



Designation: **B280—16 B280 – 18**

## Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service<sup>1</sup>

This standard is issued under the fixed designation B280; 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.

*This standard has been approved for use by agencies of the U.S. Department of Defense.*

### 1. Scope\*

1.1 This specification establishes the requirements for seamless copper tube intended for use in the connection, repairs, or alternations of air conditioning or refrigeration units in the field.

NOTE 1—Fittings used for soldered or brazed connections in air conditioning and refrigeration systems are described in ASME Standard B16.22.

NOTE 2—The assembly of copper tubular systems by soldering is described in Practice B828.

NOTE 3—Solders for joining copper tubular systems are described in Specification B32. The requirements for acceptable fluxes for these systems are described in Specification B813.

1.2 The tube shall be produced from the following coppers, and the manufacturer has the option to supply any one of them, unless otherwise specified:

Copper UNS No.	Previously Used Designation	Description
C10200	OF	Oxygen free without residual deoxidants
C12000	DLP	Phosphorus deoxidized, low residual phosphorus
C12200	DHP	Phosphorus deoxidized, high residual phosphorus

1.3 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.

1.4 The following hazard statement pertains only to the test method described in 18.2.4 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

### 2. Referenced Documents

2.1 *ASTM Standards:*<sup>2</sup>

[B32 Specification for Solder Metal](#)

[B153 Test Method for Expansion \(Pin Test\) of Copper and Copper-Alloy Pipe and Tubing](#)

[B577 Test Methods for Detection of Cuprous Oxide \(Hydrogen Embrittlement Susceptibility\) in Copper](#)

[B601 Classification for Temper Designations for Copper and Copper Alloys—Wrought and Cast](#)

[B813 Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube](#)

[B828 Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings](#)

[B900 Practice for Packaging of Copper and Copper Alloy Mill Products for U.S. Government Agencies](#)

<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.

Current edition approved April 1, 2016/March 1, 2018. Published April 2016/March 2018. Originally approved in 1953. Last previous edition approved in 2013/2016 as B280—13: B280 – 16. DOI: 10.1520/B0280-16:10.1520/B0280-18.

<sup>2</sup> 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

- E3 Guide for Preparation of Metallographic Specimens
- E8/E8M Test Methods for Tension Testing of Metallic Materials
- E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- E53 Test Method for Determination of Copper in Unalloyed Copper by Gravimetry
- E62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods) (Withdrawn 2010)<sup>3</sup>
- E112 Test Methods for Determining Average Grain Size
- 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
- 2.2 ASME Standard:<sup>4</sup>
- B1622 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

### 3. Terminology

#### 3.1 Definitions:

- 3.1.1 *average diameter (for round tubes only), n*—the average of the maximum and minimum outside diameters, or maximum and minimum inside diameters, whichever is applicable, as determined at any one cross section of the tube.
- 3.1.2 *bright anneal, n*—a thermal treatment carried out in a controlled atmosphere so that surface oxidation is reduced to a minimum and the surface remains relatively bright.
- 3.1.3 *coil, n*—a length of the product wound into a series of connected turns. The unqualified term “coil” as applied to tube usually refers to a bunched coil.
  - 3.1.3.1 *bunched, n*—a coil in which the turns are bunched and held together such that the cross section of the bunched turns is approximately circular.
  - 3.1.3.2 *level or traverse wound, n*—a coil in which the turns are wound into layers parallel to the axis of the coil such that successive turns in a given layer are next to one another. (Sometimes called “helical coil.”)
  - 3.1.3.3 *single layer flat, n*—a coil in which the product is spirally wound into a single disc-like layer. (Sometimes called “pancake coil” or “single layer spirally wound coil.”)
  - 3.1.3.4 *double layer flat, n*—a coil in which the product is spirally wound into two connected disc-like layers such that one layer is on top of the other. (Sometimes called “double layer pancake coil” or “double layer spirally wound coil.”)
- 3.1.4 *lengths, n*—straight pieces of the product.
  - 3.1.4.1 *specific, n*—straight lengths that are uniform in length, as specified, and subject to established length tolerances.
  - 3.1.4.2 *standard, n*—uniform lengths recommended in a Simplified Practice Recommendation or established as a Commercial Standard.
- 3.1.5 *tube, seamless, n*—a tube produced with a continuous periphery in all stages of the operations.

