

SPECIFICATION FOR SEAMLESS COPPER-NICKEL PIPE AND TUBE



SB-466/SB-466M

(Identical with ASTM Specification B 466/B 466M-03, except for correction of the chemistry requirements for Alloys C70400 and C71000 in Table 1, elimination of Section 11 and para. 5.1.7, Purchases for U.S. Government Agencies, and deletion of paras. 9.6 and 9.6.1.)

1. Scope

1.1 This specification establishes the requirements for seamless copper-nickel pipe and tube in straight lengths, suitable for general engineering purposes. The alloys involved are copper alloys UNS Nos. C70400, C70600, C70620, C71000, C71500, C71520, and C72200.

1.1.1 Copper alloys UNS Nos. C70620 and C71520 are intended for product that will be subsequently welded.

1.2 Units— The values stated in inch-pound or SI units are to be regarded separately as standard. The values in each system are not exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

1.3 The following safety hazard caveat pertains only to the test methods described in the Test Methods section 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 Tubing
- B 251 Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube
- B 251M Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube [Metric]
- B 601 Classification for Temper Designations for Copper and Copper Alloys-Wrought and Cast
- B 846 Terminology for Copper and Copper Alloys

- E 8 Test Methods for Tension Testing of Metallic Materials
- E 8M Test Methods for Tension Testing of Metallic Materials [Metric]
- E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
- E 62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods)
- E 75 Test Methods for Chemical Analysis of Copper-Nickel and Copper-Nickel-Zinc Alloys
- E 76 Test Methods for Chemical Analysis of Nickel-Copper Alloys
- E 118 Test Methods for Chemical Analysis of Copper-Chromium Alloys
- E 243 Practice for Electromagnetic (Eddy-Current) Examination of Copper and Copper-Alloy Tubes
- E 255 Practice for Sampling Copper and Copper Alloys Determination of Chemical Composition
- E 478 Test Methods for Chemical Analysis of Copper Alloys

3. General Requirements

3.1 The following sections of Specification B 251 or B 251M constitute a part of this specification:

- 3.1.1** Terminology,
- 3.1.2** Materials and Manufacture,
- 3.1.3** Dimensions, Mass, and Permissible Variations,
- 3.1.4** Workmanship, Finish, and Appearance,
- 3.1.5** Sampling,
- 3.1.6** Number of Tests and Retests,
- 3.1.7** Test Specimens,
- 3.1.8** Test Methods,
- 3.1.9** Significance of Numerical Limits,

TABLE 1
CHEMICAL REQUIREMENTS

Copper Alloy UNS Nos.	Composition, %									
	Copper incl Silver	Nickel incl Cobalt	Lead, max	Iron	Zinc, max	Manganese	Sulfur, max	Phosphorus, max	Chromium	Other Named Elements
C70400	remainder	4.8 to 6.2	0.05	1.3 to 1.7	1.0	0.30 to 0.8	...	...	...	...
C70600	remainder	9.0 to 11.0	0.05	1.0 to 1.8	1.0	1.0 max	...	...	...	...
C70620	86.5 min	9.0 to 11.0	0.02	1.0 to 1.8	0.50	1.0 max	0.02	0.02	...	Carbon 0.05 max ^A
C71000	remainder	19.0 to 23.0	0.05 ^A	0.50 to 1.0	1.0 ^A	1.0 max	...	...	...	...
C71500	remainder	29.0 to 33.0	0.05	0.40 to 1.0	1.0	1.0 max	...	...	...	...
C71520	65.0 min	29.0 to 33.0	0.02	0.40 to 1.0	0.50	1.0 max	0.02	0.02	...	Carbon 0.05 max ^{A, B}
C72200	remainder	15.0 to 18.0	0.05 ^A	0.50 to 1.0	1.0 ^A	1.0 max	0.02	0.02	0.30 to 0.7	...

^A When the product is for subsequent welding applications, and so specified by the purchaser, zinc shall be 0.50% max, lead 0.02% max, and carbon 0.05% max.

^B Silicon 0.03 max, titanium 0.03 max.

3.1.10 Inspection,

3.1.11 Rejection and Rehearing,

3.1.12 Certification,

3.1.13 Packing and Package Marking, and

3.1.14 Mill Test Report.

3.2 In addition, when a section with a title identical to that referenced in 3.1, above, appears in this specification, it contains additional requirements which supplement those appearing in Specification B 251 or B 251M.

