

# AN INTRODUCTION TO ASTM B898, THE REACTIVE AND REFRACTORY CLAD METAL PLATE SPECIFICATION

**John G. Banker, V.P., DMC Clad Metal Div.**  
**5405 Spine Road**  
**Boulder, CO 80301 USA**  
**e-mail : jbanker@dynamicmaterials.com**  
**Phone : 1.303.604.3915**  
**Fax : 1.303.604.1893**

Presented at Wah Chang  
Reactive Metal Conference, 12  
September 2001. Published in  
proceedings.

## ABSTRACT

In 1999 the ASTM B10 committee Task Force on Clad Metal completed development and approvals of a specification covering Reactive and Refractory Metal Clad Plate. The task force effort included participation by representatives from equipment fabricators, chemical companies, metal manufacturers, explosion clad producers and rollbond clad producers. Participation was global . B898 applies to clad of any-type manufacture, consisting of reactive or refractory metals and their alloys clad onto steel or any other structural metal. The presentation describes the basic details covered by the specification to assure that product technical requirements are properly addressed without unnecessarily burdening manufacturing costs. It will also review product quality and testing options available within the specification.

## KEY WORDS

Titanium, Zirconium, Tantalum, Clad metal, Explosion Clad, ASTM, Specification

## INTRODUCTION AND BACKGROUND

Clad plate products consisting of a thin layer of reactive (or refractory) metal integrally bonded onto a lower cost, thicker base metal, have been used in construction of corrosion resistant process equipment for over 30 years. The most extensively used product has been titanium clad to steel. There has also been significant production of zirconium and tantalum clad plates. There were no industry wide or internationally accepted specifications covering titanium, zirconium and tantalum clad plates. Typically the clad materials were produced to a manufacturer's or purchaser's proprietary specifications.

Explosion cladding was the primary technology for manufacturing these clad products. The dominant explosion cladding companies recognized the potential benefits of an internationally accepted specification. In 1990, initial efforts to develop a unified specification were undertaken by the International Explosion Metalworking Association (IEMA)<sup>1</sup>, a worldwide association of explosion clad manufacturing companies. This effort resulted in the development of IEMA Guidenote 100, a recommended specification guideline for clad plate for the pressure vessel industry. Each IEMA member company then revised its proprietary specifications appropriately. This resulted in uniformity of proprietary specifications within the explosion cladding industry.

---

<sup>1</sup> IEMA was disbanded in 1996. Guidenote 100 is available from DMC Clad Metal Division, Boulder, CO USA.

In the mid 1990's, several of the IEMA member companies initiated an effort to develop an industry wide specification accepted universally by manufacturers, fabricators, and owners, to replace the proprietary specifications. ASTM was the logical platform for this effort. After review of precedent set with other clad specifications, the ASTM B10 Committee for Reactive and Refractory Metals agreed that it was the appropriate base committee for this subject. In 1997, ASTM B10 established a Clad Metal Taskforce to evaluate the need for a new specification and proceed with specification development as appropriate. The initial draft of the proposed specification was a blend of the requirements of IEMA Guidenote 100 and the four existing ASTM specifications for clad plates (A263 and A264 for stainless steel clad, A265 for nickel alloy clad, and B432 for copper alloy clad. Reference 1,2,3,4)

The B10 Clad Metal Task force was comprised of members representing clad metal manufacturers, cladding alloy suppliers and clad equipment fabricators. During the specification development and review effort, a considerably broader group was brought into the discussion. The clad metal manufacturers included both explosion cladders and rollbond cladders from North America, Europe, and Japan. Comments were received from reactive metal manufacturing companies in these regions plus former Soviet countries and China. Equipment fabricators from Europe, North America, Japan, and Australia provided additional specification input. The primary equipment owner companies who contributed to the review effort were from the US. In 1999, the B10 Committee approved the proposed specification, assigning number B898 (Ref. 5). Overall the development of B898 was a worldwide and industry wide consensus effort.

### **HIGHLIGHTS OF ASTM B898**

**Scope:** ASTM B898 applies to clad plates consisting of titanium, zirconium, tantalum, niobium, and their alloys integrally bonded to a base metal plate of steel or any other metal. The cladding may be performed by any technology which produces a compliant product. Cladding methods may be, but are not limited to, explosion bonding, roll bonding, and weld overlay.

**Cladding Metal Requirements:** The cladding alloys are limited to those covered by ASTM B265, B393, B551, and B708. The cladding metal must comply with the chemical, metallurgical, and heat treatment requirements of the applicable specification. As with all other ASTM clad specifications, and IEMA Guidenote 100, the cladding metal is exempt from the mechanical property requirements of the parent specification, unless specifically required in the clad metal purchase contract. This is a common specification exception for two primary reasons: the cladding metal is typically required for corrosion allowance only, and the cladding metal is typically thin making verification of mechanical properties in the cladding layer quite difficult.

**Base Metal Requirements:** The base metal specification must be specified by the purchaser. Manufacture is not limited to ASTM specification metals. The base metal must comply with all technical requirements of the base metal specification. If heat treatments are required during manufacture, or if simulated post delivery heat treatments are specified by the purchaser, the mechanical tests used for certification must include all of these heat treatments.

**Mechanical Properties:** The mechanical properties of the cladding and base metals are as specified above. The shear strength of the bonded product shall be no less than 20,000 psi (137.9 Mpa) when tested using the standard ASTM clad shear test specimen, B898 Figure 1. Shear testing of plates supplied on a contract is not mandatory. It is the manufacturer's responsibility to perform adequate

testing to assure that his product will meet the minimum requirements when and if tested. Supplementary Requirement S1 can be specified which mandates performance of shear tests.

