EXPLOCLAD METAL WORKS

The Explosive Sloution to

Metallurgical Bonding

EXPLOBOND

EXPLOSION CLADDING PROCESS

The cladding plate is placed over the backer plate with a small gap between the two. A layer of specially prepared explosive charge is spread on top of the cladding plate. On detonation the cladding plate collides progressively with the backer plate at a high velocity. This collision is completed in milli seconds and removes the contaminating surface films like oxides and adsorbed gases in the form a Tine jet at collision front thereby bringing together two virgin metal surfaces to form a metallurgical bond by electron sharing. This unique solid state welding process of Explosion cladding retains the individual characteristics of each metal such as corrosion resistance of the cladding metal and strength/economy of the backer metal
The process is very versatile as most of the common metals can be clad. The metals which cannot be clad readily by conventional methods, e.g., Aluminium + Steel, Titanium Steel, can be easily clad by this process. The process is flexible and a wide range of sizes and quantities can be handled as required by users. IDL manufactures Explosion clad plates under trade name EXPLOBOND®

ADVANTAGES OF EXPLOBOND PRODUCTS

- Guaranteed strong Metallurgical bonds
- Wide range of metal combinations
- Wide range of sizes and composite thicknesses
- Custom made products
- Adoption of conventional fabrication procedures
- Extremely low electrical resistance at interface. Good heat transfer
- Licenced technology, years of experience with varied and best industry skills backed by large site with emphasis on safety making Explobond your dependable first choice.

METAL COMBINATIONS

Cladding on both sides of a backer metal with the same/different cladding metal is possible. Multi-layered clad composites are possible. Cladding on cup forging and lipped forgings is possible. Cladding of pipes and rods are also technically possible. In case your requirement does not fit into the above range, we can together find a solution, please don't hesitate to contact us.

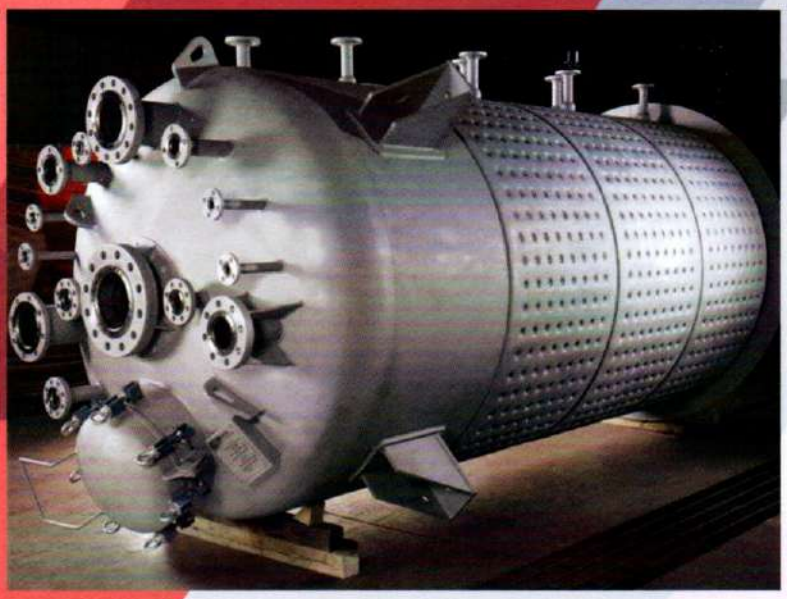
	CLADDING METALS											
BACKER METALS	Silver	Tantalum	Titanium	Incoloy	Hastelloy	Nickel & Nickel alloy	Copper & Copper alloy	Aluminium	Ferritic stainless steel	Austenitic stainless steel	Pressure vessel steel	Structural steel
Structural steel	●	●	●	●	●	●	●	●	●	●	●	●
Pressure vessel steel	●	●	●	●	●	●	●	●	●	●	●	●
Austenitic stainless steel	●	●	●	●	●	●	●		●	●	●	●
Ferritic stainless steel				●	●			●	●	●	●	●
Aluminium	●			●			●	●				●
Copper & Copper alloy	●	●	●				●	●		●	●	●
Nickel & Nickel alloy			●			●				●	●	●
Hastelloy					●							
Incoloy				●								
Titanium			●			●	●	●	●	●		
Tantalum		●										
Silver	●											

