



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

## 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 Steel Plates for Special Applications
- B 96 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
- E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

<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.

### 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 Definitions of Terms Specific to This Standard:

3.1.1 *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 *blind flange, n*—same as a cover.

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

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

3.1.9 *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 *tubesheet, n*—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

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

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

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),
- 4.1.2 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 6),
- 4.1.4 Base metal specification (see Section 6),
- 4.1.5 Advise if the part is to be used as a tubesheet, cover, or blind flange,
- 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 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 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:*

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 *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.

**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 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.

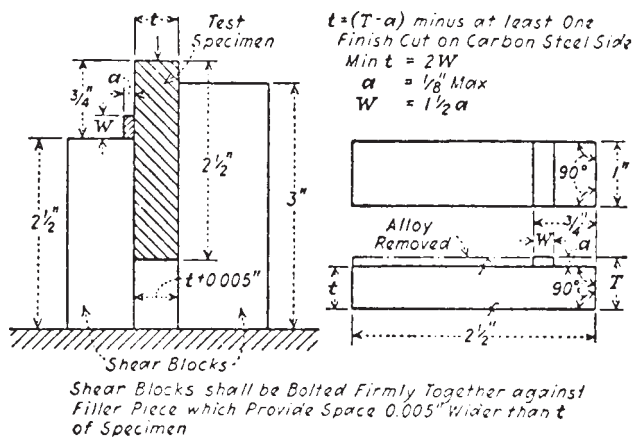
7.2 *Bond Strength Requirements:*

7.2.1 *Shear Strength Test*—When required by the purchaser, 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 *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.



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**

## 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.

## 9. Test Specimens

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

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 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 A 20/A 20M or A 6/A 6M as applicable based on the base metal specification.

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

11.4 Permissible variations for excess thickness of the total composite shall be the greater of 0.125 in. (3 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 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 A 20/A 20M or A 6/A 6M as applicable based on the base metal specification.

11.6 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 restrictive or less restrictive permissible variations may be agreed upon by the purchaser and the manufacturer.

## 12. 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.

## 13. Bond Quality

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

**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 (9.52)	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, $\pm$
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)

**13.2 Inspection:**

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 A 578/A 578M.

13.2.3 Areas of non-bond detected visually in 13.2.1 shall be explored ultrasonically to determine the extent of the condition per 13.2.2. For purposes of defining non-bond, the cladding shall be interpreted to be non-bonded when there is complete loss of back reflection accompanied by an echo indication from the plane of the interface of the clad and backing steel. Areas within 1 in. (25 mm) of a cut edge on the plate that contain indications exceeding 50 % of the back reflection at the bond interface shall be considered to be non-bonded.

13.2.4 The extent of ultrasonic examination shall be at the discretion of the manufacturer and sufficient to provide the quality level in 13.3 specified by the purchaser. Plates shall be examined with 100 % coverage when Supplementary Requirement S1 is specified.

**13.3 Quality Levels:**

13.3.1 *Class A*—No single unbonded area exceeding 1 in. (25 mm) in its longest dimension with total unbonded area not to exceed 1 % of the total clad surface area.

13.3.2 *Class B*—No single unbonded area exceeding 3 in. (75 mm) in its longest dimension with total unbonded area not to exceed 3 % of the total clad surface area.

13.3.3 *Class C*—No single unbonded area exceeding 9 in.<sup>2</sup> (58 cm<sup>2</sup>) with total unbonded area not to exceed 5 % of the total clad surface area.

13.3.4 The Class to be supplied shall be listed on the purchase order. When none has been specified, plates shall be furnished as Class C.

**14. Rework of Cladding by Welding**

14.1 The material manufacturer may rework defects in cladding by welding provided the following requirements are met:

14.1.1 When specified in the purchase order, prior approval shall be obtained from the purchaser.

14.1.2 The welding procedure and the welders or welding operators shall be qualified in accordance with ASME BPV Code Section IX, as applies to overlays.

14.1.3 The defective area shall be removed, and the area prepared for rework shall be examined by a liquid penetrant method compliant with ASME Code Section VIII, Division 1, Appendix 8, to ensure all defective area has been removed.

