



Designation: ~~B432-04~~ Designation: **B 432 – 09**

## 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 reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope\*

1.1 This specification ~~covers~~ establishes the requirements for plate of a carbon steel or low-alloy steel base to which is integrally and continuously bonded on one or both sides a layer of copper or copper-base alloy. The material is generally intended for pressure vessel use but may be used in other structural applications where corrosion resistance or conductivity of the alloy is of prime importance.

1.2 Units—The values stated in inch-pound units are to be regarded as ~~the~~ standard. The SI units values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

### 2. Referenced Documents

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

A 6/A 6M [Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling](#)

A 20/A 20M [Specification for General Requirements for Steel Plates for Pressure Vessels](#)

A 370 [Test Methods and Definitions for Mechanical Testing of Steel Products](#)

A 578/A 578M [Specification for Straight-Beam Ultrasonic Examination of ~~Plain and Clad~~ Rolled Steel Plates for Special Applications](#)

B96 ~~96/B 96M~~ [Specification for Copper-Silicon Alloy Plate, Sheet, Strip, and Rolled Bar for General Purposes and Pressure Vessels](#)

B 152/B 152M [Specification for Copper Sheet, Strip, Plate, and Rolled Bar](#)

B 171/B 171M [Specification for Copper-Alloy Plate and Sheet for Pressure Vessels, Condensers, and Heat Exchangers](#)

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

[ASTM B432-09](#)

<https://standards.iteh.ai/catalog/standards/sist/be2bb73c-ce9f-4cb9-bf55-9a0f966de19d/astm-b432-09>

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

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<sup>2</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.

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

**B 846 Terminology for Copper and Copper Alloys**

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

**2.2 ASME Code:**

Boiler and Pressure Vessel Code, Section VIII<sup>3</sup>

Boiler and Pressure Vessel Code, Section IX, Welding Qualifications<sup>3</sup>

**3. Terminology**

3.1

3.1 For definitions of terms related to copper and copper alloys, refer to Terminology B 846.

3.2 Definitions of Terms Specific to This Standard:

3.1.1

3.2.1 base metal (backing steel), n—component to which the cladding metal is applied, usually the greater percentage of the composite plate and usually consisting of carbon or low-alloy steel.

3.1.2

3.2.2 blind flange, n—same as a cover.

3.1.3

3.2.3 bonding, n—adhesion of one surface to another without the use of an adhesive as a bonding agent.

3.2.4 cladding metal, n—the copper or copper-base alloy component of the composite plate.

3.1.4

3.2.5 cover, n—a component with similar features to a tubesheet which is used as a closure and which typically requires surface machining over part of the face while maintaining minimum specified minimum thickness.

3.1.5

3.2.6 double-clad, n—material is considered as double-clad when both sides of the steel base metal are covered with copper cladding.

3.1.6

3.2.7 interface, n—of the clad product, is that region of the thickness in which the product transitions from essentially 100 % base metal to 100 % cladding metal, also referred to as the bond or bondzone.

3.1.7

3.2.8 integrally and continuously bonded, adv—a condition in which the cladding metal and base metal are brought together to form a metallurgical bond at essentially the entire interface of the two metals by means other than those processes that do not produce a homogeneous composite plate.

3.1.8

3.2.9 plate, n—the term plate as used in this specification applies to material 0.188 in. (4.77(4.78 mm) and over in thickness, and over 10 in. (254 mm) in width.

3.1.9 3.2.10 single-clad, n—material is considered as single-clad when only one side of the steel base metal is covered with copper cladding.

3.1.10

3.2.11 tubesheet, n—the term tubesheet as used in this specification applies to a clad plate, which is used in a heat exchanger to separate the tubeside and shell side components. Typically, but not necessarily, tubesheets are round, relatively thick, and require that the cladding and/or base be machined flat over part or all of the face while maintaining specified minimum thicknesses.