4. Terminology

4.1 Definitions—For definitions of terms related to copper and copper alloys, refer to Terminology B 846.

4.2 Definitions of Terms Specific to This Standard:

4.2.1 capable of, adj—as used in this specification, the test need not be performed by the manufacturer or the producer; however, should subsequent testing by the purchaser establish that the product does not meet these requirements, the product shall be subject to rejection.

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 Alloy UNS No. (Scope section),

5.1.3 Temper (Temper section),

5.1.4 Dimensions; diameter or distance between parallel surfaces, wall thickness, or size (see also Table X1.1),

5.1.5 Total length, total weight, or number of pieces of each size, and

5.1.6 When the product in alloys C71000 or C72200 is to be welded subsequently (Table 1, Footnote A).

5.1.7 DELETED

5.2 The following options are available and, when required, are to be specified in the contract or purchase order at the time of placing of the order.

5.2.1 When tension tests are required for large diameter tube (Mechanical Property Requirements section),

5.2.2 Hydrostatic Test (Nondestructive Test Requirements section),

5.2.3 Pneumatic Test (Nondestructive Test Requirements section),

5.2.4 Heat identification or traceability requirements, or both,

5.2.5 Certification (Specification B 251 or B 251M),

5.2.6 Mill test report (Specification B 251 or B 251M), and

5.2.7 When product is ordered for ASME Boiler & Pressure Vessel Code Application.

6. Materials and Manufacture

6.1 Materials—The material of manufacture shall be cast billets of copper alloys UNS Nos. C70400, C70600, C70620, C71000, C71500, C71520, and C72200 as specified in the ordering information and shall be of such quality and soundness as to be suitable for processing into finished lengths or coils of tube to meet the properties prescribed herein.

6.2 Manufacture—The product shall be manufactured by such hot extrusion or piercing and subsequent cold working and annealing as to produce a uniform, seamless wrought structure in the finished product.

TABLE 2
MECHANICAL REQUIREMENTS

Standard Temper	Former Temper	Copper Alloy UNS Nos.	Tensile Strength, min		Yield Strength, ^A min		Rockwell ^B Hardness 30 T
			ksi	MPa	ksi	MPa	
O60	Soft anneal ^C	C70400	37	255	12	85	45 max
		C70600 & C70620	38	260	13	90	45 max
		C71000	45	310	16	110	48 max
		C71500 & C71520	52	345	18	125	51 max
		C72200	40	275	14	95	45 max
H55	Light drawn	C70400	40	275	30	205	41 to 65
		C70600 & C70620	45	310	35	240	45 to 70
		C72200	48	330	42	290	55 to 70
H80	Hard drawn	C70400	45	310	35	240	60 min
		C70600 & C70620	50	345	40	275	63 min
		C71000	55	380	43	295	67 min
		C71500 & C71520	70	485	45	310	70 min
		C72200	55	380	44	305	67 min

^A At 0.5% extension under load.

^B Rockwell hardness values shall apply only to tube or pipe having a wall thickness of 0.020 in. [0.5 mm] or over and an outside diameter of $\frac{5}{16}$ in. [8 mm] or over. For all other tube no Rockwell hardness values shall apply. Rockwell hardness tests shall be made on the inside surface of the tube. 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.

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

7. Chemical Composition

7.1 The material shall conform to the chemical composition requirements prescribed in Table 1 for the copper alloy UNS No. designation specified in the ordering information.

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

7.2.1 For alloys in which copper is specified as “remainder,” copper is the difference between the sum of results for all of the elements determined and 100%.

7.2.2 When all of the elements in Table 1 are determined, the sum of results shall be as shown below:

Copper Alloy UNS No.	Copper Plus Named Elements, % min
C70400	99.5
C70600 & C70620	99.5
C71000	99.5
C71500 & C71520	99.5
C72200	99.8

8. Temper

8.1 Annealed Temper— The product shall be furnished in the O60 (annealed) temper when specified in the ordering information.

8.2 Drawn Tempers— The product shall be furnished in either the H55 (light drawn), H80 (hard drawn), or HE80 (hard drawn and end annealed) temper when specified in the ordering information.

NOTE 1— The H55 (light drawn) temper is used only when product of some stiffness yet capable of being bent is needed. The H80 (hard drawn) temper is used only when there is a need for material as strong as commercially feasible.

