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Standard Specification for Seamless and Welded Copper–Nickel Tubes for Water Desalting Plants[1]

This standard is issued under the fixed designation B 552; 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*

~~1.1This specification establishes requirements for seamless and welded copper-nickel tubes from 0.625 to 1.25 in. (15.9 to 31.8 mm) in diameter for use in heat exchangers in water desalting plants. The following alloys are involved: Copper Alloy UNS Nos. C70600, C71500, C71640, and C72200.~~

~~1.2The values stated in inch-pound units are the standard. Values given in parentheses are provided for information only.~~

1.1 This specification establishes requirements for seamless and welded copper-nickel tubes from 0.250 to 2.125 in. (6.35 to 54.0 mm) in diameter for use in heat exchangers in water desalting plants. The following alloys are involved:

Copper or Copper Alloy UNS No.	Type of Metal
C70600	90-10 copper-nickel
C70620	90-10 copper-nickel (Modified for Welding)
C71500	70-30 copper-nickel
C71520	70-30 copper-nickel (Modified for Welding)
C71640	copper-nickel-iron-manganese
C72200	copper-nickel

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

1.3 The following safety hazard caveat pertains only to the test methods of Section 16 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 its use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

B 111/B 111M Specification for Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock

B 153 Test Method for Expansion (Pin Test) of Copper and Copper-Alloy Pipe and Tubing

~~B543Specification for Welded Copper and Copper-Alloy Heat Exchanger Tube~~ 154 Test Method for Mercurous Nitrate Test for Copper Alloys

B 543 Specification for Welded Copper and Copper-Alloy Heat Exchanger Tube

B 601 Classification for Temper Designations for Copper and Copper Alloys—Wrought and Cast

B 846 Terminology for Copper and Copper Alloys

B 858 Test Method for Ammonia Vapor Test for Determining Susceptibility to Stress Corrosion Cracking in Copper Alloys

E 3 Guide for Preparation of Metallographic Specimens

E 8 Test Methods for Tension Testing of Metallic Materials

E 62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods)

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

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[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.**

E 255 Practice for Sampling Copper and Copper Alloys for the Determination of Chemical Composition
E 478~~Test Methods for Chemical Analysis of Copper Alloys~~ Test Methods for Chemical Analysis of Copper Alloys
E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
E 112 Test Methods for Determining Average Grain Size

3. Terminology

3.1 For definitions of terms related to copper and copper alloys, refer to Terminology B 846.

4. Classification

4.1 Tubes furnished to this specification are classified into two types, as follows:
4.1.1 Seamless tube and
4.1.2 Welded tube.

5. Ordering Information

5.1 Orders for products under this specification shall include the following information:
5.1.1 ASTM designation and year of issue,
5.1.2 Copper Alloy UNS number designation,
5.1.3 Whether seamless or welded (Section 4),
5.1.4 Temper (Section 8),
5.1.5 Dimensions: diameter and wall thickness (whether minimum or nominal), and length (Section 12),
5.1.6 Total number of pieces of each size, and
5.1.7 How furnished, whether in straight lengths or coils.
5.2 The following options are available and, when required, are to be specified at the time of placing of the order:
~~5.2.1Whether further finish processing of welded tube is needed (6.2.2.1),~~
~~5.2.2Hydrostatic test (11.2),~~
~~5.2.3Pneumatic test (~~
5.2.1 Hydrostatic test (11.3),
~~5.2.4Certification (Section~~
5.2.2 Pneumatic test (11.4),
5.2.3 Certification (Section 20), and
5.2.~~5~~4 Mill test report (Section 21).

6. Materials and Manufacture

6.1 *Material*:

~~6.1.1The material of manufacture shall be cast billets of Copper Alloys UNS Nos. C70600, C71500, C71640, 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.~~

6.1.1 *Seamless Tube*—The material of manufacture shall be cast billets of the Copper Alloys UNS Nos. C70600, C70620, C71500, C71520, C71640, and C72200 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.

6.1.2 *Welded Tube*—The material of manufacture shall be strip of one of the Copper Alloy UNS Nos. C70600, C70620, C71500, C71520, C71640, and C72200 and shall be of such purity and soundness as to be suitable for processing into the products prescribed herein.

6.2 *Manufacture*:

6.2.1 *Seamless Tube*— 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.

6.2.2 *Welded Tube*~~— The product shall be manufactured from cold rolled strip which is subsequently formed and welded by an automatic welding process.~~

~~6.2.2.1As-welded tubes are permitted to have further processing when agreement is established between the manufacturer or supplier and purchaser.~~ — The product shall be manufactured from flat rolled strip which is subsequently formed and welded. This is usually accomplished by a forge-weld process or a fusion-weld process.