**TABLE 1 Standard Dimensions and Weights, and Tolerances in Diameter and Wall Thickness for Straight Lengths**

NOTE 1—Applicable to drawn temper tube only.

Standard Size, in.	Outside Diameter, in. (mm)	Wall Thickness, in. (mm)	Weight, lb/ft (kg/m)	Tolerances	
				Average <sup>A</sup> Outside Diameter, Plus and Minus, in. (mm)	Wall <sup>B</sup> Thickness, Plus and Minus, in. (mm)
¼	0.250 (6.35)	0.025 (0.635)	0.068 (0.102)	0.001 (0.025)	0.0025 (0.06)
⅜	0.375 (9.52)	0.030 (0.762)	0.126 (0.187)	0.001 (0.025)	0.003 (0.08)
½	0.500 (12.7)	0.035 (0.889)	0.198 (0.295)	0.001 (0.025)	0.004 (0.10)
⅝	0.625 (15.9)	0.040 (1.02)	0.285 (0.424)	0.001 (0.025)	0.004 (0.10)
¾	0.750 (19.1)	0.042 (1.07)	0.362 (0.539)	0.001 (0.025)	0.004 (0.10)
⅞	0.875 (22.3)	0.045 (1.14)	0.455 (0.677)	0.001 (0.025)	0.004 (0.10)
1 ⅛	1.125 (28.6)	0.050 (1.27)	0.655 (0.975)	0.0015 (0.038)	0.004 (0.10)
1 ⅜	1.375 (34.9)	0.055 (1.40)	0.884 (1.32)	0.0015 (0.038)	0.006 (0.15)
1 ½	1.625 (41.3)	0.060 (1.52)	1.14 (1.70)	0.002 (0.051)	0.006 (0.15)
2 ⅛	2.125 (54.0)	0.070 (1.78)	1.75 (2.60)	0.002 (0.051)	0.007 (0.18)
2 ⅝	2.625 (66.7)	0.080 (2.03)	2.48 (3.69)	0.002 (0.051)	0.008 (0.20)
3 ⅛	3.125 (79.4)	0.090 (2.29)	3.33 (4.96)	0.002 (0.051)	0.009 (0.23)
3 ⅝	3.625 (92.1)	0.100 (2.54)	4.29 (6.38)	0.002 (0.051)	0.010 (0.25)
4 ⅛	4.125 (105)	0.110 (2.79)	5.38 (8.01)	0.002 (0.051)	0.011 (0.28)

<sup>A</sup> The average outside diameter of a tube is the average of the maximum and minimum outside diameters as determined at any one cross section of the tube.

<sup>B</sup> The tolerances listed represent the maximum deviation at any point.

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

<sup>4</sup> Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

3.1.5.1 *tube, air conditioning, n*—a seamless copper tube conforming to a standard series of sizes (Table 1) and to specified internal cleanliness requirements, normally furnished in drawn temper straight lengths with the ends capped or sealed.

3.1.5.2 *tube, refrigeration service, n*—a seamless copper tube conforming to a standard series of sizes (Table 2) and to special internal cleanliness and dehydration requirements, normally furnished in soft temper coils and with ends capped or sealed.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *capable of*—the test need not be performed by the producer of the material. However, if subsequent testing by the purchaser establishes that the material does not meet these requirements, the material shall be subject to rejection.

**4. Ordering Information**

4.1 Include this information for contracts or purchase orders for products furnished to this specification:

- 4.1.1 ASTM designation and year of issue (for example, B280 – 03),
- 4.1.2 Copper UNS No. (not necessary unless a specific copper is desired),
- 4.1.3 Dimensions; wall thickness, diameter, and so forth (Section 13),
- 4.1.4 How furnished: coils or straight lengths,
- 4.1.5 Temper (for example, O60 or H58),
- 4.1.6 Size (Tables 1 and 2),
- 4.1.7 Length (Section 13),
- 4.1.8 Quantity (total pieces of each size and type),
- 4.1.9 When product purchased for agencies of the U.S. Government (Section 12).