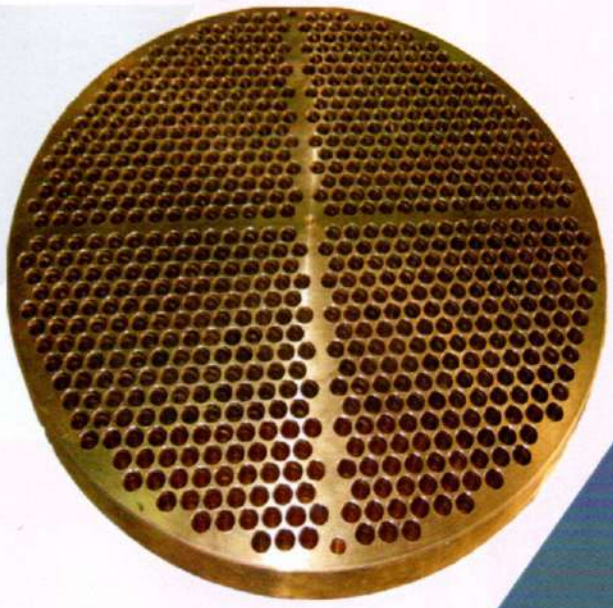
SUPPLIES

Explobond® clads are custom made to meet the specifications, dimensions and quality. Normally EXPLOBOND® clad plates for shell and dish heads are flattened to commercial tolerances and are supplied untrimmed with non-bonds along the edges if any marked.

EXPLOBOND® clad plates are supplied as clad, as heat treated, or when required with the cladding surface ground to 80 grit finish. EXPLOBOND® clad tube plates are flattened to special tolerances and extra thickness is provided for machining if required. When desired, we can take up cutting, machining, forming and supply clad tube sheet blanks duly machined or clad dish heads to your

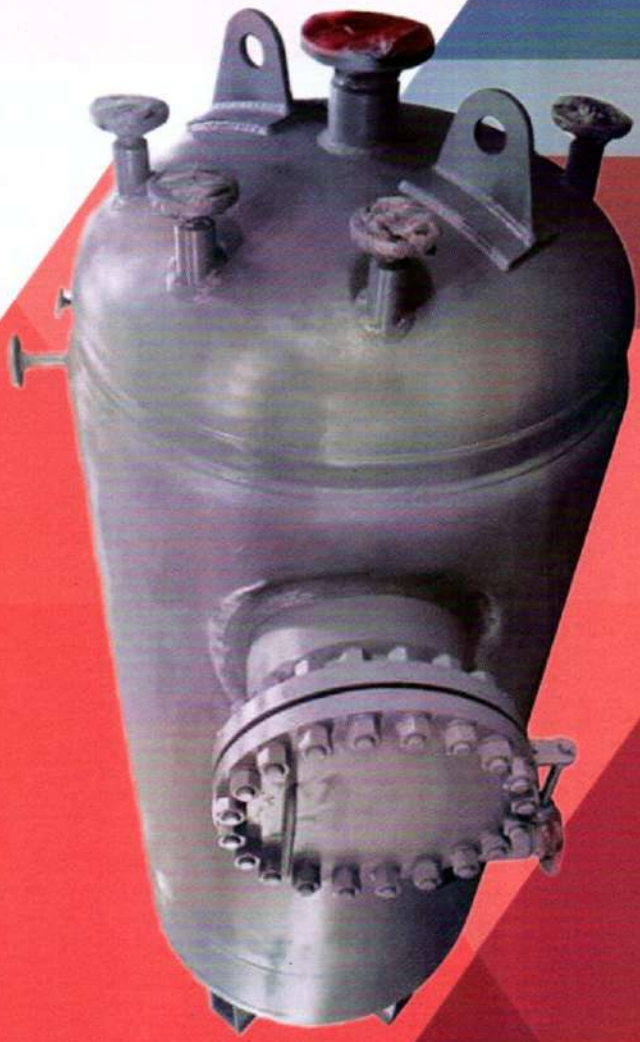
requirements. In special cases we also offer fabricated equipment involving clad metals. In order to cater to the requirements, we normally carry inventory of some of the widely use cladding metals. We can also take up job work of cladding on materials supplied by customers.





CORROSION RESISTANT EXPLOBOND® CLAD PLATES

Clad plates over the years have become the favoured material of construction for equipment with most designers and fabricators. Clad plates offer a cost-effective solution even for the most demanding applications. Clad plates have a proven ability to withstand elevated temperature, thermal and pressure cycling. Efficient heat transfer property of clad plates reduces the operating costs. Conventional fabrication methods can be used.



