



Designation: B706 – 00 (Reapproved 2006)

Standard Specification for Seamless Copper Alloy (UNS No. C69100) Pipe and Tube¹

This standard is issued under the fixed designation B706; 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 establishes the requirements for copper alloy UNS No. C69100 seamless pipe in standard pipe sizes, both regular and extra strong, and seamless tube in straight lengths for general engineering purposes.

1.2 Values stated in inch-pound units are the standard. SI values given in parenthesis are provided for information only.

1.3 The following safety hazard caveat pertains only to the test method portion, Section described in this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*²

B193 Test Method for Resistivity of Electrical Conductor Materials

B846 Terminology for Copper and Copper Alloys

E8 Test Methods for Tension Testing of Metallic Materials

E20 Practice for Particle Size Analysis of Particulate Substances in the Range of 0.2 to 75 Micrometres by Optical Microscopy³

E54 Test Methods for Chemical Analysis of Special Brasses and Bronzes

E243 Practice for Electromagnetic (Eddy-Current) Examination of Copper and Copper-Alloy Tubes

E255 Practice for Sampling Copper and Copper Alloys for the Determination of Chemical Composition

E478 Test Methods for Chemical Analysis of Copper Alloys

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms related to copper and copper alloys, refer to Terminology B846, unless otherwise stated.

3.1.2 *stock, n*—straight lengths that are mill cut and stored in advance of orders. They usually are 10, 12, or 20 ft (3.05, 3.66, or 6.10 m) in length and subject to established length tolerances.

4. Ordering Information

4.1 Orders for products shall include the following information:

4.1.1 ASTM designation and year of issue, that is, B706–XX.

4.1.2 UNS designation, that is, C69100.

4.1.3 Temper (see Section 7).

4.1.4 Dimensions, diameter, and wall thickness.

4.1.5 How furnished: straight lengths or coils.

4.1.6 Finish.

4.1.7 Total length, or number of pieces, of each size.

4.1.8 Total weight, each size.

4.1.9 When product is purchased for agencies of the U.S. government.

4.2 The following options are available and shall be included in the contract or purchase order when required.

4.2.1 Heat identification or traceability details.

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 For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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

- 4.2.2 Electromagnetic (eddy-current) examination.
- 4.2.3 Expansion test.
- 4.2.4 Flattening test.
- 4.2.5 Certification.
- 4.2.6 Mill test report.

5. Materials and Manufacture

5.1 Material:

5.1.1 The material of manufacture shall be cast or extruded shells of Copper Alloy UNS No. C69100 of such purity and soundness as to be suitable for processing into the products prescribed herein.

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

NOTE 1—Because of the discontinuous nature of the processing of castings into wrought products, it is not always practical to identify a specific casting analysis with a specific quantity of finished material.

5.2 Manufacture:

5.2.1 The product shall be manufactured by such hot-working, cold-working, and annealing processes as to produce a uniform wrought structure in the finished product.

5.2.2 The product shall be hot or cold worked to the finished size, and subsequently, annealed, when required, to meet the temper properties specified.

6. Chemical Composition

6.1 The material shall conform to the chemical composition requirements specified in Table 1.

6.2 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 purchaser.

6.3 For Alloy UNS C69100 where zinc is listed as “remainder,” zinc is the difference between the sum of results of all elements determined and 100 %. When all elements in Table 1 are determined, the sum of results shall be 99.5 % minimum.

7. Temper

7.1 The tempers for products described in this specification shall be in accordance with Table 2.

7.1.1 TB00 (soft-annealed),

7.1.2 TF00 (precipitation-hardened), and

7.1.3 HR50 (drawn stress relieved).

8. Physical Property Requirements

8.1 *Electrical Resistivity Requirement*—When specified in the contract or purchase order, the product furnished shall be capable of conforming to a specific resistant of 1.13 $\mu\Omega/\text{mm}$ (+ < 5 %) at 20°C when tested in accordance with Test Method B193.

