



## Standard Specification for Nickel-Chromium-Molybdenum-Tungsten Alloys (UNS N06110) Plate, Sheet, and Strip<sup>1</sup>

This standard is issued under the fixed designation B 755; 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 covers rolled nickel-chromium-molybdenum-tungsten alloys (UNS N06110)<sup>2</sup> plate, sheet, and strip.

1.2 The values stated in inch-pound units are to be regarded as the standard. The SI units in parentheses are provided for information only.

1.3 *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 become familiar with all hazards including those identified in the appropriate Material Safety Data Sheet (MSDS) for this product/material as provided by the manufacturer, to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use.*

### 2. Referenced Documents

2.1 *ASTM Standards:*<sup>3</sup>

**B 446** Specification for Nickel-Chromium-Molybdenum-Columbium Alloy (UNS N06625), Nickel-Chromium-Molybdenum-Silicon Alloy (UNS N06219), and Nickel-Chromium-Molybdenum-Tungsten Alloy (UNS N06650)\*  
Rod and Bar

**B 756** Specification for Nickel-Chromium-Molybdenum-Tungsten Alloy (UNS N06110) Rod and Bar

**B 880** Specification for General Requirements for Chemical Check Analysis Limits for Nickel, Nickel Alloys and Cobalt Alloys

**E 8** Test Methods for Tension Testing of Metallic Materials

**E 29** Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

**E 527** Practice for Numbering Metals and Alloys (UNS)

**E 1473** Test Methods for Chemical Analysis of Nickel, Cobalt, and High-Temperature Alloys

### 3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 The terms given in **Table 1** shall apply.

### 4. Ordering Information

4.1 It is the responsibility of the purchaser to specify all requirements that are necessary for the safe and satisfactory performance of material ordered under this specification. Examples of such requirements include, but are not limited to, the following:

4.1.1 *ASTM designation.*

4.1.2 *Alloy name or UNS number.*

4.1.3 *Condition—Table 2 and Appendix X1.*

4.1.4 *Finish—Appendix X1.*

4.1.5 *Dimensions—Thickness, width, and length.*

4.1.6 *Quantity.*

4.1.7 *Optional Requirements:*

4.1.7.1 *Sheet and Strip*—Whether to be furnished in coil, in cut straight lengths, or in random straight lengths, and

4.1.7.2 *Plate*—How plate is to be cut (**Table 3** and **Table 4**).

4.1.8 *Certification*—State if certification is required (see **Section 15**).

4.1.9 *Samples for Product (Check) Analysis*—Whether samples for product (check) analysis should be furnished (see **5.2**).

4.1.10 *Purchaser Inspection*—If the purchaser wishes to witness tests or inspection of material at place of manufacture, the purchase order must so state indicating which tests or inspections are to be witnessed (see **Section 13**).

### 5. Chemical Composition

5.1 The material shall conform to the composition limits specified in **Table 5**.

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee B02 on Nonferrous Metals and Alloys and is the direct responsibility of Subcommittee B02.07 on Refined Nickel and Cobalt and Their Alloys.

Current edition approved June 1, 2006. Published June 2006. Originally approved in 1986. Last previous edition approved in 2000 as B 755 – 00.

<sup>2</sup> New designation established in accordance with Practice **E 527** and SAE J1086, Recommended Practice for Numbering Metals and Alloys (UNS).

<sup>3</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.



TABLE 1 Product Description

| Product                        | Thickness, in. (mm)                          | Width, in. (mm)        |
|--------------------------------|----------------------------------------------|------------------------|
| Hot-rolled plate <sup>A</sup>  | 3/16 (4.8) and over (Table 4 and Table 5)    | (Table 7) <sup>B</sup> |
| Hot-rolled sheet <sup>A</sup>  | 0.018 to 0.250 (0.46 to 6.4), incl (Table 6) | (Table 9)              |
| Cold-rolled sheet <sup>C</sup> | 0.018 to 0.250 (0.46 to 6.4), incl (Table 6) | (Table 9)              |
| Cold rolled strip <sup>C</sup> | 0.005 to 0.250 (0.13 to 6.4), incl (Table 6) | (Table 9)              |

<sup>A</sup> Material 3/16 to 1/4 in. (4.8 to 6.4 mm), incl, in thickness may be furnished as sheet or plate provided the material meets the specification requirements for the condition ordered.

<sup>B</sup> Hot-rolled plate, in widths 10 in. (254 mm) and under, may be furnished as hot-finished rectangles with shared or cut edges in accordance with Specification B 446 provided the mechanical property requirements of this specification are met.

<sup>C</sup> Material under 48 in. (1219 mm) in width may be furnished as sheet or strip provided the material meets the specification requirements for the condition ordered.

TABLE 2 Mechanical Properties for Plate, Sheet, and Strip (All Thicknesses and Sizes Unless Otherwise Indicated)

| Condition (Temper)            | Tensile strength, min, ksi (MPa) | Yield strength <sup>A</sup> (0.2% offset), min, ksi (MPa) | Elongation in 2 in. or 50 mm (or 4D) min, % <sup>B</sup> |
|-------------------------------|----------------------------------|-----------------------------------------------------------|----------------------------------------------------------|
| Hot-Rolled Plate <sup>C</sup> |                                  |                                                           |                                                          |
| Annealed                      | 95 (655)                         | 45 (310)                                                  | 50                                                       |
| Hot-Rolled Sheet              |                                  |                                                           |                                                          |
| Annealed                      | 95 (655)                         | 45 (310)                                                  | 50                                                       |
| Cold-Rolled Sheet             |                                  |                                                           |                                                          |
| Annealed                      | 95 (655)                         | 45 (310)                                                  | 50                                                       |
| Cold-Rolled Strip             |                                  |                                                           |                                                          |
| Annealed                      | 95 (655)                         | 45 (310)                                                  | 50                                                       |

<sup>A</sup>Yield strength requirements do not apply to material under 0.020 in. (0.51 mm) in thickness.

<sup>B</sup> Not applicable for thicknesses under 0.010 in. (0.25 mm).

<sup>C</sup>Applicable to 2.75 in. (70 mm) thickness and below.

5.2 If a product (check) analysis is performed by the purchaser, the material shall conform to the product (check) analysis variations in accordance with Specification B 880.

