



Designation: B 587 – 97^{ε1}

Standard Specification for Welded Brass Tube¹

This standard is issued under the fixed designation B 587; 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 reappraisal. A superscript epsilon (ε) indicates an editorial change since the last revision or reappraisal.

^{ε1} NOTE—3.1.7 and Note 3 were deleted editorially in March 2000.

1. Scope *

1.1 This specification establishes the requirements for round, rectangular, and square copper alloy welded tube for general engineering applications.

1.2 The values stated in inch-pound units are the standard except for grain size which is stated in SI units. SI values given in parentheses are for information only.

1.3 The following hazard statement pertains only to the test method described in 18.2.3, 18.2.4, 18.2.6, and 18.2.7 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

- B 153 Test Method for Expansion (Pin Test) of Copper and Copper-Alloy Pipe and Tubing²
- B 154 Test Method for Mercurous Nitrate Test for Copper and Copper-Alloys²
- B 428 Test Method for Angle of Twist in Rectangular and Square Copper and Copper Alloy Tube²
- B 601 Practice for Temper Designations for Copper and Copper Alloys—Wrought and Cast²
- E 3 Methods of Preparation of Metallographic Specimens³
- E 8 Test Methods for Tension Testing of Metallic Materials³
- E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials³
- E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications⁴
- E 112 Test Methods for Determining Average Grain Size³
- E 243 Practice for Electromagnetic (Eddy Current) Examination of Copper and Copper Alloy Tubes⁵
- E 255 Practice for Sampling Copper and Copper Alloys for

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² *Annual Book of ASTM Standards*, Vol 02.01.

³ *Annual Book of ASTM Standards*, Vol 03.01.

⁴ *Annual Book of ASTM Standards*, Vol 14.02.

⁵ *Annual Book of ASTM Standards*, Vol 03.03.

Determination of Chemical Composition⁶

E 478 Test Methods for Chemical Analysis of Copper Alloys⁶

E 527 Practice for Numbering Metals and Alloys (UNS)⁷

3. Terminology

3.1 Definitions:

3.1.1 *average diameter (for round tubes only)*, *n*—the average of the maximum and minimum outside diameters, or the maximum and minimum inside diameters, whichever is applicable, as determined at any one cross section of the tube.

3.1.2 *coil*—a length of the product wound into a series of connected turns. The unqualified term “coil” as applied to tube is normally understood as referring to a bunched coil.

3.1.2.1 *mill length*—lengths that can be conveniently manufactured in the mills.

3.1.2.2 *mill lengths with ends*—lengths, including ends, that can be conveniently manufactured in the mills.

3.1.3 *flash or bead*—weld metal that protrudes beyond the normal wall, both inside or outside.

3.1.4 *lengths*—straight pieces of the product.

3.1.4.1 *ends*—straight pieces, shorter than the nominal length, left over after cutting the product into mill lengths, stock lengths, or specified lengths. They are subject to minimum length and maximum weight requirements.

3.1.4.2 *specific*—straight lengths that are uniform in length, as specified, and subject to established tolerances.

3.1.4.3 *stock*—straight lengths that are mill cut and stored in advance of orders. They are usually subject to established tolerances.

3.1.5 *scarfing*—the removing of flash or bead by a cutting operation.

3.1.6 *tube*—a hollow product of round or any other cross section, having a continuous periphery.

3.1.6.1 *welded*—product made from sheet, strip, or plate with a seam made by welding.

3.1.6.2 *as-welded*—a condition created as a result of shaping sheet, strip, or plate into a tubular form and welding without subsequent heat treatment or cold work, or both.

3.1.6.3 *welded and annealed*—welded tube that has been annealed to produce a uniformed grain size appropriate to the

⁶ *Annual Book of ASTM Standards*, Vol 03.05.

⁷ *Annual Book of ASTM Standards*, Vol 01.01.

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

specified annealed temper.

3.1.6.4 *welded and cold-drawn*—welded tube with internal flash removed by scarfing and subsequently cold-drawn to conform to the specified temper.

3.1.6.5 *fully finished*—welded tube with internal and processed to conform to the specified temper.

4. Classification (Type)

4.1 The basic types of welded tube are:

4.1.1 *Type I*—As-welded tube finished by passing through sizing and straightening rolls at ambient temperature.

4.1.2 *Type II*—As-welded tube finished by sizing, straightening, and annealing.

4.1.3 *Type III*—As-welded tube finished by cold reducing or cold drawing over a plug or mandrel.

4.1.4 *Type IV*—As-welded tube finished by both cold drawing over a plug or mandrel and annealing, and redrawing and annealing when necessary to conform to a specified size and temper.

4.1.4.1 Type IV tube may be substituted for Types I, II, and III by agreement between the manufacturer or supplier and the purchaser. The temper of substituted Type IV tube shall be stated in the contract or purchase order.

