



DMC Specification for Detaclad® Explosion Clad
DMC 100 Rev 0(a)
NC501 Rev 6
PD103 Rev D¹

1 November 2006

1. Scope

This specification covers DMC Detaclad® Explosion Clad products which are intended for pressure vessel use.

Table 1: Summary of Tests and Inspections for Detaclad Plates

Test	Section in Spec.	When Performed
Base Metal Tensile	Sec. 8	Always
Base Metal Chemical	Sec. 9	Always
Cladding Metal Chemical	Sec. 9	Always
Ultrasonic Inspection of Bond	Sec. 12	Always
Dimension Inspection	Sec. 11	Always
Flatness Inspection	Sec. 11.3	Always
Certifications for All Tests	Sec. 16	Always
Base Metal Ultrasonic Inspection	Sec. 12	When required by the Contract
Cladding Metal Ultrasonic Inspection	Sec. 12	When required by the Contract
Bond Shear Strength Testing	SR S1	When required by the Contract
Ductility Bend	SR S3	When required by the Contract
AD-W8 Test Group	SR S4	When required by the Contract
Positive Material Identification	SR S5	When required by the Contract
Product Chemical Analysis	SR S6	When required by the Contract
Simulated Heat Treatments	SR S7	When required by the Contract
Impact Tests	SR S8	When required by the Contract
Ferroxyl Inspection	SR S9	When required by the Contract
Hardness	SR S10	When required by the Contract
Penetrant Inspection	SR S11	When required by the Contract

2. Referenced Documents

2.1 ASTM Standards:

- 2.1.1 A263 Standard Specification for Stainless Chromium Steel Clad Plate
- 2.1.2 A264 Standard Specification for Stainless Chromium-Nickel Steel Clad Plate
- 2.1.3 A265 Standard Specification for Nickel and Nickel-Base Alloy-Clad Steel Plate
- 2.1.4 A578 Standard Specification for Straight-Beam Ultrasonic Examination of Plain and Clad Steel Plates for Special Applications
- 2.1.5 B432 Standard Specification for Copper and Copper-Base Alloy Clad Steel Plate
- 2.1.6 B898 Standard Specification for Reactive and Refractory Metal Clad Plate

2.2 ASME Code:

- 2.2.1 Boiler and Pressure Vessel Code, Section IX, Welding Qualifications
- 2.2.2 Boiler and Pressure Vessel Code, Section VIII, Division 1
- 2.2.3 Boiler and Pressure Vessel Code, Section II, SA and SB equivalents to ASTM specifications as applicable

2.3 European Specifications

- 2.3.1 EN10204, Test Certificates
- 2.3.2 AD Merkblatt, AD-W8

2.4 NACE Standards NACE MR-0175

¹ PD103 and NC501 are prior specifications which will be superseded by DMC100 over time.

- 3 **Terminology:** Definitions of Terms Specific to This Specification:
- 3.1 base metal, n—the component that comprises the greatest percentage of total thickness, typically but not necessarily steel.
 - 3.2 cladding metal, or cladding metals, n—the component, or components, which individually comprise less than the greatest percentage of total thickness, typically selected for corrosion resistance or other non structural features
 - 3.3 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.
 - 3.4 Contract, n – the DMC Order Acknowledgment or the Customer Purchase Order which specifies the requirements for the required clad product
 - 3.5 interface, n—of the clad product, is that region of thickness in which the product transitions from essentially 100 % base metal to 100 % cladding metal. Also known as bond or bond zone
 - 3.6 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
 - 3.7 preweld, n- a weld that is made in a cladding metal component before the cladding operation

4 **Ordering Information:** Orders for material under this specification shall include the following information at a minimum in the Contract