## 6. Mechanical Properties

6.1 The material shall conform to the mechanical properties specified in Table 2.

## 7. Dimensions and Permissible Variations

### 7.1 Thickness and Weight:

7.1.1 *Plate*—For plate up to 2 in. (50.8 mm), inclusive, in thickness, the permissible variation under the specified thickness and permissible excess in overweight shall not exceed the amounts prescribed in Table 6.

7.1.1.1 For use with Table 6, plate shall be assumed to weigh 0.303 lb/in.<sup>3</sup> (8.386 g/cm<sup>3</sup>).

7.1.2 *Plate*—For plate over 2 in. (50.8 mm) in thickness, the permissible variations over the specified thickness shall not exceed the amounts prescribed in Table 7.

7.1.3 *Sheet and Strip*—The permissible variations in thickness of sheet and strip shall be as prescribed in Table 8. The thickness of strip and sheet shall be measured with the micrometer spindle 3/8 in. (9.5 mm) or more from either edge for material 1 in. (25.4 mm) or over in width and at any place on the strip under 1 in. in width.

### 7.2 Width or Diameter:

7.2.1 *Plate*—The permissible variations in width or rectangular plates and diameter of circular plates shall be as prescribed in Table 3 and Table 9.

7.2.2 *Sheet and Strip*—The permissible variations in width for sheet and strip shall be as prescribed in Table 10.

### 7.3 Length:

7.3.1 Sheet and strip of all sizes may be ordered to cut lengths, in which case a variation of 1/8 in. (3.2 mm) over the specified length shall be permitted.

7.3.2 Permissible variations in length of rectangular plate shall be as prescribed in Table 4.

### 7.4 Straightness:

7.4.1 The edgewise curvature (depth of chord) of flat sheet, strip, and plate shall not exceed 0.05 in. multiplied by the length in feet (0.04 mm multiplied by the length in centimeters).

7.4.2 Straightness for coiled material is subject to agreement between the manufacturer and the purchaser.

### 7.5 Edges:

7.5.1 Sheet and strip shall have sheared or slit edges.

7.5.2 Plate shall have sheared or cut (machines, abrasive cut, powder cut, or inert arc cut) edges, as specified.

7.6 *Squareness (Sheet)*—For sheets of all thicknesses, the angle between adjacent sides shall be 90 ± 0.15° (1/16 in. in 24 in.) 1.6 mm in 610 mm).

7.7 *Flatness*—Standard flatness tolerances for plate shall conform to the requirements of Table 11.

## 8. Workmanship, Finish, and Appearance

8.1 The material shall be uniform in quality and temper, smooth, commercially straight or flat, and free of injurious imperfections.

## 9. Sampling

### 9.1 Lot Definition:

9.1.1 A lot for chemical analysis shall consist of one heat.

9.1.2 A lot for mechanical testing shall consist of all material from the same heat, nominal thickness, and condition.

9.1.2.1 Where material cannot be identified by heat, a lot shall consist of not more than 500 lb (227 kg) of material in the same thickness and condition, except for plates weighing over 500 lb in which case only one specimen shall be taken.

### 9.2 Test Material Selection:

9.2.1 *Chemical Analysis*—Representative samples from each lot shall be taken during pouring or subsequent processing.

9.2.1.1 *Product (check) Analysis*—Product analysis shall be wholly the responsibility of the purchaser.

9.2.2 *Mechanical Properties*—Samples of the material to provide test specimens for mechanical properties shall be taken from such locations in each lot as to be representative of that lot.

TABLE 3 Permissible Variations in Width<sup>A</sup> of Sheared, Plasma Torch-Cut, and Abrasive-Cut Rectangular Plate<sup>BC</sup>

