



Designation: B 432 – 91 (Reapproved 1998)

## Standard Specification for Copper and Copper Alloy Clad Steel Plate<sup>1</sup>

This standard is issued under the fixed designation B 432; 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 approval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This specification covers base metal plate of carbon steel or low-alloy steel to which a thickness of copper or copper alloy is continuously and integrally bonded on one or both sides.

1.2 The product is designated single-clad plate or double-clad plate depending upon whether one or both sides are clad.

1.3 This specification does not normally pertain to weld deposit clad plates.

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

### 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:

A 283/A283M Specification for Low and Intermediate Tensile Strength Carbon Steel Plates<sup>2</sup>

A 285/A285M Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength<sup>2</sup>

A 515/A515M Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service<sup>2</sup>

A 516/A516M Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service<sup>2</sup>

B 96 Specification for Copper-Silicon Alloy Plate, Sheet, Strip, and Rolled Bar for General Purposes and Pressure Vessels<sup>3</sup>

B 152 Specification for Copper Sheet, Strip, Plate, and Rolled Bar<sup>3</sup>

B 171 Specification for Copper-Alloy Plate and Sheet for Pressure Vessels, Condensers, and Heat Exchangers<sup>3</sup>

B 402 Specification for Copper-Nickel Alloy Plate and Sheet for Pressure Vessels<sup>4</sup>

E 8 Test Methods for Tension Testing of Metallic Materials<sup>5</sup>

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications<sup>6</sup>

### 3. Terminology

#### 3.1 Definitions:

3.1.1 *blank*—a piece of flat product intended for subsequent fabrication by forming, bending, cupping, drawing, hot pressing, and so forth.

3.1.2 *capable of*—the term “capable of” as used in this specification means that the test need not be performed by the producer of the material. However, should subsequent testing by the purchaser establish that the material does not meet these requirements, the material shall be subject to rejection.

3.1.3 *lengths*—straight pieces of the product.

3.1.3.1 *specific*—straight lengths that are uniform in length, as specified, and subject to established length tolerances.

3.1.4 *plate*—a wrought, flat product over 0.188 in. (5.0 mm) thick and over 12 in. (300 mm) wide, in straight lengths.

### 4. Ordering Information

4.1 Orders for products under this specification should include the following:

4.1.1 Quantity (number of pieces),

4.1.2 Name of product: clad steel plate (specify whether clad one or both sides) (1.2) and for tube sheets when applicable,

4.1.3 Base metal required (6.1.1),

4.1.4 Cladding metal required (6.1.2),

4.1.5 If tensile, bend, or shear tests are required (Section 9),

4.1.6 Dimensions: diameter or length and width of plate and thickness of each component (8.1 and 8.2),

4.1.7 Whether product is to be edge machined or flame cut (8.1.1 and 8.1.2),

4.1.8 Flatness tolerance, if required (see 8.3),

4.1.9 Specification number, and

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee B-5 on Copper and Copper Alloys and is the direct responsibility of Subcommittee B05.01 on Plate, Sheet, and Strip.

Current edition approved Nov. 15, 1991. Published January 1992. Originally published as B 432 – 66. Last previous edition B 432 – 76a (1989)<sup>ε1</sup>.

<sup>2</sup> *Annual Book of ASTM Standards*, Vol 01.04.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 02.01.

<sup>4</sup> Discontinued, see 1986 *Annual Book of ASTM Standards*, Vol 02.01.

<sup>5</sup> *Annual Book of ASTM Standards*, Vol 03.01.

<sup>6</sup> *Annual Book of ASTM Standards*, Vol 14.02.

4.1.10 Whether ultrasonic testing is required.

## 5. Materials and Manufacture

5.1 The cladding metal may be bonded to the base metal by any method that will produce a metallurgically bonded clad steel conforming to the requirements of this specification.

## 6. Chemical Composition

6.1 The clad plate shall conform to any desired combination of base metal and cladding metal components as described in the following paragraphs:

6.1.1 *Base Metal*—The base metal may be carbon steel or low-alloy steel, chemically conforming to an ASTM specification for steel plate. The chemical composition of a specified low-alloy steel not so covered shall be as agreed upon by the manufacturer or supplier and the purchaser. The base metal shall conform to the requirements of the specification to which it is ordered.