- 4.1 Quantity
- 4.2 Product type, such as plate, tubesheet, flat cover, or formed component.
- 4.3 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. If the product is a tubesheet or flat cover, and a machining allowance is required to protect the specified thickness after future machining, it should be stated.
- 4.4 Cladding metal type and specification (the Cladding Metal Specification)
- 4.5 Base metal type and specification (the Base Metal Specification)
- 4.6 Other applicable Clad Specifications, if any (Sec. 5)
- 4.7 Flatness requirements (Sec. 11.3)
- 4.8 Ultrasonic inspection level (Sec. 12)
- 4.9 Non standard heat treatment requirements, if any.
- 4.10 Restrictions limiting or disallowing welding, or weld rework, or both, if any (Sec. 13)
- 4.11 Any additional codes and standards specified by the purchaser or manufacturer, if any.
- 4.12 Supplementary Requirements (S1 through S11 of this specification), if any
- 4.13 Restrictions on country of origin of cladding and/or base metal if any

5 **Dual Compliance with Other Specifications:**

- 5.1 DMC Detaclad plates shall conform to the requirements of this specification.
- 5.2 When specified in the Contract, DMC Detaclad plate shall additionally conform to the applicable ASTM specification and/or applicable ASME specification.
- 5.3 In addition to providing compliance with the ASTM/ASME specifications, this specification addresses criteria unique to explosion clad and Detaclad products which are not addressed in the others.

6 **Materials and Manufacture**

- 6.1 Process:
 - 6.1.1 The base metal shall be manufactured in accordance with all applicable requirements of the Base Metal Specification (Sec. 4.4).
 - 6.1.2 The cladding metal shall be manufactured in accordance with all applicable requirements of the Cladding Metal Specification (Sec. 4.3).
 - 6.1.3 The cladding metal shall be bonded to the base metal by the patented DMC Detaclad Explosion Cladding Process.
 - 6.1.4 Cladding may be applied to one or both faces of the base metal. The cladding metal on the second side may be a different alloy, produced to a different Cladding Metal Specification, than the cladding metal on the first side.
 - 6.1.5 The cladding metal may be fabricated from multiple sheets or plates by prewelding prior to the cladding operation.
 - 6.1.6 The cladding thickness may consist of multiple layers of the cladding metal to produce the total required thickness.
 - 6.1.7 An interlayer metal may be included in the clad product to facilitate bonding or improve bond properties. Its composition and nominal thickness shall be stated in the Contract and reported in the certification.

- 6.1.8 At DMC's option, unless specifically stated otherwise in the Contract, the initiation point for the cladding operation may be in the finished clad product area providing the UT requirements of Section 12 are conforming.
- 6.2 Heat Treatment
 - 6.2.1 DMC may perform heat treatments on clad plates or clad plate components as considered appropriate to assure highest quality metal or bond properties.
 - 6.2.2 Stress relief heat treatments are standard practice for the following metals: Titanium, Zirconium, 400 Series Stainless Steels, and alloy steels. Stress relief heat treatments are performed at 1125°F (+/- 25°) [605°C (+/- 15°)]. Minimum holding times are 1 hr for the first 1-in (25mm) of thickness and 15 min for each additional 1-in (25mm) with a maximum of 2 hr more than the minimum. When specified in the Contract different heat treatment temperatures or times shall be used.
 - 6.2.3 Heat treatments performed as part of the cladding operation shall be reported in the certification (sec. 16)

7 Chemical Composition

- 7.1 Cladding Metal—The cladding metal shall conform to the chemical composition requirements of the applicable Cladding Metal Specification.
- 7.2 Base Metal— The base metal shall conform to the chemical composition requirements of the Base Metal Specification.

8 Mechanical Properties

- 8.1 The base metal shall conform to the mechanical property requirements of the Base Metal Specification.
- 8.2 It is not necessary that the cladding metal conform to the mechanical property requirements of the Cladding Metal Specification, either before or after cladding, unless otherwise specified in the Contract.

9 Chemical Analysis

- 9.1 The Detaclad Process does not alter the chemical composition of the cladding or base metal. The chemical composition certification by the metal manufacturer may be used for clad certification.
- 9.2 When Supplementary Requirement S5 is specified in the Contract, positive material identification shall be performed on the finished clad product.
- 9.3 When Supplementary Requirement S6 is specified, chemical analysis shall be performed on the finished clad product.

