—See Table 7 for diameter of drilled holes — inch-pound values.

Tube Outside Diameter	Diameter of Drilled Holes	Drill No.
mm	mm	
6.0–19.0, incl	0.65	72
Over 19.0–25.4, incl	0.80	68
Over 25.4–31.8, incl	0.92	64
Over 31.8–38.1, incl	1.1	58
Over 38.1–44.4, incl	1.2	56
Over 44.4–50.8, incl	1.3	55

13.1.3 *Pneumatic Test*—When specified, each tube shall be subjected to an internal air pressure of 60 psig [400 kPa] minimum for 5 s without showing evidence of leakage. The test method used shall permit easy visual detection of any leakage, such as by having the tube under water or by the pressure-differential method. Any evidence of leakage shall be cause for rejection.

14. Dimensions, Mass, and Permissible Variations

14.1 *Diameter*—The outside diameter of the tubes shall not vary from that specified by more than the amounts shown in Table 9 or Table 10 as measured by "go" and "no-go" ring gages. Where no values are shown in the table, dimensions shall be as agreed upon between the purchaser and the manufacturer or supplier.

14.2 *Wall Thickness Tolerances:*

14.2.1 *Tubes Ordered to Minimum Wall*— No tube at its thinnest point shall be less than the specified wall thickness or greater than the specified wall thickness plus twice the tolerance values shown in Table 11 or Table 12.

14.2.2 *Tubes Ordered to Nominal Wall*— The maximum plus and minus deviation from the nominal wall at any point shall not exceed the values shown in Table 11 or Table 12.

TABLE 9 Diameter Tolerances — Inch-Pound Values

NOTE 1—See Table 10 for diameter tolerances — SI values.

Outside Diameter, in.	Wall Thickness, in.				
	0.020[A] 0.022 0.025 0.028	0.032	0.035	0.042	0.049 and Over
	Diameter Tolerance, Plus and Minus, in.				
Up to 0.500, incl	0.003	0.0025	0.0025	0.0025	0.0025
Over 0.500–0.740, incl	0.004	0.004	0.004	0.0035	0.003
Over 0.740–1.000, incl	0.006	0.006	0.005	0.0045	0.004
Over 1.000–1.250, incl	...	0.009	0.008	0.006	0.0045
Over 1.250–1.375, incl	...	...	...	0.008	0.005
Over 1.375–2.000, incl	...	...	...	...	0.006
Over 2.000–3.125, incl	...	...	...	...	0.0065

[A] Thin wall thicknesses are supplied only in light cold-worked tubes.

TABLE 10 Diameter Tolerances — SI Values

NOTE 1—See Table 9 for diameter tolerances — inch-pound values.

Outside Diameter, mm	Wall Thickness, mm				
	0.508[A] 0.559 0.635 0.711	0.813	0.889	1.07	1.24 and Over
	Diameter Tolerance, Plus and Minus, mm				
Up to 12, incl	0.076	0.064	0.064	0.064	0.064
Over 12–18, incl	0.10	0.10	0.10	0.089	0.076
Over 18–25, incl	0.15	0.15	0.13	0.11	0.10
Over 25–35, incl	...	...	...	0.20	0.13
Over 35–50, incl	...	...	...	...	0.15
Over 50–79	...	...	...	...	0.17

[A] Thin wall thicknesses are supplied only in light cold-worked tubes.

TABLE 11 Wall Thickness Tolerances — Inch-Pound Values

NOTE 1—See Table 12 for SI values.

Wall Thickness, in.	Outside Diameter, in.			
	Over ⅛ to ⅝, incl	Over ⅝ to 1, incl	Over 1 to 2, incl	Over 2 to 3.125, incl
	Wall Thickness Tolerances, Plus and Minus, in.			
0.020 incl, to 0.032	0.003	0.003	...	...
0.032 incl, to 0.035	0.003	0.003	0.004	...
0.035 incl, to 0.058	0.004	0.0045	0.0045	0.005
0.058 incl, to 0.083	0.0045	0.005	0.005	0.0055
0.083 incl, to 0.120	0.005	0.0065	0.0065	0.0065
0.120 incl, to 0.135	0.007	0.007	0.0075	0.008

TABLE 12 Wall Thickness Tolerances, Plus and Minus — SI Values

NOTE 1—See Table 11 for inch-pound values.