| Specified Thickness            | Permissible Variations in Widths for Widths Given, in. (mm) |     |                                            |     |                                              |     |                                               |     |                                               |     |
|--------------------------------|-------------------------------------------------------------|-----|--------------------------------------------|-----|----------------------------------------------|-----|-----------------------------------------------|-----|-----------------------------------------------|-----|
|                                | Up to 30<br>(760), incl                                     |     | Over 30 to<br>72<br>(760 to 1830),<br>incl |     | Over 72 to<br>108<br>(1830 to 2740),<br>incl |     | Over 108 to<br>144<br>(2740 to 3660),<br>incl |     | Over 144<br>to 160<br>(3660 to 4070),<br>incl |     |
|                                | +                                                           | –   | +                                          | –   | +                                            | –   | +                                             | –   | +                                             | –   |
| Inches                         |                                                             |     |                                            |     |                                              |     |                                               |     |                                               |     |
| Sheared: <sup>D</sup>          |                                                             |     |                                            |     |                                              |     |                                               |     |                                               |     |
| 3/16 to 5/16, excl             | 3/16                                                        | 1/8 | 1/4                                        | 1/8 | 3/8                                          | 1/8 | 1/2                                           | 1/8 | ...                                           | ... |
| 5/16 to 1/2, excl              | 1/4                                                         | 1/8 | 3/8                                        | 1/8 | 3/8                                          | 1/8 | 1/2                                           | 1/8 | 5/8                                           | 1/8 |
| 1/2 to 3/4, excl               | 3/8                                                         | 1/8 | 3/8                                        | 1/8 | 1/2                                          | 1/8 | 5/8                                           | 1/8 | 3/4                                           | 1/8 |
| 3/4 to 1, excl                 | 1/2                                                         | 1/8 | 1/2                                        | 1/8 | 5/8                                          | 1/8 | 3/4                                           | 1/8 | 7/8                                           | 1/8 |
| 1 to 1 1/4, incl               | 5/8                                                         | 1/8 | 5/8                                        | 1/8 | 3/4                                          | 1/8 | 7/8                                           | 1/8 | 1                                             | 1/8 |
| Abrasive-cut: <sup>E,F</sup>   |                                                             |     |                                            |     |                                              |     |                                               |     |                                               |     |
| 3/16 to 1 1/4, incl            | 1/8                                                         | 1/8 | 1/8                                        | 1/8 | 1/8                                          | 1/8 | 1/8                                           | 1/8 | 1/8                                           | 1/8 |
| Over 1 1/4 to 2 3/4, incl      | 3/16                                                        | 1/8 | 3/16                                       | 1/8 | 3/16                                         | 1/8 | 3/16                                          | 1/8 | 3/16                                          | 1/8 |
| Plasma torch-cut: <sup>G</sup> |                                                             |     |                                            |     |                                              |     |                                               |     |                                               |     |
| 3/16 to 2, excl                | 1/2                                                         | 0   | 1/2                                        | 0   | 1/2                                          | 0   | 1/2                                           | 0   | 1/2                                           | 0   |
| 2 to 2 3/4, incl               | 5/8                                                         | 0   | 5/8                                        | 0   | 5/8                                          | 0   | 5/8                                           | 0   | 5/8                                           | 0   |
| Millimetres                    |                                                             |     |                                            |     |                                              |     |                                               |     |                                               |     |
| Sheared: <sup>D</sup>          |                                                             |     |                                            |     |                                              |     |                                               |     |                                               |     |
| 4.8 to 7.9, excl               | 4.8                                                         | 3.2 | 6.4                                        | 3.2 | 9.5                                          | 3.2 | 12.7                                          | 3.2 | ...                                           | ... |
| 7.9 to 12.7, excl              | 6.4                                                         | 3.2 | 9.5                                        | 3.2 | 9.5                                          | 3.2 | 12.7                                          | 3.2 | 15.9                                          | 3.2 |
| 12.7 to 19.1, excl             | 9.5                                                         | 3.2 | 9.5                                        | 3.2 | 12.7                                         | 3.2 | 15.9                                          | 3.2 | 19.1                                          | 3.2 |
| 19.1 to 25.4, excl             | 12.7                                                        | 3.2 | 12.7                                       | 3.2 | 15.8                                         | 3.2 | 19.1                                          | 3.2 | 22.2                                          | 3.2 |
| 25.4 to 31.8, incl             | 15.9                                                        | 3.2 | 15.9                                       | 3.2 | 19.1                                         | 3.2 | 22.2                                          | 3.2 | 25.4                                          | 3.2 |
| Abrasive-cut: <sup>E,F</sup>   |                                                             |     |                                            |     |                                              |     |                                               |     |                                               |     |
| 4.8 to 31.8, incl              | 3.2                                                         | 3.2 | 3.2                                        | 3.2 | 3.2                                          | 3.2 | 3.2                                           | 3.2 | 3.2                                           | 3.2 |
| Over 31.8 to 69.8, incl        | 4.8                                                         | 3.2 | 4.8                                        | 3.2 | 4.8                                          | 3.2 | 4.8                                           | 3.2 | 4.8                                           | 3.2 |
| Plasma torch-cut: <sup>G</sup> |                                                             |     |                                            |     |                                              |     |                                               |     |                                               |     |
| 4.8 to 50.8, excl              | 12.7                                                        | 0   | 12.7                                       | 0   | 12.7                                         | 0   | 12.7                                          | 0   | 12.7                                          | 0   |
| 50.8 to 69.8, incl             | 15.9                                                        | 0   | 15.9                                       | 0   | 12.7                                         | 0   | 12.7                                          | 0   | 12.7                                          | 0   |

<sup>A</sup> Permissible variations in width for powder- or inert arc-cut plate shall be as agreed upon between the manufacturer and the purchaser.

<sup>B</sup> Permissible variations in machined, powder-, or inert arc-cut circular plate shall be as agreed upon between the manufacturer and the purchaser.

<sup>C</sup> Permissible variations in plasma torch-cut sketch plates shall be as agreed upon between the manufacturer and the purchaser.

<sup>D</sup> The minimum sheared width is 24 in. (610 mm).

<sup>E</sup> The minimum abrasive-cut width is 2 in. (50.8 mm) and increases to 4 in. (101.6 mm) for thicker plates.

<sup>F</sup> These tolerances are applicable to lengths of 240 in. (6100 mm), max. For lengths over 240 in., an additional 1/16 in. (1.6 mm) is permitted, both plus and minus.

<sup>G</sup> The tolerance spread shown for plasma torch cutting may be obtained all on the minus side, or divided between the plus and minus side if so specified by the purchaser.

## 10. Number of Tests

10.1 *Chemical Analysis*—One test per lot.

10.2 *Mechanical Properties*—One test per lot.

## 11. Specimen Preparation

11.1 Tension test specimens shall be taken from material in the final condition (temper) and tested transverse to the direction of rolling when width will permit.

11.2 Tension test specimens shall be any of the standard or subsize specimens shown in Test Methods E 8.

11.3 In the event of disagreement, referee specimens shall be as follows:

11.3.1 Full thickness of the material, machined to the form and dimensions shown for the sheet-type specimen in Test Methods E 8 for material under 1/2 in. (12.7 mm) in thickness.

11.3.2 The largest possible round specimen shown in Test Methods E 8 for material 1/2 in. (12.7 mm) and over.

## 12. Test Methods

12.1 The chemical composition, mechanical, and other properties of the material as enumerated in this specification

shall be determined, in case of disagreement, in accordance with the following methods:

| Test               | ASTM Designation |
|--------------------|------------------|
| Chemical analysis  | E 1473           |
| Tension            | E 8              |
| Rounding procedure | E 29             |

12.2 For purposes of determining compliance with the specified limits for requirements of the properties listed in the following table, an observed value or a calculated value shall be rounded in accordance with the rounding method of Practice E 29.

| Test                                                              | Rounded Unit for Observed or Calculated Value                                                                                                                                                                                                                    |
|-------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Chemical composition, and tolerances (when expressed in decimals) | Nearest unit in the last right-hand place of figures of the specified limit. If two choices are possible, as when the digits dropped are exactly a 5, or a 5 followed only by zeros, choose the one ending in an even digit, with zero defined as an even digit. |
| Tensile strength and yield strength                               | nearest 1000 psi (6.9 MPa)                                                                                                                                                                                                                                       |
| Elongation                                                        | nearest 1 %                                                                                                                                                                                                                                                      |

