



Designation: B 98/B 98M – 9803

Standard Specification for Copper-Silicon Alloy Rod, Bar and Shapes¹

This standard is issued under the fixed designation B 98/B 98M; 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.

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

¹ This specification is under the jurisdiction of ASTM Committee B-5 B05 on Copper and Copper Alloys and is the direct responsibility of Subcommittee B05.02 on Rod, Bar, Wire, Shapes, and Forgings.

Current edition approved Oct. 10, 1998; 2003. Published January 1999; May 2003. Originally published as B 98-34T, approved in 1934. Last previous edition approved in 1998 as B 98/B 98M-978.

1. Scope *

1.1 This specification establishes requirements for copper-silicon rod, bar, and shapes for UNS Alloys ~~C65100 (Low Silicon Bronze B)~~, ~~C65500 (High Silicon Bronze A)~~, C65100, C65500, and C66100.

NOTE 1—Material for hot forging is covered by Specification B 124.

NOTE 2—For ASME Boiler and Pressure Vessel Code applications, see Specification SB-98 in Section II of that code.

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

2. Referenced Documents

2.1 The following documents of the issue in effect on date of material purchase form a part of this specification to the extent referenced herein:

2.2 *ASTM Standards:*

B 124/B 124M Specification for Copper and Copper Alloy Forging Rod, Bar, and Shapes²

B 249/B 249M Specification for General Requirements for Wrought Copper and Copper-Alloy Rod, Bar, Shapes and Forgings²

~~B-249M Specification 601 Classification for General Requirements for Wrought Copper and Copper-Alloy Rod, Bar, Shapes and Forgings [Metric]³~~

~~B-601 Practice for Temper Designations for Copper and Copper Alloys—Wrought and Cast²~~

E 8 Test Methods for Tension Testing of Metallic Materials³

E 8M Test Methods for Tension Testing of Metallic Materials [Metric]³

E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials³

E 5462 Test Methods for Chemical Analysis of ~~Special Brasses Copper and Bronzes~~⁴ Copper Alloys (Photometric Method)⁵

E 62478 Test Methods for Chemical Analysis of Copper and Copper Alloys ~~(Photometric Method)~~⁵

² For ASME Boiler and Pressure Vessel Code applications see related Specification SB-98 in Section II

² ~~Annual Book of that code:~~ *ASTM Standards*, Vol 02.01.

³ *Annual Book of ASTM Standards*, Vol 02.01.

⁵ *Annual Book of ASTM Standards*, Vol 03.04+5.

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

~~E 478 Test Methods for Chemical Analysis of Copper Alloys⁶⁴~~

3. General Requirements

3.1 The following sections of Specification B 249-~~or~~/B 249M constitute a part of this specification:

- 3.1.1 Terminology,
- 3.1.2 Materials and Manufacture,
- 3.1.3 Workmanship, Finish, and Appearance,
- 3.1.4 Sampling,
- 3.1.5 Number of Tests and Retests,
- 3.1.6 Specimen Preparation,
- 3.1.7 Test Methods,
- 3.1.8 Significance of Numerical Limits,
- 3.1.9 Inspection,
- 3.1.10 Rejection and Rehearing,
- 3.1.11 Certification,
- 3.1.12 Test Report (Mill),
- 3.1.13 Packaging and Package Marking, and
- 3.1.14 Supplemental Requirements.

3.2 In addition, when a section with a title identical to one of those referenced in 3.1 appears in this specification, it contains additional requirements that supplement those which appear in Specification B 249-~~or~~/B 249M.

4. Ordering Information

4.1 ~~Include the following information in orders for product under this specification should include the following information:~~
specification:

- 4.1.1 ASTM Designation and year of issue,
- 4.1.2 Copper Alloy UNS No. designation,
- 4.1.3 Temper designation,
- 4.1.4 Quantity; total weight or length, or number of pieces of each temper, form, or alloy,
- 4.1.5 Dimensions; diameter or distance between parallel surfaces,
- 4.1.6 Type of edge; edge contours,
- 4.1.7 How furnished; specific lengths with or without ends, and
- 4.1.8 When material is purchased for agencies of the U.S. Government (see Specifications B 249-~~or~~/B 249M).