10 Testing of Mechanical Properties

- 10.1 When tension, bend, and/or impact tests are 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 DMC option.
- 10.2 Since the Detaclad Process does not significantly alter the applicable mechanical properties of many metal types and thicknesses when tested in accordance with the Base Metal Specification, the mechanical property test data certified by the base metal manufacturer may be used for clad product certification.
- 10.3 Unless simulated post cladding heat treatments are specified by the purchaser, SR S7, the mechanical test specimens shall be representative of the material in the heat treatment condition of product being shipped by DMC.
- 10.4 Tensile Test
 - 10.4.1 Except per 10.4.2, 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 specimens are taken from the clad plate, the cladding shall be removed.
 - 10.4.2 When A/SA263, A/SA264, or A/AS265 are applicable, and when that specification requires testing of full thickness specimens, a tensile test shall be performed on clad specimens in accordance with that specification.
- 10.5 Bond Shear Strength - When bond shear strength testing is specified in the Contract, SR S1, the bond shear strength of the clad product shall be in accordance with Table S1-1 when tested in accordance with Fig. S1-1.
- 10.6 Other mechanical testing shall be performed when the applicable Supplementary Requirement is Specified (Refer to Supplementary Requirements Section at end of this specification.)
- 10.7 When testing is to be performed on the clad plate, and when it is not practical to obtain the mechanical test specimens from the clad plate manufactured for supply to the customer (for

example, clad plates on circular forged base metal discs), testing may be performed on a Test Specimen Clad manufactured from the same lot of metals using the same cladding parameters.

11 Dimensions and Flatness, Permissible Variations

- 11.1 Thickness: The Detaclad process reduces the thickness of the component metals a small amount. Two terms are used to define thickness, "Specified Thickness" and "Starting Thickness".
- 11.1.1 Specified Thickness: This is the clad product thickness specified in the Contract and is defined as either "nominal" or "minimum" in the Contract, Sec 4.3.
- 11.1.2 Starting Thickness: This is the thickness of the component metals as purchased by DMC for cladding. Due to the thinning during cladding, the Starting Thickness may be greater than the Specified Thickness.
- 11.1.3 The customer shall be advised of the required Starting Thickness of both the cladding metal and base metal components necessary to assure compliance with minimum thickness requirements.
- 11.1.4 Cladding metal thickness tolerances are specified in Table 2 and base metal thickness tolerances are specified in Table 3. Other thickness tolerances may be agreed upon between DMC and the purchased and specified in the Contract.

TABLE 2 Cladding Metal Thickness Tolerance for Clad Plates				
	When the Specified Cladding Metal Thickness (t) is defined as:			
	Minimum		Nominal	
Specified Thickness, t	≤ 0.150 in. (≤ 3.8 mm)	> 0.150 in. (> 3.8 mm)	< 0.188 in. (< 4.8 mm)	≥ 0.188 in. (≥ 4.8 mm)
Minimum Permissible Thickness	t	t	t - 0.030 in. (t - 0.75mm)	t - 0.060 in. (t - 1.5mm)
Maximum Permissible Thickness	2 t	1.5 t	2 t	1.5 t

TABLE 3 Base Metal Thickness Tolerance for Clad Plates				
Base Metal Thickness Tolerances				
	When the Specified Base Metal Thickness (t) is defined as:			
	Minimum		Nominal	
Specified Thickness, t	<1.0 in (< 25.4 mm)	≥1.0 in. (≥ 25.4 mm)	<1.0 in (< 25.4 mm)	≥1.0 in. (≥ 25.4 mm)
Minimum Permissible Thickness	t	t	t - 0.01 in (t - 0.25mm)	t - 0.01 in (t - 0.25mm)
Maximum Permissible Thickness	t + 0.21 in (t + 5.3 mm)	t + 0.26 in (t + 6.6 mm)	t + 0.20 in (t + 5.1 mm)	t + 0.26 in (t + 6.4 mm)

- 11.1.5 When the product is specified as a tubesheet or cover and when the Specified Thickness is "Minimum After a Machining Allowance", the minimum thickness of the "as-supplied product" shall exceed the Specified Minimum Thickness by a machining allowance equivalent to the Out-of-Flatness tolerance specified in Table 7. The additional Starting Thickness required may exceed the tolerances in Table 2 and 3. DMC may chose to supply a lower Out-of-Flatness tolerance and an equivalently thinner "as-supplied product".
- 11.1.6 When specifications A263, A264, and A265 are specified, Sec. 5, the total thickness shall not exceed 10% of the Specified Total Nominal Thickness, if less than specified herein, unless otherwise agreed.