8.2 *Coefficient of Thermal Expansion*—When specified in the contract or purchase order, the product furnished shall be capable of conforming to a coefficient of linear expansion of 0.000 019 (or 19×10^{-6}) per °C, in the range 20 to 200°C when tested in accordance with an appropriate test method.

9. Mechanical Property Requirements

9.1 Tensile Strength Requirements :

9.1.1 Product furnished under this specification shall conform to the tensile requirements prescribed in Table 2 when tested in accordance with Test Methods E8.

9.1.2 Acceptance or rejection based upon mechanical properties shall depend only on tensile strength.

9.2 *Rockwell Hardness*—The approximate hardness value for alloy UNS C69100 lies within the range 69 to 76 Rockwell B, being for general information and assistance in testing, and shall not be used as a basis for product rejection.

TABLE 1 Chemical Requirements

Element	Composition, % Max (Unless Shown as a Range or Minimum)
Copper (incl. Ag)	81.0–84.0
Lead	0.05
Iron	0.25
Zinc	remainder
Aluminum	0.7–1.2
Manganese	0.10 min
Silicon	0.8–1.3
Tin	0.10
Nickel (incl. Co)	0.8–1.4



TABLE 2 Tensile Requirements

Temper Designation	TB00 (Soft Annealed)	TF00 (Precipitation- Hardened)	HR50 (Drawn-Stress Relieved)
Tensile strength, min, ksi ^A (MPa ^B)	55 (380)	60 (420)	79 (550)
Yield strength at 0.5 % extension under load, ksi (MPa) ^A	16.5 (115)	31 (214)	48 (335)
Elongation in 2 in. or 50 mm, min, %	50	40	10

^A ksi = 100 psi.^B See Appendix X1.

NOTE 2—The Rockwell hardness test offers a quick and convenient method of checking for general conformity to the specification requirements for temper, tensile strength and grain size.

10. Other Requirements

10.1 Nondestructive Testing:

10.1.1 Pipe or tube must be tested in the final heat-treated condition as supplied to the purchaser unless otherwise agreed upon between the manufacturer and purchaser. Unless otherwise specified, the manufacturer shall have the option of testing the pipe or tube by one of the following tests:

10.1.1.1 *Eddy-Current Test*—Each tube or pipe in standard sizes 1/8 in. (3.18 mm) up to and including 2 1/2 in. (63.5 mm) regular and extra strong, shall be subject to an eddy-current test following the procedures of Practice E243 and using an end effect suppression device. The pipe or tube shall be passed through the eddy-current testing unit to provide information on the suitability of each piece for the intended application.

10.1.1.2 Notch-depth standards, rounded to the nearest 0.001 in. (0.025 mm), shall be 10 % of the nominal wall thickness. Notch-depth tolerances shall be ±0.0005 in. (0.013 mm). Alternatively, when a manufacturer uses speed-insensitive equipment that can select a maximum unbalance signal, such a signal of 0.3 % may be used.

10.1.1.3 Pipes or tubes that do not activate the signaling device of the eddy-current tester shall be considered as conforming to the requirements of this test. Lengths with discontinuities indicated by the tester 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 provided the pipe or tube dimensions are still within the prescribed limits and the pipe or tube is suitable for its intended application.

10.1.2 *Hydrostatic Test*—Each length shall stand, 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 internal pressure. The pipe or tube need not be tested at a hydrostatic pressure of over 1000 psi (6.9 MPa) unless so specified.

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

where:

P = hydrostatic pressure, psi (or MPa);

t = thickness of pipe or tube wall, in. (or mm);

D = nominal outside diameter of the pipe or tube, in. (or mm); and

S = allowable stress of the material, psi (or MPa).

11. Dimensions, Mass, and Permissible Variations

11.1 General:

11.1.1 The standard method of specifying wall thicknesses shall be in decimal fractions of an inch.

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

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

11.2 *Dimensions*—Nominal dimensions and nominal weights of standard pipe sizes shall be in accordance with Table 3.

11.3 *Wall Thickness Tolerances*—Wall thickness tolerances shall be in accordance with Table 4. Wall thickness tolerances for tube shall be in accordance with Table 5.