6.1.2 *Cladding Metal*—The cladding metal covered by this specification may include any copper or copper alloy that is specified and shall be made according to an ASTM specification covering that copper or copper alloy. If an ASTM specification is not available for that copper or copper alloy, agreement between the purchaser and manufacturer must be obtained before fabrication of the cladding metal as to chemical composition, mechanical properties, tolerances, and so forth.

## 7. Mechanical Requirements

7.1 The product, after bonding, with cladding removed shall be capable of meeting the minimum mechanical properties required of the specified base steel plate.

7.2 The minimum shear strength of the bond between the alloy cladding and base metal shall be 12 ksi (85 MPa).

7.3 When required by the purchase order, the clad steel plate shall be ultrasonically tested for bond integrity. See Supplementary Requirements.

## 8. Dimensions and Permissible Variations

### 8.1 Diameter, or Length and Width:

8.1.1 When clad plate is to be supplied in the edge machined condition, the following tolerances shall apply:

Diameter, or Length and Width	Tolerance, Plus and Minus
Under 60 in. (1.52 m)	1/16 in. (1.6 mm)
60 to 84 in. (1.52 to 2.13 m)	1/8 in. (3.2 mm)

8.1.2 When clad plate is to be supplied flame cut, tolerances shall be as agreed upon between purchaser and supplier.

8.2 *Thickness*—Components of clad plate shall be supplied in any standard gage with standard tolerances. Special gages and tolerances may be supplied by special arrangement.

### 8.3 Flatness:

8.3.1 The flatness of clad plate to be used as tube sheets shall be measured on the cladding component side across the diameter of the circular tube sheet or the width and length dimensions of a rectangular tube sheet and shall conform to the applicable tolerances in Table 1. Variations in flatness along the lengths of plate up to 18 ft (5.5 m) in length or along any 12-ft (3.7-m) length of plate longer than 18 ft (5.5 m) shall not exceed tabular amount specified for width of plate.

8.3.2 The flatness tolerance (maximum concavity across width or length) of rectangular clad plate intended for purposes other than tube sheet shall conform to Table 2 or shall be agreed upon between purchaser and producer.

8.3.3 Measurement of flatness shall be made by placing the plate on a flat surface, applying a straight edge across the plate, and measuring the depth of arc between the straight edge and the plate.

## 9. Workmanship, Finish, and Appearance

9.1 The material shall be free from defects of a nature that interferes with normal commercial operations. It shall be well cleaned and free of dirt. A superficial film of residual light lubricant is normally present and is permissible unless otherwise specified.

## 10. Sampling

10.1 All tests shall be made on specimens in the same condition and temper as that in which the composite plate is furnished.

10.2 Test specimens may be taken at the manufacturer's option from the excess portion of the material after the final cut to size or from separate pieces produced under the same specification and temper.

10.3 When the bend test samples are taken from the product to be supplied, these shall be taken from the middle of one end of the plate and the axis of the test coupon shall be transverse to the major axis of rolling of the plate.

## 11. Number of Tests

11.1 When specified, one or more tension tests, as required by the specification for the base metal one face-bend test (cladding metal in tension), one reverse-bend test (cladding metal in compression), and one shear test shall be made.

**TABLE 1 Flatness Tolerances for Tube Sheets, Clad One Side Only<sup>A</sup>**

Total Thickness, in. (mm)	Maximum Deviation from True Flatness <sup>B</sup> for a Given Diameter, Width, or Length, in. (mm)				
	To 48 (1219)	Over 48 (1219) to 72 (1829)	Over 72 (1829) to 96 (2438)	Over 96 (2438) to 120 (3048)	Over 120 (3048)
To 2½ (63.5)	1/8 (3.18)	1/8 (3.18)	3/16 (4.76)	1/4 (6.35)	1/2 (12.7)
Over 2½ (63.5) to 4 (102)	1/8 (3.18)	1/8 (3.18)	1/4 (6.35)	1/2 (12.7)	1/2 (12.7)
Over 4 (102) to 6 (152)	1/8 (3.18)	1/4 (6.35)	3/8 (9.52)	1/2 (12.7)	1/2 (12.7)
Over 6 (152) to 8 (203)	3/16 (4.76)	3/8 (9.52)	1/2 (12.7)	1/2 (12.7)	1/2 (12.7)

<sup>A</sup>Two side clads by special arrangement.