4.2 The following options are available under this specification and should be specified in the contract or purchase order when required:

- 4.2.1 Certification (Specifications B 249-~~or~~/B 249M), and
- 4.2.2 Mill Test Report (Specifications B 249/B 249M).
- 4.2.3 Tensile test required for alloys in Table 4 or B-249M. Table 5 (see 8.1.1.1).

5. Material and Manufacture

5.1 ~~Materials~~—The starting material shall be cast billets or rods of Copper Alloy UNS ~~Numbers~~ Nos. C65100, C65500, or C66100, and shall be of such soundness and structure as to enable them to be processed into the product specified in the contract or purchase order.

TABLE 1 Chemical Requirements

	Composition, % Maximum (Unless Shown as a Range or Minimum)		
	Copper Alloy UNS No.		
	C65100	C65500	C66100
Copper (Includes silver)	96.0 min	94.8 min	94.0 min
Copper (Includes silver)	remainder	remainder	remainder
Lead	0.05	0.05	0.20–0.8
Iron	0.8	0.8	0.25
Zinc	1.5	1.5	1.5
Aluminum
Manganese	0.7	0.50–1.3	1.5
Silicon	0.8–2.0	2.8–3.8	2.8–3.5
Nickel	...	0.6	...
Nickel (includes cobalt)	...	0.6	...

TABLE 2 Tensile Requirements

Temper Designation		Diameter or Distance Between Parallel Surfaces, ^A in.	Tensile Strength min, ksi	Yield Strength at 0.5 % Extension Under Load, min, ksi	Elongation in 4 × Diameter or Thickness of Specimen, min, % ^B
Standard	Name				
Copper Alloy UNS No. C65100 Rods, Bars, and Shapes					
O60	Soft anneal	All forms, all sizes	40	12	30
H02	Half-hard	Rods: Up to ½, incl Over ½ to 2, incl	55 55	20 20	11 12
		Bars and shapes	— ^C	— ^C	— ^C
H04	Hard	Rods: Up to ½, incl Over ½ to 2, incl	65 65	35 35	8 10
		Bars and shapes	— ^C	— ^C	— ^C
H06	Extra-hard	Rods: Up to ½, incl Over ½ to 1, incl Over 1 to 1½, incl	85 75 75	55 45 40	6 8 8
Copper Alloy UNS Nos. C65500 and C66100 Rectangular Bars					
O60	Soft anneal	All sizes	52	15	35
H04	Hard	Up to 1, incl Over 1 to 1½, incl Over 1½ to 3, incl	65 60 55	38 30 24	20 25 27
Copper Alloy UNS Nos. C65500 and C66100 Rods, Square Bars, and Shapes					
O60	Soft anneal	All forms, all sizes	52	15	35
H01	Quarter-hard	All forms, all sizes	55	24	25
H02	Half-hard	Rods and square bars: Up to 2, incl	70	38	20
		Shapes	— ^C	— ^C	— ^C
H04	Hard	Rods and square bars: Up to ¼, incl Over ¼ to 1, incl Over 1 to 1½, incl Over 1½ to 3, incl Over 3	90 90 80 70 — ^C	55 52 43 38 — ^C	8 13 15 17 — ^C
		Shapes	— ^C	— ^C	— ^C
H06	Extra-hard	Rods: up to ½, incl	100	55	7

^A For rectangular bar, the Distance Between Parallel Surfaces refers to thickness.

^B In any case a minimum gage length of 1 in. shall be used.

^C As agreed upon between manufacturer and purchaser.

5.2 Manufacture— The product shall be manufactured by such hot-working, cold-working, straightening, and annealing processing as to produce a uniform wrought structure and obtain the required finish properties.

6. Chemical Composition

6.1 The product shall conform to the chemical requirements specified in Table 1 for the Copper Alloy UNS No. designated in the ordering information.

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

6.1.2 When all elements listed in Table 1 are determined for the designated alloy, the sum of results shall be 99.5 % min.

6.1.2 ~~Copper may be determined as the difference between the sum of results for all elements analyzed and 100 %.~~

6.2 These composition limits do not preclude the presence of other elements. Limits may be established and analysis required for unnamed elements by agreement between the manufacturer and the purchaser.