APPLICATIONS

EXPLOBOND® clad plates are generally Carbon or alloy steel plates/ forgings with a thinner layer of exotic metals which offer resistance to different corrosive environments in diverse industries like chemical, pulp & paper, off shore & petrochemical, petroleum refineries, nuclear, thermal & hydroelectric plants, fertilizer, irrigation, desalination effluent-treatment & pollution control plants etc. Components such as heat exchanger tube plates, surface condensers, shell and dished heads for equipment's as pressure vessels, columns, evaporators, pulp digesters, absorber towers, pipeline & pipe fittings, separators, hydrocrackers, penstock expansion joints, radial gates of dams etc.

EXPLOBOND® clad plates have been supplied and used by a host of customers as per their requirements and have stood the test of time in various projects/plants for over two decades. All dad plates are ultrasonically tested to international standards such as ASME SA 578. Clad plates are destructively tested as per relevant code of ASME SA 263,264,265 and ASTM B 432 under various reputed third-party inspection agencies as desired by customer.

FABRICATION OF CLAD PLATES

The fabrication of EXPLOBOND® dad plates is possible using conventional methods but a few precautions should be observed depending on the nature of the cladding metal Equipment used should be very clean to avoid any contamination of the cladding metal.

CUTTING

Shearing of clad plates should always be done with dad side up to prevent particles of base metal coming into contact with the cladding. The burr should be on the backing steel side. Drilling and machining are also generally performed from clad side with appropriate tool & methods.

FLAME CUTTING

Stainless Steel and Nickel Alloy clad steel plates can be cut with a flame torch, with oxygen acetylene/propane/ natural gas either with a hand torch or automatic flame cutting machines. Standard nozzles can be used, but it is advisable to use nozzles one size larger than those for same thickness of ordinary steel. Cutting shall commence from the steel side such that the cladding metal is cut by its own fusion and helped by the base metal slag. When plates with cladding metals on both faces are to be flame cut a groove must be cut on one of the cladding metal faces, Titanium clad plates can be cut from the Titanium side just like cutting mild steel plate.

PLASMA CUTTING

Plasma arc can cut most dad metals and result in a good finish. Cutting must be from cladding metal side. The thickness ratio and nature of metals will define the best choice. Aluminium clad plate as well as copper and copper alloy clad plates are best cut by mechanical methods.

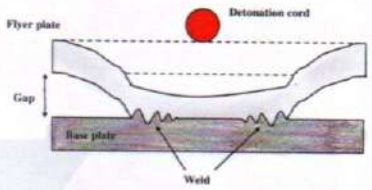
FORMING

EXPLOBOND® clad plates can withstand cold forming operations of roll forming, pressing etc. The surface of all tools should be clean without any sharp comers & angles. Al working surfaces of the plate and machine must be free of loose scale, steel particles & shop dirt to prevent pitting and embedding of foreign material in the cladding metal Work hardening may occur when heavy plates are being shaped or deformed and in such, cases an intermediate heat treatment may be required. Hot forming can also be performed. However, care must be taken to maintain backing steel properties and corrosion resistance of cladding.

Furnace atmosphere during heating is important to prevent carburizing. sulphur embrittlement etc. etc such that corrosion resistance of cladding metals is not impaired. Low sulphur fuels for heating, removal of grease, paint, iron particles/dust from cladding metal surface prior to loading in furnace are to be ensured. Care should be taken to avoid sensitizing range of temperatures for certain alloys and long heating cycles.

WELDING

Various welding techniques like MIG, TIG, and coated electrode may be used for welding clad plates. As clad plates are composed of two different metals it is usually necessary to weld the base metal and clacking material in



Different ways. One of the most important precautions is to avoid dilution in the cladding The edges of the two dad plates. should be carefully aligned such that they are very near to each other and the bond interface of the two plates are on the same plane during butt welding the root of the chamfer on the base metal side must not reach. the line of contact with the cladding metal. The first bead deposited from the base metal side must be carefully controlled by using thin electrodes. When dilution is to be avoided the upper most face of each row of beads should be ground or chipped before depositing the next run.

A suitable edge preparation is to be selected depending on the thickness ratio, chemical composition/ nature of cladding metal and shall be compatible to the welding technique chosen. For all stainless-steel claddings, the fist lead on the clad side should be made with a (25 cr 20Ni or 25N) high Nickel & Chromium containing electrode and the for following one with electrodes

chosen to suit the cladding metal. For Nickel and Nickel alloys the fist and subsequent one should be made with the weld metal appropriate for cladding material. The typical welding procedures/practices adopted are shown in table.