TABLE 4 Permissible Variations in Length<sup>A</sup> of Sheared, Plasma-Torch-Cut,<sup>B</sup> and Abrasive-Cut Rectangular Plate<sup>C</sup>

| Specific Thickness             | Permissible Variation in Length for Lengths Given, in. (mm) |       |                                             |       |                                              |       |                                               |       |                                               |       |                                                 |       |                                                   |       |                      |       |
|--------------------------------|-------------------------------------------------------------|-------|---------------------------------------------|-------|----------------------------------------------|-------|-----------------------------------------------|-------|-----------------------------------------------|-------|-------------------------------------------------|-------|---------------------------------------------------|-------|----------------------|-------|
|                                | Up to 60<br>(1520), incl                                    |       | Over 60<br>to 96<br>(1520 to 2440),<br>incl |       | Over 96<br>to 120<br>(2440 to 3050),<br>incl |       | Over 120<br>to 240<br>(3050 to 6096),<br>incl |       | Over 240<br>to 360<br>(6096 to 9144),<br>incl |       | Over 360<br>to 450<br>(9144 to<br>11 430), incl |       | Over 450<br>to 540<br>(11 430 to<br>13 716), incl |       | Over 540<br>(13 716) |       |
|                                | Plus                                                        | Minus | Plus                                        | Minus | Plus                                         | Minus | Plus                                          | Minus | Plus                                          | Minus | Plus                                            | Minus | Plus                                              | Minus | Plus                 | Minus |
| Inches                         |                                                             |       |                                             |       |                                              |       |                                               |       |                                               |       |                                                 |       |                                                   |       |                      |       |
| Sheared: <sup>D</sup>          |                                                             |       |                                             |       |                                              |       |                                               |       |                                               |       |                                                 |       |                                                   |       |                      |       |
| 3/16 to 5/16, excl             | 3/16                                                        | 1/8   | 1/4                                         | 1/8   | 3/8                                          | 1/8   | 1/2                                           | 1/8   | 5/8                                           | 1/8   | 3/4                                             | 1/8   | 7/8                                               | 1/8   | ...                  | ...   |
| 5/16 to 1/2, excl              | 3/8                                                         | 1/8   | 1/2                                         | 1/8   | 1/2                                          | 1/8   | 1/2                                           | 1/8   | 5/8                                           | 1/8   | 3/4                                             | 1/8   | 7/8                                               | 1/8   | 1                    | 1/8   |
| 1/2 to 3/4, excl               | 1/2                                                         | 1/8   | 1/2                                         | 1/8   | 5/8                                          | 1/8   | 5/8                                           | 1/8   | 3/4                                           | 1/8   | 7/8                                             | 1/8   | 1 1/8                                             | 1/8   | 1 3/8                | 1/8   |
| 3/4 to 1, excl                 | 5/8                                                         | 1/8   | 5/8                                         | 1/8   | 5/8                                          | 1/8   | 3/4                                           | 1/8   | 7/8                                           | 1/8   | 1 1/8                                           | 1/8   | 1 3/8                                             | 1/8   | 1 5/8                | 1/8   |
| 1 to 1 1/4, incl               | 3/4                                                         | 1/8   | 3/4                                         | 1/8   | 3/4                                          | 1/8   | 7/8                                           | 1/8   | 1 1/8                                         | 1/8   | 1 3/8                                           | 1/8   | 1 5/8                                             | 1/8   | ...                  | ...   |
| Abrasive-cut: <sup>E</sup>     |                                                             |       |                                             |       |                                              |       |                                               |       |                                               |       |                                                 |       |                                                   |       |                      |       |
| 3/16 to 1 1/4, incl            | 1/8                                                         | 1/8   | 1/8                                         | 1/8   | 1/8                                          | 1/8   | 1/8                                           | 1/8   | 1/8                                           | 1/8   | 1/8                                             | 1/8   | ...                                               | ...   | ...                  | ...   |
| over 1 1/4 to 2 3/4, incl      | 3/16                                                        | 1/8   | 3/16                                        | 1/8   | 3/16                                         | 1/8   | 3/16                                          | 1/8   | 3/16                                          | 1/8   | 3/16                                            | 1/8   | ...                                               | ...   | ...                  | ...   |
| Plasma-torch-cut: <sup>F</sup> |                                                             |       |                                             |       |                                              |       |                                               |       |                                               |       |                                                 |       |                                                   |       |                      |       |
| 3/16 to 2, excl                | 1/2                                                         | 0     | 1/2                                         | 0     | 1/2                                          | 0     | 1/2                                           | 0     | 1/2                                           | 0     | 1/2                                             | 0     | 1/2                                               | 0     | 1/2                  | 0     |
| 2 to 2 3/4, incl               | 5/8                                                         | 0     | 5/8                                         | 0     | 5/8                                          | 0     | 5/8                                           | 0     | 5/8                                           | 0     | 5/8                                             | 0     | 5/8                                               | 0     | 5/8                  | 0     |
| Millimetres                    |                                                             |       |                                             |       |                                              |       |                                               |       |                                               |       |                                                 |       |                                                   |       |                      |       |
| Sheared: <sup>D</sup>          |                                                             |       |                                             |       |                                              |       |                                               |       |                                               |       |                                                 |       |                                                   |       |                      |       |
| 4.8 to 7.94, excl              | 4.8                                                         | 3.2   | 6.4                                         | 3.2   | 9.5                                          | 3.2   | 12.7                                          | 3.2   | 15.9                                          | 3.2   | 19.0                                            | 3.2   | 22.2                                              | 3.2   | ...                  | ...   |
| 7.94 to 12.7, excl             | 9.5                                                         | 3.2   | 12.7                                        | 3.2   | 12.7                                         | 3.2   | 12.7                                          | 3.2   | 15.9                                          | 3.2   | 19.0                                            | 3.2   | 22.2                                              | 3.2   | 25.4                 | 3.2   |
| 12.7 to 19.0, excl             | 12.7                                                        | 3.2   | 12.7                                        | 3.2   | 15.9                                         | 3.2   | 15.9                                          | 3.2   | 19.0                                          | 3.2   | 22.2                                            | 3.2   | 28.6                                              | 3.2   | 34.9                 | 3.2   |
| 19.0 to 25.4, excl             | 15.9                                                        | 3.2   | 15.9                                        | 3.2   | 15.9                                         | 3.2   | 19.0                                          | 3.2   | 22.2                                          | 3.2   | 28.6                                            | 3.2   | 34.9                                              | 3.2   | 41.3                 | 3.2   |
| 25.4 to 31.8, incl             | 19.0                                                        | 3.2   | 19.0                                        | 3.2   | 19.0                                         | 3.2   | 22.2                                          | 3.2   | 28.6                                          | 3.2   | 34.9                                            | 3.2   | 41.3                                              | 3.2   | ...                  | ...   |
| Abrasive-cut: <sup>E</sup>     |                                                             |       |                                             |       |                                              |       |                                               |       |                                               |       |                                                 |       |                                                   |       |                      |       |
| 4.8 to 31.8, incl              | 3.2                                                         | 3.2   | 3.2                                         | 3.2   | 3.2                                          | 3.2   | 3.2                                           | 3.2   | 3.2                                           | 3.2   | 3.2                                             | 3.2   | ...                                               | ...   | ...                  | ...   |
| over 31.8 to 69.9, incl        | 4.8                                                         | 3.2   | 4.8                                         | 3.2   | 4.8                                          | 3.2   | 4.8                                           | 3.2   | 4.8                                           | 3.2   | 4.8                                             | 3.2   | ...                                               | ...   | ...                  | ...   |
| Plasma-torch-cut: <sup>F</sup> |                                                             |       |                                             |       |                                              |       |                                               |       |                                               |       |                                                 |       |                                                   |       |                      |       |
| 4.8 to 50.8, excl              | 12.7                                                        | 0     | 12.7                                        | 0     | 12.7                                         | 0     | 12.7                                          | 0     | 12.7                                          | 0     | 12.7                                            | 0     | 12.7                                              | 0     | 12.7                 | 0     |
| 50.8 to 69.8, incl             | 15.9                                                        | 0     | 15.9                                        | 0     | 15.9                                         | 0     | 15.9                                          | 0     | 15.9                                          | 0     | 15.9                                            | 0     | 15.9                                              | 0     | 15.9                 | 0     |