**4. Ordering Information**

~~4.1 It is the responsibility of the purchaser to specify all requirements that are necessary for material ordered under this specification. Such requirements may include, but are not limited to the following:~~

~~4.1.1 Quantity (weight or number of pieces);~~

~~4.1 Include the following information when placing orders for product under this specification, as applicable:~~

~~4.1.1 ASTM designation and year of issue,~~

~~4.1.2 Dimensions, including the thickness of the cladding alloy and the backing steel, or of the total composite plate, and if more or less restrictive thickness tolerances apply,~~

~~4.1.3 Cladding metal specification (see Section~~

~~4.1.3 Quantity—total weight or number of pieces of each size.~~

~~4.1.4 Cladding metal specification (see Section 6),~~

~~4.1.4 Base metal specification (see Section~~

~~4.1.5 Base metal specification (see Section 6),~~

~~4.1.5 Advise if the part is to be used as a tubesheet, cover, or blind flange;~~

<sup>3</sup> Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

~~4.1.6 Shear testing requirements if any (see Sections 7 and 8);~~

~~4.1.7 Restrictions, if required, on repair by welding (see Section~~

~~4.1.6 Advise if the part is to be used as a tubesheet, cover, or blind flange,~~

~~4.1.7 Restrictions, if required, on repair by welding (see Section 11);~~

~~4.1.8 Additions to the specification or special requirements.~~

~~4.2 The purchaser is referred to the listed supplementary requirements in this specification and to the detailed requirements in Specifications A 20/A 20M).~~

~~4.2 The following options are available and should be specified at the time of placing of the order when required:~~

~~4.2.1 Shear testing requirements if any (see Sections 7 and 8).~~

~~4.2.2 Certification,~~

~~4.2.3 Test Report,~~

~~4.2.4 Options presented in the Supplementary Requirements Section of this specification,~~

~~4.2.5 Additions to the specification or special requirements,~~

~~4.2.6 The purchaser is referred to the listed supplementary requirements in this specification and to the detailed requirements in Specifications A 20/A 20M or A 6/A 6M as applicable. If the requirements of this specification are in conflict with the requirements of Specification A 20/A 20M or A 6/A 6M, the requirements of this specification shall prevail.~~

## 5. Materials and Manufacture

~~5.1 Process~~Materials:

~~5.1.1 The steel shall be made by the open-hearth, electric-furnace (with separate degassing and refining optional), or basic-oxygen processes, or by secondary processes whereby steel made from these primary processes is remelted using, but not limited to electroslag remelting or vacuum arc remelting processes.~~

~~5.1.2 The cladding metal may be integrally and continuously bonded to the base metal by any method that will produce a clad steel that will conform to the requirements of this specification.~~

~~5.1.3~~

~~5.1.1 The base metal shall be manufactured in accordance with all applicable requirements of the base metal specifications (see 4.1.5).~~

~~5.1.2 The cladding metal shall be manufactured in accordance with all applicable requirements of the cladding metal specifications (see 4.1.4).~~

~~5.2 Manufacture:~~

~~5.2.1 The cladding metal shall be bonded to the base metal by any cladding operation that will produce a clad product which will conform to the requirements of this specification. Cladding methods are, but not limited to, explosion bonding, roll bonding, and weld overlay.~~

~~5.2.2 The cladding metal may be fabricated from multiple sheets or plates by edge butt welding prior to the cladding operation.~~

~~5.2.3 The cladding thickness may consist of multiple layers of the cladding metal.~~

~~5.3 Heat Treatment—Material shall be furnished in a condition that the manufacturer determines is most appropriate, unless a heat treatment is specified by the base metal specification, cladding material specification, or by mutual agreement between manufacturer and purchaser.—Unless otherwise specified or agreed between the purchaser and the manufacturer, all heat treatments shall be performed as needed in the cladding operation to assure the following:~~

~~5.3.1 The cladding metal conforms to the applicable requirements of the cladding metal specification.~~

~~5.3.2 The base metal conforms to the applicable requirements of the base metal specification, and~~

~~5.3.3 The clad bond exhibits optimum resistance to disbonding during common fabrication processes.~~

## 6. Chemical Composition

6.1 The clad plate shall conform to any combination of base metal and cladding metal as described in 6.2 and 6.3, and as agreed upon between the purchaser and the manufacturer.

6.2 *Base Metal*—The base metal may be carbon steel or low-alloy steel conforming to the ASTM specifications for steels for either pressure vessels or general structural applications, or other, as agreed upon by the purchaser and manufacturer. The base metal shall conform to the chemical requirements of the specification to which it is ordered.

