Welding Aluminium to Steel

TRICLAD®

Merrem & laPorte

Merrem & la Porte BV is a multi divisional company with subsidaries in the Netherlands and Belgium, supplying high quality metals, glass fiber and non woven materials, Water & Sludge treatment, industrial filters for Air, Dust and Liquid filtration including maintenance and service. The HiTech Metals division of Merrem & la Porte BV is the worlds premier supplier of TRICLAD® aluminium/ steel transition joints to the maritime industry. This product is used to provide an efficient and maintenance free welded connection between aluminium and steel structures on board vessels and offshore constructions.

Merrem & la Porte is committed to provide their TRICLAD customers with the best possible service, both technical and commercial.

This brochure is designed to illustrate the depth of our commitment.

Additionally, we give you:

- The most competitive pricing available.
- Very short delivery time if not available off the shelf.
- Full mill test certification and LRS certificates at no extra cost.
- Prompt response to commercial enquiries with a target of same day response in 98% of cases.
- The quality, service and support that you may expect from an ISO 9001 approved company.
- The added value of TRICLAD as a registered trademark of Merrem & la Porte.
- The service of knowledgeable staff with a long experience in this specialised product, and the industry in which it is used.
- Quick response to technical queries with a target of same day response in 90% of cases.
- Flexible delivery terms, from ex-works to free delivered with payment terms to suit.
- Waterjet cutting equipment is available for special shapes such as circles, rings, bends and others.
- For special/demanding applications special TRICLAD versions are or can be made available.
- All cut pieces hard stamp marked for positive identification/traceability.
- Strips marked with LRS inspection logo.
- Type approvals held from various classification authorities.
- Material meeting MIL-J-24445A requirements.
- Full technical back-up.

ISO gecertificeerd

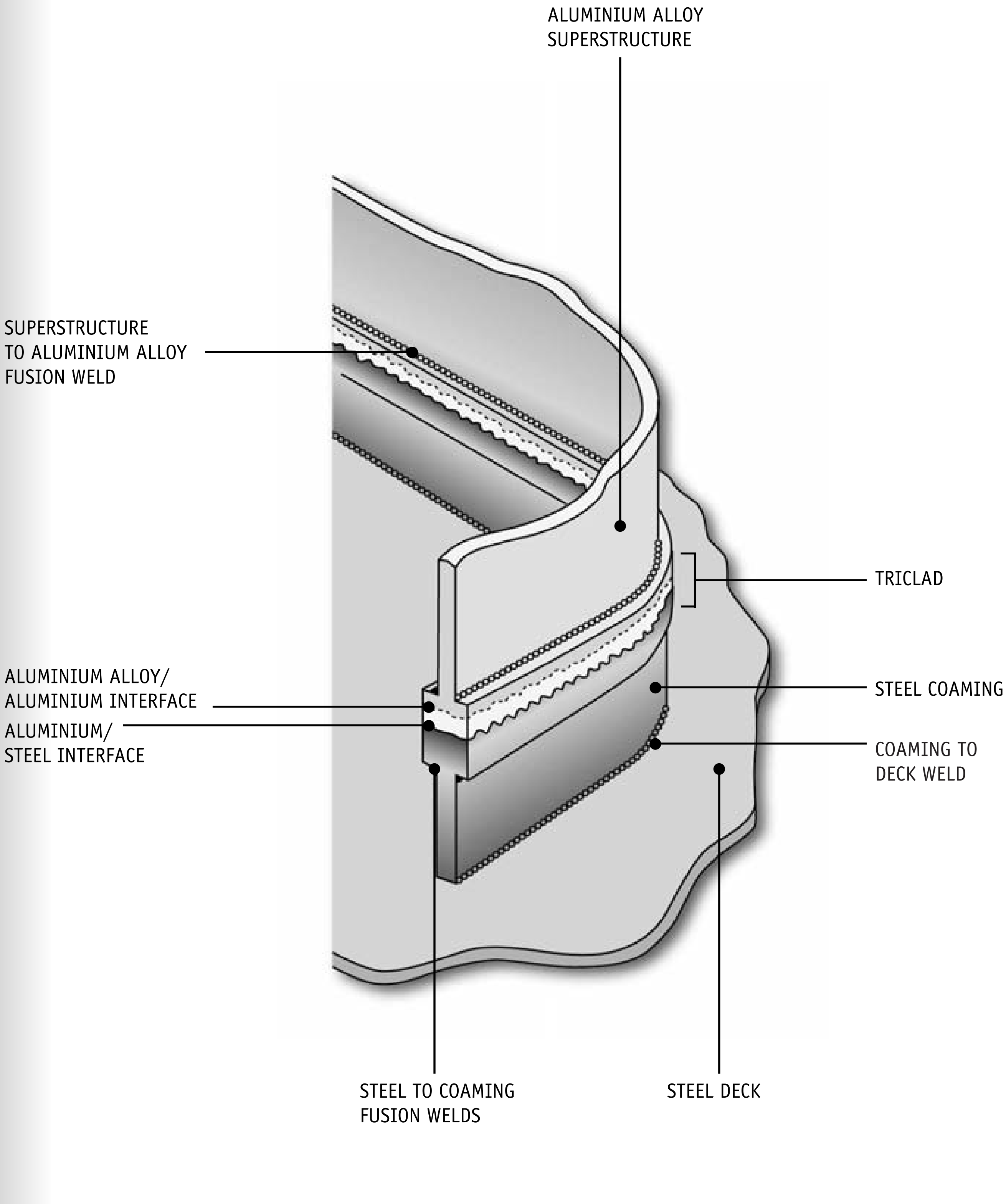
Accredited by the Dutch Council for Certification