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

- 4.2.1 Tensile test (Section 9),
- 4.2.2 Expansion test (Section 10.1),
- 4.2.3 Cleanliness test (Sections 10.2 and 18.2.4),
- 4.2.4 Microscopical Examination for Hydrogen Embrittlement, Procedure B (10.3.2),
- 4.2.5 Certification (Section 22), and
- 4.2.6 Test report (Section 23).

**5. Materials and Manufacture**

5.1 *Materials*—The material of manufacture shall be billets, bars, or tube and shall be of such soundness as to be suitable for processing into the tubular products described.

5.2 *Manufacture:*

5.2.1 The tube shall be manufactured by such hot or cold working processes as to produce a homogeneous uniform wrought structure in the finished product. The tube shall be cold drawn to the finished size and wall thickness.

5.2.2 Coiled lengths specified O60, soft annealed temper, shall be bright annealed after coiling, then dehydrated, and capped, plugged, crimped, or otherwise closed at both ends so as to maintain the internal cleanliness of the tubing under normal conditions of handling and storage.

5.2.3 Straight lengths specified H58 drawn general purpose shall be cleaned and capped, plugged, or otherwise closed at both ends so as to maintain the internal cleanliness of the tubing under normal conditions of handling and storage.

**6. Chemical Composition**

6.1 The chemical composition shall conform to the chemical requirements in Table 3 for the specific type of copper.

**TABLE 2 Standard Dimensions and Weights, and Tolerances in Diameter and Wall Thickness for Coil Lengths**

Standard Size, in.	Outside Diameter, in. (mm)	Wall Thickness, in. (mm)	Weight, lb/ft (kg/m)	Tolerances	
				Average <sup>A</sup> Outside Diameter, Plus and Minus, in. (mm)	Wall <sup>B</sup> Thickness, Plus and Minus, in. (mm)
1/8	0.125 (3.18)	0.030 (0.762)	0.0347 (0.0516)	0.002 (0.051)	0.003 (0.08)
3/16	0.187 (4.75)	0.030 (0.762)	0.0575 (0.0856)	0.002 (0.051)	0.003 (0.08)
1/4	0.250 (6.35)	0.030 (0.762)	0.0804 (0.120)	0.002 (0.051)	0.003 (0.08)
5/16	0.312 (7.92)	0.032 (0.813)	0.109 (0.162)	0.002 (0.051)	0.003 (0.08)
3/8	0.375 (9.52)	0.032 (0.813)	0.134 (0.199)	0.002 (0.051)	0.003 (0.08)
1/2	0.500 (12.7)	0.032 (0.813)	0.182 (0.271)	0.002 (0.051)	0.003 (0.08)
5/8	0.625 (15.9)	0.035 (0.889)	0.251 (0.373)	0.002 (0.051)	0.004 (0.11)
3/4	0.750 (19.1)	0.035 (0.889)	0.305 (0.454)	0.0025 (0.064)	0.004 (0.11)
7/8	0.875 (22.3)	0.045 (1.14)	0.455 (0.677)	0.003 (0.076)	0.004 (0.11)
1 1/8	1.125 (28.6)	0.050 (1.27)	0.655 (0.975)	0.0035 (0.089)	0.005 (0.13)
1 3/8	1.375 (34.9)	0.055 (1.40)	0.884 (1.32)	0.004 (0.10)	0.006 (0.15)
1 5/8	1.625 (41.3)	0.060 (1.52)	1.14 (1.70)	0.0045 (0.11)	0.006 (0.15)

<sup>A</sup> The average outside diameter of a tube is the average of the maximum and minimum outside diameters as determined at any one cross section of the tube.

<sup>B</sup> The tolerances listed represent the maximum deviation at any point.

**TABLE 3 Chemical Composition—Weight %**

Element	Copper UNS No.		
	C10200 <sup>A</sup>	C12000	C12200
Copper, <sup>B</sup> min	99.95	99.90	99.9
Phosphorus	. . .	0.004–0.012	0.015–0.040

<sup>A</sup> Oxygen shall be 10 ppm max.

