



Designation: ~~B898-05~~<sup>ε1</sup> Designation: **B898 - 11**

## Standard Specification for Reactive and Refractory Metal Clad Plate<sup>1</sup>

This standard is issued under the fixed designation B898; 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.

~~ε<sup>1</sup>Note—11.1.2 was corrected editorially in July 2006.~~

### 1. Scope

1.1 This specification covers plate consisting of a base metal to which is bonded, integrally and continuously, on one or both sides a layer of one of the following: titanium, zirconium, tantalum, niobium, and their alloys. The material generally is intended for pressure vessel use.

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

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

### 2. Referenced Documents

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

A265 Specification for Nickel and Nickel-Base Alloy-Clad Steel Plate

A578/A578M Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications

B265 Specification for Titanium and Titanium Alloy Strip, Sheet, and Plate

B393 Specification for Niobium and Niobium Alloy Strip, Sheet, and Plate

B551/B551M Specification for Zirconium and Zirconium Alloy Strip, Sheet, and Plate

B708 Specification for Tantalum and Tantalum Alloy Plate, Sheet, and Strip

#### 2.2 ASME Code:<sup>3</sup>

Boiler and Pressure Vessel Code, Section ~~IX~~, IX Welding Qualifications

Boiler and Pressure Vessel Code, Section ~~VIII~~, VIII Divisions 1, 2, 3

#### 2.3 Military Standard:<sup>4</sup>

MIL-J-24445A Joint, Bimetallic Bonded, Aluminum to Steel

### 3. Terminology

#### 3.1 Definitions of Terms Specific to This Standard:

3.1.1 This material is considered as single-clad or double-clad dependent upon whether one or both sides of the base metal are covered by a cladding metal.

3.1.2 *base metal, n*—the component that comprises the greatest percentage of total thickness.

3.1.3 *cladding metal, or cladding metals, n*—the component, or components, which individually comprise less than the greatest percentage of total thickness.

3.1.4 *cladding operation, n*—the production event, which results in the formation of the bond between the cladding and base metal components, plus all related prebonding and post bonding operations, prior to supply to the purchaser.

3.1.5 *interface, n—of the clad product*, is that region of thickness in which the product transitions from essentially 100 % base

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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.

<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>.

<sup>4</sup> Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, <http://dodssp.daps.dla.mil>.

metal to 100 % cladding metal. Also known as bond or bond zone.

3.1.6 *interlayer, n*—a metal layer of a type or grade different from the cladding metal and base metal, which is applied between the cladding and base metal.

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.

#### 4. Ordering Information

4.1 Orders for material under this specification shall include the following information:

4.1.1 Quantity.

4.1.2 Product dimensions, including thickness of both cladding metal and base metal. It should state whether each thickness value is minimum or nominal. If not stated, thickness values shall be nominal.

4.1.3 Cladding metal type and specification (the cladding metal specification) (see Section 6).

4.1.4 Base metal type and specification (the base metal specification) (see Section 6).

4.1.5 Flatness requirements (see 10.3).

4.1.6 Ultrasonic inspection level (see Section 11).

4.1.7 Heat treatment requirements, if any.

4.1.8 Restrictions limiting or disallowing welding, or weld repair, or both, if any (see Section 12).

4.1.9 Any additional codes and standards specified by the purchaser or manufacturer.

4.1.10 Supplementary Requirements, if any.

4.1.11 Additional requirements, if any.

#### 5. Materials and Manufacture

5.1 *Process*:

5.1.1 The base metal shall be manufactured in accordance with all applicable requirements of the base metal specification (see 4.1.4).

5.1.2 The cladding metal shall be manufactured in accordance with all applicable requirements of the cladding metal specification (see 4.1.3).

5.1.3 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 may be, but are not limited to, explosion bonding, roll bonding, and weld overlay.

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

5.1.5 The cladding thickness may consist of multiple layers of the cladding metal.

5.2 *Heat Treatment*—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:

5.2.1 The cladding metal conforms to the applicable requirements of the cladding metal specification,

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

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

#### 6. Chemical Composition

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

6.2 *Cladding Metal*—The cladding metal shall conform to the requirements as to chemical composition prescribed in the applicable cladding metal specification: B265, B393, B551/B551M, or B708.

6.3 *Base Metal*—The base metal shall be steel or any other product conforming to specifications for metal plate. The base metal shall conform to the requirements as to chemical composition prescribed in the base metal specification.

#### 7. Mechanical Properties

7.1 The base metal shall conform to the mechanical property requirements prescribed in the base metal specification.

7.2 The mechanical properties of the cladding metal may not conform necessarily to the mechanical property requirements prescribed in the cladding metal specification unless otherwise agreed upon between manufacturer and purchaser.