11.4 *Diameter Tolerances*—Diameter tolerances for pipe shall be as follows:

11.4.1 *Nominal Pipe Size 1 1/2 in. (38 mm) and Under*—+0.016, −0.031 in. (+0.40, −0.79 mm).

11.4.2 *Nominal Pipe Size Over 1 1/2 in. (38 mm)*—±1 % of specified diameter.

11.4.3 The dimensional limits of standard pipe sizes are shown in Table 4.

11.4.4 Diameter tolerances of tube shall be in accordance with Table 6.

TABLE 3 Dimensions and Weights of Copper Alloy Pipe, Standard Pipe Sizes^A

Standard Pipe Size, in.	Nominal Dimension, in. (mm)			Cross-Sectional Area of Bore, in. ² (cm ²)	Nominal Weight, lb/ft (kg/m)
	Outside Diameter	Inside Diameter	Wall Thickness		
Regular					
1/8	0.405 (10.3)	0.269 (6.83)	0.068 (1.73)	0.057 (0.367)	0.266 (0.395)
1/4	0.540 (13.7)	0.364 (9.25)	0.088 (2.24)	0.104 (0.670)	0.462 (0.686)
3/8	0.675 (17.1)	0.493 (12.5)	0.091 (2.31)	0.191 (1.23)	0.617 (0.917)
1/2	0.840 (21.3)	0.622 (15.8)	0.109 (2.77)	0.304 (1.96)	0.925 (1.37)
3/4	1.050 (26.7)	0.824 (20.9)	0.113 (2.87)	0.533 (3.44)	1.23 (1.83)
1	1.315 (33.4)	1.049 (26.6)	0.133 (3.38)	0.864 (3.57)	1.83 (2.72)
1 1/4	1.660 (42.2)	1.380 (35.1)	0.140 (3.56)	1.496 (9.66)	2.47 (3.68)
1 1/2	1.900 (48.3)	1.610 (40.9)	0.145 (3.68)	2.036 (13.1)	2.95 (4.40)
2	2.375 (60.3)	2.067 (52.5)	0.154 (3.91)	3.356 (21.7)	3.97 (5.91)
2 1/2	2.875 (73.0)	2.469 (62.7)	0.203 (5.16)	4.788 (30.9)	6.30 (9.37)
3	3.500 (88.9)	3.068 (77.9)	0.216 (5.49)	7.393 (47.7)	8.24 (12.3)
Extra Strong					
1/8	0.405 (10.3)	0.215 (5.46)	0.095 (2.41)	0.036 (0.232)	0.342 (0.508)
1/4	0.540 (13.7)	0.302 (7.67)	0.119 (3.02)	0.072 (0.464)	0.582 (0.865)
3/8	0.675 (17.1)	0.423 (10.7)	0.126 (3.20)	0.141 (0.909)	0.803 (1.19)
1/2	0.840 (21.3)	0.546 (13.9)	0.147 (3.73)	0.234 (1.51)	1.183 (1.76)
3/4	1.050 (26.7)	0.742 (18.8)	0.154 (3.91)	0.432 (2.79)	1.60 (2.39)
1	1.315 (33.4)	0.957 (24.3)	0.179 (4.55)	0.719 (4.64)	2.36 (3.52)
1 1/4	1.660 (42.2)	1.278 (32.5)	0.191 (4.85)	1.283 (8.28)	3.26 (4.85)
1 1/2	1.900 (48.3)	1.500 (38.1)	0.200 (5.08)	1.767 (11.4)	3.95 (5.88)
2	2.375 (60.3)	1.939 (49.3)	0.218 (5.54)	2.953 (19.1)	5.46 (8.12)
2 1/2	2.875 (73.0)	2.323 (59.0)	0.276 (7.01)	4.238 (27.3)	8.33 (12.4)
3	3.500 (88.9)	2.900 (73.7)	0.300 (7.62)	6.605 (42.6)	11.1 (16.6)

^A Copper Alloy UNS No. C69100 is presently available only in standard pipe sizes up to 3 in.