<sup>B</sup> Copper + silver.

6.1.1 These limits do not preclude the presence of other elements. When included in the contract or purchase order, and agreed upon by the manufacturer or supplier and the purchaser, limits shall be established and analysis required for unnamed elements.

## 7. Temper

7.1 Product under this specification shall be furnished in either O60 (soft annealed) or H58 (drawn general purpose) temper, as specified in the contract or purchase order and defined in Classification **B601**.

7.1.1 Coils are normally furnished in O60 temper and straight lengths in H58 temper.

## 8. Grain Size

8.1 Coiled lengths shall be furnished in the O60 temper and shall have a recrystallized grain size of 0.040 mm minimum when determined in accordance with Test Methods **E112**.

## 9. Tensile Requirements

9.1 The tube shall conform to the tensile requirements prescribed in **Table 4**.

9.2 Tensile tests need not be performed except when specified in the contract or purchase order.

## 10. Performance Requirements

### 10.1 Expansion Test:

10.1.1 Tube furnished in the O60 soft annealed temper shall be capable of being expanded in accordance with Test Method **B153** to the following extent:

10.1.1.1 The expanded tube shall show no cracking or other defects visible to the unaided eye.

10.1.1.2 Unless specified in the contract or purchase order, this test is not required to be performed by the manufacturer.

### 10.2 Cleanness of Interior Surface:

10.2.1 When specified in the contract or purchase order, this test shall be performed by the manufacturer.

10.2.2 After evaporation of the cleaning solvent, the residue weight shall not exceed 0.0035 g/ft<sup>2</sup> (0.038 g/m<sup>2</sup>) of the interior surface. The maximum amount of residue in grams per tube shall not exceed the limits specified in **Table 5** and **Table 6**.

### 10.3 Microscopical Examination for Susceptibility to Hydrogen Embrittlement:

10.3.1 Tubes furnished in Copper UNS No. C10200 and C12000 shall be essentially free of cuprous oxide as determined by Procedure A of Test Methods **B577**. When Copper UNS No. C12200 is supplied, examination is not required. In case of a dispute, Procedure C of Test Methods **B577** shall be used as the referee method.

10.3.2 Tubes furnished in all coppers shall be capable of passing the embrittlement test specified in Procedure B of Test Methods **B577**. The actual performance of the test is not required unless specifically requested in the ordering document. In case of a dispute, Procedure C of Test Methods **B577** shall be used as the referee method.

## 11. Nondestructive Testing

### 11.1 Electromagnetic (Eddy-Current) Examination:

11.1.1 Each straight length of tube up to and including 3 1/8 in. (79.4 mm) in outside diameter, shall be subjected to examination.

11.1.2 Tubes that do not actuate the signaling device on the testing unit, after having been adjusted to provide information on the suitability of the tube for the intended application, shall conform to the requirements of this test. Testing shall be in accordance with Practice **E243**.

**TABLE 4 Tensile Requirements**

Form	Temper Designation		Tensile Strength, min		Elongation in 2 in. (50.8 mm), min, %
	Standard	Former	ksi <sup>A</sup>	MPa <sup>B</sup>	
Coiled lengths	O60	soft annealed	30	205	40
Straight lengths	H58	drawn general purpose	36	250	. . .

<sup>A</sup> ksi = 1000 psi.

<sup>B</sup> See **Appendix X1**.