6.3 *Cladding Metal*—The copper or copper-base alloy cladding metal specified shall conform to the requirements as to chemical composition prescribed in the respective cladding metal Specifications B 96/B 96M, B 152/B 152M, or B 171/B 171M, or other copper-base alloy specification as agreed upon by the purchaser and manufacturer.

## 7. Mechanical Requirements

7.1 *Tensile Property Requirements* :

7.1.1 Tensile tests shall be performed on the base metal only.

7.1.2 Tensile tests shall conform to the requirements of the Base Metal Specification.

7-2

**8. Performance Requirements**

8.1 Bond Strength Requirements :

7.2.1

8.1.1 Shear Strength Test—When required by:

8.1.1.1 When specified in the contract or purchase order, the minimum shear strength of the interface shall be 12 000 psi (84 MPa). The shear test, when specified, shall be made in the manner indicated in Fig. 1. The shear test is not applicable when the specified minimum cladding thickness is 0.075 in. (1.9 mm) or less.

7.2.2

8.1.2 Alternate Bond Strength Test—As an alternative to the shear strength test provided in 7.2.1 or when agreed upon by the purchaser and the manufacturer, three bend tests shall be made with the alloy cladding in compression to determine the quality of the bond. These bend tests shall be made using 1.5 in (38 mm) wide by full thickness specimens and shall be bent through an angle of 180° to the bend diameters provided for in the base metal specification. At least two of the three tests shall show not more than 50% separation on both edges of the bent portion. Greater separation shall be cause for rejection. The bond strength bend test is generally not recommended for cladding thicknesses where the shear test is applicable.

7.3 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 from the same heat under the same manufacturing conditions.

7.4 Additional mechanical tests may be performed. See Supplementary Requirements.

**8. Number of Tests and Retests**

8.1 One or more tension tests, as required by the base metal specification, and when specified, one shear test or three bond strength bend tests, as applicable, shall be made, representing each manufacturing lot. Each specimen shall be in the final condition of heat treatment required for the plate, including any SPWHT (Simulated Post Weld Heat Treatment) if required, Supplementary Requirement S3. A manufacturing lot shall be defined as all product from each base plate as-rolled which is clad under the same conditions.

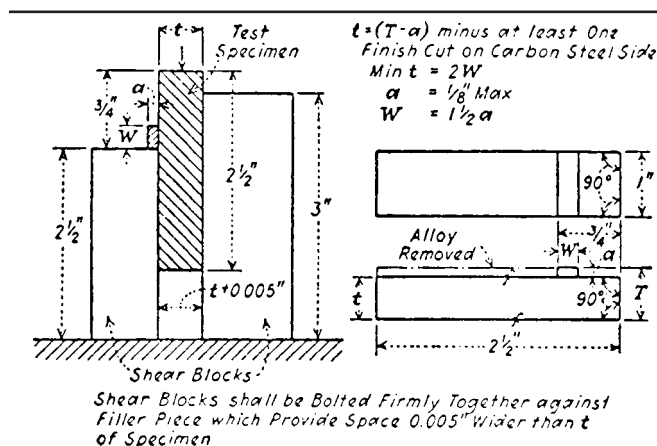
8.2 If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.;

8.1.2.1 As an alternative to the shear strength test provided in 8.1.1 or when agreed upon by the purchaser and the manufacturer, three bend tests shall be made with the alloy cladding in compression to determine the quality of the bond. These bend tests shall be made using 1.5 in (38 mm) wide by full thickness specimens and shall be bent through an angle of 180° to the bend diameters provided for in the base metal specification. If the base metal specification does not specify bend test diameter, the test diameter shall be times the test specimen thickness unless otherwise agreed upon. At least two of the three tests shall show not more than 50 % separation on both edges of the bent portion. Greater separation shall be cause for rejection. The bond strength bend test is generally not recommended for cladding thicknesses where the shear test is applicable.

8.2 Additional mechanical tests may be performed. See Supplementary Requirements.

**9. Test Specimens**

9.1 The tension test specimens shall conform to the requirements prescribed in the specifications for the base metal.



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. 1 Test Specimen and Method of Making Shear Test of Clad Plate**

9.2 When required by the purchaser, the shear test specimen shall be taken near a top or bottom corner of the plate as rolled, parallel to its longitudinal axis, or other location that is representative of the final product.