5. Ordering Information

5.1 The contract or purchase order for product under this specification should include the following information:

5.1.1 ASTM designation and year of issue (for example, B 587 – 97),

5.1.2 Copper Alloy UNS⁸ No. (for example, C21000) (Section 6),

5.1.3 Classification (type) (Section 4),

5.1.4 Temper (Section 8 and Table 2 and Table 3),

5.1.5 Dimensions (diameter, distances between parallel surfaces, wall thickness and so forth) (Section 13),

5.1.6 How furnished (coils or lengths, specific or stock, with or without ends),

5.1.7 Number of coils or pieces, each size and type, and

5.1.8 Total weight, each size and type.

5.2 The following options are available under this specification and should be specified in the contract or purchase order when required:

5.2.1 Mercurous nitrate test (11.1),

5.2.2 Hydrostatic test (12.2),

5.2.3 Pneumatic test (12.3),

5.2.4 Certification (Section 22),

5.2.5 Mill test report (Section 23), and

5.2.6 Product marking (Section 24).

6. Material and Manufacture

6.1 *Material*—The material shall be strip, sheet, or plate produced of Copper Alloy UNS No. C21000, C22000, C23000, C26000, C26800, C27000, or C27200 and shall be of such quality and soundness as to be suitable for processing into the products described in this specification.

⁸ Refer to Practice E 527 for explanation of the Unified Numbering System (UNS).

6.2 Manufacture:

6.2.1 Tubes shall be welded by any process which produces forged or fusion welds.

6.2.1.1 Tube welded from cold-rolled strip can be regularly furnished by welding standard strip tempers and shall have mechanical properties as agreed upon between the manufacturer or supplier and the purchaser.

6.2.2 Forged-welded tube shall be scarfed to remove both internal and external flash.

6.2.2.1 Forged-welded tube to be drawn over a mandrel to produce Types III and IV may have the internal flash completely removed.

6.2.2.2 Forged-welded Types I, II, and III tube may contain a residual thickness at the weld not to exceed 0.006 in. (0.15 mm) or 10 % of the nominal wall thickness, whichever is greater.

6.2.3 Fusion-welded tube shall be mechanically worked to produce a smooth external and internal surface without the application of scarfing or other removal of the weld metal bead.

7. Chemical Composition

7.1 The material shall conform to the chemical requirements given in Table 1 for the specified alloy.

7.1.1 These composition limits do not preclude the presence of other elements. Limits may be established and analysis required for unnamed elements by agreement between the manufacturer and the purchaser.

7.2 Either copper or zinc may be taken as the difference between the sum of results of all elements determined and 100 %; however, when copper is so determined, that difference shall conform to the limits given in Table 1 for copper.

7.3 When all elements in Table 1 for the specified alloy are determined, the sum of results shall be as follows:

Copper Alloy UNS No.	Copper Plus Specified Elements, min, %
C21000, C22000, C23000	99.8
C26000, C26800, C27000, C27200	99.7

8. Temper

8.1 The material furnished shall be one of the tempers indicated in Table 2 or Table 3.

8.1.1 Light-drawn and hard-drawn tempers are normally available in round tube only.

8.1.2 Special temper requirements are subject to agreement between the manufacturer or supplier and the purchaser.

9. Physical Properties

9.1 Grain Size:

TABLE 1 Chemical Requirements

Copper Alloy UNS No.	Composition, %			
	Copper	Lead, max	Iron, max	Zinc
C21000	94.0–96.0	0.05	0.05	remainder
C22000	89.0–91.0	0.05	0.05	remainder
C23000	84.0–86.0	0.05	0.05	remainder
C26000	68.5–71.5	0.07	0.05	remainder
C26800	64.0–68.5	0.15	0.05	remainder
C27000	63.0–68.5	0.10	0.07	remainder
C27200	62.0–65.0	0.07	0.07	remainder


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TABLE 2 Tensile Strength Requirements and Approximate Rockwell Hardness Values for Welded (Type I), Welded and Cold-Worked (Type III), and Fully Finished (Type IV) Tube