<sup>B</sup>Measured along the radial arms of a planar reference wheel placed on the plate.

TABLE 2 Flatness Tolerances for Plate Other than Tube Sheets

NOTE 1—Flatness Variations for Length—The longer dimension specified is considered the length, and variation in flatness along the length should not exceed the tabular amount for the specified width in plates up to 12 ft (3.66 m) in length or in any 12 ft (3.66 m) of longer plates.

NOTE 2—Flatness Variations for Width—The flatness variation across the width should not exceed the tabular amount for the specified width.

NOTE 3—When the longer dimension is under 36 in. (916 mm), the variation in flatness along the length and across the width should not exceed 1/4 in. (6.35 mm) in each direction. When the longer dimension is from 36 to 72 in. (916 to 1832 mm), inclusive, the flatness variation should not exceed 75 % of the tabular amount for the specified width, but in no case less than 1/4 in. (6.35 mm).

NOTE 4—The tolerances given in the above table apply to plates which have a minimum specified tensile strength not over 60 000 psi (415 MPa) or compatible chemistry or hardness. For plates specified to a higher minimum tensile strength or compatible chemistry or hardness, the limits given in the table are increased in 1 1/2 times the amounts in the table below.

NOTE 5—The table below and notes cover the flatness tolerances of circular and sketch plates based on the maximum dimensions of those plates.

Specified Thickness, in.	Variations from a Flat Surface for Specified Widths, in.										
	Over 8 to 36 excl	36 to 48 excl	48 to 60 excl	60 to 72 excl	72 to 84 excl	84 to 96 excl	96 to 108 excl	108 to 120 excl	120 to 144 excl	144 to 168 excl	168 and over
To 1/4, excl	9/16	3/4	15/16	1 1/4	1 1/8	1 1/2	1 5/8	1 3/4	1 7/8	...	...
1/4 to 3/8, excl	1/2	5/8	3/4	15/16	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	...	...
3/8 to 1/2, excl	1/2	9/16	5/8	5/8	3/4	7/8	1	1 1/8	1 1/4	1 7/8	2 1/8
1/2 to 3/4, excl	7/16	1/2	9/16	5/8	5/8	3/4	1	1	1 1/8	1 1/2	2
3/4 to 1, excl	7/16	1/2	9/16	5/8	5/8	5/8	3/4	7/8	1	1 3/8	1 3/4
1 to 2, excl	3/8	1/2	1/2	9/16	5/8	5/8	5/8	5/8	1 1/16	1 1/8	1 1/2
2 to 4, excl	5/16	3/8	7/16	1/2	1/2	1/2	1/2	9/16	5/8	7/8	1 1/8
4 to 6, excl	3/8	7/16	1/2	1/2	9/16	9/16	5/8	3/4	7/8	7/8	1

Specified Thickness, mm	Variations from a Flat Surface for Specified Widths, mm										
	Over 203 to 916 excl	916 to 1219 excl	1219 to 1524 excl	1524 to 1829 excl	1829 to 2134 excl	2134 to 2438 excl	2438 to 2743 excl	2743 to 3048 excl	3048 to 3658 excl	3658 to 4267 excl	4267 and over
To 6.35 excl	14.3	19.0	23.8	31.8	34.9	38.1	41.3	44.5	47.6	...	...
6.35 to 9.52 excl	12.7	15.9	19.0	23.8	28.6	31.8	34.9	38.1	41.3	...	...
9.52 to 12.7 excl	12.7	14.3	15.9	15.9	19.0	22.2	25.4	28.6	31.8	47.6	54.0
12.7 to 19.0 excl	11.1	12.7	14.3	15.9	15.9	19.0	25.4	25.4	28.6	38.1	50.8
19.0 to 25.4 excl	11.1	12.7	14.3	15.9	15.9	15.9	19.0	22.2	25.4	34.9	44.5
25.4 to 50.8 excl	9.5	12.7	12.7	14.3	14.3	15.9	15.9	15.9	27.0	28.6	38.1
50.8 to 102 excl	7.9	9.5	11.1	12.7	12.7	12.7	12.7	14.3	15.9	22.2	28.6
102 to 152 excl	9.5	11.1	12.7	12.7	14.3	14.3	15.9	19.0	22.2	22.2	25.4

12. Test Specimens

12.1 Tension and bend test specimens shall conform to the requirements prescribed in the specification for the base metal.