EXPLOBOND ELECTRICAL TRANSITION JOINTS

Explobond electrical transition joints are inserts used for joining dissimilar metals in a current carrying system. The fact that during explosion bonding the surfaces undergoes a cleansing process is reflected in the practically zero electrical resistance of the bond interface. This is unlike other alternatives such as braze welding, weld deposition etc, where large amounts of inter-metallic/alloy layers coupled with defects like shrinkage cavities contribute to electrical resistance of joints.

APPLICATIONS:

EXPLOBOND electrical transition joints are widely used in the electrochemical industries like chlor alkali and electrometallurgical industries such as Aluminium Smelters, Zinc electrolysers apart from electrical contacts. These processes usually employ very high current (at low voltages) and reduction of voltage drops at the joints, result in considerable power savings, EXPLOBOND transition Joints serve to providing reliable, energy saving, maintenance free and strong electrical connections between dissimilar metals.

In the pot lines of Morden Aluminium smelters, the electrode holders are steel and bus bars usually Aluminium, Aluminium and steel cannot be welded by conventional processes. EXPLOBOND electrical clad transition joints are interposed between the bus bar and the electrodes to complete the circuit Standard EXPLOBOND electrical transition joints for Aluminium smelters are:

Type-A

Aluminium 99.5% purity : 12.7 mm thick
Carbon Steel AISI 1008 : 38.1 mm thick
Minimum tensile strength : 80 MPa in as clad condition
Minimum tensile strength : 65 MPa after 24 hours soaking at 300 degrees centigrade

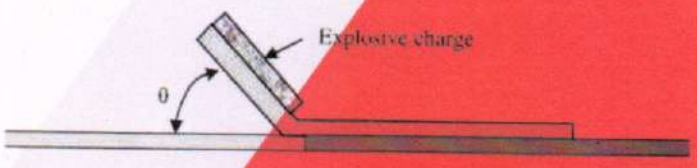
Type-B

Aluminium 99.5% purity : 12.7 mm thick
Titanium B 265 Grade 1 : 1.5 mm thick nominal
Carbon Steel AISI 1008 : 38.1 mm thick
Minimum tensile strength : 150 MPa in as clad condition
Minimum tensile strength : 80 MPa after 24 hours soaking at 500 degrees centigrade.

Most combinations, and dimensions are possible depending on customer requirements like Aluminium Copper, Copper+Aluminium +Copper, Copper Steel and many others.
The following table lists the measured electrical resistances of the of explosion clad and mechanically bolted joint interfaces. The resistances are measured by passing a known current through a bimetallic rod and measuring the voltage drop across the composite rod. The resistance of the compound materials is subtracted from the resistance of the composite to yield the value for the bond zone.
These values reflect the amount of power that can be saved by the use of Explobond® electrical transition joints. The electrical resistance of the explosion bonded composites is low and stable as long as they are not exposed to temperatures higher than specified for each combination.

Mechanical Characteristics of the Bond

Explosion clad materials are characterized by high bond strengths. Generally equal to or higher than the strength of the weaker component in the composite. The table below lists the minimum strength values specified for typical composites.



Clad Composite	Min. Shear strength of Kg/Sq.mm
Aluminium + Steel	5.6
Aluminium + Copper	5.6
Copper + Steel	10.5

WELDING, FABRICATION AND USE OF CLAD ELECTRICAL TRANSITION JOINT

The practical use of electrical transition joints is illustrated in figure where to weld two dissimilar metals 'A' and 'B', and explosion clad composite 'C' made up these two metals to interposed and welding complete by conventional welding of similar metals. The only precaution to be taken during welding of transition joint is to observe that the bond interface does not get heated to temperatures specified in the table below.

Composite	Max allowable bond zone temperatures during welding °C	Safe working temperatures °C
Aluminium-Steel	315	260
Aluminium-Ti-Steel	480	425
Aluminium-Copper	260	450
Copper-Steel	600	535