Merrem & la Porte

Technical Information

TRICLAD®

Merrem & laPorte


ALUMINIUM ALLOY
SUPERSTRUCTURE
SUPERSTRUCTURE
TO ALUMINIUM ALLOY
FUSION WELD
TRICLAD
ALUMINIUM ALLOY/
ALUMINIUM INTERFACE
ALUMINIUM/
STEEL INTERFACE
STEEL COAMING
COAMING TO
DECK WELD
STEEL TO COAMING
FUSION WELDS
STEEL DECK

Joining aluminium to Steel?

INTRODUCTION

This brochure is intended to look at TRICLAD structural transition joints (STJ) as marketed by Merrem & la Porte in many countries around the world and give an insight into the history, applications and technical aspects of these joints. Also practical advice regarding their use is incorporated in this brochure.

Firstly, what is a transition joint, what is it used for, and how does Merrem & la Porte come to market the product ?

Transition joints are bimetallic strips or pads used to facilitate the joining of dissimilar metals by welding. Particularly where those metals cannot be joined by conventional welding processes, and where, if mechanical joining techniques are used, corrosion sets in after a relatively short service life.

Their uses are generally found in marine construction, but are equally applicable in other industries where a permanent, maintenance free joint between aluminium and steel is called for. Increasingly, aluminium is being used in shipbuilding to reduce weight. However, on grounds of cost and durability, it is not normally used for the whole of the hull, which may be mainly steel. With aluminium being used to a greater or lesser degree for structures above the waterline to reduce overall deadweight or to lower the centre of gravity, thus improving roll performance. This is paticularly beneficial on RO-RO ferries.

Typical applications of Transition Joints are to:

- Join aluminium superstructures to steel decks.
- Join aluminium decks (or even bulkheads) to steel hulls.
- Fit shelter decks to steel fishing boats.
- Retrofit “containers” of electronic equipment to steel decks of warships during refits.
- Add additional accommodation to existing vessels (these can be prefabricated).
- Fit any other components, such as pillars, partitions, etc., where a permanent joint is required between steel or stainless steal and aluminium.