**TABLE 5 Interior Surface Residue Limits of Soft Coiled Lengths**

Standard Size, in.	Wall Thickness, in. (mm)	Internal Area per Length of Tube, ft <sup>2</sup> (m <sup>2</sup> )		Residue <sup>A</sup> Limit per 50-ft (15.2-m) Coil, g
		1 ft (0.305 m)	50 ft (15.2 m)	
1/8	0.030 (0.762)	0.0171 (0.001 59)	0.85 (0.0795)	0.0030
3/16	0.030 (0.762)	0.0333 (0.003 09)	1.67 (0.155)	0.0058
1/4	0.030 (0.762)	0.0498 (0.004 67)	2.49 (0.234)	0.0087
5/16	0.032 (0.813)	0.0605 (0.006 04)	3.25 (0.302)	0.0114
3/8	0.032 (0.813)	0.0815 (0.007 57)	4.08 (0.379)	0.0143
1/2	0.032 (0.813)	0.1142 (0.0106)	5.71 (0.530)	0.0200
5/8	0.035 (0.889)	0.1453 (0.0135)	7.26 (0.675)	0.0254
3/4	0.035 (0.889)	0.1780 (0.0165)	8.90 (0.827)	0.0312
7/8	0.045 (1.14)	0.2055 (0.0191)	10.28 (0.955)	0.0360
1 1/8	0.050 (1.27)	0.2683 (0.0249)	13.42 (1.24)	0.0470
1 3/8	0.055 (1.40)	0.3312 (0.0308)	16.56 (1.54)	0.0580
1 5/8	0.060 (1.52)	0.3940 (0.0366)	19.70 (1.83)	0.0690

<sup>A</sup> Residue limit 0.0035-g/ft<sup>2</sup> (0.038-g/m<sup>2</sup>) inside area.

**TABLE 6 Interior Surface Residue Limits of Straight Lengths**

Standard Size, in.	Wall Thickness, in. (mm)	Internal Area per Length of Tube, ft <sup>2</sup> (m <sup>2</sup> )		Residue <sup>A</sup> Limit per 20-ft (6.10-m) Straight Length, g
		1 ft (0.305 m)	20 ft (6.10 m)	
1/4	0.025(0.635)	0.0524(0.00486)	1.04(0.097)	0.0037
3/8	0.030 (0.762)	0.0824 (0.007 65)	1.65 (0.153)	0.0058
1/2	0.035 (0.889)	0.1126 (0.0105)	2.25 (0.210)	0.0079
5/8	0.040 (1.02)	0.1427 (0.0133)	2.85 (0.266)	0.0100
3/4	0.042 (1.07)	0.1744 (0.0162)	3.49 (0.324)	0.0122
7/8	0.045 (1.14)	0.2055 (0.0191)	4.11 (0.382)	0.0144
1 1/8	0.050 (1.27)	0.2683 (0.0249)	5.37 (0.498)	0.0188
1 3/8	0.055 (1.40)	0.3312 (0.0308)	6.62 (0.616)	0.0232
1 5/8	0.060 (1.52)	0.3940 (0.0366)	7.88 (0.732)	0.0276
2 1/8	0.070 (1.78)	0.5197 (0.0423)	10.39 (0.846)	0.0364
2 5/8	0.080 (2.03)	0.6453 (0.0599)	12.91 (1.120)	0.0453
3 1/8	0.090 (2.29)	0.7710 (0.0716)	15.42 (1.43)	0.0540
3 5/8	0.100 (2.54)	0.8966 (0.0833)	17.93 (1.67)	0.0628
4 1/8	0.110 (2.79)	1.0220 (0.0949)	20.44 (1.90)	0.0717

<sup>A</sup> Residue limit 0.0035-g/ft<sup>2</sup> (0.038-g/m<sup>2</sup>) inside area.

ASTM B280-18  
<https://standards.iteh.ai/catalog/standards/sist/003066ad-f558-416a-9e9e-7033dce3a41e/astm-b280-18>

11.1.3 Testing of coiled lengths shall be subject to negotiation between the manufacturer and the purchaser.

11.1.4 For tubes too large for the testing unit, the test method to be used shall be by agreement between the manufacturer and the purchaser.

## 12. Purchases for Agencies of the U.S. Government

12.1 When specified in the contract or purchase order, product purchased for agencies of the U.S. Government shall conform to the requirements stipulated in the Supplementary Requirements.

## 13. Dimensions, Mass, and Permissible Variations

13.1 The standard dimensions and weights per foot for the various nominal sizes are given in **Table 1** and **Table 2**.

13.2 *Wall Thickness and Diameter*—The tolerances for wall thickness and diameter shall conform to the requirements specified in **Table 2** and **Table 1**.