TABLE 4 Length and Width, or Diameter, Tolerance	
Dimensional Tolerances (imperial)	
Total Specified 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
Dimensional Tolerances (metric)	
Total Specified 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

11.2 Length and Width or Diameter Tolerances:

- 11.2.1 Clad products shall be supplied with edges cut to the dimensions specified in the Contract. Cutting may be performed by thermal or mechanical means or any other method, which does not deleteriously affect the bulk product quality. Clad plates and tubesheets shall conform to the length and width or diameter tolerances of Table 4, except when 11.2.2 or 11.2.3 are specified. Other tolerances may be agreed upon.
- 11.2.2 When specified by the Contact, clad plate shall be supplied with "as-clad" edges (mill edge). Minimum sound bond size shall be specified, and length and width tolerances of the as-supplied product shall be stated in the Contract. All edge nonbond areas, or otherwise unusable areas, outside of the specified minimum sound bond area shall be marked clearly on the surface, and/or the boundary of the required sound bond area shall be marked clearly on the sound bond portion of the surface.
- 11.2.3 When the product is specified as a tubesheet or flat cover, and machining of the OD is required in the Contract, the diameter tolerances shall conform to Table 5.

Table 5: Tolerances for machined diameters	
Specified Diameter	Permissible Variation from Specified Diameter
< 20in (500 mm)	+0.06in, -0.0 (1.5mm, -0)
≥ 20 in <97in (≥500mm <2500mm)	+0.12in, -0.0 (+3.0mm, -0)
≥ 97.0 (≥ 2500mm)	To Be Agreed

- 11.3 Flatness: Flatness of the clad product shall be in accordance with one of the following flatness tolerance requirements. When flatness requirements are not specified by the customer, flatness tolerances of 11.3.1.1 shall apply.
 - 11.3.1 When product is specified as a Plate:
 - 11.3.1.1 Standard Plate Flatness: Out-of-flatness of the cladding face shall not exceed the requirements of Table 6. This flatness criteria typically is appropriate for clad plates intended for subsequent forming, or fabrication, or both.
 - 11.3.1.2 Special Plate Flatness: Out-of-flatness of the cladding face shall not exceed 0.118 in (3 mm) over any 39.4in (1000mm) span when measured using a 39.4-in (1000mm) straight edge. For plates less than 39.4-in (1000mm) the maximum out-of-flatness shall not exceed 0.118 in (3 mm).

TABLE 6 Standard Flatness – Permissible Variations in Flatness of Cladding Metal Surface			
Flatness Tolerances (imperial)			
Total Thickness (in.)	Maximum Out-of-Flatness Over any 39.4 in. ^{A,C,D}	Maximum Out-of-Flatness Over any 78.8 in. ^{A,B}	
<0.50	0.39	0.55	
≥0.50 <1.0	0.31	0.48	
≥1.0 <6.0	0.24	0.39	
≥6.0	To be agreed upon	To be agreed upon	

Flatness Tolerances (metric)			
Total Thickness (mm)	Maximum Out-of-Flatness mm Over any 1000 mm ^{A,C,D}	Maximum Out-of-Flatness mm Over any 2000 mm ^{A,B}	
<12.7	10	14	
≥12.7 <25.4	8	12	
≥25.4 <150	6	10	
≥152	To be agreed upon	To be agreed upon	

^AFlatness is measured by placing a straight edge of 39.4-in.(1000mm) length or a straight edge of 78.8-in (2000mm), or both, on the plate surface, and then measuring the maximum deviation between the plate surface and the straight edge. Equalizing of the straight edge on a high point is an acceptable measurement technique.