They can even be used to:-

- Fit steel components to aluminium hulls (engine mounts in High Speed Catamarans, davits, etc.).
- Repair or strengthen corroded mechanical-gasketed joints on ships where transition joints were not originally specified (even to make these watertight by welding over the joint face).
- Provide a wear resistant keel on beach launched aluminium vessels.

Other uses are to:-

- Fit helidecks to ships or oil rigs.
- Fix aluminium walkways or accommodation modules on oil rigs.

Additionally, there may be potential applications in road- and rail vehicles or even in civil engineering and chemical plants.
Specialised joints, incorporating an extra layer, in this case titanium, can be used to attach aluminium cryotanks to steel decks.

What are the advantages of using TRICLAD as opposed to "traditional" methods of joining ?

	TRICLAD		TRADITIONAL
1	Permanent, maintenance free, "fit and forget"	1	Generally require use of bolts or rivets , plus gaskets. Can work loose, due to flexing of the hull, creating gaps in which corrosion develops. Rivet or bolt needs to be insulated from aluminium
2	Can be installed by one operative	2	Generally, two operatives necessary
3	Continuous joint, even stress distribution	3	Rivets/bolts give uneven stress
4	Rigorously tested approved product	4	Difficult to assess quality of joint
5	Watertight. Any corrosion self extinguishing	5	Tend to leak

Merrem & la Porte's involvement in the marketing of al/st transition joints stems from having been originally appointed as agents in the Benelux countries for explosion bonded plates manufactured by Nobelclad, France subsidiary of Dynamic Materials Corporation (DMC).
When it was perceived that, the Netherlands being the shipbuilding nation that they were and still are, there should be a significant and growing market in Holland for STJ's, Merrem & la Porte was asked to trial market the product. The sales were so successful that, it was a logical step to increasingly source STJ's for world markets. Selling either direct, or through agents / distributors in close contact with the national shipbuilding industry, Merrem & la Porte has since been the global and exclusive outlet for DMC produced STJ's.

General background of explosion

Merrem & la Porte's supplier, DMC based in France, Sweden and USA, manufacture explosively bonded clad plate in a wide variety of materials. Explosive bonding is a bonding process which uses the high energy of explosives to cold weld two or more materials together, producing a molecular bond which is generally at least as strong as the weaker of the individual metals, and does so without dilution of either metal with the other. The process is described in detail later in this section, but is one which was initially discovered by accident. The exact time of this discovery is unclear, but suffice it to say that it was first commercialised in the late 50's/early 60's, initially in the USA, and then more widely adopted in the late 60's /early 70's in Europe.

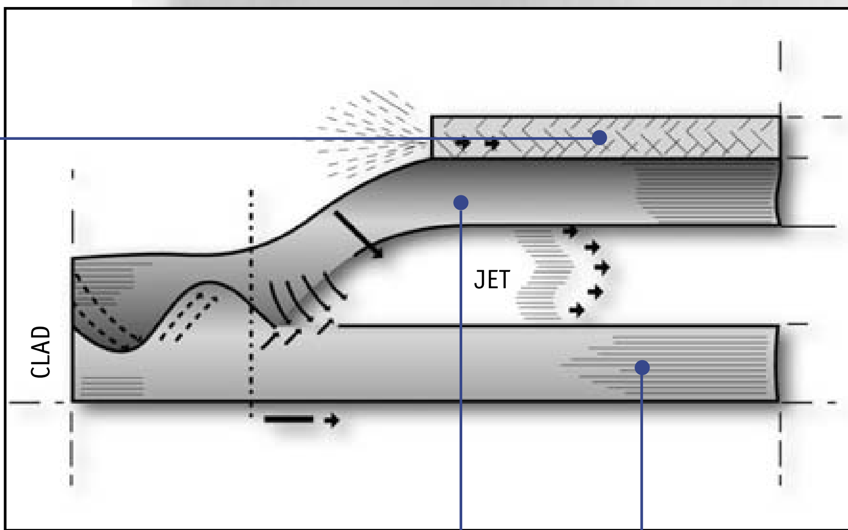
Explosion bonding as a process was formalised in the USA when investigation of the accidentally produced bonds showed them to have many desirable features. They are produced at ambient temperature with virtually no dilution of either metal. This feature was demonstrated to allow the joining of very dissimilar metals without the production of undesirable alloys.
Essentially, the process involves the use of the transient application of extremely high pressure at the interface between the two metals to produce the bond.