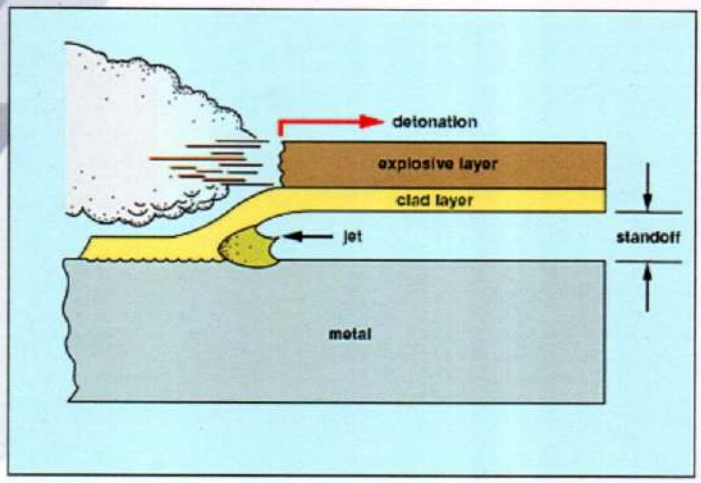
Some busbar connections have to be disconnected at intervals often when conveying a high current. For such periodic make and break contacts, if Aluminium busbars are used, such connections are highly unsatisfactory. These Aluminium-Aluminium contacts have high electrical resistance due to presence of highly insulating surface oxide film on Aluminium. They also erode readily by arcing thus aggravating the problem. Employing explosion clad Aluminium-Copper joints overcomes this problem by converting Aluminium-Aluminium contacts into Copper-Copper contact which has a low electrical resistance.

CLAD AND ROLLED PRODUCTS

Explobond clads can be further rolled and extruded into thinner sheets, rods and wires, when quantities are very large.

EXPLOBOND STRUCTURAL TRANSITION JOINTS

A major area of application of explosion bonded transition joints is in structures consisting of dissimilar metals. Structural transition joints may be either flat or tubular joints for effecting permanent, strong, crevice-free and leak proof metallurgical weld between dissimilar metals and alloys. The different areas of applications and most standard products offered are as below.



SHIP BUILDING & SHIP REPAIR YARDS

EXPLOBOND structural transition joints are composite strips made of Aluminium Magnesium alloy + Aluminium + Steel used in building & repairs of passenger ships, utility ships, Catamarans, Naval vessels and offshore constructions.

EXPLOBOND Aluminium + Steel transition joints are also used on ship tankers transporting liquefied natural gas. Huge spherical tanks of Aluminium employed to hold LNG and to weld these Aluminium spheres in position with the steel tanker body.

With increasing use of Aluminium bodies on construction of trucks and buses, Aluminium + Steel transitions joints ease the problem of joining the Aluminium parts to steel chassis. In most of these vessels the superstructures is made of Aluminium alloys and are to be joined to the steel hull/body. EXPLOBOND® structural transition joints provide a Metallurgically strong crevice free and reliable joint between Aluminium alloy& stool. The Aluminium steel interface is smooth, can be securely protected, by paints and easy to maintain.

EXPLOBOND Aluminium alloy + Aluminium + Steel transition joints are approved by LRS, ABS, IRS and Indian Navy.

Typical standard EXPLOBOND® Clads:

Aluminum Magnesiumalloy: (AA5063/1S54300)6mm to12mm thick

Aluminum : (M1050/AA 1100/1S 19500/1S 19000) 3mm to 12 mm thick

Carbon steel SA515Gr : (LLOYDS Grade A/IS 2062/55860) 19mm to 25mm thick.

Composite thickness : a combination of above individual thicknesses

Width : Standard widths are 20 mm, 25mm; 30mm; the empirical rule of joining Aluminium and steel plate is to use a structural transition joint four times as wide as thickness of Aluminium being welded to it. Any other widths are also possible.

Minimum Shear Strength : 5.4 Kgs/mm square

Minimum Tensile strength : 7.0 Kgs/mm square

WELDING FABRICATION OF STRUCTURAL CLAD TRANSITION JOINTS

Cutting Mechanical cawing process need to be used for cutting Aluminium + Steel transition joints. Bending - Al + Steel transition joints can be bent to curves with a

radius of 300mm or more.

Welding - Butt weld between the ends of transition joints is earned out as shown in figure. Both Aluminium &Steel welding may be performed by MIG/T1G processes. Before welding, strips to be butted end to end and secured firmly. The steel weld should be completed fist by several short passes. The Aluminium weld should be made using stringer passes with intermittent cooling periods such that the bond interface temperature remains below 300 degrees centigrade. Post weld hammer peening of non-welded space between Aluminium and steel may be performed to ensure a leak tight joint.

TUBULAR TRANSITION JOINTS

Tubular Transition Joints are usually machined out from dad plates and these are used to weld dissimilar tubes. These are generally of stainless steel and Aluminium used to weld Aluminium alloy and stainless-steel tubes in cryogenic and nuclear applications.

