Designation: B552 – 12

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

This standard is issued under the fixed designation B552; 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 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 *Units*—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]

B111/B111M Specification for Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock

B153 Test Method for Expansion (Pin Test) of Copper and Copper-Alloy Pipe and Tubing

B154 Test Method for Mercurous Nitrate Test for Copper Alloys

B543 Specification for Welded Copper and Copper-Alloy Heat Exchanger Tube

B601 Classification for Temper Designations for Copper and Copper Alloys—Wrought and Cast

B846 Terminology for Copper and Copper Alloys

B858 Test Method for Ammonia Vapor Test for Determining Susceptibility to Stress Corrosion Cracking in Copper Alloys

B968/B968M Test Method for Flattening of Copper and Copper-Alloy Pipe and Tube

E3 Guide for Preparation of Metallographic Specimens

E8/E8M Test Methods for Tension Testing of Metallic Materials

E62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods) (Withdrawn 2010)[3]

E76 Test Methods for Chemical Analysis of Nickel-Copper Alloys (Withdrawn 2003)[3]

E118 Test Methods for Chemical Analysis of Copper-Chromium Alloys (Withdrawn 2010)[3]

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

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E112 Test Methods for Determining Average Grain Size

## 3. Terminology

3.1 For definitions of terms related to copper and copper alloys, refer to Terminology B846.

## 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.

[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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

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

## 5. Ordering Information

5.1 Include the following specified choices when placing orders for products under this specification, as applicable:

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,

5.1.7 How furnished, whether in straight lengths or coils, and

5.1.8 Intended application.

5.2 The following options are available and shall be specified in the contract or purchase order when required:

5.2.1 Hydrostatic test (11.3),

5.2.2 Pneumatic test (11.4),

5.2.3 Certification (Section 20),

5.2.4 Test report (Section 21), and

5.2.5 Package marking of the specification number (Section 22).

## 6. Materials and Manufacture

6.1 *Material:*

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 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 |

**TABLE 1 Chemical Requirements**

| Copper or Copper Alloy by UNS No. | Composition, % Copper (incl silver) | Nickel (incl cobalt) | Lead, max | Iron | Zinc, max | Manganese | Phosphorus | Other named elements |
|---|---|---|---|---|---|---|---|---|
| C70600 | Remainder | 9.0 – 11.0 | 0.05 | 1.0 – 1.8 | 1.0 | 1.0 | | |
| C70620 | 86.5 min | 9.0 – 11.0 | .02 | 1.0 – 1.8 | .50 | 1.0 | | C .05 max<br>P .02 max<br>S .02 max |
| 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<br>P .02 max<br>S .02 max |
| C71640 | Remainder[A] | 29.0 – 32.0 | 0.05[A] | 1.7 – 2.3 | 1.0[A] | 1.5 – 2.5 | [A] | C .06 max[A]<br>S .03 max[A] |
| C72200 | Remainder[A] | 15.0 – 18.0 | 0.05[A] | .50 – 1.0 | 1.0[A] | 1.0 | [A] | Cr 0.30 – 0.7<br>Si .03 max<br>Ti .03 max[A] |

[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. Temper

8.1 Tempers within this specification are as defined in Classification B601.

8.1.1 *Seamless Tube*— 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*— 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.

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 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 E8/E8M.

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

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

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.

**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 *Reverse-Bend Test Requirements (welded tube only):*

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 (Seamless Tube):*

11.1.1 Each tube shall be subjected to an eddy-current test. Testing shall follow the procedures of Practice E243. 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 E243 shall not apply.

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 E243, 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:*

11.3.1 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.

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

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).

11.4 *Pneumatic Test:*

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 .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 as agreed upon between the purchaser and the manufacturer or supplier.

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

**TABLE 4 Diameter Tolerances**

| Outside Diameter, in. | Wall Thickness, in. | | | | |
|---|---|---|---|---|---|
| | 0.020<br>0.022<br>0.025<br>0.028 | 0.032 | 0.035 | 0.042 | 0.049 and Over |
| | Diameter Tolerance, Plus and Minus, in. | | | | |
| 0.250 – 0.500, incl | 0.003 | 0.003 | | | |
| Over 0.500 – 0.740, incl | 0.004 | 0.004 | 0.004 | 0.0035 | 0.003 |
| Over 0.740 – 1.000, incl | 0.006 | 0.006 | 0.005 | 0.0045 | 0.004 |
| Over 1.000 – 1.250, incl | ... | 0.009 | 0.008 | 0.006 | 0.0045 |
| Over 1.250 – 1.375, incl | ... | ... | ... | 0.008 | 0.005 |
| Over 1.375 – 2.125, incl. | ... | ... | ... | ... | 0.006 |

12.2 *Wall Thickness*—Tubes shall be furnished as specified, with wall thicknesses in the range of 0.022 to 0.065 in. (0.559 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 internal flash in forge-welded tube shall be removed to the extent that it shall not exceed 0.006 in. (.15 mm) in height or 10 % of the nominal wall thickness, whichever is greater.

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 5. 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 (depth of arc in inches) shall not exceed ¼ 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 ½ in. (13 mm).

## 13. Workmanship, Finish, and Appearance

13.1 Roundness, straightness, uniformity of the wall thickness, and inner and outer surface of the tube shall be such as to make it suitable for the intended application. Unless otherwise specified on the purchase order, the cut ends of the tubes shall be deburred by use of a rotating wire wheel or other suitable tool.