Wall Thickness, mm	Outside Diameter, mm		
	Over 12 to 25, incl	Over 25 to 50, incl	Over 50 to 80, incl
0.50, incl to 0.80	0.08	...	...
0.80, incl to 0.90	0.08	0.10	...
0.90, incl to 1.5	0.11	0.11	0.13
1.5, incl to 2.1	0.13	0.13	0.14
2.1, incl to 3.0	0.17	0.17	0.17
3.0, incl to 3.4	0.18	0.19	0.20

14.3 *Length*—The length of the tubes shall not be less than that specified when measured at a temperature of 20°C, but may exceed the specified value by the amounts given in Table 13 or Table 14.

14.4 *Squareness of Cut*—The departure from squareness of the end of any tube shall not exceed the values shown in Table 15 or Table 16.

TABLE 13 Length Tolerances — Inch-Pound Values

NOTE 1—See Table 14 for SI values.

Specified length, ft	Tolerance, all Plus, in.
Up to 15	3/32
Over 15–20, incl	1/8
Over 20–30, incl	5/32
Over 30–60, incl	3/8
Over 60–100, incl[A]	1/2

[A] Condenser tubes in lengths over 100 ft are not in present demand. Tolerance values for these lengths will be developed as experience dictates. Tolerance values for lengths in wall thicknesses of 0.020, incl to 0.032 shall be agreed upon between the manufacturer or supplier and the purchaser.

TABLE 14 Length Tolerances — SI Values

NOTE 1—See Table 13 for inch-pound values.

Specified Length, mm	Tolerance, all Plus, mm
Up to 4500	2.4
Over 4500–6000, incl	3.2
Over 6000–10 000, incl	4.0
Over 10 000–18 000, incl	9.5
Over 18 000–30 000, incl[A]	13.0

[A] Condenser tubes in lengths over 30 000 mm are not in present demand. Tolerance values for these lengths will be developed as experience dictates. Tolerance values for lengths in wall thicknesses of 0.5, inclusive to 0.8 shall be agreed upon between the manufacturer or supplier and the purchaser.

TABLE 15 Squareness of Cut — Inch-Pound Values

NOTE 1—See Table 16 for SI values.

Tube Outside Diameter, in.	Tolerance, in.
Up to 5/8 , incl	0.010 in.
Over 5/8	0.016 in./in. of diameter

TABLE 16 Squareness of Cut — SI Values

NOTE 1—See Table 15 for inch-pound values.

Tube Outside Diameter, mm	Tolerance, mm
Up to 16, incl	0.25 mm
Over 16	0.40 mm/mm of diameter

NOTE 2—For the purpose of determining conformance with the dimensional requirements prescribed in this specification, any measured value outside the specified limiting values for any dimension may be cause for rejection.

15. Workmanship, Finish, and Appearance

15.1 Roundness, straightness, uniformity of the wall thickness, and inner and outer surface of the tube shall be such as to make it suitable for the intended application. Unless otherwise specified on the purchase order, the cut ends of the tubes shall be deburred by use of a rotating wire wheel or other suitable tool.

15.2 Welded and annealed, fully finished annealed, or stress-relieved tubes shall be clean and smooth but may have a superficial, dull iridescent film on both the inside and the outside surfaces. All other tubes shall be clean and smooth but may have a superficial film of drawing or other lubricant on the surfaces.

16. Sampling

16.1 *Sampling*—The lot size, portion size, and selection of sample pieces shall be as follows:

16.1.1 *Lot Size*—600 tubes or 10 000 lb [4550 kg] or a fraction of either, whichever constitutes the greater weight.

16.1.2 *Portion Size*—Sample pieces from two individual lengths of finished product.

16.2 Samples taken for the purpose of the tests prescribed in the specification shall be selected in a manner that will represent correctly the material furnished and avoid needless destruction of finished material when samples representative of the material are available from other sources.

