



# Standard Specification for Seamless and Welded Copper–Nickel Tubes for Water Desalting Plants<sup>1</sup>

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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope\*

1.1 This 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.

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

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:<sup>2</sup>

- B 111 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
- 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
- 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<sup>3</sup>

<sup>1</sup> 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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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> Withdrawn.

- 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 for Determination of Chemical Composition
- E 478 Test Methods for Chemical Analysis of Copper Alloys

## 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:

- 5.2.1 Whether further finish processing of welded tube is needed (6.2.2.1),
- 5.2.2 Hydrostatic test (11.2),
- 5.2.3 Pneumatic test (11.3),
- 5.2.4 Certification (Section 20), and
- 5.2.5 Mill test report (Section 21).

## 6. Materials and Manufacture

6.1 *Material:*

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



6.1.1 The 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.

6.2 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.

6.2.2.1 As-welded tubes are permitted to have further processing when agreement is established between the manufacturer or supplier and purchaser.

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:

Table with 2 columns: Copper Alloy UNS No. and Copper Plus Named Elements, % min. Rows include C70600, C71500, C71640, and C72200.

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.

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.

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 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 B 153. The expanded tube shall show no cracking or rupture visible to the unaided eye.

10.2 Flattening Test Requirements:

10.2.1 Tube 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.

10.2.1.1 For 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.

10.2.1.2 For 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

TABLE 1 Chemical Requirements

Table with 5 columns: Element, and four columns for Copper Alloy UNS No. (C70600, C71500, C71640, C72200) under the heading Composition, %.

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.

TABLE 2 Tensile Requirements

Table with 4 columns: Copper Alloy UNS No., Temper (Standard, Former), and Tensile Strength, min, ksi (MPa). Rows list various alloy and temper combinations.



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
C71500	O61	annealed	30
	W061	welded and annealed	30
	H55	light drawn, light cold worked	15
	WC55	welded and light cold worked	15
C71640	O61	annealed	30
	W061	welded and annealed	30
	H55	light drawn, light cold worked	15
	WC55	welded and light cold worked	15
C72200	O61	annealed	30
	W061	welded and annealed	30
	H55	light drawn, light cold worked	15
	WC55	welded and light cold worked	15

been further processed after welding and the weld cannot be located, the test shall be performed in accordance with 10.2.1.

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.

11. Nondestructive Test Requirements

11.1 Electromagnetic (Eddy-Current) Test:

11.1.1 Each tube shall be subjected to an eddy-current test. Testing shall follow the procedures of Practice E 243.

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

11.1.3 When tested in accordance with Practice E 243, tubes that do not actuate the signaling device of the testing unit shall be considered as conforming to the requirements of the test.

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

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

11.1.4.2 Drilled hole standards shall be per Table X1.2 of Practice E 243.

11.2 Hydrostatic Test:

11.2.1 When specified in the contract or purchase order, 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. 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) (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 Pneumatic Test:

11.3.1 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.

12. Dimensions, Mass, and Permissible Variations

12.1 Diameter—Tubes to be furnished shall range in outside diameter, as specified, from 5/8 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)

12.1.1 When tubes are supplied in coils for straightening at jobsite the above tolerances apply to the finished straightened tubes.

12.2 Wall Thickness—Tubes shall be furnished as specified, with wall thicknesses in the range of 0.035 to 0.065 in. (0.889 to 1.65 mm), inclusive.

12.2.1 The wall thickness at any point shall not be less than that specified except when tubes are specifically ordered to a “nominal” wall thickness. When tube is ordered to a “nominal” wall thickness the deviation of the wall thickness from “nominal” shall not exceed ±10 % of the nominal wall thickness, expressed to the nearest 0.0005 in. (0.013 mm).

12.2.2 The residual inner-bead reinforcement after removal at seam-weld areas shall not exceed 0.006 in. (0.15 mm) in height.

12.3 Length—The lengths of the straight tubes shall not be less than that specified when measured at a temperature of 20°C but may exceed the specified value by the amounts given in Table 4. For tube ordered in coils, the length may not be less than that specified.

12.4 Squareness of Cut—The departure from squareness of the end of any straight tube shall not exceed 0.016 in./in. (0.016 mm/mm) of diameter.

12.5 Tubes furnished in straight lengths shall be reasonably straight when inspected at the mill. The maximum curvature

TABLE 4 Length Tolerance

Specified Length	Tolerance, All Plus	
	ft	(mm)
Up to 15	(4.9) incl	3/32 (2.4)
Over 15 to 20, incl	(4.9–6.6) incl	1/8 (3.2)
Over 20 to 30, incl	(6.6–9.8) incl	5/32 (4.0)
Over 30 to 60, incl	(9.9–19.7) incl	3/8 (9.5)
Over 60 to 100, incl	(19.7–32.8) incl	1/2 (12.7)



(depth of arc in inches) shall not exceed 1/4 in. (6.35 mm) in any 3-ft (0.914-m) length, except for the 3 ft (0.914 m) at the ends of individual tubes, where departure from straightness shall not exceed 1/2 in. (13 mm).