<sup>A</sup> Permissible variations in length for powder- or inert arc-cut plate shall be agreed upon between the manufacturer and the purchaser.<sup>B</sup> The tolerance spread shown for plasma torch cutting may be obtained all on the minus side or divided between the plus and minus sides if so specified by the purchaser.<sup>C</sup> Permissible variations in machined, powder- or inert arc-cut circular plate shall be as agreed upon between the manufacturer and the purchaser.<sup>D</sup> The minimum sheared length is 24 in. (610 mm).<sup>E</sup> Abrasive cut applicable to a maximum length of 144 to 400 in. (3658 to 10 160 mm) depending on the thickness and width ordered.<sup>F</sup> The tolerance spread shown for plasma torch-cut sketch plates shall be as agreed upon between the manufacturer and the purchaser.

TABLE 5 Chemical Requirements

| Element         | Composition<br>Limits, % |
|-----------------|--------------------------|
| C               | 0.15 max                 |
| Mn              | 1.0 max                  |
| Si              | 1.0 max                  |
| P               | 0.015 max                |
| S               | 0.015 max                |
| Cr              | 28.0 min<br>33.0 max     |
| Cb              | 1.0 max                  |
| W               | 1.0 min<br>4.0 max       |
| Mo              | 9.0 min<br>12.0 max      |
| Fe              | 1.0 max                  |
| Al              | 1.0 max                  |
| Ti              | 1.0 max                  |
| Ni <sup>A</sup> | 51.0 min                 |
| Cu              | 0.50 max                 |

<sup>A</sup> Element shall be determined arithmetically by difference.



TABLE 6 Permissible Variations in Thickness and Overweight of Rectangular Plates

NOTE 1—All plates shall be ordered to thickness and not to weight per square foot. No plate shall vary more than 0.01 in. (0.3 mm) under the thickness ordered, and the overweight of each lot<sup>A</sup> in each shipment shall not exceed the amount given in the table. Spot grinding is permitted to remove surface imperfections, such as spots not to exceed 0.01 in. under the specified thickness.

| Specified Thickness,<br>in. (mm) | Permissible Excess in Average Weight <sup>B,C</sup> per Square Foot of Plates for Widths Given in Inches (Millimetres) Expressed in<br>Percentage of Nominal Weights |                                     |                                     |                                     |                                     |                                      |                                       |                                       |                                       |                                       |
|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|--------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|
|                                  | Under 48<br>(1220)                                                                                                                                                   | 48 to 60<br>(1220 to<br>1520), excl | 60 to 72<br>(1520 to<br>1830), excl | 72 to 84<br>(1830 to<br>2130), excl | 84 to 96<br>(2130 to<br>2440), excl | 96 to 108<br>(2440 to<br>2740), excl | 108 to 120<br>(2740 to<br>3050), excl | 120 to 132<br>(3050 to<br>3350), excl | 132 to 144<br>(3350 to<br>3660), excl | 144 to 160<br>(3660 to<br>4070), excl |
| 3/16 to 5/16 (4.8 to 7.9), excl  | 9.0                                                                                                                                                                  | 10.5                                | 12.0                                | 13.5                                | 15.0                                | 16.5                                 | 18.0                                  | ...                                   | ...                                   | ...                                   |
| 5/16 to 3/8 (7.9 to 9.5), excl   | 7.5                                                                                                                                                                  | 9.0                                 | 10.5                                | 12.0                                | 13.5                                | 15.0                                 | 16.5                                  | 18.0                                  | ...                                   | ...                                   |
| 3/8 to 7/16 (9.5 to 11.1), excl  | 7.0                                                                                                                                                                  | 7.5                                 | 9.0                                 | 10.5                                | 12.0                                | 13.5                                 | 15.0                                  | 16.5                                  | 18.0                                  | 19.5                                  |
| 7/16 to 1/2 (11.1 to 12.7), excl | 6.0                                                                                                                                                                  | 7.0                                 | 7.5                                 | 9.0                                 | 10.5                                | 12.0                                 | 13.5                                  | 15.0                                  | 16.5                                  | 18.0                                  |
| 1/2 to 5/8 (12.7 to 15.9), excl  | 5.0                                                                                                                                                                  | 6.0                                 | 7.0                                 | 7.5                                 | 9.0                                 | 10.5                                 | 12.0                                  | 13.5                                  | 15.0                                  | 16.5                                  |
| 5/8 to 3/4 (15.9 to 19.1), excl  | 4.5                                                                                                                                                                  | 5.5                                 | 6.0                                 | 7.0                                 | 7.5                                 | 9.0                                  | 10.5                                  | 12.0                                  | 13.5                                  | 15.0                                  |
| 3/4 to 1 (19.1 to 25.4), excl    | 4.0                                                                                                                                                                  | 4.5                                 | 5.5                                 | 6.0                                 | 7.0                                 | 7.5                                  | 9.0                                   | 10.5                                  | 12.0                                  | 13.5                                  |
| 1 to 2 (25.4 to 50.8), incl      | 4.0                                                                                                                                                                  | 4.0                                 | 4.5                                 | 5.5                                 | 6.0                                 | 7.0                                  | 7.5                                   | 9.0                                   | 10.5                                  | 12.0                                  |