Non-destructive Bond Testing: All plates manufactured under B898 shall be inspected for bond integrity using the ultrasonic testing (UT) procedures of ASTM A578. Acceptance/rejection criteria of B898 is different from A578. Three UT Acceptance Criteria for the clad bond are specified, Table 1.

*Table I: B898 Ultrasonic Testing Options*

| UT Option | Inspection Coverage       | Maximum Indication               | Min. Sound Bond Area |
|-----------|---------------------------|----------------------------------|----------------------|
| Class A   | 100% of surface           | 25 mm longest dimension (1.0 in) | 99.0%                |
| Class B   | 100% of surface           | 75 mm longest dimension (3 in)   | 97.0%                |
| Class C   | 230 mm (9 in) square grid | 58 sq cm area (9-square inches)  | 95.0%                |

Dimensional Tolerances: Tolerances on length and width are typical for mill produced plates. Plates may require re-cutting and re-squaring before they would be suitable for fabrication into pressure vessel cylinders. Thicknesses undergage tolerances are similar to those of the component metal specifications, but overgage tolerances are greater. This is primarily driven by of the compounding of tolerances of the component metals. Special attention should be paid to overgage tolerances when determining plate lengths for rolling into cylinders, actual tubesheet blank thicknesses, and as produced clad product weights.

Flatness: Flatness requirements for plates are typical of those for mill produced plates. Measuring methods are simplified from those of the other ASTM clad specifications, reducing compliance debate. Since clad plates are frequently used for heat exchanger tubesheets, two “Special Flatness” options are specified. When “Machined Flatness” is specified, the products are to be machined flat within 0.01” (0.25mm) over any 36” (915mm). When “Suitable for Machining Flat” is specified, the product shall exhibit suitable flatness and thickness overgage to allow the part to be machined flat by the purchaser without reducing thickness below the permitted minimums. (This assumes proper set-up for machining by the purchaser.)

Interlayers and Multiple Layers: B898 permits a manufacturer to achieve the specified cladding metal thickness by cladding of multiple layers when needed. This is not an unusual approach for some tubesheet requirements where cladding metal thicknesses are high to allow for retained gaskets or similar features. B898 also permits use of a third metal interlayer between the cladding plate and the base plate when determined necessary by the manufacturer. Since thicker interlayer sheets may affect subsequent operations, such as fabrication welding, the thickness and composition of any interlayer exceeding 0.005” (0.127mm) must be reported to the customer.

Welding: B898 permits the welding of cladding metal sheets together prior to cladding (edge butt welds), to produce cladding sheets that are larger than those available from the producing mills. Rework by welding can only be performed after approval by the purchaser. All welds are to be made in accordance with the requirements of ASME Section IX. All welds in the delivered product shall be inspected over 100% of the weld area by PT after completion of all relevant manufacturing operations, acceptance is per ASME Section VIII Div. 1. All repair welds made to the base metal must conform to

the requirements of ASME Section VIII Div. 1. The purchaser may disallow cladder seam welds or require approval of all welds and procedures. Any references to ASME Codes may be replaced with mutually agreed alternative construction codes.

B898 allows fusion weld rework of nonbond areas when an acceptable procedure is demonstrated by the manufacturer and approved by the purchaser. At the time that B898 was created, there were no known, appropriate procedures for repair of nonbonds in any of the products with a steel base metal.

Certification: Certification requirements are typical for similar products supplied for pressure vessel and corrosion control applications.

Supplementary Requirements: Many of the potential but less common testing and inspection operations are incorporated as Supplementary Requirements. These include:

S1: Mandatory Bond Shear Strength Testing

S2: Ductility Bend Tests (ASTM B263,4,5 type)

S3: Side Bend Tests (AD W8 type)

S4: Product Chemical Analysis

S5: Simulated Heat Treatment of Mechanical Test Coupons

S6: Impact Testing

S7: Component Metal Ultrasonic Inspection

S8: Bond Tensile Strength Tests

S9: Criteria When the Cladding Metal is part of the Design Strength Requirement. (Presently not allowed in ASME Code design.)

## **CONCLUSION**

ASTM B898 provides an internationally accepted alternative to proprietary specifications for titanium, zirconium, niobium, and tantalum clad plate. Extensive review and input internationally by equipment owners, fabricators, clad manufacturers, and metal suppliers assures that the concerns of each stakeholder are adequately addressed in the specification. B898 is truly and international consensus specification.

## **ACKNOWLEDGMENTS**

Many people worked together to make B898 as success. Special thanks must be given to the Chairman of the B10 Committee, Badri Narayan, to Chairman of the B10.01 Subcommittee, Jim Grauman, to Tim Brooke, the ASTM Staff Adviser, to members of the original Clad Task Force, including David Frey, Vladimir Belov, Ned Huber, and to all who helped during specification development and review. A special thanks also to Elmar Upitis who volunteered his time to do the detailed editing, formatting, and clean-up.

## **REFERENCES**

[1] ASTM A263, "Standard Specification for Corrosion-Resisting Chromium Steel-Clad Plate, Sheet, and Strip", ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428 USA

[2] ASTM A264, “Standard Specification for Stainless Chromium-Nickel Steel-Clad Plate, Sheet, and Strip”, ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428 USA

[3] ASTM A265, “Standard Specification for Nickel and Nickel-Base Alloy-Clad Steel Plate”, ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428 USA

[4] ASTM B432, “Standard Specification for Copper and Copper Alloy Clad Steel Plate”, ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428 USA

[5] ASTM B898, “Standard Specification for Reactive and Refractory Metal Clad Plate”, ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428 USA