7. Temper

7.1 The standard tempers, as defined in ~~Practice Classification B 601, available under~~ for products described in this specification are O60 (soft anneal), H01 (quarter-hard), H02 (half-hard), H04 (hard), H06 (extra hard), M20 (as given in Tables 2-5.

7.1.1 Soft annealed O60,

7.1.2 ¼-hard H01,

7.1.3 ½-hard H02,

7.1.4 Hard H04,

7.1.5 Extra-hard H06,

7.1.6 As hot-rolled), and M30 (as rolled M20, and

7.1.7 As hot extruded) M30.

7.2 Product of bars and shapes in the ~~H06 (extra-hard)~~ temper H06 is normally not produced.

TABLE 3 Tensile Requirements

Temper Designation		Diameter or Distance Between Parallel Surfaces, ^A mm	Tensile Strength min, MPa	Yield Strength at 0.5 % Extension Under Load, min, MPa	Elongation, min, % ^B
Standard	Name				
Copper Alloy UNS No. C65100 Rods, Bars, and Shapes					
O60	Soft anneal	All forms, all sizes	275	85	30
H02	Half-hard	Rods:			
		Up to 12, incl	380	140	11
		Over 12 to 50, incl	380	140	12
		Bars and shapes	\bar{c}	\bar{c}	\bar{c}
H04	Hard	Rods:			
		Up to 12, incl	450	240	8
		Over 12 to 50, incl	450	240	10
		Bars and shapes	\bar{c}	\bar{c}	\bar{c}
H06	Extra-hard	Rods:			
		Up to 12, incl	585	380	6
		Over 12 to 25, incl	515	310	8
		Over 25 to 38, incl	515	275	8
Copper Alloy UNS Nos. C65500 and C66100 Rectangular Bars					
O60	Soft anneal	All sizes	360	105	35
H04	Hard	Up to 25, incl	450	260	20
		Over 25 to 38, incl	415	205	25
		Over 38 to 75, incl	380	165	27
Copper Alloy UNS Nos. C65500 and C66100 Rods, Square Bars, and Shapes					
O60	Soft anneal	All forms, all sizes	360	105	35
H01	Quarter-hard	All forms, all sizes	380	165	25
H02	Half-hard	Rods and square bars:			
		Up to 50, incl	485	260	20
		Shapes	\bar{c}	\bar{c}	\bar{c}
H04	Hard	Rods and square bars:			
		Up to 6, incl	615	380	8
		Over 6 to 25, incl	615	360	13
		Over 25 to 38, incl	545	295	15
		Over 38 to 75, incl	485	260	17
		Over 75	\bar{c}	\bar{c}	\bar{c}
		Shapes	\bar{c}	\bar{c}	\bar{c}
H06	Extra-hard	Rods: up to 12, incl	690	380	7

^A For rectangular bar, the Distance Between Parallel Surfaces refers to thickness.

^B Elongation values are based on a gage length of 5.65 times the square root of the area for dimensions greater than 2.5 mm.

^C As agreed upon between manufacturer and purchaser.

TABLE 4 Rockwell Hardness Requirements^A

Temper Designation		Diameter or Distance Between Parallel Surfaces, ^B in.	Rockwell B Hardness Determined on the Cross Section Midway Between Surface and Center
Standard	Name		
Copper Alloy UNS No. C65100 Rods, Bars, and Shapes			
H02	Half-hard	0.5 to 2.0, incl	60–85
H04	Hard	0.5 to 2.0, incl	65–90
H06	Extra-hard ^C	0.5 to 1.5, incl	75–95
Copper Alloy UNS Nos. C65500 and C66100 Rectangular Bars			
H04	Hard	0.5 to 3.0, incl	60–95
Copper Alloy UNS Nos. C65500 and C66100 Rods, Square Bars, and Shapes			
H02	Half-hard	0.5 to 1.0, incl	75–95
		over 1.0 to 1.5, incl	75–95
		over 1.5 to 3.0, incl	75–95
H04	Hard	0.5 to 1.0, incl	85–100
		over 1.0 to 1.5, incl	80–95
		over 1.5 to 3.0, incl	75–95

^A Rockwell hardnesses are not established for diameters less than 0.5 in..