<sup>A</sup> The term "lot" applied to this table means all of the plates of each group width and each group thickness.

<sup>B</sup> The permissible overweight for lots of circular and sketch plates shall be 25 % greater than the amounts given in this table.

<sup>C</sup> The weight of individual plates shall not exceed the nominal weight by more than 1 1/4 times the amount given in the table and Footnote B.

TABLE 7 Permissible Variations in Thickness for Rectangular Plates Over 2 in. (51 mm) in Thickness

NOTE 1—Permissible variation under specified thickness, 0.01 in. (0.3 mm).

| Specified Thickness, in. (mm)      | Permissible Variations, in. (mm), over Specified<br>Thickness for Widths Given, in. (mm) |                                 |                                  |                                   |                                    |                        |
|------------------------------------|------------------------------------------------------------------------------------------|---------------------------------|----------------------------------|-----------------------------------|------------------------------------|------------------------|
|                                    | To 36 (915), excl                                                                        | 36 to 60 (915 to<br>1520), excl | 60 to 84 (1520 to<br>2130), excl | 84 to 120 (2130 to<br>3050), excl | 120 to 132 (3050 to<br>3350), excl | 132 (3350 and<br>over) |
| Over 2 to 2 3/4 (51 to 69.8), incl | 1/16 (1.6)                                                                               | 3/32 (2.4)                      | 7/64 (2.8)                       | 1/8 (3.2)                         | 1/8 (3.2)                          | 9/64 (3.6)             |

TABLE 8 Permissible Variations in Thickness of Sheet and Strip  
(Permissible Variations, Plus and Minus, in Thickness, in. (mm), for Widths Given in in. (mm))

| Specified Thickness,<br>in. (mm), incl | Sheet <sup>A</sup>                                  |                                          |                        |                                          |
|----------------------------------------|-----------------------------------------------------|------------------------------------------|------------------------|------------------------------------------|
|                                        | Hot-Rolled                                          |                                          | Cold-Rolled            |                                          |
|                                        | 48 (1220) and<br>Under                              | Over 48 to 60<br>(1220 to 1520),<br>incl | 48 (1220) and<br>Under | Over 48 to 60<br>(1220 to 1520),<br>incl |
| 0.018 to 0.025 (0.5 to 0.6)            | 0.003 (0.08)                                        | 0.004 (0.10)                             | 0.002 (0.05)           | 0.003 (0.08)                             |
| Over 0.025 to 0.034 (0.6 to 0.9)       | 0.004 (0.10)                                        | 0.005 (0.13)                             | 0.003 (0.08)           | 0.004 (0.10)                             |
| Over 0.034 to 0.043 (0.9 to 1.1)       | 0.005 (0.13)                                        | 0.006 (0.15)                             | 0.004 (0.10)           | 0.005 (0.13)                             |
| Over 0.043 to 0.056 (1.1 to 1.4)       | 0.005 (0.13)                                        | 0.006 (0.15)                             | 0.004 (0.10)           | 0.005 (0.13)                             |
| Over 0.056 to 0.070 (1.4 to 1.8)       | 0.006 (0.15)                                        | 0.007 (0.18)                             | 0.005 (0.13)           | 0.006 (0.15)                             |
| Over 0.070 to 0.078 (1.8 to 1.9)       | 0.007 (0.18)                                        | 0.008 (0.20)                             | 0.006 (0.15)           | 0.007 (0.18)                             |
| Over 0.078 to 0.093 (1.9 to 2.4)       | 0.008 (0.20)                                        | 0.009 (0.23)                             | 0.007 (0.18)           | 0.008 (0.20)                             |
| Over 0.093 to 0.109 (2.4 to 2.8)       | 0.009 (0.23)                                        | 0.010 (0.25)                             | 0.007 (0.18)           | 0.009 (0.23)                             |
| Over 0.109 to 0.125 (2.8 to 3.2)       | 0.010 (0.25)                                        | 0.012 (0.31)                             | 0.008 (0.20)           | 0.010 (0.25)                             |
| Over 0.125 to 0.140 (3.2 to 3.6)       | 0.012 (0.31)                                        | 0.014 (0.36)                             | 0.008 (0.20)           | 0.010 (0.25)                             |
| Over 0.140 to 0.171 (3.6 to 4.3)       | 0.014 (0.36)                                        | 0.016 (0.41)                             | 0.009 (0.23)           | 0.012 (0.31)                             |
| Over 0.171 to 0.187 (4.3 to 4.8)       | 0.015 (0.38)                                        | 0.017 (0.43)                             | 0.010 (0.25)           | 0.013 (0.33)                             |
| Specified Thickness, in. (mm), incl    | Cold-Rolled Strip <sup>A,B</sup>                    |                                          |                        |                                          |
|                                        | Widths 12 in. (305 mm) and under, plus<br>and minus |                                          |                        |                                          |
| Up to 0.050 (1.27), incl               | 0.0015 (0.038)                                      |                                          |                        |                                          |
| Over 0.050 to 0.093 (1.27 to 2.39)     | 0.0025 (0.063)                                      |                                          |                        |                                          |
| Over 0.093 to 0.125 (2.39 to 3.18)     | 0.004 (0.11)                                        |                                          |                        |                                          |

<sup>A</sup> Measured 3/8 in. (9.5 mm) or more from edge except for strip under 1 in. (25.4 mm) in width which is measured at any place.