Copper Alloy UNS No.	Temper	Type	Outside Diameter, in. (mm)	Wall Thickness, in. (mm)	Rockwell 30T Hardness, ^A min	Tensile Strength, min, ksi ^B (MPa) ^C
C21000	welded from annealed strip	I	all	all	7	34 (235)
C21000	welded from cold-rolled strip	I	all	all	<i>D</i>	<i>D</i>
C21000	cold reduced or light drawn	III, IV	all	all	34	37 (255)
C21000	cold reduced or hard drawn	III, IV	up to 1 (25.4) incl	0.020–0.119 (0.508–3.02)	52	46 (315)
			over 1 to 2 (25.4 to 50.8) incl	0.035–0.119 (0.889–3.02)		
			over 2 to 3½ (50.8 to 88.9) incl	0.060–0.119 (1.52–3.02)		
C22000	welded from annealed strip	I	all	all	10	37 (255)
C22000	welded from cold-rolled strip	I	all	all	<i>D</i>	<i>D</i>
C22000	cold reduced or light drawn	III, IV	all	all	38	40 (275)
C22000	cold reduced or hard drawn	III, IV	up to 1 (25.4) incl	0.020 to 0.119 (0.508 to 3.02)	55	52 (360)
			over 1 to 2 (25.4 to 50.8) incl	0.035 to 0.119 (0.889 to 3.02)		
			over 2 to 3½ (50.8 to 88.9) incl	0.060 to 0.119 (1.52 to 3.02)		
C23000	welded from annealed strip	I	all	all	24	40 (275)
C23000	welded from cold-rolled strip	I	all	all	<i>D</i>	<i>D</i>
C23000	cold reduced or light drawn	III, IV	all	all	43	44 (305)
C23000	cold reduced or drawn (general purpose)	III, IV	all	all	43	44 (305)
C23000	cold reduced or hard drawn	III, IV	up to 1 (25.4) incl	0.020 to 0.119 (0.508 to 3.02)	65	57 (395)
			over 1 to 2 (25.4 to 50.8) incl	0.035 to 0.119 (0.889 to 3.02)		
			over 2 to 3½ (50.8 to 88.9) incl	0.060 to 0.119 (1.52 to 3.02)		
C26000, C26800, C27000, C27200	welded from annealed strip	I	all	all	25	48 (330)
C26000, C26800, C27000, C27200	welded from cold-rolled strip	I	all	all	<i>D</i>	<i>D</i>
C26000, C26800, C27000, C27200	cold reduced or drawn (general purpose)	III, IV	all	all	53	54 (370)
C26000, C26800, C27000, C27200	cold reduced or hard drawn ^E	III, IV	up to 1 (25.4) incl	0.020 to 0.119 (0.508 to 3.02)	70	66 (455)
			over 1 to 2 (25.4 to 50.8) incl	0.035 to 0.119 (0.889 to 3.02)		
			over 2 to 3½ (50.8 to 88.9) incl	0.060 to 0.119 (1.52 to 3.02)		

^ARockwell hardness values shall only apply to: (a) tubes having a wall thickness of 0.012 in. (0.305 mm) or greater; (b) round tube having an inside diameter of 5/16 in. (7.94 mm) or greater; and (c) rectangular and square tube having an inside major distance between parallel surfaces of 3/4 in. (4.76 mm) or greater. Rockwell hardness tests shall be made on the inside surface of the tube, and the value of the Rockwell hardness number of each specimen shall be established by taking the arithmetical average of at least three readings. When suitable equipment is not available for determining the specified Rockwell hardness, other Rockwell scales and values may be specified subject to agreement between the manufacturer and the purchaser.

^Bksi = 1000 psi.

^CSee Appendix X1.

^DTube welded from cold-rolled strip can be regularly supplied by welding standard strip tempers and shall have mechanical properties as agreed upon between the purchaser and the supplier.

^ELight-drawn and hard-drawn tempers are normally available in round tube only.

9.1.1 Type II and Type IV tubes with tempers designated as W060 (welded and soft-annealed) and W050 (welded and light-annealed) shall conform to the requirements prescribed in Table 3 for the specified copper alloy UNS No. and temper when tested in accordance with Test Methods E 112.

9.1.2 Grain size shall be the basis for acceptance or rejection based upon physical properties.

10. Mechanical Properties

10.1 Tensile Strength Requirements:

10.1.1 Type I, Type III, and Type IV tube in drawn tempers shall conform to the requirements prescribed in Table 2 for the

specified copper alloy and temper when tested in accordance with Test Methods E 8.

10.1.2 The tensile test results shall be the basis for acceptance or rejection based upon mechanical properties.

10.2 *Rockwell Hardness*—The approximate Rockwell hardness value(s) for each copper alloy and temper given in Table 2 and Table 3 are for general information and assistance in testing.

NOTE 1—The Rockwell hardness test offers a quick and convenient method for checking for general conformity to the requirements for tensile strength or grain size.



TABLE 3 Grain Size Requirements and Approximate Rockwell Hardness Values for Welded Tube and Fully Finished Tube When Furnished in the Annealed Temper

Copper Alloy UNS No.	Temper		Types	Outside Diameter, in. (mm)	Wall Thickness, in. (mm)	Rockwell Hardness ^A		Avg Grain Size, mm										
	Designation	Name				Scale	Max	min	max									
C21000	WO60	soft anneal	II, IV	all	up to 0.045 (1.14) incl over 0.045 (1.14)	30T F	17 61	0.025 0.025	0.060 0.060									
C21000	WO50	light anneal	II, IV	all	up to 0.045 (1.14) over 0.045 (1.14)	30T F	27 68	^B ^B	0.035 0.035									
C22000	WO60	soft anneal	II, IV	all	up to 0.045 (1.14) incl over 0.045, (1.14)	30T F	30 70	0.025 0.025	0.060 0.060									
C22000	WO50	light anneal	II, IV	all	up to 0.045 (1.14) incl over 0.045, (1.14)	30T F	37 78	^B ^B	0.035 0.035									
C23000	WO60	soft anneal	II, IV	all	up to 0.045 (1.14) incl over 0.045, (1.14)	30T F	36 75	0.025 0.025	0.060 0.060									
C23000	WO50	light anneal	II, IV	all	up to 0.045 (1.14) incl over 0.045 (1.14)	30T F	39 85	^B ^B	0.035 0.035									
C26000 C26800 C27000 C27200	} WO60	soft anneal	II, IV	all	{ up to 0.30 (0.762) incl over 0.030 (0.762)	30T F	40 80	0.025 0.025	0.060 0.060									
C26000 C26800 C27000 C27200										} WO50	light anneal	II, IV	all	{ up to 0.30 (0.762) incl over 0.030 (0.762)	30T F	60 90	^B ^B	0.035 0.035