^B For rectangular bar, the Distance Between Parallel Surfaces refers to thickness.

^C Bars and shapes are not produced in the H06 temper.

8. Mechanical Property Requirements

8.1 The product shall conform to the mechanical property requirements given in Tables 2 and 3 2-5 for the Copper Alloy UNS No. designation specified in the ordering information.

8.1.1 *Rockwell Hardness*—For the alloys and tempers listed, product 0.5 in. [12.7 [12 mm] and over in diameter or distance between parallel surfaces shall conform with the requirements given in Table 3, 4 and Table 5, when tested in accordance with Test Methods E 18 or B 249M. E 18.

8.1.1.1 For the alloys and tempers listed in Table 3, 4 and Table 5, Rockwell hardness shall be the basis of acceptance or rejection for mechanical properties except when the tensile test is specified in the contract or purchase order.



TABLE 5 Rockwell Hardness Requirements^A

Temper Designation		Diameter or Distance Between Parallel Surfaces, ^B mm	Rockwell B Hardness Determined on the Cross Section Midway Between Surface and Center
Standard	Name		
Copper Alloy UNS No. C65100 Rods, Bars, and Shapes			
H02	Half-hard	12 to 50, incl	60–85
H04	Hard	12 to 50, incl	65–90
H06	Extra-hard ^C	12 to 50, incl	75–95
Copper Alloy UNS Nos. C65500 and C66100 Rectangular Bars			
H04	Hard	12 to 75, incl	60–95
Copper Alloy UNS Nos. C65500 and C66100 Rods, Square Bars, and Shapes			
H02	Half-hard	12 to 25, incl	75–95
		25 to 38, incl	75–95
H04	Hard	over 38 to 75, incl	75–95
		12 to 25, incl	85–100
		over 25 to 38, incl	80–95
		over 38 to 75, incl	75–95

^A Rockwell hardnesses are not established for diameters less than 12 mm.
^B For rectangular bar, the Distance Between Parallel Surfaces refers to thickness.
^C Bars and shapes are not produced in the H06 temper.

8.1.2 *Tensile Strength*— The product shall conform with the requirements of Table 2 and Table 3 when tested in accordance with Test Methods E 8 or ~~B 249M~~ E 8M.

8.1.2.1 The tensile requirements for all alloys and forms of M20 and M30 tempers shall be as agreed upon between the manufacturer and purchaser at time of order.

9. Dimensions, Mass and Permissible Variations

9.1 Refer to the appropriate paragraphs in Specification B 249/B 249M with particular reference to the following tables:

9.2 *Diameter or Distance Between Parallel Surfaces:*

9.2.1 *Rod: Round, Hexagonal, Octagonal*—Refer to Table 1 for Alloy C65100 and to Table 2 for Alloys C65500 and C66100.

9.2.2 *Rod: Round M20 Temper*—Refer to Table 6.

9.2.3 *Rod: Round, Hexagonal, Octagonal, M30 Temper*—Refer to Table 5.

9.2.4 *Bar: Rectangular and Square*—Refer to Tables 8 and 10 for Alloy C65100, and Tables 9 and 11 for Alloys C65500 and C66100.

9.2.5 *Bar: M30 Temper*— Refer to Table 5 for thickness and width tolerances.

9.3 *Shapes*—The dimensional tolerance for shapes shall be as agreed upon between the manufacturer and the purchaser, and shall be specified in the order.

9.4 *Length:*

9.4.1 *Rod, Bar and Shapes*—Refer to Tables 13 and 15.

9.5 *Straightness:*

9.5.1 *Rod and Bar*— Refer to Table 16.

9.6 *Edge Contours:*

9.6.1 *Rod and Bar*— Refer to the section entitled, “Edge Contours” and to Figs. 1, 2, and 3.

10. Test Methods

10.1 Chemical composition shall, in case of disagreement, be determined as follows:

follows:

Element	Test Methods
Copper	E 478
Lead	E 478, Atomic absorption
Manganese	E 62
Nickel	E 478, Photometric
Silicon	E 54, Perchloric acid dehydration
Silicon	E 62
Zinc	E 478, Atomic absorption

10.1.1 Test Method(s) to be followed for the determination of elements required by contractual or purchase order agreement shall be as agreed upon between the supplier and purchaser.