^BFor plate dimensions exceeding 78.8 in. (2000mm), both the 39.4-in.(1000mm) and 78.8-in. (2000mm) measurements shall apply.

^CFor plate dimensions between 39.4 in.(1000mm) and 78.8 in. (2000mm), only the 39.4 in. (1000mm) measurement shall apply.

^DFor plate dimensions less than 39.4 in. (1000mm), the maximum out of flatness shall be the ratio of (applicable dimension / 39.4 in. (1000mm)) × (above value for 39.4-in. (1000mm) measurement), but no less than 0.118-in (3mm).

11.3.2 When the product is specified as a tubesheet or flat cover:

11.3.2.1 Standard Tubesheet Flatness: The maximum out-of-flatness from a best-fit planar surface shall not exceed the values in Table 7 or 0.06in (1.5mm) whichever is greater. Out-of-flatness determination may be made using any suitable method of defining a virtual or real planar surface and measuring the deviation between it and the surface of the part being evaluated. Unless specified otherwise in the Contract, out-of-flatness exceeding the amount permissible in Table 7 is permissible within a distance from the edge of 0.5 x Total Thickness, providing the cladding metal thickness in the affected region exceeds the specified minimum value.

11.3.2.2 Machined Tubesheet Flatness: When machined flatness is specified, out-of-flatness of one or both faces, as specified by the Contract, shall not exceed 0.012 in (0.30mm) over any 39.4in (1000 mm) span when measured with a straight edge. Flatness is typically achieved by machining or grinding. The Starting Cladding Metal and/or Base Metal Thickness shall be sufficient to assure that the Specified Minimum Thicknesses are not compromised after machining.

Thickness	Diameter (D) or Longest Dimension if not Round		
	≤96in (2438mm)	>96in (2438mm) ≤120in(3050mm)	>120in (3050mm)
<1.3in (30mm)	0.004 x D	0.0045 x D	To be Agreed
≥1.3in (30mm), ≤6.0in (152mm)	0.0025 x D	.0030 x D	To be Agreed
>6.0in (152 mm)	To be Agreed	To be Agreed	To be Agreed

11.3.3 Other Flatness—Other flatness requirements may be agreed upon mutually between the DMC and the purchaser.

12 Nondestructive Testing

12.1 Ultrasonic Inspection: After the completion of all mechanical and thermal processing components of the cladding operation, clad plates shall be inspected for bond integrity by ultrasonic testing. Three Quality Levels shall apply. When not specified otherwise by the

customer, Class C shall apply. Inspection shall be in accordance with the procedures and methods of Specification A 578. Scanning shall be performed with a 1in (25mm) transducer. Any indication which causes 100% loss of back reflection accompanied by a reflection from the clad interface shall be recordable.

- 12.1.1 Class A - Scanning shall be performed over 100% of the clad surface. Any single recordable indication exceeding 1-in (25 mm) in its longest dimension shall be cause for rejection. The minimum sound bond area shall be 99%.
- 12.1.2 Class B - Scanning shall be performed over 100% of the clad surface. Any single recordable indication exceeding 3-in (75 mm) in its longest dimension shall be cause for rejection. The minimum sound bond area shall be 97%.
- 12.1.3 Class C—Scanning shall be along continuous perpendicular grid lines on nominal 9-in (225 mm) centers, or at DMC option, shall be along continuous parallel paths on nominal 4-in (100mm) centers. When an indication is observed during general scanning, the indication shall be evaluated. Any single recordable indication exceeding 58 cm² (9 in.²) in area shall be cause for rejection. The minimum sound bond area shall be 95 %.
- 12.2 Component Metal Ultrasonic Inspection:
 - 12.2.1 Both the Cladding Metal and Base Metal component of the clad product shall be ultrasonically inspected for internal defects in accordance with the procedures of A578. Recordable conditions shall be reported.
 - 12.2.2 When specified in the Contract, the Rejection criteria of the stated A578 requirement shall apply.