16.3 *Chemical Analysis*—Samples for chemical analysis shall be taken in accordance with Practice E255. Drillings, millings, and so forth, shall be taken in approximately equal weight from each of the sample pieces selected in accordance with 16.1.2 and combined into one composite sample. The minimum weight of the composite sample that is to be divided into three equal parts shall be 150 g.

16.3.1 Instead of sampling in accordance with Practice E255, the manufacturer shall have the option of determining conformance to chemical composition as follows: Conformance shall be determined by the manufacturer by analyzing samples taken at the time the castings are poured or samples taken from the semi-finished product. If the manufacturer determines the chemical composition of the material during the course of manufacture, he shall not be required to sample and analyze the finished product. The number of samples taken for determination of chemical composition shall be as follows:

16.3.1.1 When samples are taken at the time the castings are poured, at least one sample shall be taken for each group of castings poured simultaneously from the same source of molten metal.

16.3.1.2 When samples are taken from the semi-finished product, a sample shall be taken to represent each 10 000 lb [4550 kg] or fraction thereof, except that not more than one sample shall be required per piece.

16.3.2 Due to the discontinuous nature of the processing of castings into wrought products, it is not practical to identify specific casting analysis with a specific quantity of finished material.

16.3.3 In the event that heat identification or traceability is required, the purchaser shall specify the details desired.

17. Number of Tests and Retests

17.1 *Tests:*

17.1.1 *Chemical Analysis*—Chemical composition shall determine in accordance with element mean of the results from at least two replicate analyses of the samples, and the results of each replication must meet the requirements of the product specification.

17.1.2 *Tension Tests:*

17.1.2.1 When tensile strength is specified, two tubes shall be selected from each lot and subjected to the tension test which shall, in case of disagreement, be made in accordance with Test Methods E8.

17.1.3 *Other Tests:*

17.1.3.1 For tests specified in Sections 9; 11; and 12, specimens shall be taken from each of the pieces selected in accordance with 16.1.

17.2 *Retests:*

17.2.1 When test results obtained by the purchaser fail to conform with the product specification requirement(s), the manufacturer or supplier shall have the option to perform a retest.

17.2.2 Retesting shall be as directed in this specification for the initial test, except the number of test specimens shall be twice that required normally for the test.

17.2.3 Test results for all specimens shall conform to the requirement(s) of this specification in retest, and failure to comply shall be cause for lot rejection.

18. Specimen Preparation

18.1 *Chemical Analysis:*

18.1.1 Preparation of the analytical test specimen shall be the responsibility of the reporting laboratory.

18.2 *Grain Size:*

18.2.1 Test specimen shall be prepared in accordance with Guide E3.

18.3 *Tensile Test:*

18.3.1 The test specimen shall be of the full section of the tube and shall conform to the requirements of the section titled "Specimens for Pipe and Tube" in Test Methods E8.

18.3.1.1 When the limitations of the testing machine preclude the use of a full section specimen, specimens conforming to "Tension Test Specimens for Large-Diameter Tubular Products" of Test Methods E8 shall be used.

18.4 *Expansion ((Pin Test):*

18.4.1 Test specimen shall conform to the requirements of the Specimen Preparation section of Test Method B153.

18.5 *Flattening Test:*

18.5.1 Test specimen shall be cut in accordance with B968/B968M. When the temper is other than annealed, the sample may be annealed prior to testing.

18.6 *Reverse Bend Test:*

18.6.1 A representative tube sample shall be cut to a length that will accommodate the test. The sample is permitted to be annealed when the temper is other than annealed.

18.6.2 The product test specimen shall be cut longitudinally, 90° on each side of the weld, when visible or identifiable.

18.7 *Mercurous Nitrate Test:*

18.7.1 Specimens for the mercurous nitrate test shall be 6 in. [152 mm] in length and shall conform to the requirements of Test Method B154.

18.8 *Ammonia Vapor Test:*

18.9 Specimens for the ammonia vapor test shall be 6 in. [152 mm] in length and shall conform to the requirements of Test Method B858.