^ARockwell hardness values only apply to: (a) tube having a wall thickness of 0.015 in. (0.38 mm) or greater; (b) round tube having an inside diameter of 5/16 in. (7.94 mm) or greater; and (c) rectangular and square tube having an inside major distance between parallel surfaces of 3/16 in. (4.76 mm) or greater. Rockwell hardness values do not apply for other tube. Rockwell hardness tests shall be made on the inside surface of the tube and the value of the Rockwell hardness number of each specimen shall be established by taking the arithmetical average of at least three readings. When suitable equipment is not available for determining the specified Rockwell hardness, other Rockwell scales and values may be specified subject to agreement between the manufacturer and the purchaser.

^BAlthough no minimum grain size is specified, the product must, nevertheless, have a fully recrystallized grain structure.

11. Performance Requirements

11.1 *Mercurous Nitrate Test*—When specified in the contract or purchase order, specimens of annealed tube in all copper alloys and tempers shall show no cracks when tested in accordance with Test Method B 154.

11.2 *Expansion Test*—The annealed tube shall be expanded in accordance with Test Method B 153 to the following amounts.

Standard Size, in. (mm)	Expansion in Outside Diameter, %
3/4 (19.0) and under	20
Over 3/4 (19.0)	15

The expanded tube shall not show cracking or rupture visible to the unaided eye.

11.3 Flattening Test:

11.3.1 The annealed tube flattened elements shall show no cracking or rupture visible to the unaided eye.

11.3.1.1 The weld when visible or identifiable shall be at the point of maximum bend on at least one half of the flattening elements.

11.4 *Reverse Bend Test*—After bending, the annealed tube test specimen shall show no evidence of cracks, or lack of penetration in the weld, or of overlaps resulting from flash removal visible to the unaided eye.

12. Nondestructive Testing

12.1 *Electromagnetic (Eddy-Current) Examination*—Each tube up to and including 3 1/8-in. (79.4-mm) outside diameter or within the capabilities of the testing unit shall be passed through the testing unit adjusted to provide information on the suitability of the tube for the intended application in accor-

dance with Practice E 243. Tube that does not actuate the signalling device shall be considered as conforming with test requirements.

12.2 Hydrostatic Test:

12.2.1 When specified in the contract or purchase order, each tube shall withstand an internal hydrostatic pressure sufficient to subject the material to a fiber stress of 6000 psi (41 MPa) without leakage.

12.2.2 The tube need not be tested at a gage pressure over 1000 psi (6.9 MPa) unless so specified in the contract or purchase order.

12.3 *Pneumatic Test*—When specified in the contract or purchase order, each tube shall withstand an internal air pressure of 60 psi (415 kPa) minimum for 5 s without leakage.

13. Dimensions, Mass, and Permissible Variations

13.1 Tube diameter shall be expressed as outside diameter or inside diameter in numerical fractions of an inch. Wall thickness shall be expressed in decimal fractions of an inch.

13.2 Tolerances on a given tube may be specified with respect to any two, but not all three, of the following: outside diameter, inside diameter, and wall thickness.

13.3 For purposes of determining conformance with the dimensional requirements prescribed in this specification, any measured value outside the specified limiting values for any dimension shall be cause for rejection.

13.4 *Wall Thickness Tolerances*—Wall thickness tolerances for round tube shall conform to the tolerances listed in Table 4. Wall thickness tolerances for rectangular including square tube shall be in accordance with Table 5.

13.5 Diameter tolerances for round tubes furnished in straight lengths only shall be in accordance with Table 6.

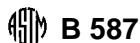


TABLE 4 Wall Thickness Tolerances^A for Welded Brass Tube

NOTE 1—*Maximum Deviation at any Point*—The following tolerances are plus and minus. If tolerances all plus or all minus are desired, double the values given.