13 Welding and Rework

- 13.1 Welding of the clad components is permitted for cladding metal prewelding (Sec 6.1.4) and for product rework. Any welding, which is part of the delivered product, shall be performed by welders or welding operators that are qualified in accordance with ASME Section IX and using a welding procedure specification (WPS) that is in accordance with ASME Section IX
- 13.2 If the cladding metal has been prewelded, the exposed surface of the welds are to be 100 % penetrant inspected in accordance with ASME Section VIII, Division 1, Appendix 8. Radiographic inspection of cladding metal prewelds, shall be at DMC discretion, unless specified otherwise in the contract.
- 13.3 Weld Rework: Rework of defects in the cladding and/or base metal may be performed by welding, provided the following requirements are met:
 - 13.3.1 The defective area is removed and the area prepared for rework is examined by a magnetic particle method or a liquid penetrant method to ensure all defective area has been removed.
 - 13.3.2 Welds to the cladding metal shall be suitable so as to leave the surface condition similar in corrosion resistance to the adjacent cladding.
 - 13.3.3 The reworked area shall be inspected in accordance with the penetrant inspection requirements of ASME Section VIII, Division 1, Appendix 8 and the applicable ultrasonic inspection requirements of Section 12.
 - 13.3.4 The location and extent of the weld rework, together with the examination results, shall be transmitted as a part of the certification.
 - 13.3.5 When specified in the Contract, the welding procedure specification (WPS) shall be subject to approval by the purchaser prior to rework welding.
- 13.4 If a Specification invoked in Sec 5 requires customer approval for rework welds, and if DMC100 is invoked in the contract, weld rework approval will be considered to be given by the inclusion of DMC100 unless specifically prohibited in Sec. 4.10.
- 13.5 References to ASME Design Code shall be replaced with comparable requirements of other national or international standards when agreed upon by the DMC and the purchaser (Section 4.1.11).

14 Workmanship, Finish and Appearance

- 14.1 The product surfaces shall be free of excess imperfections and extraneous materials as determined by visual examination. Excessive imperfections are those which exceed the standards of the cladding and base metal specifications respectively or which compromise minimum thickness requirements.
- 14.2 The cladding metal surface finish shall comply with one of the following options as defined in the Contract. Unless stated otherwise, 14.2.1 shall apply.
 - 14.2.1 Basic Cleaning: Light grinding, brushing, or blasting to remove cladding process residue
 - 14.2.2 Blasting: Blasting with iron free sand, or similar media, to remove residual operation residues and heavy oxides, providing a uniform textured finish of approximately ISO 8501-1 Sa2.5

- 14.2.3 Grinding: Grinding to provide a surface texture of an essentially parallel grind pattern using 80 grit or finer grinding medium.
- 14.3 The base metal surface condition shall be in accordance with the requirements of the base metal specification.
- 14.4 Surface defects may be blended by grinding, providing the metal thickness is not reduced below the specified minimum. Deeper surface defects shall be reworked in accordance with Sec. 13, when possible, before final blending. Non-reworkable conditions shall be reported to the purchaser for disposition.

15 Additional Inspections

- 15.1 When an outside or third party inspector is appointed by the purchaser, DMC shall afford the appointed inspector all reasonable facilities to satisfy him that the material is being furnished in accordance with this specification. Unless otherwise specified in the Contract, purchaser appointed inspections shall be at customer expense.
- 15.2 Additional inspections shall be performed when an applicable Supplementary Requirement is Specified. This additional testing is not recommended as a general practice due to the added costs.

16 Certification: At a minimum the following shall be certified by DMC:

- 16.1 The chemical analysis of the cladding metal and base metal and interlayers if applicable.
- 16.2 The results of mechanical tests of Section 10,
- 16.3 Compliance with the nondestructive tests of Section 12 and 13 when applicable
- 16.4 Compliance with the requirements of this specification.
- 16.5 Certification of any heat treatments performed as part of the cladding process.
- 16.6 Unless stated otherwise in the Contract, certificates shall be in accordance with EN 10204 type 3.1.