6.2.2.1 For forged-welded tube, the edges of the strip shall be heated to a required welding temperature, usually by high-frequency electric current, and be pressed firmly together causing a forged-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 in forge-welded tube shall be removed to the extent that it shall not exceed 0.006 in. in height or 10 % of the nominal wall thickness, whichever is greater.

6.2.2.4 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 bead.

6.2.3 The product shall be cold worked and annealed as necessary to meet properties of the temper specified.

7. Chemical Composition

7.1 The product shall conform to the chemical composition requirements specified in Table 1 for the Copper Alloy UNS number designation specified in the ordering information.

7.2 These composition limits do not preclude the presence of other elements. When required, limits for unnamed elements shall be established and analysis required by agreement between the manufacture or supplier and purchaser.

7.2.1 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 %.

7.2.1.1 When all the elements in Table 1 are analyzed, their sum shall be as shown in the following table:

Copper Alloy UNS No.	Copper Plus Named Elements, % min
C70600	99.5
C70620	99.5
C71500	99.5
C71520	99.5
C71640	99.5
C72200	99.8

8. Temper

8.1 Tempers within this specification are as defined in Classification B 601.

8.1.1 *Seamless Tube*— The product shall be furnished in either the O61 (annealed), or the H55 (light drawn, light cold-worked) temper, as specified in the ordering information. — Tubes of Copper Alloy UNS Nos. C71500, C71520, and C71640 shall be supplied in either the annealed (061) or drawn and stress-relieved (HR50) tempers.

8.1.1.1 Tubes of Copper Alloy UNS Nos. C70600, C70620, and C72200 may be supplied in either the light-drawn (H55) or annealed (061) temper.

8.1.2 *Welded Tube*— The product shall be furnished in either the WO61 (welded and annealed) or the WC55 (welded and light cold worked) temper as specified in the ordering information. — Tubes of Copper Alloy UNS Nos. C70600, C70620, C71500, C71520, C71640, and C72200 are normally supplied in either the WO61 (welded and annealed) or the WC55 (welded and light cold worked) temper as specified in the purchase order, without stress relief treatment.

TABLE 1 Chemical Requirements

Element								Composition, %
Copper Alloy UNS No.								
Copper or Copper Alloy by UNS No.	Copper (incl silver)	Nickel (incl cobalt)	Lead, max	Iron	Zinc, max	Manganese	Phosphorus	Other named elements
C70600	C71500	C71640	C722005	1.0 – 1.8	1.0	1.0		
C70600	Remainder	9.0 – 11.0	0.05	1.0 – 1.8	1.0	1.0		
Copper (incl silver)	re mainder	remainder	remainder	re1.0 – 1.8	.50	1.0		C .05 mainder
C70620	86.5 min	9.0 – 11.0	.02	1.0 – 1.8	.50	1.0		C .05 max P .02 max S .02 max
Lead, max	0.05[A]	29.0 – 33.0	0.05	.40 – 1.0	1.0	1.0		
C71500	Remainder	29.0 – 33.0	0.05	.40 – 1.0	1.0	1.0		
C71520	65.0 min	29.0 – 33.0	.02	.40 – 1.0	.50	1.0		C .05 max P .02 max S .02 max
C71640	Remainder[A]	29.0 – 32.0	0.05[A]	0.7 – 2.3	1.05[A]			
C71640	Remainder[A]	29.0 – 32.0	0.05[A]	1.7 – 2.3	1.0[A]			
Iron	1.0–1 .8	0.40–1.0	1.7–2.3	0.5–1.0				
Iron	1.5 – 2.5	0.40–1.0	1.7–2.3	0.5–1.0				
Zinc, max	1.0[A]	1 .0[A]1 .0[A]						
Zinc, max	1.0[A]	C .06 max[A] S .03 max[A]						
C72200	1.0[A]							
C72200	Remainder[A]							
Nickel (incl cobalt)	9.0 – 11.0	29.0–33.029.0–32.0	15.0–18.0					
Nickel (incl cobalt)	15.0 – 18.0	0.029.0–32.0	15.0–18.0					
Manganese	1.0 max	1.0 max	1.5–2.5	1.0				
Chromium	. . .	. . .	. . .	0.30–0.70				
Other named elements	[A]	.50 – 1.0	1.0[A]	1.0	[A]	[A]		
Other named elements	[A]	.50 – 1.0	1.0[A]	1.0	[A]	Cr 0.30 – 0.7 Si .03 max Ti .03 max[A]		
Copper + elements with specific limits	. . .	. . .	. . .	99.5 min				

[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, phosphorus 0.02 % max, sulfur 0.02 % max, and carbon 0.05 % max.

8.2 Tubes shall conform to the tensile requirements shown in Table 2.

9. Mechanical Property Requirements

9.1 *Tensile Strength*:

9.1.1 The product shall conform ~~with~~to the tensile strength requirements prescribed in Table 2 for the temper, alloy and type specified in the ordering information when tested in accordance with Test Methods E 8.