12.1.1 For base plates 1/2 in. (38.1 mm) and under in thickness, tension and bend test specimens shall be the full thickness of the material and shall be machined to the form and dimensions shown in Fig. 1, or the bend test specimens may be machined with both edges parallel. The sides of the bend test specimen may have the corners rounded to a radius not over 1/16 in. (1.59 mm).

12.1.2 For base plates over 1/2 in. (38.1 mm) in thickness, tension and bend test specimens need not be greater in thickness than 1 1/2 in. (38.1 mm), but shall not be less than 1 1/2 in. (38.1 mm). The sides of the bend test specimen may have the corners rounded to a radius not over 1/8 in. (3.2 mm). Specimens shall be in the form and dimensions shown in Fig. 2.

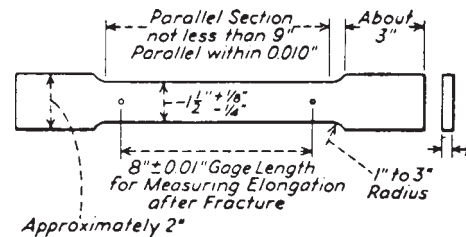
12.2 The shear test shall be made as indicated in Fig. 3.

13. Test Methods

13.1 The properties enumerated in this specification shall, in case of disagreement, be determined in accordance with the ASTM standards listed in 2.2.

14. Significance of Numerical Limits

14.1 For purposes of determining compliance with the specific limits for requirements of the properties listed in the



SI Equivalents			
in.	mm	in.	mm
0.01	0.254	1 1/2	38.1
1/8	3.18	2	50.8
1/4	6.35	3	76.2
1	25.4	8	203.2

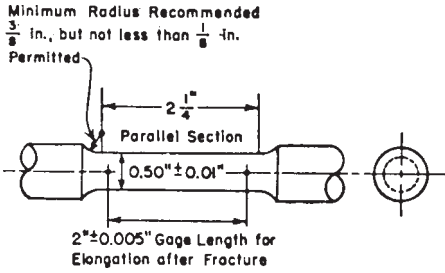
NOTE 1—When necessary, it is permissible to use a narrower specimen, but in such a case, the reduced portion shall not be less than 1 in. in width.

NOTE 2—Punch marks for measuring elongation after fracture shall be made on the flat or on the edge of the specimen and within the parallel section; either a set of nine punch marks 1 in. apart, or one or more sets of 8-in. punch marks may be used.

NOTE 3—The dimension *t* is the thickness of the test specimen as provided for in the applicable material specifications.

FIG. 1 Standard Rectangular Tension Test Specimen with 3-in. Gage Length

following tabulation, an observed value or calculated value

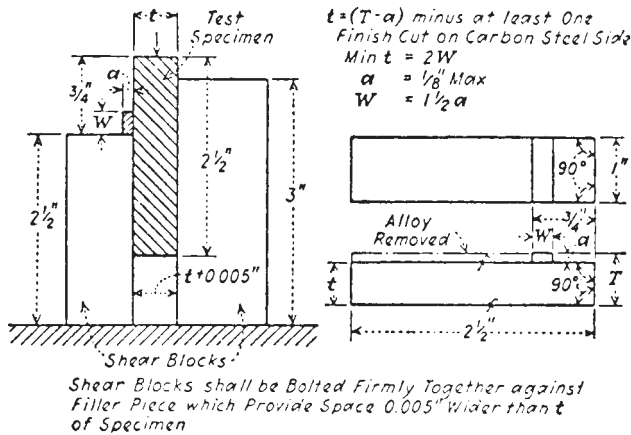


SI Equivalents

in.	mm	in.	mm
0.003	0.076	3/8	9.52
0.005	0.127	0.50	12.7
0.01	0.254	2	50.8
1/8	3.18	2 1/4	67.2

NOTE 1—The gage length and fillets shall be as shown, but the ends may be of any shape to fit the holders of the testing machine in such a way that the load shall be axial. The reduced section shall have a gradual taper from the ends toward the center, with the ends 0.003 to 0.005 in. larger in diameter than the center.