13. Workmanship, Finish and Appearance

13.1 The product shall be clean and free from defects, but blemishes of a nature that do not interfere with the intended application are acceptable. Annealed temper tubes may have a dull iridescent film on both the inside and outside surface, and drawn temper tubes may have a superficial film of drawing lubricant on the surfaces.

13.2 Minor dents having a rounded contour that does not exceed 0.030 in. (0.76 mm) in depth and permit passage of the tube at the dented point in a "go" gage are acceptable. Ends shall be smooth and free of burrs.

13.3 Welded Tube—The weld seam shall show complete fusion and penetration with no undercutting. The bead reinforcements that remain on the outside and inside of the tube after welding shall be removed by cutting. After removal, the weld shall show no sign of any crevice, crack, or porosity upon visual inspection.

14. Sampling

14.1 The lot size, portion size, and sample size of the finished product shall be as follows:

14.1.1 Lot Size—An inspection lot shall be 300 tubes or 30 000 lbs (13 600 kg) or fraction thereof, subject to inspection at one time, whichever is the greater weight.

14.1.2 Portion Size—Portion size shall be sample pieces from two individual lengths of each lot.

14.2 Chemical Analysis—Samples for chemical analysis shall be taken in accordance with Practice E 255. Drillings, millings, and so forth shall be taken in approximately equal weight from each of the sample pieces selected in accordance with 14.1.2 and combined into one composite sample. The minimum weight of the composite sample that is to be divided into three equal parts shall be 150 g.

14.2.1 Instead of sampling in accordance with Practice E 255, the manufacturer shall have the option of determining conformance to chemical composition as follows: Conformance shall be determined by the manufacturer by analyzing samples taken at the time the castings are poured or samples taken from the semifinished product. If the manufacturer determines the chemical composition of the material during the course of manufacture, he shall not be required to sample and analyze the finished product. The number of samples taken for determination of chemical composition shall be as follows:

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

14.2.1.2 When samples are taken from the semifinished product, a sample shall be taken to represent each 10 000 lbs (4550 kg) or fraction thereof, except that not more than one sample shall be required per piece.

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

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

14.3 Spectrographic Analysis—Samples for spectrographic analysis shall be taken from a 3-in. (76.2-mm) long section of tube selected in accordance with 14.1.2.

15. Specimen Preparation

15.1 Chemical Analysis:

15.1.1 Sample preparation shall be in accordance with Practice E 255.

15.1.2 Analytical specimen preparation shall be the responsibility of the reporting laboratory.

16. Test Methods

16.1 Chemical Analysis:

16.1.1 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

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

16.2 Other Tests:

16.2.1 Tensile Strength shall be determined in accordance with Test Methods E 8.

16.2.1.1 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.

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

16.2.2.1 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).

16.2.2.2 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).

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

16.2.2.4 Tubes that do not activate the signaling device of the eddy current tester 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.

16.2.3 *Hydrostatic 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.

16.2.4 *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.

## **17. Number of Tests and Retests**

### *17.1 Tests:*

17.1.1 *Chemical Analysis*—Chemical composition shall be determined as the per element mean of results from at least two replicate analyses of the sample(s) and the results of each replication must meet the requirements of this specification.

17.1.2 *Other Tests*—The results of each specimen tested must meet the requirements of this specification.

### *17.2 Retests:*

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

17.2.2 Retesting shall be conducted using twice the number of tests specimens normally required for test. Test results for specimens shall conform to the product specification requirement(s) in retest and failure to conform to the requirements shall be cause for rejection of the entire lot.

## **18. Inspection**

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

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

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

## **19. Rejection and Rehearing**

### *19.1 Rejection:*

19.1.1 Product that fails to conform to the requirements of this specification when tested by the purchaser or purchaser's agent, shall be subject to rejection.

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

19.1.3 In case of dissatisfaction with results of the test upon which rejection is based, the manufacturer, or supplier, may make claim for a rehearing.

### *19.2 Rehearing:*

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

## **20. Certification**

20.1 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 requirements have been met.

## **21. Test Report**

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

## **22. Packaging and Package Marking**

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

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

## **23. Keywords**

23.1 copper-nickel; desalting; heat exchangers; seamless tube; tube; water desalting; welded tube



**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 1 kg gives it an acceleration of 1 m/s<sup>2</sup> (N = kg·m/s<sup>2</sup>). The derived

SI unit for pressure or stress is the newton per square metre (N/m<sup>2</sup>), which has been named the pascal (Pa) by the General Conference Weights and Measures. Since 1 ksi = 6 894 757 Pa, metric equivalents are expressed as megapascal (MPa), which is the same as MN/m<sup>2</sup> and N/mm<sup>2</sup>.

**SUMMARY OF CHANGES**

This section identifies the changes that have been incorporated since the printing of B 552–92 as follows:

- (1) A five-year review was conducted. Editorial revisions to most sections were made to incorporate current form and style practice.
- (2) A greatly expanded and updated section on nondestructive testing was added.

- (3) Tensile strength requirements for Copper Alloys UNS Nos. C70600 and C71500 were changed to match those of analogous tempers in Specifications B 111 and B 543.

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