### 13.3 Lengths and Tolerances:

13.3.1 *Standard Lengths and Tolerances*—The standard length for coils shall be 50 ft (15.2 m). The length tolerances for 50-ft coils shall be +12 in. (305 mm) and –0 in. The standard length for straight lengths shall be 20 ft (6.1 m). The length tolerances for 20-ft lengths shall be +1 in. (25 mm) and –0 in.

13.3.2 Tubes supplied in other than standard lengths and tolerances shall be in accordance with requirements established by agreement between the manufacturer or supplier and the purchaser.

13.4 *Roundness*—For drawn unannealed tube in straight lengths, the roundness tolerance as specified in **Table 7**. The deviation from roundness is measured as the difference between major and minor diameters as determined at any one cross section of the tube. Roundness tolerance has not been established for annealed tube in straight lengths nor for tubes furnished in coils.

**TABLE 7 Roundness Tolerance**

NOTE 1—Applicable to drawn unannealed straight length tube only.

<i>t/D</i> (Ratio of Wall Thickness to Nominal Outside Diameter)	Roundness Tolerance Percent of Nominal Outside Diameter (Expressed to Nearest 0.001 in. or 0.010 mm)
0.01 to 0.03, incl	1.5
Over 0.03 to 0.05, incl	1.0
Over 0.05 to 0.10, incl	0.8

13.5 *Squareness of Cut*—For tube in straight lengths, the departure from squareness of the end of any tube shall not exceed more than 0.010 in. (0.25 mm) for tube up to and including 5/8-in. (15.9-mm) standard size; and not more than 0.016 in./in. (0.016 mm/mm) of outside diameter, for tube larger than 5/8-in. standard size.

13.6 For the purpose of determining conformance with the dimensional requirements prescribed in this specification, any measured value outside the specified limiting values for any dimension shall be subject to rejection.

#### 14. Workmanship, Finish, and Appearance

14.1 The finished tube product shall be smooth, free of internal and external mechanical imperfections, and shall have a clean, bright appearance free of defects, but blemishes of a nature that do not interfere with the intended application are acceptable.

#### 15. Sampling

15.1 The lot size, portion size, and selection of sample pieces shall be as follows:

15.1.1 *Lot Size*—The lot size shall be 10 000 lbs (4500 kg) or fraction thereof.

15.1.2 *Portion Size*—Sample pieces shall be selected to be representative of the lot as shown in Table 8.

15.1.2.1 In the case of tube furnished in coils, a length sufficient for all necessary tests shall be cut from each coil selected for purpose of test. The remaining portion of these coils shall be included in the shipment, and the permissible variations in length on such coils shall be waived.

15.2 *Chemical Composition*:

15.2.1 The sample shall be taken in approximately equal weight from each piece selected in 15.1.2 and prepared in accordance with Practice E255. The minimum weight of the composite sample shall be 150 g.

15.2.2 Instead of sampling in accordance with Practice E255, the manufacturer shall have the option of sampling at the time castings are poured or from the semifinished product. When the composition is determined during the course of manufacture, sampling of the finished product is not required.

15.2.3 The number of samples taken during the course of manufacture shall be as follows:

15.2.3.1 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.

15.2.3.2 When samples are taken from the semifinished product, a sample shall be taken to represent each 10 000 lbs (4500 kg) or fraction thereof, except that not more than one sample per piece shall be required.

15.3 *Other Tests*—Specimens for all other tests shall be taken from two of the sample pieces selected in 15.1.2. In the event only one sample piece is selected, all specimens shall be taken from that piece.

#### 16. Number of Tests and Retests

16.1 *Tests*:

16.1.1 Chemical composition shall be reported as the average of results from at least two replicate determinations for each specified element and each determination must meet specification requirement.

16.1.2 Tensile and grain size shall be reported as the average of results from the specimens tested and all specimens must conform to specification requirements.

16.1.3 Specimens for all other tests must meet specification requirements.

**TABLE 8 Sampling Schedule**

NOTE 1—Each sample piece shall be taken from a separate tube.

Number of Pieces in Lot	Number of Sample Pieces to be Taken
1 to 50	1
51 to 200	2
201 to 1500	3
Over 1500	0.2 % of total number of pieces in the lot, but not to exceed 10 pieces