17 Product Marking:

- 17.1 The following shall be marked legibly on each finished clad plate
 - 17.1.1 DMC factory designation
 - 17.1.2 DMC's processing identification number,
 - 17.1.3 This specification number,
 - 17.1.4 Base metal specification number
 - 17.1.5 Cladding metal specification number.
- 17.2 The marking shall be by steel die stamping unless paint marking is specified in the Contract.
- 17.3 The making shall be on the base metal surface unless specified otherwise in the Contract.
- 17.4 Markings on the base metal face shall be in two locations, no less than 12 in. (300 mm) from the edges, except that when the clad product is less than 72 in. (1830 mm) in its largest lateral dimension the marking shall be in a single location only.

18 Packaging: Packaging suitable for the product and transport method shall be agreed upon between DMC and the purchaser and specified in the Contract. Packaging options are as follows. If unspecified, packaging option 18.1. shall apply.

- 18.1 No Packing: Plates will be loaded on trucks, with or without skids and surface protection at DMC option. Care will be taken to avoid undue iron contamination of the cladding surface during transport. This method is typically used for domestic truck shipment.
- 18.2 Basic Packing: Plates shall be strapped to wood or steel skids, plastic film shall be applied to protect the cladded side of the plates, and an additional surface layer, such as hardboard or plywood shall be layered over the cladded surface to protect against mechanical damage. Multiple plates may be packaged together with a separation layer, such as hardboard or plywood, to prevent surface damage of the lower plate. Durable shrink wrapping or other plastic enclosure materials may be used to minimize environmental damage during transport. This method is typically used for Oversea Shipments or critical Continental Truck shipments.
- 18.3 Overseas Boxing: Plates shall be packaged in a strong wooden box with additional water-resistant protection, compliant with SNE Category IV. This method is typically used for large finished products such as condenser tubesheets. This method is generally discouraged for other large, heavy plates because the clad plates are far more durable than the wood packaging and adequate protection can be provided in less expensive ways.
- 18.4 Air Freight Packaging: The plates shall be skidded and protected with plastic and hardboard. The plates shall be additionally protected by wooden boxing when appropriate. Care shall be taken to minimize excess packaging weight.
- 18.5 When specified in the Contract, any wood products shall be compliant with specific national requirements for pest control such as required by Australia and China.

Supplementary Requirements

Supplementary requirements are optional and only apply when specifically invoked in the Contract.

S1. Bond Shear Strength Testing

- 1.1 Bond shear strength testing shall be performed on the product when specified by the Contract.
- 1.2 Shear test specimens shall be made in the manner indicated in Fig. S1-1. Shear testing shall be performed in accordance with the procedures of Specification A265. The minimum permissible shear strength shall be in accordance with Table S1-1.
- 1.3 One shear test shall be performed for each lot of clad plates, which consist of the same cladding and base metal lots (material from the same heat having the same thickness and same heat treatment), and which are clad under the same cladding conditions. When specified in the Contract, shear tests shall be performed on each clad plate. When a clad plate is comprised of a prewelded cladding metal plate or sheet (Sec 6.1.5) which is comprised of metal from multiple heats, only one shear test shall be performed on the plate.
- 1.4 The location of the shear test specimen shall be at DMC's option and shall be representative of the product.
- 1.5 Bond shear strength testing is not recommended when the cladding metal thickness is ≤ 0.078 in (2 mm) Starting Thickness.
- 1.6 When necessary, Sec. 10.7, shear tests shall be performed on material from a separate test clad.

Table S1-1: Shear Strength Requirements				
Cladding Alloy		Minimum Shear Strength (psi)	Minimum Shear Strength (MPa)	Shear Lug Width "W" in. (mm)
Titanium		22,000.	150	0.375 (9.5)
Zirconium		20,000	137	0.375 (9.5)
Stainless Steel & Nickel Alloys		35,000	240	0.188 (4.9)
Copper		15,000	103	0.188 (4.9)
Copper Alloys		20,000	137	0.188 (4.9)

Figure S1-1: Shear Test Specimen

1. If cladding metal thickness, t , exceeds 0.12in(3mm), it shall be reduced to 0.12in
2. If base metal thickness, T , exceeds 1.0in(25.4mm), it shall be reduced to 1.0in

S2. Supply of clad product in the Formed Head or Rolled Cylinder condition.