9.3 Bend test specimens for the alternative bond strength tests shall be taken at right angles to its longitudinal axis.

**10. Product Analysis**

10.1 Product analysis may be performed on the cladding metal, the base metal, or both, as specified in the contract.

10.2 When product analysis is specified for the cladding alloy on finished product, the chemical analysis may be accomplished by wet chemical or instrumental procedures. If wet chemical procedures are used, millings may be taken only when the composite plate thickness is sufficient to permit obtaining millings without danger of contamination from the adjacent layer. If spectrometric procedures are used, the sample shall be exposed on the center line of the cladding when there is sufficient cladding thickness available so that there is no contamination from the adjacent base metal.

10.3 If product analysis is specified by the purchaser for the cladding alloy, it shall be made on a sample taken from the finished product or a broken test specimen. For wet chemical analysis, in order to avoid contamination by the base plate metal, millings of cladding samples shall be taken from the test coupon by removal and discard of all the base metal plus 40% of the cladding thickness from the bonded side, not to exceed 0.063 in. (1.6 mm). The material shall be cleaned and sufficient millings taken to represent the full cross-section of the remainder.

10.4 The results of the product analysis shall conform to the requirements of the cladding metal and base metal specifications, as applicable.

10.5 Results of the product analysis for the backing steel when required shall conform to the requirements of Section 7 of Specification A20/A20M—Dimensions and Permissible Variations

9.1 Unless otherwise specified herein, permissible variations except for thickness shall be in accordance with Specifications A 20/A 20M or A 6/A 6M, as applicable.

**11. Dimensions and Permissible Variations**

11.1 Unless otherwise specified herein, permissible variations except for thickness shall be in accordance with Specification A20/A20M or A6/A6M as applicable based on the base metal specification.

11.2 Minimum 9.2 Minimum thickness of the alloy cladding metal and of the backing steel, or of the total composite plate, shall be as required by purchase order documents when ordered to minimum thickness.

11.3 Permissible 9.3 Permissible variation in thickness when ordered to nominal thicknesses shall be 0.01 in. (0.3(0.25 mm) under each for backing steel or total composite, and 0.03 in. (0.8(0.76 mm) under for the alloy cladding.

11.4 Permissible 9.4 Permissible variations for excess thickness of the total composite shall be the greater of 0.125 in. (3.2 mm) or 10 % of the total composite thickness ordered and may occur in either backing steel, cladding, or both, provided the minimum for each is met.

11.5 When 9.5 When the product is specified for use as tubesheets, covers, or blind flanges in the ordering information, the flatness tolerances of Table 1 shall apply, otherwise flatness shall be in accordance with Specifications A 20/A 20M or A 6/A 6M as applicable based on the base metal specification.

11.6 When 9.6 When the product is specified for use as tubesheets, covers, or blind flanges in the ordering information and a machined edge condition is specified, the diameter tolerances of Table 2 shall apply.

11.7 More 9.7 More restrictive or less restrictive permissible variations may be agreed upon by the purchaser and the manufacturer.

**12.10. Workmanship, Finish and Appearance**

12.1 The material shall be free of injurious defects and shall have a workmanlike appearance.

12.2 Unless otherwise specified, the clad surface may be supplied as-rolled, ground, blasted (descaled by means of sand, grit, shot or wire followed by pickling), or 100% conditioned.

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

**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)	⅛ (3.18)	⅛ (3.18)	⅜ (4.76)	¼ (6.35)	½ (12.7)
Over 2½ (63.5) to 4 (102)	⅛ (3.18)	⅛ (3.18)	¼ (6.35)	½ (12.7)	½ (12.7)
Over 4 (102) to 6 (152)	⅛ (3.18)	¼ (6.35)	⅜ (9.52)	½ (12.7)	½ (12.7)
Over 6 (152) to 8 (203)	⅜ (4.76)	⅜ (9.52)	½ (12.7)	½ (12.7)	½ (12.7)

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

<sup>B</sup> Measured distance from an imaginary plane representing the best fit to the part surface. Measurement methods may include, but are not limited to, planar grids, planar radial wheels, setup on a machining table, or laser surveying.