As the process uses a large quantity of specially produced explosive, the actual cladding operation is generally carried out in a remote place. The two (or more) metals to be joined are first prepared for cladding. The faces are cleaned and the plates set up one above the other with a pre-determined gap. The gap and gapping method vary with the metal combination and metal thicknesses. Generally, the thinner metal (the cladder) is uppermost and slightly larger than the base metal. The overhang is again determined by the thicknesses of the metals. As the gap is critical, it is important that the plates are flat (generally better than 3mm/m). The plates are placed on a firm sand base, such that they are evenly supported, care being taken to ensure that no foreign material enters the gap. A frame is positioned round the periphery of the cladder, the depth of which is designed to ensure that the quantity of explosive (the loading) per unit area, is consistent with the loading prescribed for the metal combination and the cladder thickness.
The explosive loading ensures that the cladder is accelerated to the optimum speed for bonding, and the velocity of the explosion front across the plate ensures that the angle between the cladder and the base is the optimum for the metals. The extremely high pressure generated at the point where the metals initially meet vaporises the surface contaminants (oxides) which are ejected, thus producing the molecular bond between the two virgin surfaces. The layer of metal removed is

only microns thick. Some very localised work hardening occurs, but in general the properties of the two metals remain unchanged. The metal temperature after cladding is such that you can place your hand on the surface. In most cases the interface is slightly wavy; the amplitude again varies with the metals and is

cladding

most pronounced with aluminium/steel. In a very limited number of cases the bond may contain some (harmless) intermetallics. In an even smaller number of combinations the bond properties may be improved with a low temperature heat treatment. Whilst in most cases, the bond between the two metals is consistent, there are some where the metal structures differ considerably. The bond quality can then be improved by using an interlayer.



One such case is between aluminium alloy and steel, where the interlayer generally used is commercially pure aluminium. This is the origin of the name TRICLAD. For specialist applications titanium may be used.

Each plate is ultrasonically examined for defects, and leveled as appropriate for it's duty (the bonding operation causes the plates to bow, due to the very high transient loadings). The plates as clad, are slightly larger than the required size, as the interfacial pressure produced by the explosive decays towards the edge, producing an inferior bond in this area. Additionally, some thinning can occur in this region. This "trim" material is cut away and discarded. Again, if the final duty of the plate requires, a small amount of additional material inboard of the trim area may be removed for destructive testing.

TRICLAD

TRICLAD is the tradename of Merrem & la Porte for aluminium/steel structural transition joint material. Structural Transition Joints (STJ's) are used for joining structures made from dissimilar metals, where problems may arise with the more traditional mechanical means, or where fusion welding of the two metals is not feasible.

As indicated, TRICLAD is a special clad, designed generally to facilitate the joining of marine grade aluminium structures to steel structures. It is produced as a standard sized "parent plate" in the as clad size 1.5 x 4 mtrs , with a useable area of 1300 x 3800 mm from which strips or other shapes can be cut. The metal grades chosen are designed to be compatible with the commonly used marine grades of aluminium and steel. DMC have standarised on the following grades and nominal metal thicknesses:

ASTM A516 Gr.55 / Aluminium 1050A /Aluminium 5086 *

Thickness: 19 + 9.5 + 6 mm
Shear strength: min 60 MPa / typical 94 MPa
Tensile strength: min 76 MPa / typical 126 MPa

Shipbuilding steel Gr.D / Aluminium 1050A /Aluminium 5083

Thickness: 15 + 3 + 10 mm and 20 + 3 + 10 mm
Shear strength: min 70 MPa / typical 94 MPa
Tensile strength: min 80 MPa / typical 181 MPa

ASTM A516 Gr.55 / Aluminium 1050A /Aluminium 5083

Thickness: 10 + 5 + 4 mm
Shear strength: min 60 MPa / typical 94 MPa
Tensile strength: min 76 MPa / typical 126 MPa

Availability

Standard strip length 3800 mm
Minimum strip width 10 mm

Commonly used strip widths carried in stock are 16 - 20 - 24 - 25 - 30 mm.