9. Mechanical Property Requirements

9.1 Tensile Strength Requirements— Product furnished under this specification shall conform to the tensile strength requirements prescribed in Table 2 when tested in accordance with Test Methods E 8 or E 8M.

9.2 Yield Strength Requirements— Product furnished under this specification shall conform to the yield strength requirements prescribed in Table 2 when tested in accordance with Test Methods E 8 or E 8M.

9.3 Rockwell Hardness Requirements— Product furnished under this specification shall conform to the Rockwell hardness requirements prescribed in Table 2 when tested in accordance with Test Methods E 18.

9.4 The mechanical requirements for tubes of all alloys in the H80 temper are only applicable to the following sizes:

Outside diameter, in. (mm)	Wall Thickness, in. (mm)
Up to 1 (25) incl	0.020–0.120 (0.5–3.0) incl
Over 1–2 (25–50) incl	0.035–0.180 (0.9–4.5) incl
Over 2–4 (50–100) incl	0.060–0.250 (1.5–6.5) incl

9.4.1 For other sizes in the H80 (hard drawn) temper, the mechanical requirements shall be established by agreement between the manufacturer and the purchaser.

9.5 The mechanical property requirements for tubes of the HE80 (hard drawn and end annealed) temper shall be established by agreement between the manufacturer or supplier and the purchaser.

9.6 DELETED

9.6.1 DELETED

10. Performance Requirements

10.1 Expansion Test Requirements:

10.1.1 Tube furnished in the O60 (annealed) temper and the HE80 (hard drawn and end annealed) shall withstand an expansion to 30% of the outside diameter when tested in accordance with Test Method B 153.

10.1.1.1 The expanded sample shall show no cracking or other defect visible to the unaided eye.

10.1.1.2 The expansion test is not required for tube furnished in tempers other than O60 and HE80.

10.2 Flattening Test Alternative:

10.2.1 As an alternate to the expansion test for product over 4 in. [100 mm] in diameter, the flattening test described in the Test Method section in 15.2.2 may be performed.

10.2.2 During inspection, the flattened areas of the test specimen shall be free of defects, but blemishes of a nature that do not interfere with the intended application are acceptable.

11. DELETED

12. Nondestructive Test Requirements

12.1 Electromagnetic (Eddy Current) Test:

12.1.1 Each tube up to and including 3.125-in. [80-mm] nominal outside diameter shall be subjected to an eddy current test. Testing shall follow the procedures of Practice E 243 and the Test Methods section of this specification.

12.1.1.1 The provisions for the determination of “end-effect” in Practice E 243 shall not apply.

12.1.1.2 Hydrostatic Test Alternative— As an alternative to the eddy current test for tubes of diameters

above 1.25 in. [32 mm], the manufacturer shall have the option to perform the hydrostatic test to the method in the Test Methods section.

12.1.2 The tested tubes, which do not actuate the signaling device of the testing unit, shall be considered as conforming to the requirements of the test.

12.1.3 Either notch depth or drilled hole standards shall be used.

12.1.3.1 Notch depth standards shall be 22% of the wall thickness.

12.1.3.2 The sizes of drilled hole standards shall in accordance with Table X1.2 of Practice E 243.

12.2 Hydrostatic Test:

12.2.1 When specified in the contract or purchase order, or as an alternate to the eddy current test for tubes above 1.25 in. [32 mm] in diameter (see 12.1.1.2), each tube shall stand, without showing evidence of leakage, an internal hydrostatic pressure sufficient to produce a fiber stress of 7000 psi [48 MPa] as determined by the following equation for thin hollow cylinders under tension:

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

where:

P = hydrostatic pressure, psi [MPa];

t = wall thickness of the material, in. [mm];

D = outside diameter of the material, in. [mm]; and

S = allowable stress of the material, psi [MPa].

12.2.1.1 The tube need not be subjected to a pressure gage reading over 1000 psi [7 MPa] unless specifically stipulated in the contract or purchase order.

12.2.2 When the hydrostatic test is specified for tubes of less than 0.50 in. [12 mm] in outside diameter and less than 0.060 in. [1.5 mm] in wall thickness, the manufacturer shall have the option to perform either the hydrostatic test to the requirements specified in 12.2 or the pneumatic test to the requirements specified in 12.3.

12.3 Pneumatic Test— When specified in the contract or purchase order, each tube shall be subjected to a minimum internal air pressure of 60 psig [415 kPa] for 5 s without showing evidence of leakage.