Wall Thickness, ^B in. (mm)	Outside Diameters, ^C in. (mm)				
	1/32 (0.794) to 1/8 (3.18), incl	Over 1/8 (3.18) to 5/16 (15.9), incl	Over 5/16 (15.9) to 1 (25.4), incl	Over 1 (25.4) to 2 (50.8), incl	Over 2 (50.8) to 3 1/2 (88.9), incl
Up to 0.017 (0.432), incl	0.002 (0.051)	0.001 (0.025)	0.0015 (0.038)	0.002 (0.051)	...
Over 0.017 (0.432) to 0.024 (0.610), incl	0.003 (0.076)	0.002 (0.051)	0.002 (0.051)	0.0025 (0.064)	...
Over 0.024 (0.610) to 0.034 (0.864), incl	0.003 (0.076)	0.0025 (0.064)	0.0025 (0.064)	0.003 (0.076)	0.004 (0.10)
Over 0.034 (0.864) to 0.057 (1.48), incl	0.003 (0.076)	0.003 (0.076)	0.0035 (0.089)	0.0035 (0.089)	0.005 (0.13)
Over 0.057 (1.48) to 0.082 (2.08), incl	...	0.0035 (0.089)	0.004 (0.10)	0.004 (0.10)	0.006 (0.15)
Over 0.082 (2.08) to 0.119 (3.02), incl	...	0.004 (0.10)	0.005 (0.13)	0.005 (0.13)	0.007 (0.18)

^AThe thickness tolerance is the maximum deviation at any point from the specified thickness.

^BThe wall thickness at the weld in Types I, II, and III tube may exceed the nominal wall thickness by an amount double the value shown in the tolerance table.

^CWhen round tube is ordered by outside and inside diameters, the maximum plus and minus deviation of the wall thickness from the nominal at any point shall not exceed the values given in the table by more than 50 %.

TABLE 5 Wall Thickness Tolerances^A for Rectangular and Square Welded Brass Tube

NOTE 1—*Maximum Deviation at Any Point*—The following tolerances are plus and minus. If tolerances all plus or all minus are desired, double the values given.

Wall Thickness, in. (mm)	Distance Between Outside Parallel Surfaces, ^B in. (mm)					
	1/32 (0.794) to 1/8 (3.18), incl	Over 1/8 (3.18) to 5/16 (15.9), incl	Over 5/16 (15.9) to 1 (25.4), incl	Over 1 (25.4) to 2 (50.8), incl	Over 2 (50.8) to 4 (102), incl	Over 4 (102) to 6 (152), incl
Up to 0.017 (0.432), incl	0.002 (0.051)	0.002 (0.051)	0.0025 (0.064)	0.003 (0.076)
Over 0.017 (0.432) to 0.024 (0.610), incl	0.003 (0.076)	0.0025 (0.064)	0.003 (0.076)	0.0035 (0.089)
Over 0.024 (0.610) to 0.034 (0.864), incl	0.0035 (0.089)	0.0035 (0.089)	0.0035 (0.089)	0.004 (0.10)	0.006 (0.15)	...
Over 0.034 (0.864) to 0.057 (1.45), incl	0.004 (0.10)	0.004 (0.10)	0.0045 (0.11)	0.005 (0.12)	0.007 (0.18)	0.009 (0.23)
Over 0.057 (1.45) to 0.082 (2.08), incl	...	0.005 (0.13)	0.006 (0.15)	0.007 (0.18)	0.008 (0.20)	0.010 (0.25)
Over 0.082 (2.08) to 0.119 (3.02), incl	...	0.007 (0.18)	0.008 (0.20)	0.009 (0.23)	0.010 (0.25)	0.012 (0.30)

^AThe thickness tolerance is the maximum deviation at any point from the specified thickness.

^BIn the case of rectangular tube, the major dimension determines the thickness tolerance applicable to all walls.

TABLE 6 Average Diameter Tolerances^A

NOTE 1—Applicable to straight lengths only.

Specified Diameter, in. (mm)	Outside Diameter
	Tolerance, plus and minus
	in. (mm)
1/4 to 5/8 (6.35 to 15.9), incl	0.002 (0.051)
Over 5/8 to 1 (15.9 to 25.4), incl	0.0025 (0.064)
Over 1 to 2 (25.4 to 50.8), incl	0.003 (0.076)
Over 2 to 3 (50.8 to 76.2), incl	0.004 (0.10)
Over 3 to 3 1/2 (76.2 to 88.9), incl	0.005 (0.13)

^AWhen tolerances are required for inside diameter, double the values shown.

Tolerances have not been established for tube furnished in coils.

13.6 Tolerances on distance between parallel surfaces for rectangular including square tube shall be in accordance with Table 7.

13.7 *Lengths and Tolerances:*

13.7.1 Tube in straight lengths shall be furnished in stock lengths with ends unless the order requires specific lengths or specific lengths with ends.

13.7.2 The tolerances on the length for tubes furnished in straight lengths shall be in accordance with Table 8.

13.7.3 The schedule of ends for tubes furnished in specific or stock lengths with ends shall be in accordance with Table 9.

13.7.4 The tolerances for tubes furnished in coils shall be in accordance with Table 10, Table 11, and Table 12.

13.8 *Roundness:*

TABLE 7 Tolerances on Distance Between Parallel Surfaces for Rectangular and Square Welded Brass Tube

NOTE 1—The following tolerances are plus and minus. If tolerances all plus or all minus are desired, double the values given.