Up to the parent plate width of 1350 mm we can cut any requested strip width within a matter of days, if not available off the shelf. Cutting tolerances on strip width will usually be within +/- 1 mm per linear metre.

Additionally we can cut squares, rectangles, discs, or even complex shapes. The latter two by means of a water jet which will minimize the need for finish machining.

Cutting processes vary. Strips and pads can be cut using band saws or friction discs. Shapes can be cut by machining, or water jet, depending upon application and/or accuracy/ finish required.

** Alloy 5086 may in future be replaced by Alloy 5083*

Technical Data

Mechanical properties of TRICLAD composition

The MIL-J-24445A specification, which TRICLAD conforms to, calls for the mentioned minimum properties in both the as-clad condition as well as after a simulated welding cycle (heat treatment 15 minutes, 315°C + Air cool). DMC will release parent plates on the basis of these criteria.

However, typical values for TRICLAD are considerably higher. After simulated welding cycle:

Through thickness tensile strength 120 MPa
Bond shear strength 88 MPa

First article testing for compliance with the MIL-J 24445A specification also included axial fatigue strength testing as well as tensile strength determination on welded specimens. Again all criteria were well met.

Rigorous quality procedures and regular authority verification have earned TRICLAD product/use approval from the following authorities:
Lloyd's Register of Shipping (LRS)
Det Norske Veritas (DNV)
Bureau Veritas (BV)
American Bureau of Shipping (ABS)
(Copies of which are available upon request.)

Non-standard Triclad

It has been at the request of our customers, and after extensive R&D work, that we have developed other variants on the standard Triclad material using titanium interlayer.

The incorporation of a titanium interlayer in lieu of CP Aluminium will allow the use of narrower STJ strip then what the "4 times thumb rule"would call for. This obviously is due to the superior mechanical characteristics of titanium as compared to the Aluminium 1050 that is used in standard TRICLAD version.

Nominal chemical analyses of the composite metals

Steel ASTM A516 Gr 55 / Shipbuilding grade D		CP Alum. 1050		Alum. Alloy 5086 / 5083	
C	0,20 / 0.20%	Si	0.25%	Si	0.40 / 0.40%
Mn	0.60-1.20 / 1,6%	Fe	0.40%	Fe	0.50 / 0.40%
P	0,035 / 0.035%	Cu	0.05%	Cu	0.10 / 0.10%
S	0,035 / 0.035%	Mn	0.05%	Mn	0.20-0.70 / 0.40-1.0%
Si	0,035 / 0,55%	Mg	0.05%	Mg	3.5-4.5 / 4.0-4.9%
		Zn	0.07%	Cr	0.05-0.25 / 0.05-0.25%
		Ti	0.05%	Zn	0.25 / 0.25%
				Ti	0.15 / 0.15%

Mechanical properties of composite metals

	Steel	CP Aluminium	Aluminium Alloy 5086/5083
Tensile Strength (MPa)	380-515	65-95	240-310/275-350
Yield Strength (MPa) min	205	20	100/125
A5/Elongation (%) min	27	35	18/17

Certificates

Certificates available on request for each order include:

- LRS certificate
- Mill test certificate for the parent cladplate(s)
- EN 10204/3.1.B certificates for the composite metals

Stainless Steel Triclad
This product enables you to weld stainless steel components such as anchor hawse holes, bollards, railings, stairs, etc. to an aluminium deck.