13. Dimensions, Mass, and Permissible Variations

13.1 Wall Thickness Tolerances— The wall thickness tolerances shall be in accordance with Table 3.

13.2 Diameter Tolerances— The diameter tolerances shall be in accordance with Table 4.

13.3 Tolerance on distances between parallel surfaces for tubes other than round shall be as agreed between the manufacturer or supplier and purchaser.

TABLE 4
AVERAGE DIAMETER^A TOLERANCES

Specified Diameter		Tolerance Applies to	Tolerances, plus and minus, ^B in. for Tubes of Copper Alloy UNS Nos. C70400, C70600, C70620, C71000, C71500, C71520, and C72200	Tolerances, plus and minus, ^B mm for Tubes of Copper Alloy UNS Nos. C70400, C70600, C70620, C71000, C71500, C71520, and C72200
in.	mm			
Up to 1/8, incl	Up to 3.2, incl	inside diameter	0.003	0.076
Up to 1/8, incl	Up to 3.2, incl	outside diameter	0.0025	0.064
Over 1/8 to 5/8, incl	Over 3.2 to 16, incl	inside or outside	0.0025	0.064
Over 5/8 to 1, incl	Over 16 to 25, incl	inside or outside	0.003	0.076
Over 1 to 2, incl	Over 25 to 50, incl	inside or outside	0.004	0.10
Over 2 to 3, incl	Over 50 to 75, incl	inside or outside	0.005	0.13
Over 3 to 4, incl	Over 75 to 100, incl	inside or outside	0.006	0.15
Over 4 to 5, incl	Over 100 to 125, incl	inside or outside	0.008	0.20
Over 5 to 6, incl	Over 125 to 150, incl	inside or outside	0.009	0.23
Over 6 to 8, incl	Over 150 to 200, incl	inside or outside	0.010	0.25
Over 8 to 10, incl	Over 200 to 250, incl	inside or outside	0.013	0.33

^A The average outside or inside diameter of a tube is the average of the maximum and minimum outside diameter, or of the maximum and minimum inside diameters, whichever is applicable, as determined at any one cross section of the tube.

^B If tolerances all plus or all minus are desired, double the values given.

13.4 The following tolerances shall be in accordance with the applicable subsection of Section 5 of the current edition of Specification B 251 or B 251M as follows:

13.4.1 *Length Tolerances*— Section 5.5 and Table 5.

13.4.2 *Roundness*— Section 5.4.

13.4.3 *Squareness of Cut*— Section 5.6.

13.4.4 *Straightness Tolerances*— Section 5.7.1 and Table 7.

14. Specimen Preparation

14.1 *Chemical Analysis*— Analytical specimen preparation shall be the responsibility of the reporting laboratory.

14.2 *Flattening Test*— A test specimen shall be cut to a length that will allow the tube to be flattened once, with the flattened area to be at least 4 in. [100 mm] in length. When the temper is other than annealed, the sample may be annealed prior to testing.

15. Test Methods

15.1 *Chemical Analysis:*

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

Element	Test Method
Carbon	E 76
Chromium	E 118
Copper	E 478
Iron	E 478
Lead	E 478; atomic absorption
Manganese	E 62
Nickel	E 478; photometric
Phosphorus	E 62
Sulfur	E 76
Zinc	E 478; titrimetric

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

15.2 *Other Tests:*

15.2.1 *Tensile Strength*— Tensile strength shall be determined in accordance with Test Methods E 8 or E 8M.

15.2.1.1 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.

15.2.2 *Flattening Test*— Each test specimen shall be flattened in a press. The flattened area shall be at least 4 in. [100 mm] in length. A flattened test specimen shall allow a micrometer caliper set at three (3) times the wall thickness to pass freely over the flattened area. The flattened areas of the test specimen shall be inspected for surface defects.

15.2.3 Electromagnetic (Eddy Current) Test— Testing shall follow the procedures in Practice E 243, except for the determination of “end-effect.”

15.2.3.1 Notch-depth standards shall be rounded to the nearest 0.001 in. [0.025 mm]. The notch depth tolerance shall be ± 0.0005 in. [0.013 mm].

15.2.3.2 Drilled hole standards shall be rounded to the nearest 0.001 in. (0.025 mm). The drilled hole tolerance shall be ± 0.0005 in. [0.013 mm].