10. Performance Requirements

10.1 *Expansion Test Requirements* :

10.1.1 Tube specimens selected for test shall withstand the expansion shown in Table 3 ~~at one end when tested in accordance with Test Method B153. The expanded tube shall show no cracking or rupture visible to the unaided eye.~~ at one end when tested in accordance with Test Method B 153. The expanded tube shall be free of defects, but blemishes of a nature that do not interfere with the intended application are acceptable.

10.2 ~~*Flattening Test Requirements*~~ Flattening Test (Welded and Seamless Tube):

~~10.2.1Tube specimens approximately 4 ft (1.22 m) long shall be tested in the annealed condition by flattening on different elements throughout the length. Each element shall be flattened by one stroke of a press. The term "flattened" shall be interpreted as follows: a micrometer set at three times the wall thickness shall pass over the tube freely throughout the flattened part except as the points where the change in element of flattening takes place.~~

~~10.2.1.1For seamless tube the flattened elements shall not show cracking or rupture visible to the unaided eye. Superficial ruptures resulting from surface imperfections shall not be cause for rejection.~~

~~10.2.1.2For seam-welded tube, the weld shall be placed in a position of maximum bend for at least one fourth of the flattened elements. The flattened elements shall not show cracking or rupture visible to the unaided eye. If the tube has been further processed after welding and the weld cannot be located, the test shall be performed in accordance with 10.2.1.~~

10.2.1 When specified in the contract or purchase order, the flattening test described in the Test Method section 16.3 shall be performed.

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

10.3 ~~*Weld Quality Test Requirements*~~ :

~~10.3.1*Seam Welds*—Conformance to the quality requirements of 13.3 shall be demonstrated at the welding job site by a 180° reverse-bend test. Specimens approximately 1½ in. (38.1 mm) long containing the weld shall be sectioned along the longitudinal axis of the tube with the seam weld centered in one of the test sections. The sections containing the seam weld shall be flattened in a vise or equivalent tool before bending, and then bent 180° over a radius equal to three times the nominal tube wall thickness. The root of the weld shall be located on the outside surface of the knuckle of the bend. There shall be no evidence of cracks or lack of penetration in the weld. In cases in which the seam-welded tube is further processed, it may be difficult or impossible to locate the weld, and then this paragraph will not be a requirement.~~ Reverse-Bend Test Requirements (welded tube only).

TABLE 2 Tensile Requirements

Copper Alloy UNS No.	Temper		Tensile Strength, min, ksi (MPa)
	Standard	Former	
C70600	O61	annealed	40 (275)
	W061	welded and annealed	40 (275)
	H55	light drawn, light cold worked	45 (310)
	WC55	welded and light cold worked	45 (310)
C70620	061	annealed	40 (275)
	WO61	welded and annealed	40 (275)
	H55	light drawn, light cold worked	45 (310)
	WC55	welded and light cold worked	45 (310)
C71500	O61	annealed	52 (360)
	WO61	welded and annealed	52 (360)
	H55	light drawn, light cold worked	54 (370)
	WC55	welded and light cold worked	54 (370)
C71520	060	annealed	52 (360)
	WO61	welded and annealed	52 (360)
	H55	light drawn, light cold worked	54 (370)
	WC55	welded and light cold worked	54 (370)
C71640	O61	annealed	63 (435)
	WO61	welded and annealed	63 (435)
	H55	light drawn, light cold worked	75 (515)
	WC55	welded and light cold worked	75 (515)
C72200	O61	annealed	45 (310)
	WO61	welded and annealed	45 (310)
	H55	light drawn, light cold worked	50 (345)
	WC55	welded and light cold worked	50 (345)

TABLE 3 Expansion Test Requirements

Copper Alloy UNS No.	Temper		Expansion of Tube Outside Diameter, % of Original Outside Diameter
	Standard	Former	
C70600	O61	annealed	30
	W061	welded and annealed	30
	H55	light drawn, light cold worked	15
	WC55	welded and light cold worked	15
C70620	061	annealed	30
	WO61	welded and annealed	30
	H55	light drawn, light cold worked	15
	WC55	welded and light cold worked	15
C71500	O61	annealed	30
	WO61	welded and annealed	30
	H55	light drawn, light cold worked	15
	WC55	welded and light cold worked	15
C71520	061	annealed	30
	WO61	welded and annealed	30
	H55	light drawn, light cold worked	15
	WC55	welded and light cold worked	15
C71640	O61	annealed	30
	WO61	welded and annealed	30
	H55	light drawn, light cold worked	15
	WC55	welded and light cold worked	15
C72200	O61	annealed	30
	WO61	welded and annealed	30
	H55	light drawn, light cold worked	15
	WC55	welded and light cold worked	15

10.3.1 When specified in the contract or purchase order, the reverse bend test described in the Test Method section in 16.4 shall be performed.