- 2.1 When clad material produced to this specification is supplied as a formed head or cylinder by DMC, the bonded material shall conform to all of the applicable quality requirements of this specification after forming, except for thickness over-gauge. The finished product size, configuration, and any special finish conditions shall be defined in the Contract. The forming procedures, heat treatments, and contour tolerances shall be in accordance with the applicable requirements of the ASME Code Section VIII and the component metal specifications, as applicable.

2.2 Specific features of the product including, but not limited to, head type and contour, edge weld preparations, extent of edge welding when applicable, shall be defined in the Contract.

2.3 When agreed upon, head blanks may be fabricated by butt seam welding of multiple smaller explosion clad plates. All welding shall be performed in accordance with the applicable requirements of ASME Code Section VIII and IX. Steel welds shall be 100% radiographed prior to forming. The cladder metal restoration welds shall be 100% penetrant inspected before and after forming. NDE procedures and acceptance criteria shall be in accordance with ASME Section VIII.

2.4 Certification of NDE inspection and Code Compliance shall be included in the Certificate Package, Para. 16.0.

S3. Ductility Bend Testing: Ductility bend tests shall be performed. Two bend tests of the composite plate shall be made, one with the cladding metal in tension and the other with the cladding metal in compression. At the DMC's option, the specimen shall be either the design specified in ASTM A265 or 1-in x 1-in (25 x 25 mm) x sufficient length to assure a full 180 degree bend. In the latter design, if the cladding metal thickness exceeds 0.5-in (12.5 mm), it shall be reduced to 0.5-in(12.5 mm) maximum. Bending radius and acceptance criteria shall be in accordance with the cladding metal specification when the cladding is in tension and the base metal specification when the base metal is in tension.

S4. AD-W8 Testing: Testing shall be performed in accordance with the requirements of AD-W8. Testing requirements and test frequency shall be as defined by the relevant TUV inspector. In general, but not necessarily, AD-W8 testing includes one or more of the following tests taken from the clad plate: tensile, side bends, and impacts.

S5. Positive Material Identification (PMI): Product verification by Positive Metal Identification (PMI) techniques shall be performed on either the cladding metal or base metal or both, as specified in the Contract.

S6. Product Analysis: Product analysis shall be performed on the cladding, or base metal, or both, as specified by the Contract. The specimen for analysis shall be taken from each plate, as-clad, after completion of all mechanical and thermal processing component of the cladding operation.

S7. Simulated Heat Treatment of Mechanical Test Coupons: The test specimens representing the plate in the as-supplied heat treat condition shall be given additional heat treatments which simulate thermal processing which is to be performed after supply. The temperature range, time, and heating/cooling rates, as applicable, shall be specified in the Contract. Unless otherwise agreed upon, these tests shall replace those representative of the product in the as-supplied condition.

S8. Charpy V-Notch Impact Test of Base Metal: Charpy V-Notch tests shall be performed in accordance with the relevant requirements of the base metal specification. Specimen orientation, temperature, and acceptance criteria are to be specified by the purchaser. Testing shall be performed on specimens representative of the finished clad product unless S7 is specified. When S7 is specified, the specimens shall be representative of the specified simulated heat treatment condition.

S9. Ferroxyl Testing: The Potassium Ferricyanide test shall be performed in accordance with ASTM A 380, 7.3.4., modified as needed, to inspect for iron contamination on the cladding alloy surface.

S10. Hardness Testing

10.1 When hardness testing in accordance with NACE MR-0175 is specified, hardness measurements are to be made on the cladding and base metal surfaces. A minimum of one test per lot (as defined in S1.3) shall be performed.

10.2 Other hardness testing may be performed as mutually agreed upon.

S11. Penetrant Testing: The cladding metal surface shall be inspected over 100% of its surface for cracks and other defects. Testing shall be in accordance with ASME VIII Div 1 Appendix 8.

Revisions:

Rev 0, Original Issue, 30 April 2006

Rev 0(a), Corrects typographical errors in 11.1.5, 1 November 2006