Major Outside Dimensions, ^A in. (mm)	Tolerances
	in. (mm)
Up to 1/8 (3.18), incl	0.003 (0.076)
Over 1/8 to 5/16 (3.18 to 15.9), incl	0.004 (0.10)
Over 5/16 to 1 (15.9 to 25.4), incl	0.005 (0.13)
Over 1 to 2 (25.4 to 50.8), incl	0.006 (0.15)
Over 2 to 3 (50.8 to 76.2), incl	0.007 (0.18)
Over 3 to 4 (76.2 to 102), incl	0.008 (0.20)
Over 4 to 5 (102 to 127), incl	0.009 (0.23)
Over 5 to 6 (127 to 152), incl	0.010 (0.25)

^AThe major outside dimension determines the tolerance applicable to minor outside dimension.

13.8.1 For as-welded from cold-worked strip, and redrawn unannealed tube in straight lengths, the roundness tolerances shall be in accordance with Table 13.

13.8.2 Compliance with the roundness tolerance shall be determined by taking measurements on the outside diameter only, irrespective of the manner in which the tube dimensions are specified. The deviation from roundness is measured as the difference between major and minor diameters as determined at any one cross section of the tube.

13.8.3 Tolerances have not been established for redrawn tube, annealed tube, tube as welded from annealed strip, any tube furnished in coils, or tube whose wall thickness is under 0.016 in. (0.406 mm).

arc) in any 6-ft (1.83-m) portion of the total length. (Not applicable to redraw tube, tube as welded from annealed strip, or any annealed tube.)

13.11 *Corner Radius, Rectangular and Square Tubes*—The permissible radii for commercially square corners applicable to welded rectangular and square tubes shall be in accordance with Table 15.

13.12 *Twist Tolerances, Rectangular and Square Tubes*—The maximum twist about the longitudinal axis of drawn temper and as welded from cold-rolled strip temper rectangular and square tubes shall not exceed 1°/ft (0.305 m) length, measured to the nearest degree, and the total angle of twist shall not exceed 20° when measured in accordance with Test Method B 428. The requirement is not applicable to any annealed tubes, tubes as welded from annealed strip, or tubes whose specified major dimension is less than 1/2 in. (12.7 mm).

14. Workmanship, Finish, and Appearance

14.1 Tubes covered by this specification shall be free from defects of a nature that interfere with normal commercial applications. They shall be reasonably clean and free of dirt.

15. Sampling

15.1 The lot size, portion size, and number of sample pieces to be taken shall be as follows:

15.1.1 *Lot Size*—The lot size shall be 10 000 lbs (4550 kg) or fraction thereof.

15.1.2 *Portion Size*—The number of pieces to be randomly selected shall be in accordance with the following schedule:

Number of Tubes in Lot	Number of Pieces to be Taken ^A
1 to 50	1
51 to 200	2
201 to 1500	3
Over 1500	0.2 % of the total number of pieces in the lot, but not to exceed 10 pieces

^AEach sample piece shall be taken from a separate tube.

15.2 Chemical Composition:

15.2.1 The sample shall be taken in approximately equal weight from each portion piece selected in 15.1.2 and in accordance with Practice E 255. The minimum weight of the composite sample shall be 150 g.

15.2.2 Instead of sampling in accordance with Practice E 255, the manufacturer shall have the option of sampling at the time castings are poured or taken from the semifinished product. When chemical composition is determined during the course of manufacture, sampling of the finished product is not required.

15.2.3 The number of samples taken during the course of manufacture shall be as follows:

15.2.3.1 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.

15.2.3.2 When samples are taken from the semifinished product, at least one sample shall be taken to represent each 10 000 lbs or fraction thereof, except that not more than one sample per piece shall be required.

15.3 Other Tests:

15.3.1 Unless otherwise specified in the contract or purchase order, specimens for all other tests shall be taken from two of the sample pieces taken in 15.1.2. In the event only one sample piece is required, all specimens shall be taken from the piece selected.

15.3.1.1 When tube is furnished in coils, a length sufficient for all necessary tests shall be taken from each coil selected for sampling. The remaining portion of the sampled coil shall be included in the shipment with the permissible variation for such coils waived.

16. Number of Tests and Retests

16.1 Tests:

16.1.1 *Chemical Analysis*—Chemical composition shall be determined as the per element mean of results from at least two replicate analyses of the sample.

16.1.2 *Other Tests*—Grain size and tensile strength shall be reported as the test results obtained from specimens prepared from each of two pieces selected in 15.1.2, except where only one piece was required, and all specimens shall meet the minimum test requirement.

16.2 Retests:

16.2.1 When requested by the manufacturer or supplier, a retest shall be permitted when test results obtained by the purchaser fail to conform with product specification requirement(s).

16.2.2 Retesting shall be as directed in the product specification for the initial test except for the number of test specimens which shall be twice that normally required for the test. Test results for all specimens shall conform to the product specification requirement(s) in retest, and failure to comply shall be cause for lot rejection.

17. Specimen Preparation

17.1 *Chemical Analysis*—Preparation of the analytical test specimens shall be the responsibility of the reporting laboratory.

17.2 *Grain Size*—The test specimens shall be prepared in accordance with Methods E 3. The test specimen surface shall approximate a radial longitudinal section of round tube or a longitudinal section of rectangular and square tube perpendicular to, and bisecting, the major dimensional surface.