Typical uses are to insert stainless steel valves into Aluminium piping, to connect stainless steel piping to Aluminium heat exchangers. These are used in air separation plants, helium liquefies, natural gas liquefaction plants, fuel systems, irradiation and space simulation chambers etc. For better low temperature mechanical strength and vacuum tightness usually a thin interlayer of tantalum or silver is interposed between stainless steel and Aluminium alloy.

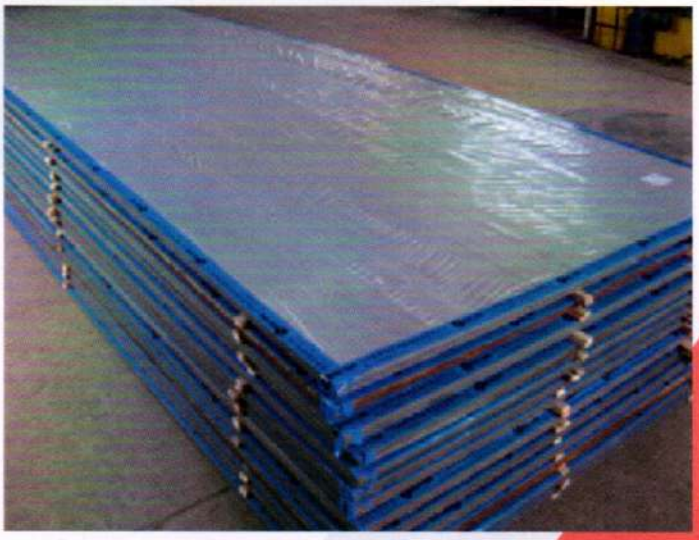
QUALITY ASSURANCE

IDL is committed to quality and customer satisfaction. A well-established Quality assurance system fully backed by ISO 9001: 2008 certification is adopted.

Inward Inspection: The base and cladding metal plates received with cast marks and inspectors stamp along with mill test certificate and identification report are verified& checked with the specifications/ customer requirements and are documented. Dimensions, welds, check tests; ultrasonic tests are done where necessary. Corrective actions where required are taken before releasing material for cladding.

In process Testing: After explosion cladding, flattening & heat treatment, all clad plates are ultrasonically tested to ASME A 578. Clad plates are destructively tested when specified to relevant ASME A 263, 264 265 and ASTM B 432 for bond shear test, tensile test, and typical bond shear strength values of EXPLOBOND® clad are well above the specified minimum of the relevant specification. Any special additional test like IGC test, ductility bend test, Impact test, DP, Peroxyl test can be performed by prior arrangement.

Packing: After stamping of relevant cast marks and inspector's stamp, the clad surface of clad plate is covered by polythene sheet and plywood, strapped so as to avoid damage in transit. Machined clads are normally crated before they are shipped.



Certification: Work test certificate detailing, the cladding & base metal specifications, cast marks, dimension, non-destructive and destructive

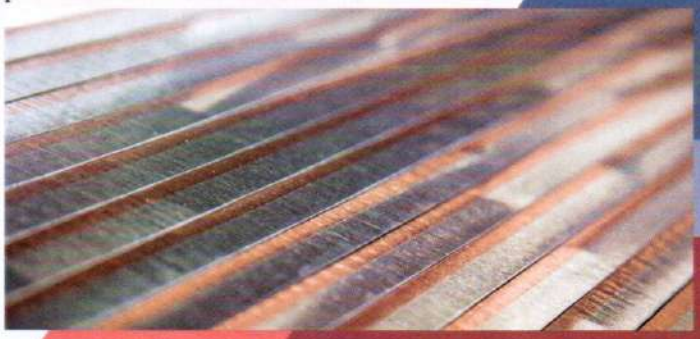
test conducted & certified by relevant third-party inspection agency

and their release note if applicable are forwarded.

Inspection: EXPLOBOND clad plates have been supplied under inspection by EIL. LRA, BVIS, DNV JACOBS, TUV, SGS, MECON, POIL BARC, NPCIL, QAL BHEL COS and many more.

Explosive Hardening

Components/Castings made of austenitic manganese steel such as railway-crossings, shovel teeth and jaw crusher plates can be pre hardened before use to increase their service lives.



Explosive Tube to Tube Plate Welding Small

explosive charges are used to expand / weld tubes to tubes plates, even incompatible metals can be welded by this process.

Explosive Compaction

Ceramic and metal powders can explosively compact into rods.

EXPLOCLAD METAL WORKS

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