19. Test Methods

19.1 Composition shall be determined, in case of disagreement, as follows:

Element	Method
Copper 99.75 to 99.99	E53 Electrolytic
Copper 60 to 99.74	E478 Electrolytic
Tin 0.9 to 1.2	E478 Titrimetric
Aluminum 1.8 to 6.5	E478 Titrimetric
Nickel, inc. Cobalt	E478 Gravimetric
Lead 0.05 to 0.10	E478 Atomic Absorption
Iron 0.05 to 1.8	E54
Zinc to 1.0	E478 Atomic Absorption
Zinc 14.0 to 30.0	E478 Titrimetric
Manganese to 1.0	E62
Arsenic 0.02 to 0.5	E62
Antimony 0.02 to 0.1	E62
Phosphorus 0.001 to 0.04	E62
Chromium 0.30 to 0.70	E118

19.1.1 Test methods for the determination of element(s) required by contractual or purchase order agreement shall be as agreed upon between the manufacturer and the purchaser.

19.2 *Other Tests:*

19.2.1 The product furnished shall conform to all other requirements when subjected to tests in accordance with the following table.

Requirement	ASTM Designation
Grain Size	E112
Tensile strength	E8
Expansion test	B153
Flattening test	Section 19.2.7
Reverse bend test	Section 19.2.8
Electromagnetic (eddy-current) test	E243
Hydrostatic test	Section 19.2.10
Pneumatic test	Section 19.2.11

19.2.2 Tension test specimens shall be of the full section of the tube and shall conform to the requirements of the Significance and Use Section of Test Methods E8.

19.2.3 Whenever tension test results are obtained from both full size and machined test specimens and they differ, the results obtained from full-size test specimens shall be used to determine conformance to the specification requirements.

19.2.4 Tension test results on material covered by this specification are not seriously affected by variations in speed of testing. A considerable range of testing speed is permissible; however, the range of stressing to the yield strength should not exceed 100 ksi/min [690 MPa/min]. Above the yield strength the movement per minute of the testing machine head under load should not exceed 0.5 in./in. [mm/mm] of gage length (or distance between grips for full-section specimens).

19.2.5 The surface of the test specimen for microscopical examination of grain size shall approximate a radial longitudinal section of the tube.

19.2.6 The surface of the test specimen for microscopical examination of the weld interface shall approximate a transverse section of the tube.

19.2.7 *Flattening Test*—Each test specimen shall be flattened in a press in accordance with B968/B968M.

19.2.8 *Reverse Bend Test*—The test specimen shall be flattened and bent around a mandrel with a diameter four times the wall thickness, with the mandrel parallel to the length and in contact with the outside surface of the tube. The weld shall be placed at the point of maximum bend.

19.2.9 *Electromagnetic (Eddy-Current) Test:*

19.2.9.1 Either notch-depth or drilled-hole, artificial discontinuity, calibration standards shall be used.

19.2.9.2 The depth of the round bottom traverse notches in the discontinuity, standard used to adjust the sensitivity of the testing unit, are shown in Table 5 or Table 6 with a tolerance of ±0.0005 in. (±0.013 mm).

19.2.9.3 The diameters of the drilled holes in the artificial discontinuity, calibration standard used to adjust the sensitivity of the testing unit, are shown in Table 7 or Table 8 and shall not vary by more than + 0.001, – 0.000 in. [+ 0.025, – 0.000 mm] of the hole diameter specified.

19.2.9.4 The manufacturer shall have the option of using a speed insensitive, eddy-current unit that is equipped capable of selecting a fraction of the maximum unbalance signal. In such instances, the following percent maximum unbalance signals shall be used:

Standard Tube Size, in.	Maximum-Percent Unbalance Signal Magnitude
Up to ⅜, incl	0.2
½ to 2, incl	0.3
Over 2 to 3, incl	0.4

19.2.9.5 The specimens with discontinuities used to calibrate the testing unit shall be permitted to be placed in the strip from which the tube will be manufactured. These calibration discontinuities will pass through the continuous operations of forming, welding, and eddy-current testing. The testing unit sensitivity required to detect the resultant discontinuities shall be equivalent to or greater than that required to detect the notches or drilled holes.