7.3 Mechanical testing of the base metal, in accordance with the base metal specification, may be performed prior to the cladding operation if the cladding operation does not affect the applicable mechanical properties of the base metal.

7.4 Unless simulated post cladding heat treatments are specified by the purchaser, Supplementary Requirement S5, the mechanical test specimens shall be representative of the material in the heat treatment condition of product being shipped from the clad manufacturer.

7.5 *Tensile Strength Requirements* —The tensile properties shall be determined by a tension test on the base metal only in accordance with the testing requirements of the base metal specification. When tension test specimen are taken from the clad plate, the cladding shall be removed before tension tests are made.

7.6 *Bond Shear Strength*—When bond shear strength testing is specified, Supplementary Requirement S1, the bond shear strength of the clad product shall be 20 000 psi (137.9 MPa) minimum when tested in accordance with Fig. 1.

**8. Chemical Analysis**

8.1 When the cladding operation does not affect the chemical composition of the cladding or base metal, or both, the chemical analysis, in accordance with cladding, or base metal specifications, or both, may be performed prior to the cladding operation. Otherwise, chemical analysis of the applicable component or components shall be performed after the cladding operation in accordance with the cladding metal or base metal specifications, or both.

8.2 When chemical analysis of the finished product is invoked, Supplementary Requirement S4, the frequency of testing, specimen location, and testing methods shall be agreed upon between manufacturer and purchaser.

**9. Location and Number of Tests and Retests**

9.1 *Tension, Bend, and Impact Tests (When Required)*—The specimen orientation, location with respect to thickness, and number of tests and retests shall be in accordance with the requirements of the base metal specification. The test specimen location within the plate shall be at the manufacturer’s option.

**10. Dimensions and Flatness, Permissible Variations**

10.1 *Thickness:*

10.1.1 Cladding metal thickness tolerances shall be in accordance with Table 1.

10.1.2 Base metal thickness tolerances shall be in accordance with Table 2.

10.1.3 When the purchaser specifies flatness in accordance with 10.3.1.3 or 10.3.1.4, overgage tolerances in excess of those specified herein may be specified by the manufacturer.

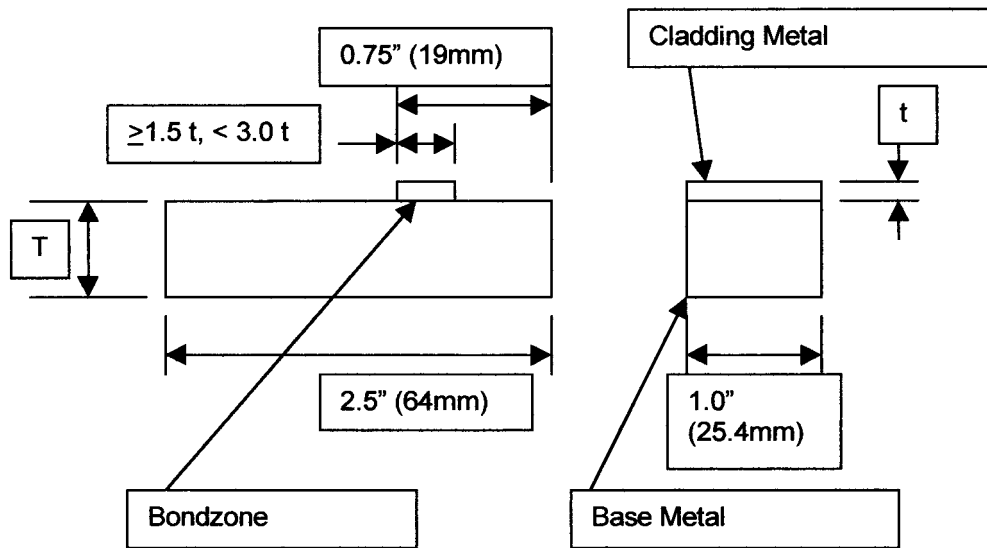
10.1.4 When agreed upon by the producer and the purchaser, overgage tolerances different from those specified herein shall apply.

10.1.5 When an interlayer metal is included in the product and when its thickness exceeds 0.005 in. (0.127 mm) nominal, its composition and nominal thickness shall be reported.

10.2 *Length and Width or Diameter Tolerances:*

10.2.1 Clad plates shall be supplied with edges cut to the dimensions specified by the purchaser. Cutting may be performed by thermal or mechanical means or any other method, which does not deleteriously affect the product quality. Clad plates shall conform to the length and width or diameter tolerances of Table 3 unless otherwise agreed upon between the manufacturer and purchaser.