<sup>B</sup> Standard sheet tolerances apply for thickness over 0.125 in. (3.2 mm) and for all thicknesses of strip over 12 in. (305 mm) wide.



TABLE 9 Permissible Variations in Diameter for Circular Plates

| Specified Diameter, in. (mm)              |                         | Permissible Variations Over Specified Diameter for Thickness Given, in. (mm) <sup>A</sup> |       |                                          |       |
|-------------------------------------------|-------------------------|-------------------------------------------------------------------------------------------|-------|------------------------------------------|-------|
|                                           |                         | To $\frac{3}{16}$ (9.5), incl                                                             |       |                                          |       |
| 20 to 32 (508 to 813), excl               |                         | $\frac{1}{4}$ (6.4)                                                                       |       |                                          |       |
| 32 to 84 (813 to 2130), excl              |                         | $\frac{5}{16}$ (7.9)                                                                      |       |                                          |       |
| 84 to 108 (2130 to 2740), excl            |                         | $\frac{3}{8}$ (9.5)                                                                       |       |                                          |       |
| 108 to 140 (2740 to 3580), incl           |                         | $\frac{7}{16}$ (11.1)                                                                     |       |                                          |       |
|                                           |                         | Plasma Torch-Cut Plate <sup>B</sup>                                                       |       |                                          |       |
|                                           |                         | Permissible Variations in Specified Diameter for Thickness Given, in. (mm) <sup>C</sup>   |       |                                          |       |
| Specified Diameter, in. (mm) <sup>A</sup> | Thickness max, in. (mm) | $\frac{3}{16}$ to 2 (4.8 to 50.8), excl                                                   |       | 2 to $2\frac{3}{4}$ (50.8 to 69.8), incl |       |
|                                           |                         | Plus                                                                                      | Minus | Plus                                     | Minus |
| 19 to 20 (483 to 508), excl               | $2\frac{3}{4}$ (69.8)   | $\frac{1}{2}$ (12.7)                                                                      | 0     | $\frac{5}{8}$ (15.9)                     | 0     |
| 20 to 22 (508 to 559), excl               | $2\frac{3}{4}$ (69.8)   | $\frac{1}{2}$ (12.7)                                                                      | 0     | $\frac{5}{8}$ (15.9)                     | 0     |
| 22 to 24 (559 to 610), excl               | $2\frac{1}{2}$ (63.5)   | $\frac{1}{2}$ (12.7)                                                                      | 0     | $\frac{5}{8}$ (15.9)                     | 0     |
| 24 to 28 (610 to 711), excl               | $2\frac{1}{4}$ (57.3)   | $\frac{1}{2}$ (12.7)                                                                      | 0     | $\frac{5}{8}$ (15.9)                     | 0     |
| 28 to 32 (711 to 812), excl               | 2 (50.8)                | $\frac{1}{2}$ (12.7)                                                                      | 0     | $\frac{5}{8}$ (15.9)                     | 0     |
| 32 to 34 (812 to 864), excl               | $1\frac{3}{4}$ (44.5)   | $\frac{1}{2}$ (12.7)                                                                      | 0     | ...                                      | ...   |
| 34 to 38 (864 to 965), excl               | $1\frac{1}{2}$ (38.1)   | $\frac{1}{2}$ (12.7)                                                                      | 0     | ...                                      | ...   |
| 38 to 40 (965 to 1020), excl              | $1\frac{1}{4}$ (31.8)   | $\frac{1}{2}$ (12.7)                                                                      | 0     | ...                                      | ...   |
| 40 to 140 (1020 to 3560), incl            | $2\frac{3}{4}$ (69.8)   | $\frac{1}{2}$ (12.7)                                                                      | 0     | $\frac{5}{8}$ (15.9)                     | 0     |

<sup>A</sup> No permissible variations under.<sup>B</sup> Permissible variations in plasma torch-cut sketch plates shall be as agreed upon between the manufacturer and the purchaser.<sup>C</sup> The tolerance spread shown may also be obtained all on the minus side or divided between the plus and minus sides if so specified by the purchaser.

TABLE 10 Permissible Variations in Width of Sheet and Strip

| Specified Thickness,<br>in. (mm)       | Specified Width,<br>in. (mm)      | Permissible Variations<br>in Specified Width,<br>in. (mm) |              |
|----------------------------------------|-----------------------------------|-----------------------------------------------------------|--------------|
|                                        |                                   | Plus                                                      | Minus        |
| Sheet                                  |                                   |                                                           |              |
| Up to 0.250 (6.35)                     | All                               | 0.125 (3.18)                                              | 0            |
| Strip                                  |                                   |                                                           |              |
| Under 0.075 (1.9)                      | Up to 12 (305), incl              | 0.007 (0.18)                                              | 0.007 (0.18) |
|                                        | Over 12 to 48 (305 to 1219), incl | 0.062 (1.6)                                               | 0            |
| 0.075 to 0.100 (1.9 to 2.5), incl      | Up to 12 (305), incl              | 0.009 (0.23)                                              | 0.009 (0.23) |
|                                        | Over 12 to 48 (305 to 1219), incl | 0.062 (1.6)                                               | 0            |
| Over 0.100 to 0.125 (2.5 to 3.2), incl | Up to 12 (305), incl              | 0.012 (0.30)                                              | 0.012 (0.30) |
|                                        | Over 12 to 48 (305 to 1219), incl | 0.062 (1.6)                                               | 0            |
| Over 0.125 to 0.160 (3.2 to 4.1), incl | Up to 12 (305), incl              | 0.016 (0.41)                                              | 0.016 (0.41) |
|                                        | Over 12 to 48 (305 to 1219), incl | 0.062 (1.6)                                               | 0            |
| Over 0.160 to 0.187 (4.1 to 4.7), incl | Up to 12 (305), incl              | 0.020 (0.51)                                              | 0.020 (0.51) |
|                                        | Over 12 to 48 (305 to 1219), incl | 0.062 (1.6)                                               | 0            |

### 13. Inspection

13.1 Inspection of the material shall be made as agreed upon between the manufacturer and the purchaser as part of the purchase contract.