TABLE 4 Dimensional Limits for Standard Pipe Sizes

Standard Pipe Size	Outside Diameter, in. (mm)			Wall Thickness, in. (mm)					
	Nominal	Min	Max	Regular			Extra Strong		
				Nominal	Min	Max	Nominal	Min	Max
1/8	0.405 (10.3)	0.374 (9.50)	0.421 (10.7)	0.068 (1.73)	0.061 (1.55)	0.075 (1.91)	0.095 (2.41)	0.086 (2.18)	0.105 (2.67)
1/4	0.540 (13.7)	0.509 (12.9)	0.556 (14.1)	0.088 (2.24)	0.079 (2.01)	0.097 (2.46)	0.119 (3.02)	0.107 (2.72)	0.131 (3.33)
3/8	0.675 (17.1)	0.644 (16.4)	0.691 (17.6)	0.091 (2.31)	0.082 (2.08)	0.100 (2.54)	0.126 (3.20)	0.113 (2.87)	0.139 (3.53)
1/2	0.840 (21.3)	0.809 (20.5)	0.856 (21.7)	0.109 (2.77)	0.098 (2.49)	0.120 (3.05)	0.147 (3.73)	0.132 (3.35)	0.162 (4.11)
3/4	1.050 (26.7)	1.019 (25.9)	1.066 (27.1)	0.113 (2.87)	0.102 (2.59)	0.124 (3.15)	0.154 (3.91)	0.139 (3.53)	0.169 (4.29)
1	1.315 (33.4)	1.284 (32.6)	1.331 (33.8)	0.133 (3.38)	0.120 (3.05)	0.146 (3.71)	0.179 (4.55)	0.161 (4.09)	0.197 (5.00)
1 1/4	1.660 (42.2)	1.629 (41.4)	1.676 (42.6)	0.140 (3.56)	0.126 (3.20)	0.154 (3.91)	0.191 (4.85)	0.172 (4.37)	0.210 (5.33)
1 1/2	1.900 (48.3)	1.869 (47.5)	1.916 (48.7)	0.145 (3.68)	0.131 (3.33)	0.160 (4.06)	0.200 (5.08)	0.180 (4.57)	0.220 (5.59)
2	2.375 (60.3)	2.351 (59.7)	2.399 (60.9)	0.154 (3.91)	0.139 (3.53)	0.169 (4.29)	0.218 (5.54)	0.196 (4.98)	0.240 (6.10)
2 1/2	2.875 (73.0)	2.846 (72.3)	2.904 (73.8)	0.203 (5.16)	0.183 (4.65)	0.223 (5.66)	0.276 (7.01)	0.248 (6.30)	0.304 (7.72)
3	3.500 (88.9)	3.465 (88.0)	3.535 (89.8)	0.216 (5.49)	0.194 (4.93)	0.238 (6.05)	0.300 (7.62)	0.270 (6.86)	0.330 (8.38)

11.5 Length Tolerances:

11.5.1 Length tolerances shall be in accordance with Table 7.

11.5.2 *Schedule of Tube Lengths*—Specific and stock lengths with ends shall be in accordance with Table 8.

11.6 *Squareness of Cut*—For pipe and tube in straight lengths, the departure from squareness of the end of any pipe or tube shall not exceed the following:

11.6.1 Pipe:

Nominal Outside Diameter, in. (mm)	Tolerance
Up to 5/8 in. (15.9 mm) incl	0.010 in. (0.25 mm)
Over 5/8 in. (15.9 mm)	0.016 in./in. (0.016 mm/mm) of dia

11.6.2 Tube:

Specified Outside Diameter, in. (mm)	Tolerance
Up to 5/8 in. (15.9 mm) incl.	0.010 in. (0.25 mm)
Over 5/8 in. (15.9 mm)	0.016 in./in. (0.016 mm/mm) of dia

11.7 The density of Copper Alloy UNS No. C69100 shall be taken to be 0.308 lb/in.³ (8.53 g/cm³).