17.3 *Tensile Test*—The test specimen shall be of the full section of the tube and shall conform to the requirements specified in the section Specimens for Pipe and Tube in Test Methods E 8. Should limitations of the testing machine preclude the use of such a specimen, specimens conforming to Type No. 1 of Fig. 13, Tension Test Specimen for Large-Diameter Tubular Products, of Test Methods E 8 may be used.

17.4 Rockwell Hardness:

TABLE 15 Permissible Radii for Commercially Square Corners for Rectangular and Square Welded Tube

Wall Thickness, in. (mm)	Maximum Radii	
	Outside Corners	Inside Corners
	in. (mm)	in. (mm)
Up to 0.058 (1.47), incl	3/64 (1.2)	1/32 (0.79)
Over 0.058 to 0.120 (1.47 to 3.03), incl	1/16 (1.6)	1/32 (0.79)
Over 0.120 to 0.156 (3.03 to 3.96), incl	3/32 (2.4)	1/32 (0.79)

17.4.1 The test specimen shall be of a size and shape to permit testing by the available test equipment and shall be taken to permit testing in a plane parallel or perpendicular to the direction of deformation given to the product.

17.4.2 The surface of the test specimen shall be sufficiently smooth and even to permit the accurate determination of hardness.

17.4.3 The test specimen shall be free from scale and foreign matter and care shall be taken to avoid any change in condition, for example, heating or cold working.

17.5 *Mercurous Nitrate Test*—The test specimen shall be prepared as described in Test Method B 154 and shall be obtained without bending, springing, polishing, or any other preparation.

17.6 *Expansion (Pin Test)*—The specimen shall be prepared as described in the Test Specimen section of Test Method B 153.

17.7 *Flattening Test*—Annealed test specimen shall be at least 4 ft (1.22 m) in length cut from the end of the tube.

17.8 *Reverse Bend Test*—An annealed section approximately 4 in. (102 mm) in length taken from the end of the tube shall be cut longitudinally (90° on each side of the weld when visible or identifiable) and flattened.

18. Test Methods

18.1 Chemical Analysis:

18.1.1 Composition shall be determined, in case of disagreement, by the following appropriate test method:

Element	Test Method
Copper	E 478
Iron	E 478
Lead	E 478 (AA)
Zinc	E 478 (Titrimetric)

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

18.2 The product furnished shall conform with the physical and mechanical and other requirements enumerated in this specification when tested in accordance with the following appropriate test method:

Test	Test Method
Grain size	E 112
Tension	E 8
Angle of twist	B 428
Expansion (pin test)	B 153
Flattening	18.2.3
Reverse bend	18.2.4
Electromagnetic examination (eddy current)	E 243
Hydrostatic	18.2.6
Pneumatic	18.2.7

18.2.1 *Grain Size*—In case of dispute, grain size shall be determined by the intercept method.

18.2.2 Tensile Strength:

18.2.2.1 Tensile strength shall be determined in accordance with Test Methods E 8. Whenever test results are obtained from both full-size and machined specimens and they differ, the test results from the full-size specimens shall prevail.

18.2.2.2 Test results are not seriously affected by variations

in speed of testing. A considerable range of testing speed is permitted; however, the rate of stressing to the yield strength should not exceed 100 ksi (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. (0.5 mm) of gage length (or distance between grips for full-section specimens).

18.2.3 *Flattening Test*—The test specimen shall be flattened on different elements throughout the length and each element shall be slowly flattened by one stroke of a press. The weld, when visible or identifiable, shall be placed in the position of maximum bend on at least one half of the flattened elements. The term “flattened” shall be interpreted as follows: A micrometer caliper set at three times the wall thickness shall pass over the tube freely throughout the flattened part except at the points where the change in element of flattening takes place.

18.2.4 Reverse Bend Test:

18.2.4.1 The specimen shall be 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.

18.2.4.2 For this test a reverse bend is the bending of the tube opposite the formed radius of the tube.

18.2.5 Electromagnetic (Eddy-Current) Examination:

18.2.5.1 The artificial discontinuity calibration standard shall be prepared in accordance with Option a or d of Practices E 243, and the notch depth shall be 22 % of the nominal wall thickness rounded to the nearest 0.001 in. (0.025 mm). The notch depth tolerance shall be ±0.0005 in. (0.013 mm). Alternatively, when the equipment is speed insensitive and equipped so that a fraction of the maximum unbalanced signal can be selected, the following percent maximum unbalance signal may be used.

Tube Size, in. (mm)	Unbalanced Signal Magnitude, max, %
Up to ¾ (9.4) incl	0.2
½ to 2 (12.7 to 50.8)	0.3
Over 2 to 3 (50.8 to 76.2) incl	0.4

18.2.5.2 Unless otherwise agreed upon, tube causing irrelevant signals because of visible and identifiable handling marks may be retested by the hydrostatic or the pneumatic test, and tube meeting the requirements of either test shall be considered to conform when the dimensions are within the prescribed limits.