FIG. 2 Standard Round Tension Test Specimen with 2-in. Gage Length



SI Equivalents

in.	mm	in.	mm
0.005	0.127	1	25.4
1/8	3.18	2 1/2	63.5
3/4	19.1	3	76.2

FIG. 3 Test Specimen and Method of Making Shear Test of Clad Plate

shall be rounded as indicated in accordance with Recommended Practice E 29.

Property	Rounded Unit for Observed or Calculated Value
----------	--

Chemical composition

nearest unit in the last right hand place of figure of the specified limit

Tensile strength

nearest 1 ksi (nearest 5 MPa)

### 15. Inspection

15.1 The manufacturer shall inspect and make the tests necessary to verify that the product furnished conforms to the requirements of this specification.

15.2 If, in addition, the purchaser elects to perform a source inspection, the manufacturer shall afford the inspector representing the purchaser all reasonable facilities to satisfy him that the product is being furnished in accordance with this specification. All tests and the inspection shall be conducted so as not to interfere unnecessarily with the operation of the works.

### 16. Rejection

16.1 Should the product on receipt at destination be found not to conform to the specification, the product may be rejected and the manufacturer notified after receipt of the material.

### 17. Certification

17.1 When specified on the purchase order, the manufacturer shall furnish to the purchaser a certificate stating that each lot has been sampled, tested, and inspected in accordance with this specification, and has met the requirements herein.

### 18. Mill Test Report

18.1 When specified on the purchase order, the manufacturer shall furnish to the purchaser a test report showing results of the tests required by the specification.

18.2 When material is ordered to ASME Specification, mill test reports are mandatory.

### 19. Packaging, and Package Marking

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

19.2 Except as specified in 19.3, the name or brand of the manufacturer, the manufacturer's test identification number, the class of the base steel, the designation of the cladding metal, and the specified minimum tensile strength shall be legibly marked on each finished single clad plate in two places on the base steel side not less than 12 in. (305 mm) from the edges. The manufacturer's test identification number shall be legibly marked on each specimen.

19.3 For double-clad material or for material under 1/4 in. (6.35 mm) in thickness, the marking specified in 19.2 shall be legibly stenciled instead of stamped.

19.4 Each shipping unit shall be legibly marked with the purchase order number, metal or alloy description, temper, size, shape, gross and net weight, and name of supplier. The specification number shall be shown, when specified.

## SUPPLEMENTARY REQUIREMENTS

S1.1 The clad steel plate shall be ultrasonically tested for bond integrity. Unless otherwise specified, the bond parameters shall be as follows:

S1.2 *Tube Sheets*—Bond area shall be at least 98 % of the total interface area with individual non-bond areas not exceeding 1 in.<sup>2</sup>.

S1.3 *Other Applications*—Bond area shall be at least 95 % of the total interface areas with individual nonbond areas not exceeding 4 in.<sup>2</sup>.

## APPENDIX

## (Nonmandatory Information)

## X1. METRIC EQUIVALENTS

X1.1 The SI unit for strength properties now shown is in accordance with the International System of Units (SI). The derived SI unit for force is the newton (N), which is defined as that force which, when applied to a body having a mass of one kilogram, gives it an acceleration of one metre per second squared ( $N = \text{kg}\cdot\text{m}/\text{s}^2$ ). The derived SI unit for pressure or

stress is the newton per square metre ( $\text{N}/\text{m}^2$ ) which has been named the pascal (Pa) by the General Conference on Weights and Measures. Since  $1 \text{ ksi} = 6\,894\,757 \text{ Pa}$ , the metric equivalents are expressed as megapascal (MPa), which is the same as  $\text{MN}/\text{m}^2$  and  $\text{N}/\text{mm}^2$ .

*The American Society for Testing and Materials 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 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, 100 Barr Harbor Drive, West Conshohocken, PA 19428.*