19.2.9.6 The round-bottom, traverse-notch, calibration discontinuities shall be on the outside tube surface or inside tube surface. The discontinuities, notch or drilled hole, shall be spaced to provide signal resolution adequate for interpretation. Each calibration discontinuity shall be detected by the testing unit.

19.2.9.7 Tubes with discontinuities indicated by the testing unit may, at the option of the manufacturer, be reexamined or retested to determine whether the discontinuity is cause for rejection. Signals that are found to have been caused by minor mechanical damage, soil, or moisture, shall not be cause for rejection of the tubes, provided the tube dimensions are still within prescribed limits and the tube is suitable for its intended application.

19.2.10 *Hydrostatic Test*—Fiber stress shall be determined by the following equation for thin hollow cylinders under tension:

$$P = 2St/(D - 0.8t) \quad (2)$$

where:

P = hydrostatic pressure, psi [MPa];
t = thickness of tube wall, in. [mm];
D = outside diameter of the tube, in. [mm]; and
S = allowable stress of the tube, psi. [MPa].

19.2.10.1 The tube need not be tested at a hydrostatic pressure over 1000 psi [7.0 MPa] unless so specified.

19.2.11 *Pneumatic Test*—Testing shall be such as to permit easy visual detection of leakage, such as a pressure differential method or submerging the tube under water.

20. Significance of Numerical Limits

20.1 For purposes of determining compliance with the specified limits for requirements of the properties listed in the following table, an observed value or a calculated value shall be rounded as indicated in accordance with the rounding method of Practice E29.

Property	Rounded Unit for Observed or Calculated Value
Chemical composition	nearest unit in the last righthand place of figures
Tensile strength and yield strength	nearest ksi (Nearest 5 MPa)
Grain size: Up to 0.055 mm, incl,	nearest multiple of 0.005 mm
Over 0.055 mm	to the nearst 0.010 mm
Expansion:	Nearest 1 %

21. Inspection

21.1 The manufacturer or supplier shall inspect and make tests necessary to verify the product furnished conforms to specification requirements.

21.2 Source inspection of the product by the purchaser may be agreed upon between the manufacturer or supplier and the purchaser as part of the purchase order. In such case, the nature of the facilities needed to satisfy the inspector representing the purchaser shall be included in the agreement. All tests and the inspection shall be conducted so as not to interfere unnecessarily with the operation of the works.

21.3 When mutually agreed upon, the manufacturer or supplier and the purchaser shall conduct the final inspection simultaneously.

22. Rejection and Rehearing

22.1 *Rejection:*

22.1.1 Product that fails to conform to the specification requirements, when tested by the purchaser or purchaser's agent, may be rejected.

22.1.2 Rejection shall be reported to the manufacturer or supplier promptly. In addition, a written notification of rejection shall follow.

22.1.3 In case of dissatisfaction with the results of the test upon which rejection is based, the manufacturer or supplier shall have the option to make claim for a rehearing.

22.2 *Rehearing*—As a result of product rejection, the manufacturer or supplier shall have the option to make claim for a retest to be conducted by the manufacturer or supplier and the purchaser. Samples of the rejected product shall be taken in accordance with the product specification and subjected to test by both parties using the test method(s) specified in the product specification, or, upon agreement of both parties, an independent laboratory may be selected for the test(s) using the test method(s) specified in the product specification.

23. Certification

23.1 When specified in the purchase order or contract, a manufacturer's certificate of compliance shall be furnished to the purchaser stating that each lot has been sampled, tested, and inspected in accordance with this specification and the requirements have been met.

23.2 When material is specified to meet the requirements of *ASME Boiler and Pressure Vessel Code*, the certification requirements are mandatory.

24. Test Reports

24.1 When specified in the contract or purchase order, a report of test results shall be furnished.

25. Packaging and Package Marking

25.1 *Packaging:*

25.1.1 The product shall be separated by size, composition, and temper and prepared for shipment by common carrier, in order to afford protection from normal hazards of transportation.