**TABLE 2 Outside Diameter Tolerances for Tubesheets, Covers, or Blind Flanges when a Machined OD is Specified**

Diameter	Tolerance, ±
Under 60 in. (1.52 m)	0.06 in. (1.5 mm)
60.0 to 84.0 in. (1.52 to 2.14 m)	0.12 in. (3.2 mm)
>84.0 in. (>2.13 m)	0.25 in. (6.4 mm)

10.2 Unless otherwise specified, the clad surface may be supplied as-rolled, ground, blasted (descaled by means of sand, grit, shot or wire followed by pickling), or 100 % conditioned.

10.3 The cladding metal shall be integrally and continuously bonded to the base metal.

## 11. Sampling

11.1 The lot size, portion size, and selection of sample pieces shall be taken according to the base metal specifications.

11.2 *Chemical Analysis*—A sample for chemical analysis from the finished clad product shall not be taken unless specified in the contract or purchase order. The copper sheet or strip that is used as the cladding for this product is to be sampled and tested as prescribed in its product specification (See 6.3). The steel plate that is used as the base metal in this product is to be sampled and tested as prescribed in either Specifications A 20/A 20M or A 6/A 6M.

## 12. Number of Tests and Retests

### 12.1 Test:

12.1.1 *Chemical Analysis*—When specified in the contract or purchase order that a chemical analysis shall be performed on the cladding metal, the base metal, or both, the tests shall be performed in accordance with the applicable requirements of the Cladding Metal and/or Base Metal Specifications.

### 12.2 Other Tests:

12.2.1 *Tensile Test*— One or more tension tests, as required by the base metal specification, and when specified, one shear test or three bond strength bend tests, as applicable, shall be made, representing each manufacturing lot. Each specimen shall be in the final condition of heat treatment required for the plate, including any SPWHT (Simulated Post Weld Heat Treatment) if required, Supplementary Requirement S3.

### 12.3 Retests:

12.3.1 When requested by the manufacturer or supplier, a retest shall be permitted when results of test obtained by the purchaser or supplier fail to conform to the requirements of the product specification.

12.3.2 The retest shall be as directed in the product specification for the initial test except that the number of test specimens shall be twice that normally required for the specified test.

12.3.3 Test results for all specimens shall conform to the product specification requirements in retest. Failure to conform shall be cause for rejection.

## 13. Bond Quality

~~13.1 The cladding metal shall be integrally and continuously bonded to the base metal. Specimen Preparation~~

### 13.1 Chemical Analysis:

13.1.1 Chemical Analysis may be performed on the cladding metal, the base metal, or both, as specified in the contract or purchase order.

13.1.2 When chemical analysis is specified for the cladding alloy on finished product, the analysis may be accomplished by wet chemical or instrumental procedures. If wet chemical procedures are used, millings may be taken only when the composite plate thickness is sufficient to permit obtaining millings without danger of contamination from the adjacent layer. If spectrometric procedures are used, the sample shall be exposed on the center line of the cladding when there is sufficient cladding thickness available so that there is no contamination from the adjacent base metal.

13.1.3 If chemical analysis is specified by the purchaser for the cladding alloy, it shall be made on a sample taken from the finished product or a broken test specimen. For wet chemical analysis, in order to avoid contamination by the base plate metal, millings of cladding samples shall be taken from the test coupon by removal and discard of all the base metal plus 40 % of the cladding thickness from the bonded side, not to exceed 0.063 in. (1.6 mm). The material shall be cleaned and sufficient millings taken to represent the full cross-section of the remainder.

13.1.4 The results of the chemical analysis shall conform to the requirements of the cladding metal and base metal specifications, as applicable.

### 13.2 Inspection Tensile Strength:

13.2.1 Clad plates less than 0.375 in. (9.5 mm) total minimum composite thickness shall be visually inspected for bond integrity prior to shipment.

13.2.2 Clad plates 0.375 in. (9.5 mm) and thicker total minimum composite thickness shall be ultrasonically inspected for bond integrity prior to shipment in accordance with the procedures and methods of Specification A578/A578M