10.2 Refer to Specifications B 249 or B 249M for other appropriate test methods.

11. Keywords

11.1 copper—rod, bar, shapes; copper-silicon alloy; high silicon bronze A; low silicon bronze B; silicon bronze

TABLE 2a Tensile Requirements

Temper Designation		Diameter or Distance Between Parallel Surfaces, in.	Tensile Strength min, ksi	Yield Strength at 0.5 % Extension Under Load; min, ksi	Elongation in 4 × Diameter or Thickness of Specimen, min, % ^A
Standard	Former				
Copper Alloy UNS No. C65100 Rods, Bars, and Shapes					
Copper Alloy bronze; UNS No. C65100 Rods, Bars, and Shapes					
060	Soft-anneal	All forms, all sizes	40	12	30
H02	Half-hard	Rods:			
		— Up to 1/2, incl	55	20	14
		— Over 1/2 to 2, incl	55	20	12
H04	Hard	Bars and shapes	<i>B</i>	<i>B</i>	<i>B</i>
		Rods:			
		— Up to 1/2, incl	65	35	8
		— Over 1/2 to 2, incl	65	35	10
		Bars and shapes	<i>B</i>	<i>B</i>	<i>B</i>
H06	Extra-hard ^C	Rods:			
		— Up to 1/2, incl	85	55	6
		— Over 1/2 to 1, incl	75	45	8
		— Over 1 to 1 1/2, incl	75	40	8
Copper Alloy UNS Nos. C65500 and C66100 Bars ^D					
Copper Alloy C65100; UNS Nos. C65500 and C66100 Bars ^D					
060	Soft-anneal	All sizes	52	15	35
H04	Hard	Up to 1, incl	65	38	20
		Over 1 to 1 1/2, incl	60	30	25
		Over 1 1/2 to 3, incl	55	24	27
Copper Alloy UNS Nos. C65500 and C66100 Rods, Square Bars, and Shapes					
060	Soft-anneal	All forms, all sizes	52	15	35
H01	Quarter-hard	All forms, all sizes	55	24	25
H02	Half-hard	Rods and square bars:			
		— Up to 2, incl	70	38	20
		Shapes	<i>B</i>	<i>B</i>	<i>B</i>
H04	Hard	Rods and square bars:			
		— Up to 1/4, incl	90	55	8
		— Over 1/4 to 1, incl	90	52	13
		— Over 1 to 1 1/2, incl	80	43	15
		— Over 1 1/2 to 3, incl	70	38	17
		— Over 3— as agreed upon by manufacturer and purchaser			
		Shapes	<i>B</i>	<i>B</i>	<i>B</i>
H06	Extra-hard ^C	Rods: up to 1/2, incl	100	55	7

^A In any case a minimum gage length of 1 in. shall be used.

^B Tensile requirements for shapes of Copper Alloy UNS Nos. C65500 and C66100 and bars and shapes of the H02 and H04 tempers of Copper Alloy UNS No. C65100 and all alloys and forms of M20 and M30 tempers shall be as agreed upon between the manufacturer and the purchaser at time of order.

^C Bars and shapes are not produced in the H06 extra-hard temper.

^D Rectangular sections having thickness less than the width.