### 14. Rejection and Rehearing

14.1 Material that fails to conform to the requirements of this specification may be rejected. Rejection should be reported to the producer promptly and in writing. In case of dissatisfaction with the results of the test, the producer or supplier may make claim for a rehearing.

### 15. Certification

15.1 When specified in the purchase order or contract, a producer's or supplier's certification shall be furnished to the

purchaser that the material was manufactured, sampled, tested, and inspected in accordance with this specification and has been found to meet the requirements. When specified in the purchase order or contract, a report of the test results shall be furnished.

### 16. Product Marking

16.1 Each bundle or shipping container shall be marked with the name of the material or UNS number; condition (temper); this specification number; the size; gross, tare, and net weight; consignor and consignee address; contract or order number.

### 17. Keywords

17.1 plate; sheet; strip; N06110

**TABLE 11 Permissible Variations From Flatness of Rectangular, Circular, and Sketch Plates**

NOTE 1—Permissible variations apply to plates up to 12 ft (3.66 m) in length, or to any 12 ft of longer plates.

NOTE 2—If the longer dimension is under 36 in. (914 mm) the permissible variation is not greater than ½ in. (12.7 mm).

NOTE 3—The shorter dimension specified is considered the width, and the permissible variation in flatness across the width does not exceed the tubular amount of that dimension.

NOTE 4—The maximum deviation from a flat surface does not customarily exceed the tabular tolerance for the longer dimension specified.

| Specified Thickness | Permissible Variations from a Flat Surface for Thickness and Widths Given, in. (mm) |                                     |                                     |                                     |                                     |                                      |                                       |                                       |                           |
|---------------------|-------------------------------------------------------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|--------------------------------------|---------------------------------------|---------------------------------------|---------------------------|
|                     | To 48<br>(1220),<br>excl                                                            | 48 to 60<br>(1220 to<br>1520), excl | 60 to 72<br>(1520 to<br>1830), excl | 72 to 84<br>(1830 to<br>2130), excl | 84 to 96<br>(2130 to<br>2440), excl | 96 to 108<br>(2440 to<br>2740), excl | 108 to 120<br>(2740 to<br>3050), excl | 120 to 144<br>(3050 to<br>3660), excl | 144<br>(3660)<br>and over |
| Inches              |                                                                                     |                                     |                                     |                                     |                                     |                                      |                                       |                                       |                           |
| 3/16 to 1/4, excl   | 1½                                                                                  | 2⅞                                  | 2½                                  | 2¾                                  | 3¼                                  | 3¼                                   | ...                                   | ...                                   | ...                       |
| 1/4 to 3/8, excl    | 1⅞                                                                                  | 1½                                  | 1⅞                                  | 2¼                                  | 2¾                                  | 2⅞                                   | 3⅞                                    | 3¾                                    | ...                       |
| 3/8 to 1/2, excl    | 1                                                                                   | 1⅞                                  | 1⅞                                  | 1½                                  | 1⅞                                  | 2¼                                   | 2½                                    | 2⅞                                    | 3½                        |
| 1/2 to 3/4, excl    | 1                                                                                   | 1⅞                                  | 1¼                                  | 1¼                                  | 1⅞                                  | 2¼                                   | 2¼                                    | 2¼                                    | 2¾                        |
| 3/4 to 1, excl      | 1                                                                                   | 1⅞                                  | 1¼                                  | 1¼                                  | 1½                                  | 1⅞                                   | 1⅞                                    | 2                                     | 2¼                        |
| 1 to 2, excl        | 1                                                                                   | 1⅞                                  | 1⅞                                  | 1⅞                                  | 1⅞                                  | 1⅞                                   | 1⅞                                    | 1½                                    | 2                         |
| 2 to 2¾, incl       | ½                                                                                   | 5/8                                 | ¾                                   | 7/8                                 | 1                                   | 1⅞                                   | 1¼                                    | 1½                                    | 1¾                        |
| Millimetres         |                                                                                     |                                     |                                     |                                     |                                     |                                      |                                       |                                       |                           |
| 4.8 to 6.4, excl    | 38.1                                                                                | 54.0                                | 63.5                                | 69.8                                | 82.6                                | 82.6                                 | ...                                   | ...                                   | ...                       |
| 6.4 to 9.5, excl    | 34.9                                                                                | 38.1                                | 47.6                                | 57.2                                | 69.8                                | 73.0                                 | 79.4                                  | 95.2                                  | ...                       |
| 9.5 to 12.7, excl   | 25.4                                                                                | 28.6                                | 34.9                                | 38.1                                | 47.6                                | 57.2                                 | 63.5                                  | 73.0                                  | 88.9                      |
| 12.7 to 19.0, excl  | 25.4                                                                                | 28.6                                | 31.8                                | 31.8                                | 41.3                                | 57.2                                 | 57.2                                  | 57.2                                  | 69.8                      |
| 19.0 to 25.4, excl  | 25.4                                                                                | 28.6                                | 31.8                                | 31.8                                | 38.1                                | 41.3                                 | 47.6                                  | 50.8                                  | 57.2                      |
| 25.4 to 50.8, excl  | 25.4                                                                                | 28.6                                | 28.6                                | 28.6                                | 34.9                                | 34.9                                 | 34.9                                  | 38.1                                  | 50.8                      |
| 50.8 to 70.0, incl  | 12.7                                                                                | 15.9                                | 19.0                                | 22.2                                | 25.4                                | 28.6                                 | 31.8                                  | 38.1                                  | 44.4                      |

## APPENDIX

### (Nonmandatory Information)

#### X1. CONDITIONS AND FINISHES NORMALLY SUPPLIED

##### X1.1 Scope

X1.1.1 This appendix lists the conditions and finishes in which plate, sheet, and strip are normally supplied. These are subject to change and the manufacturer should be consulted for the latest information available.

##### X1.2 Plate

X1.2.1 Hot-rolled, annealed, and descaled.

##### X1.3 Sheet

X1.3.1 Hot-rolled, annealed, and descaled.

X1.3.2 Cold-rolled, annealed, and descaled or bright annealed.

##### X1.4 Strip

X1.4.1 Cold-rolled, annealed, descaled, or bright annealed.

*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).*