15.2.3.3 Alternatively, at the option of the manufacturer, using speed-insensitive eddy current testing units that are equipped so that a percentage of the maximum imbalance signal can be selected, a maximum imbalance signal of 0.3% shall be used.

15.2.3.4 Tubes that do not activate the signaling device of the eddy current tested shall be considered as conforming to the requirements of this test. Tubes with discontinuities indicated by the testing unit are permitted, at the option of the manufacturer, to 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.

15.2.4 Hydrostratic Test— The test method used shall permit easy visual detection of any leakage or by pressure differential. Any evidence of leakage shall be cause for rejection.

15.2.5 Pneumatic Test— The test method used shall permit easy visual detection of any leakage or by pressure differential. Any evidence of leakage shall be cause for rejection.

16. Certification

16.1 The certification requirements of Specification B 251 or B 251M are mandatory.

17. Keywords

17.1 copper-nickel; pipe; seamless; tube; UNS No. C70400; UNS No. C70600; UNS No. C70620; UNS No. C71000; UNS No. C71500; UNS No. C71520; UNS No. C72200

APPENDIX

(Nonmandatory Information)

X1. PREFERRED SIZES

X1.1 It is recommended that wherever possible, product purchased to this specification be ordered to the diameters and wall thickness indicated in Table X1.1.

TABLE X1.1
 PREFERRED WALL THICKNESSES FOR DRAWN SEAMLESS PIPE, BASED ON SPS DIAMETER

SPS	Outside Diameter, in. [mm]	Wall Thickness						Regular, in. [mm]	Extra Strong, in. [mm]
		Specials			Regular				
		in. [mm]	in. [mm]	in. [mm]	in. [mm]	in. [mm]	in. [mm]		
1/8	0.405 [10.3]	0.058 [1.47]	...	...	...	...	0.062 [1.57]	0.100 [2.54]
1/4	0.540 [13.7]	0.065 [1.65]	0.072 [1.83]	...	...	...	0.082 [2.08]	0.123 [3.12]
3/8	0.675 [17.1]	0.065 [1.65]	0.072 [1.83]	0.095 [2.41]	0.148 [3.76]	...	0.090 [2.29]	0.127 [3.23]	
1/2	0.840 [21.3]	0.065 [1.65]	0.072 [1.83]	0.120 [3.03]	0.203 [5.16]	...	0.107 [2.72]	0.149 [3.78]	
3/4	1.050 [26.7]	0.065 [1.65]	0.083 [2.11]	0.148 [3.76]	0.238 [6.05]	...	0.114 [2.90]	0.157 [3.99]	
1	1.315 [33.4]	0.065 [1.65]	0.095 [2.41]	0.203 [5.16]	0.340 [8.64]	...	0.126 [3.20]	0.182 [4.62]	
1 1/4	1.650 [42.4]	0.072 [1.83]	0.095 [2.41]	0.120 [3.03]	0.220 [5.59]	0.380 [9.65]	0.146 [3.71]	0.194 [4.93]	
1 1/2	1.900 [48.3]	0.072 [1.83]	0.109 [2.77]	0.134 [3.40]	0.250 [6.35]	0.425 [10.8]	0.150 [3.81]	0.203 [5.16]	
2	2.375 [60.3]	0.083 [2.11]	0.120 [3.03]	0.165 [4.19]	0.340 [8.64]	0.520 [13.2]	0.156 [3.96]	0.221 [5.61]	
2 1/2	2.875 [73.0]	0.083 [2.11]	0.134 [3.40]	0.203 [5.16]	0.380 [9.65]	...	0.187 [4.75]	0.280 [7.11]	
3	3.500 [88.9]	0.095 [2.41]	0.165 [4.19]	0.250 [6.35]	0.458 [11.6]	...	0.219 [5.56]	0.304 [7.72]	
3 1/2	4.000 [102]	0.095 [2.41]	0.180 [4.57]	0.284 [7.21]	...	...	0.250 [6.35]	0.321 [8.15]
4	4.500 [114]	0.109 [2.77]	0.203 [5.16]	0.340 [8.64]	...	...	0.250 [6.35]	0.341 [8.66]
5	5.552 [141]	0.125 [3.18]	0.220 [5.59]	0.425 [10.8]	...	...	0.250 [6.35]	0.375 [9.52]
6	6.625 [168]	0.134 [3.40]	0.259 [6.58]	0.457 [11.6]	...	...	0.250 [6.35]	0.437 [11.1]