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

10.4 Microscopical Examinations.

10.4.1 When either the 061 or WO61 annealed temper is specified, tubes shall be subjected to a microscopical examination at a magnification of 75 diameters. Samples selected for test shall show uniform and complete recrystallization, and shall have an average grain size within the limits of 0.010 and 0.045 mm.

10.4.2 Samples of welded and annealed tube and of fully finished annealed tube shall be subjected to microscopical examination at a magnification of 75 diameters.

10.4.2.1 Forged-welded and annealed tube shall have a completely recrystallized grain structure, and the weld zone shall have a structure typical of hot-forged welds.

10.4.2.2 Fusion-welded and annealed tube shall have a completely recrystallized grain structure and the weld zone shall have a structure typical of a fusion weld.

10.4.2.3 Fully finished and annealed tube shall have a completely recrystallized structure of the metal when cold-worked and annealed, including the weld zone.

10.4.2.4 Samples selected for test shall be examined microscopically at a magnification of 75 diameters to establish that the weld interface is metallurgically sound.

11. Nondestructive Test Requirements

11.1 ~~*Electromagnetic (Eddy-Current) Test*~~Electromagnetic (Eddy-Current) Test (Seamless Tube):

11.1.1 Each tube shall be subjected to an eddy-current test. Testing shall follow the procedures of Practice E 243.~~—~~. The purchaser may specify either of the tests in 11.3 or 11.4 as an alternative to the eddy-current test.

11.1.2 The provisions for the determination of "end-effect" in Practice E 243 shall not apply.

~~11.1.3When tested in accordance with Practice E243, tubes that do not actuate the signaling device of the testing unit shall be considered as conforming to the requirements of the test.~~

~~11.1.4Either notch depth or drilled hold standards shall be used.~~

~~11.1.4.1Notch depth standards shall be 10% of the wall thickness.~~

~~11.1.4.2Drilled hole standards shall be per Table X1.2 of Practice E243.~~

~~11.2~~

11.1.3 Either notch depth or drilled hole standards shall be used. 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 are shown in Table 6 and Table 7, respectively.

11.1.4 Tubes that do not actuate the signaling device of the testing unit shall be considered as conforming to the requirements

of the 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 identifiable handling marks may be retested by the hydrostatic test prescribed in 11.3, or the pneumatic test prescribed in 11.4. 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 order.

11.2 *Electromagnetic (Eddy-Current) Test (Welded Tube)*:

11.2.1 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 E 243, except as modified in 11.2.4.

11.2.2 Tube supplied welded and annealed 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 11.3 or 11.4 as an alternative to the eddy-current test.

11.2.3 Either notch depth or drilled hole standards shall be used. 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 are shown in Table 6 and Table 7, respectively.

11.2.4 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 hole of Table 6 and Table 7, respectively, or other calibration discontinuities that may be used by mutual agreement between the manufacturer and the purchaser. Calibration discontinuities may be on the outside tube surface, the internal tube surface, or through wall and shall be spaced to provide signal resolution for adequate interpretation. Each calibration discontinuity shall be detected by the eddy-current tester.

11.2.5 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 identifiable handling marks may be retested by the hydrostatic test prescribed in 11.3, or the pneumatic test prescribed in 11.4. 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.

11.3 *Hydrostatic Test*:

11.~~2~~3.1 When specified in the contract or purchase order, each tube shall withstand, 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. 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.

$$P = 2St/(D - 0.8t) \tag{1}$$

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).

~~11.3~~

11.4 *Pneumatic Test*:

~~11.3.1When 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.~~

11.4.1 When specified, each tube shall be subjected to a minimum internal air pressure of 60 psig minimum (415 kPa) 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.

12. Dimensions, Mass, and Permissible Variations

12.1 *Diameter*~~—Tubes to be furnished shall range in outside diameter, as specified, from ⅝ to 1¼ in. (15.9 to 31.8 mm) inclusive. The diameter of the tubes shall not vary from that specified by more than the following amount as measured by "go" and "no go" gages:~~

~~Specified Diameter, in. (mm)~~	~~Tolerance, Plus and Minus in. (mm)~~
~~To 1 (25.4) incl~~	~~0.004 (0.10)~~
~~Over 1 to 1.250 (25.4 to 31.8) incl~~	~~0.005 (0.13)~~

—Tubes to be furnished shall range in outside diameter, as specified, from .250 to 2.125 in. (6.35 to 54.0 mm). The outside diameter of the tubes shall not vary from that specified by more than the amounts shown in Table 4 as measured by "go" and "no-go" ring gages. Where no values are shown in the table, dimensions shall be