14.1.4 The rework weld shall be deposited in accordance with a welding procedure and welding materials suitable for the cladding material. The surface condition of the reworked area shall be restored to a condition similar to the rest of the cladding.

14.1.5 The reworked area shall be examined by a liquid penetrant method in accordance with ASME Code Section VIII, Division 1, Appendix 8.

14.1.6 The location and extent of the weld rework together with the rework procedure and examination results shall be transmitted as a part of the certification.

14.2 The material manufacturer may repair defects in the base metal by welding provided repairs are permitted in the base metal specification and are made in accordance with that specification.

**15. General Requirements for Delivery**

15.1 Material furnished under this specification shall conform to the applicable requirements of the current edition of Specification A 6/A 6M or A 20/A 20M as appropriate for the backing metal.

15.2 In the event of conflicts between this specification and the general delivery requirement specification for the backing steel, this specification shall apply.

**16. Certification**

16.1 The chemical analysis of the base metal and the alloy cladding shall be certified to the purchaser by the clad plate manufacturer.

16.2 The results of the tests in Section 7 and any other tests required by the purchase order shall be reported to the purchaser.

16.3 Compliance with the clad quality level of 13.3 shall be certified. Reports shall include the results of ultrasonic inspection when Supplementary Requirement S.1 is specified.

**17. Product Marking**

17.1 Except as specified in 17.2, plates shall be marked in accordance with the requirements of Specification A 6/A 6M or A 20/A 20M for the backing steel as applicable, the cladding alloy designation, and this specification number.

17.2 For double-clad material or for material under 0.375 in. (9.5 mm) nominal in thickness or for clad plates provided with conditioned surfaces, the marking specified in 17.1 shall be legibly stenciled instead of stamped.

**18. Keywords**

18.1 bond strength; clad; cladding; clad steel plate; copper; copper-base alloy; steel



**SUPPLEMENTARY REQUIREMENTS**

Supplementary requirements shall not apply unless specified on the order.

**S1. Ultrasonic Inspection of 100 % of Surface**

S1.1 Ultrasonic inspection shall be performed with scanning over 100 % of the plate surface.

**S2. Product Analysis**

S2.1 A product analysis shall be made on either the cladding metal, base metal, or both as specified in the purchase order.

S2.2 Testing shall be in accordance with Section 10 unless Section S2.4 applies.

S2.3 The testing frequency shall be agreed upon between purchaser and manufacturer.

S2.4 Product verification by Positive Metal Identification (PMI) techniques may be used as an alternate to the requirements of Section 10 when mutually agreed upon.

**S3. Simulated Post-Weld Heat Treatment of Mechanical Test Coupons**

S3.1 Prior to testing, the test specimens representing the plate for acceptance purposes for mechanical properties shall

be thermally treated to simulate a post-weld heat treatment , using the heat treatment parameters (such as temperature range, time, and cooling rates) specified in the order. The test results for such heat-treated test specimens shall meet the applicable product specification requirements.

**S4. Charpy V-Notch Impact Test**

S4.1 Charpy V-notch impact tests shall be conducted in accordance with Supplementary Requirement S5 of A 6 or A 20, as applicable for the base metal specification.

**S5. Ultrasonic Examination of Base Metal for Soundness in Accordance with Specification A 578/A 578M**

S5.1 All plates shall be ultrasonically examined for base metal soundness in accordance with the requirements of A 578/A 578M. The acceptance level shall be specified in the order.

**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  $\text{N}/\text{mm}^2$ .

**SUMMARY OF CHANGES**

Committee B05 has identified the location of selected changes to this standard since the last issue (B 432 – 91 (1998)) that may impact the use of this standard. (Approved May 1, 2004.)

- (1) Revised Scope, Referenced Documents, and Terminology sections.
- (2) Added mandatory ultrasonic testing requirements.
- (3) Added an alternative bond strength test (bend test).
- (4) Added weld rework criteria.
- (5) Added product analysis criteria.

- (6) Deleted the flatness table for plates, defaulting to the applicable steel flatness tables.
- (7) Deleted unique test specimens, defaulting to the applicable steel tests.
- (8) Deleted other unnecessary or obsolete sections.

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