25.2 *Package Marking:*

25.2.1 Each shipping unit shall be legibly marked with the purchase order number, metal or alloy designation, temper, size, shape, total length or piece count or both, gross and net weight, and name of supplier. The specification number shall be shown, when specified.

26. Test Report

26.1 When specified in the purchase order or contract, the manufacturer or supplier shall furnish to the purchaser a manufacturer's test report showing the results of the required tests.

27. Keywords

27.1 condenser; copper; copper alloy; copper nickel; evaporator; heat exchanger; welded tube; UNS No. C10800; UNS No.C12200; UNS No. C19400; UNS No. C23000; UNS No. C44300; UNS No. C44400; UNS No. C44500; UNS No. C68700; UNS No. C70400; UNS No. C70600; UNS No. C70620; UNS No. C71000; UNS No. C71500; UNS No. C71520; UNS No. C71640; UNS No. C72200

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser in the inquiry, contract, or order, for agencies of the U. S. Government.

S1. Referenced Documents

S1.1 The following documents of the issue in effect on date of material purchase form a part of this specification to the extent referenced herein:

S1.1.1 ASTM Standards:

ASTM B900 Specification for Packaging of Copper and Copper Alloy Mill Products for US Government Purchases

Federal Standards:

Fed. Std. No. 102 Preservation, Packaging and Packing Levels[5]

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[5]

Fed. Std. No. 185 Identification Marking of Copper and Copper-Base Alloy Mill Products[5]

S1.1.2 *Military Standard:*

MIL-STD-129 Marking for Shipment and Storage[5]

S2. Quality Assurance

S2.1 *Responsibility for Inspection:*

S2.1.1 Unless otherwise specified in the contract or purchase order, the manufacturer is responsible for the performance of all inspection and test requirements specified. Except as otherwise specified in the contract or purchase order, the manufacturer may use his own or any other suitable facilities for the performance of the inspection and test requirements unless disapproved by the purchaser at the time the order is placed. The purchaser shall have the right to perform any of the inspections or tests set forth when such inspections and tests are deemed necessary to assure that the material conforms to prescribed requirements.

S3. Identification Marking

S3.1 All material shall be properly marked for identification in accordance with Fed. Std. No. 185 except that the ASTM specification number and the alloy number shall be used.

S4. Preparation for Delivery

S4.1 *Preservation, Packaging, Packing:*

S4.1.1 *Military Agencies*—The material shall be separated by size, composition, grade or class and shall be preserved and packaged, Level A or C, packed, Level A, B, or C as specified in the contract or purchase order, in accordance with the requirements of Practice B900.

S4.1.2 *Civil Agencies*—The requirements of Fed. Std. No. 102 shall be referenced for definitions of the various levels of packaging protection.

S4.2 *Marking:*

S4.2.1 *Military Agencies*—In addition to any special marking required by the contract or purchase order, marking for shipment shall be in accordance with MIL-STD-129.

S4.2.2 *Civil Agencies*—In addition to any special marking required by the contract or purchase order, marking for shipment shall be in accordance with Fed. Std. No. 123.

[5] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://dodssp.daps.dla.mil.

APPENDIX

(Nonmandatory Information)

X1. DENSITY OF COPPER AND COPPER ALLOYS

X1.1 The densities of the alloys covered by this specification are given in Table X1.1.

TABLE X1.1 Densities

NOTE 1—This information is for reference only.

Copper or Copper Alloy UNS No.	Density, lb/in.^{3}	Density, g/cm^3
C10800, C12200	0.323	8.94
C19400	0.322	8.91
C23000	0.316	8.75
C44300, C44400, C44500	0.308	8.53
C68700	0.301	8.33
C70400	0.323	8.94
C70600, C70620	0.323	8.94
C71000	0.323	8.94
C71500, C71520	0.323	8.94
C71640	0.323	8.94
C72200	0.323	8.94

SUMMARY OF CHANGES

Committee B05 has identified the location of selected changes to this standard since the last issue (B543 - 07$^{\varepsilon 1}$) that may impact the use of this standard. (Approved April 1, 2012.)

(1) Added SI values and SI tables to standard.

(2) Added Test Method B968/B968M.