 **B 98/B 98M – 9803**

TABLE 2b Tensile Requirements

Temper Designation		Diameter or Distance Between Parallel Surfaces, mm	Tensile Strength min, MPa	Yield Strength at 0.5 % Extension Under Load, min, MPa	Elongation, min, % ^A
Standard	Former				
Copper Alloy UNS No. C65100 Rods, Bars, and Shapes					
Copper Alloy C65500; UNS No. C65100 Rods, Bars, and Shapes					
O60	Soft anneal	All forms, all sizes	275	85	30
H02	Half-hard	Rods: —Up to 12.7, incl —Over 12.7 to 50.8, incl	380 380	140 140	14 12
H04	Hard	Bars and shapes Rods: —Up to 12.7, incl —Over 12.7 to 50.8, incl	 450 450	 240 240	 <i>B</i> 10
H06	Extra-hard ^C	Bars and shapes Rods: —Up to 12.7, incl —Over 12.7 to 25.4, incl —Over 25.4 to 38.1, incl	<i>B</i> 585 515 515	<i>B</i> 380 340 275	<i>B</i> 6 8 8
Copper Alloy UNS Nos. C65500 and C66100 Bars ^D					
O60	Soft anneal	All sizes	360	405	35
H04	Hard	Up to 25.4, incl Over 25.4 to 38.1, incl Over 38.1 to 76.2, incl	450 415 380	260 205 165	20 25 27
Copper Alloy UNS Nos. C65500 and C66100 Rods, Square Bars, and Shapes					
O60	Soft anneal	All forms, all sizes	360	405	35
H01	Quarter-hard	All forms, all sizes	380	465	25
H02	Half-hard	Rods and square bars: —Up to 50.8, incl Shapes	485 <i>B</i>	260 <i>B</i>	20 <i>B</i>
H04	Hard	Rods and square bars: —Up to 6.35, incl —Over 6.35 to 25.4, incl —Over 25.4 to 38.1, incl —Over 38.1 to 76.2, incl —Over 76.2—as agreed upon between manufacturer and purchaser	615 615 545 485	380 360 295 260	8 13 15 17
H06	Extra-hard ^C	Shapes Rods: up to 12.7, incl	<i>B</i> 690	<i>B</i> 380	<i>B</i> 7

^A Elongation values are based on a gage length of 5.65 times the square root of the area for dimensions greater than 2.5 mm.

^B Tensile requirements for shapes of Copper Alloy UNS Nos. C65500 and C66100 and bars and shapes of the H02 and H04 tempers of Copper Alloy UNS No. C65100 and all alloys and forms of M20 and M30 tempers shall be as agreed upon between the manufacturer and the purchaser at time of order.

^C Bars and shapes are not produced in the H06 extra-hard temper.

^D Rectangular sections having thickness less than the width.

TABLE 3 Rockwell Hardness Requirements^A

Temper Designation		Diameter or Distance Between Parallel Surfaces, in. [mm]	Rockwell B Hardness Determined on the Cross Section Midway Between Surface and Center
Standard	Former		
Copper Alloy UNS No. C65100 Rods, Bars, and Shapes			
H02	Half-hard	0.5 to 2.0 [12.7 to 50.8], incl	60–85
H04	Hard	0.5 to 2.0 [12.7 to 50.8], incl	65–90
H06	Extra-hard ^B	0.5 to 1.5 [12.7 to 38.1], incl	75–95
Copper Alloy UNS Nos. C65500 and C66100 Bars ^C			
H04	Hard	0.5 to 3.0 [12.7 to 76.1], incl	60–95
Copper Alloy UNS Nos. C65500 and C66100 Rods, Square Bars, and Shapes			
H02	Half-hard	0.5 to 1.0 [12.7 to 25.4], incl over 1.0 to 1.5 [25.4 to 38.1], incl	75–95 75–95
H04	Hard	0.5 to 3.0 [12.7 to 76.1], incl over 1.5 to 3.0 [38.1 to 50.8], incl	75–95 75–95
H04	Hard	0.5 to 1.0 [12.7 to 25.4], incl over 1.0 to 1.5 [25.4 to 38.1], incl	–85–100 80–95
		over 1.5 to 3.0 [38.1 to 50.8], incl	75–95

^A Rockwell hardnesses are not established for diameters less than 0.5 in. [12.7 mm].

^B Bars and shapes are not produced in the H06 temper.

^C Rectangular sections having thickness less than the width.

SUMMARY OF CHANGES

Committee B-5 B05 has identified the location of selected changes to this standard since the last issue (B 98/B 98M – 978) that may impact the use of this standard (approved Apr. 10, 2003).

- ~~(1) Referenced Documents section has been expanded. Correction of Table 1 to conform to UNS alloy designations.~~
- ~~(2) Mechanical Property Requirements section has been expanded.)~~ Editorial revisions throughout.

ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.

This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org).