13.2 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.

13.3 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.

13.4 *Welded Tube*—The weld seam shall show complete fusion and penetration with no undercutting. The external flash (that portion of the weld which extends beyond the normal wall) shall always be removed. 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.

**TABLE 5 Length Tolerance**

| Specified Length | | Tolerance, All Plus | |
|---|---|---|---|
| ft | (m) | in. | (mm) |
| Up to 15, incl | Up to (4.9) incl | 3⁄32 | (2.4) |
| Over 15 to 20, incl | (4.9–6.6) incl | ⅛ | (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 | ⅜ | (9.5) |
| Over 60 to 100, incl | (19.7–32.8) incl | ½ | (12.7) |

## 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 E255. 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 E255, 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*—When analyzing the chemistry of finished tube, 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 Preparation of the analytical test specimen shall be the responsibility of the reporting laboratory.

15.2 *Grain Size:*

15.2.1 Test specimen shall be prepared in accordance with Guide E3.

15.3 *Tensile Test:*

15.3.1 The test specimen shall be of the full section of the tube and shall conform to the requirements of the section titled Specimens for Pipe and Tube in Test Methods E8/E8M.

15.3.1.1 When the limitations of the testing machine preclude the use of a full section specimen, specimens conforming to Tension Test Specimens for Large-Diameter Tubular Products of Test Methods E8/E8M shall be used.

15.4 *Expansion (Pin Test):*

15.4.1 Test specimen shall conform to the requirements of the Specimen Preparation section of Test Method B153.

15.5 *Flattening Test:*

15.5.1 Test specimen shall be cut in accordance with Test Method B968/B968M. When the temper is other than annealed, the sample may be annealed prior to testing.

15.6 *Reverse Bend Test (Welded Tube Only):*

15.6.1 A representative tube sample shall be cut to a length that will accommodate the test. The sample is permitted to be annealed when the temper is other than annealed.

15.6.2 The product test specimen shall be cut longitudinally, 90° on each side of the weld, when visible or identifiable.

15.7 *Mercurous Nitrate Test:*

15.7.1 Specimens for the mercurous nitrate test shall be 6 in. [150 mm] in length and shall conform to the requirements of Test Method B154.

15.8 *Ammonia Vapor Test:*

15.8.1 Specimens for the ammonia vapor test shall be 6 in. [150 mm] in length and shall conform to the requirements of Test Method B858.

## 16. Test Methods

16.1 *Chemical Analysis:*

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

| Element | Test Method |
|---|---|
| Carbon | E76 |
| Chromium | E118 |
| Copper | E478 |
| Iron | E478 |
| Lead | E478; atomic absorption |
| Manganese | E62 |
| Nickel | E478; photometric |
| Phosphorus | E62 |
| Sulfur | E76 |
| Zinc | E478; 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 E8/E8M.

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 E243 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). (See Table 6 for tolerances.)

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). (See Table 7 for tolerances.)

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.

16.3 *Flattening Test:*

16.3.1 Test specimen shall be cut in accordance with Test Method B968/B968M. When the temper is other than annealed, the sample may be annealed prior to testing.

16.4 *Reverse-Bend Test:*

16.4.1 A representative tube sample shall be cut to a length that will accommodate the test. The sample is permitted to be annealed when the temper is other than annealed.

## 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).

**TABLE 6 Notch Depths**

| Tube Wall Thickness, in. | Tube Outside Diameter, in. | | |
|---|---|---|---|
| | Over ¼ to ¾, incl | Over ¾ to 1 ¼, incl | Over 1 ¼ to 2⅛, incl |
| Incl .022 – .032 | 0.005 | 0.006 | 0.007 |
| Incl .032 – .049 | 0.006 | 0.006 | 0.0075 |
| Incl .049 – .065 | 0.007 | 0.0075 | 0.008 |

**TABLE 7 Diameter of Drilled Holes**

| Tube O.D. | Inches | Drill No. |
|---|---|---|
| ¼ in. – ¾ in. | 0.025 | 72 |
| Over ¾ in. – 1 in. | 0.031 | 68 |
| Over 1 in. – 1 ¼ in. | 0.036 | 64 |
| Over 1 ¼ in. – 1 ½ in. | 0.042 | 58 |
| Over 1 ½ in. – 1 ¾ in. | 0.046 | 56 |
| Over 1 ¾ in. – 2 ⅛ in. | 0.052 | 55 |

17.2.2 If any test specimen representing a lot fails to conform, two additional specimens at the option of the manufacturer may be taken as before, and submitted for check analysis or subjected to any tests in which the original specimen failed, but each of these specimens shall conform to the requirements specified.

## 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 C70600; C70620; C71500; C71520; C71640; C72200; ; copper-nickel; desalting; heat exchangers; seamless tubes; tubes; water desaltingwelded tubes

# 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 $m/s^2$ ($N = kg \cdot m/s^2$). 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 Weights and Measures. Since 1 ksi = 6 894 757 Pa, metric equivalents are expressed as megapascal (MPa), which is the same as $MN/m^2$ and $N/mm^2$.

## SUMMARY OF CHANGES

Committee B05 has identified the location of selected changes to this standard since the last issue (B552 – 08) that may impact the use of this standard. (Approved October 1, 2012.)

*(1)* Added Test Method B968/B968M.
*(2)* Noted changes are in sections: 10.2.2 (deleted); 15.5.1; 16.3.1; 16.4.1.