18.2.5.3 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. Tube causing irrelevant signals because of minor mechanical damage moisture, soil, and like effects shall not be cause for rejection provided the tube dimensions are still within prescribed limits and the tube is suitable for its intended application.

18.2.6 *Hydrostatic Test*—The internal hydrostatic pressure necessary to produce the required fiber stress shall be determined by the following equation for thin hollow cylinders under tension.

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

where:

P = hydrostatic pressure, psi (or MPa);

t = thickness of tube wall, in. (or mm);
 D = outside diameter of tube, in. (or mm); and
 S = allowable fiber stress of the material, psi (or MPa).

18.2.7 *Pneumatic Test*—The test method shall permit easy visual detection of leakage, such as having the material under water or by the pressure differential method.

19. Significance of Numerical Limits

19.1 For the purpose 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 E 29:

Property	Rounded Unit for Observed or Calculated Value
Chemical composition	nearest unit in the last right-hand place of figures of the specified limit
Hardness	nearest ksi
Tensile strength	nearest multiple of 0.005 mm
Grain size up to 0.060 mm, incl	

20. Inspection

20.1 The manufacturer or supplier shall inspect and make the test necessary to verify that the product furnished conforms to the requirements specified.

20.2 Source inspection of the material by the purchaser may be agreed upon between the manufacturer, or supplier, and the purchaser as part of the purchase order. In which case, the nature of the facilities needed to satisfy the inspector representing the purchaser that the product is being furnished in accordance with the product specification shall be included in the agreement. All tests and the inspection shall be conducted so as not to interfere unnecessarily with the operations of the works.

20.3 The manufacturer, or supplier, and the purchaser may accomplish the final inspection simultaneously by mutual agreement.

21. Rejection and Rehearing

21.1 *Rejection:*

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

21.1.2 Rejection shall be reported to the manufacturer, or supplier, promptly and in writing.

21.1.3 The manufacturer, or supplier, may make claim for a

rehearing when dissatisfied with test results upon which rejection was based.

21.2 *Rehearing*—As a result of product rejection, the manufacturer or supplier may 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 tested by both parties as directed in the product specification, or, alternatively, upon agreement by both parties, an independent laboratory may be selected for the test using the test methods prescribed in the product specification.

22. Certification

22.1 When specified in the contract or purchase order, the purchaser shall be furnished certification that samples representing each lot have been either tested or inspected as directed in this specification and the requirements have been met.

23. Test Report

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

24. Product Marking

24.1 When specified in the contract or purchase order, the tube shall be identified throughout its length with a brown color marking, not less than $\frac{3}{16}$ in. (4.8 mm) in height, including a legend repeated at intervals not greater than 3 ft (0.91 m). The legend shall include the name or trademark of the manufacturer, or both, and an indication that the material is welded tube.

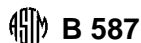
25. Packaging and Package Marking

25.1 *Packaging*—The material shall be separated by size, composition, and temper, and prepared for shipment in such a manner as to acceptance by common carrier for transportation and to afford protection from normal hazards of transportation.

25.2 *Package Marking*—Each shipping unit shall be legibly marked with the purchase order number, UNS alloy designation, temper, size, shape, total length or piece count or gross and net weight, or both, name of supplier, and whether the tubes have been hydrostatic tested. The specification number shall be shown when specified.

26. Keywords

26.1 brass tube; welded brass tube; welded tube



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APPENDIX

(Nonmandatory Information)

X1. METRIC EQUIVALENTS

X1.1 The SI unit for strength properties now shown is in accordance with the International System of Units (SI). The derived SI unit for force is the newton (N), which is defined as that force which when applied to a body having a mass of one kilogram gives it an acceleration of one metre per second squared ($N = \text{kg}\cdot\text{m}/\text{s}^2$). The derived SI unit for pressure or

stress is the newton per square metre (N/m^2), which has been named the pascal (Pa) by the General Conference on Weights and Measures. Since $1 \text{ ksi} = 6\,894\,757 \text{ Pa}$, the metric equivalents are expressed as megapascal (MPa), which is the same as MN/m^2 and N/mm^2 .

SUMMARY OF CHANGES

This section identifies the location of selected changes to this specification that have been incorporated since the 1988 issue as follows:

- | | |
|---|---|
| (1) Temper codes added to Section 9. | (5) Table 5—Wall thickness, in. (mm) over 0.119 (3.02) to 0.164 (4.17), incl, and the tolerances deleted. |
| (2) Table 2—Maximum wall thickness, in. (mm) to 0.119 (3.02). | (6) Table 5—The Distance Between Outside Parallel Surfaces, in. (mm) in the last column decreased to 6 (152), incl. |
| (3) Table 3—Temper Codes added. | (7) Table 7—Major Outside Dimensions, in. (mm) over 6 to 8 (152 to 203), incl, and the tolerances deleted. |
| (4) Table 4—Wall thickness, in. (mm) over 0.119 (3.02) to 0.164 (4.17), incl, and the tolerances deleted. | |

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