10.2.2 When specified by the purchaser, clad plate shall be supplied in the as-clad or mill edge, condition. Minimum sound bond size shall be specified, and length and width tolerances of the as-supplied product shall be as agreed upon between purchaser and manufacturer. All edge nonbond areas outside of the specified minimum sound bond area shall be marked clearly on the surface, or the boundary of the required sound bond area shall be marked clearly on the sound bond portion of the surface, or both.



*t* = Cladding Metal Thickness—If > 0.125 in. (3.2 mm), machine to 0.125 in. (3.2 mm) max  
*T* = Base Metal Thickness—If base metal thickness > 1.0 in. (25.4 mm), it may be machined to 1.0 in. (25.4 mm) nominal.  
 Remove all cladding from base metal, except for area shown.  
 All corners are 90°.

**FIG. 1 Shear Test Specimen**

**TABLE 1 Cladding Metal Thickness Tolerance**

	When Cladding Metal Thickness is Specified			
	Minimum		Nominal	
Specified Thickness	≤ 0.150 in.	> 0.150 in.	< 0.188 in.	≥ 0.188 in.
Undergage Tolerance	0	0	0.030 in.	0.060 in.
Overgage Tolerance	100 % of min	50 % of min	100 % of nominal	50 % of nominal

**TABLE 1M Cladding Metal Thickness Tolerance**

	When Cladding Metal Thickness is Specified			
	Minimum		Nominal	
Specified Thickness	≤ 3.8 mm	> 3.8 mm	< 4.8 mm	≥ 4.8 mm
Undergage Tolerance	0	0	0.75 mm	1.5 mm
Overgage Tolerance	100 % of specified minimum	50 % of specified minimum	100 % of specified nominal	50 % of specified nominal

**TABLE 2 Base Metal Thickness Tolerance**

	When Base Metal Thickness is Specified			
	Minimum		Nominal	
Specified Thickness	< 1.0 in.	≥ 1.0 in.	< 1.0 in.	≥ 1.0 in.
Undergage Tolerance	0	0	0.01 in.	0.01 in.
Overgage Tolerance	0.21 in. over min	0.26 in. over min	0.20 in. over nominal	0.25 in. over nominal

**TABLE 2M Base Metal Thickness Tolerance**

	When Base Metal Thickness is Specified			
	Minimum		Nominal	
Specified Thickness	< 25.4 mm	≥ 25.4 mm	< 25.4 mm	≥ 25.4 mm
Undergage Tolerance	0	0	0.25 mm	0.25 mm
Overgage Tolerance	5.3 over specified minimum	6.6 over specified minimum	5.1 over specified nominal	6.4 over specified nominal

**TABLE 3 Length and Width, or Diameter, Tolerance**

Total Thickness	Permissible Variation from Specified Length and Widths or Diameter
<2.0 in.	-0, + 0.8 in.
≥ 2.0 in., < 4.0 in.	-0, + 1.0 in.
≥ 4.0 in., <8.0 in.	-0, + 1.5 in.
≥ 8.0 in.	per agreement

**TABLE 3M Length and Width, or Diameter, Tolerance**

Total Thickness	Permissible Variation from Specified Length and Widths or Diameter
<50 mm	-0, + 20 mm
≥ 50, <100	-0, + 25 mm
≥ 100, <200	-0, + 38 mm
≥ 200mm	per agreement

### 10.3 Flatness:

10.3.1 Flatness of the clad plate shall be in accordance with one of the following flatness tolerance requirements. When flatness requirements are not specified by the purchaser, flatness tolerances of 10.3.1.1 shall apply.

10.3.1.1 *Standard Plate Flatness*—Out-of-flatness of the cladding face shall not exceed the requirements of Table 4. This flatness criteria typically is applicable for clad plates intended for subsequent forming, or fabrication, or both.

10.3.1.2 *Special Flatness*—Out-of-flatness of the cladding face shall not exceed 0.100 in. (2.5 mm) over any 36-in. (915-mm) span. This flatness criteria typically is applicable for plates used in the flat condition.

10.3.1.3 *Machined Flatness*—Out-of-flatness of one or both faces, as specified by the purchaser, shall not exceed 0.010 in. (0.25 mm) over any 36-in. (915-mm) span.

10.3.1.4 *Suitable for Machining Flat*—The material shall be supplied in a condition suitable for subsequent machining of specified face or faces while protecting minimum specified thickness. The combination of the flatness of the product and the thickness of the component metals shall permit the cladding metal, or the base metal, or both, as specified by the purchaser, to be