The SS TRICLAD version is made up of:
19 mm Stainless Steel AISI 316L
1.0 - 1.5 mm Titanium ASTM B265 Grade 1
10 mm Aluminium 3003

Although typical tests show significantly higher results, we suggest to use the following minimum values of the composite for design purposes for both Stainless and Titanium interlayered combination:
Tensile strength 100 MPa
Shear strength 55 MPa
In case any additional information is required, you can contact our office in the Netherlands.

Titanium interlayered Triclad
The Titanium interlayered Triclad version with Aluminium is made up of:
19 mm Steel ASTM A516 Grade 55
1.0 - 1.5 mm Titanium ASTM B265 Grade 1
10 mm Aluminium 3003

Corrosion Resistance

Unlike with mechanical joints, there are no corrosion prone crevices. Also no stress corrosion has been reported to date. Still a question often raised is how TRICLAD behaves in a marine environment relative to galvanic corrosion, given two metals with considerable differences in potential. It is clear that a suitable paint or coating will prevent contact between the electrolyte and the strip, thus avoiding corrosion. It is however worthwhile investigating more closely the effects of the absence of such protection.

Considering the lower galvanic potential of the steel, extreme corrosion of the aluminium may be anticipated; particularly near the interface. This is the area where the metal has been heavily worked and the anode is in close proximity. Initial corrosion tests on unpainted samples of approximately equal aluminium to steel areas revealed however a natural insulating effect. As expected, slight penetration began at the interface as the aluminium started to corrode. But, instead of acting as a latent area of high ion concentration and thereby accelerating corrosion, the penetration area gradually filled with an extremely hard and inert corrosion product, aluminium oxide hydrate. The oxide acted as a seal and rendered the system passive after only a very minor penetration; the exact level dependent upon the severity of the initial corrosive environment. Accelerated salt-spray tests, simulating years of exposure, further demonstrated that corrosion became negligible after the initial barrier had been built up. Painted samples, whose interface had been scratched so as to expose only a small area, were subjected to the same testing environments. With these, the only interface corrosion was a slight pinpoint area beneath the scratch. The solid metallurgical bond restricted the electrolyte from penetrating the interface, while the build up of corrosion product prevented extensive pitting. This served to prove the transition joint system's advantage over mechanical connections. In the latter, a crevice exists between the faying surfaces and once the protective coating is broken, the electrolyte rapidly penetrates the interface.

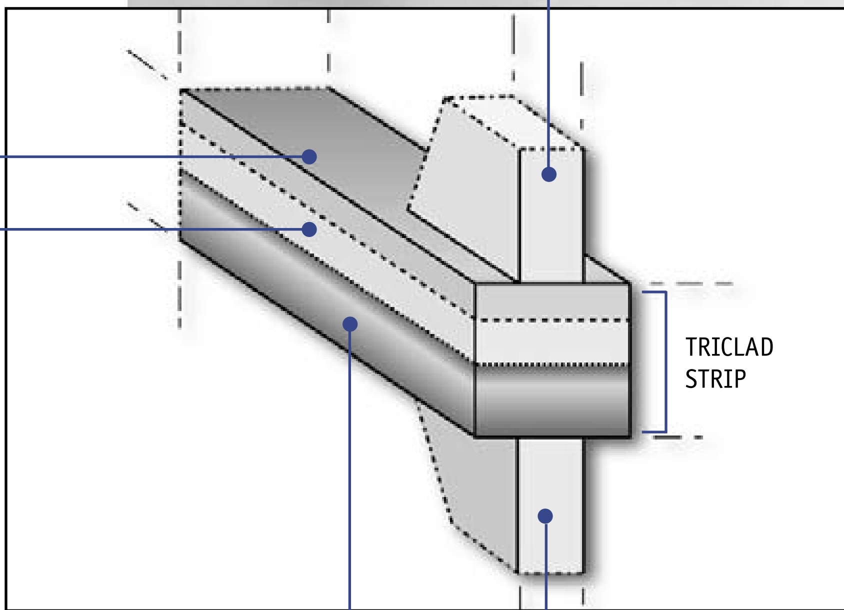
Fabrication guidelines

The first question often heard in this respect is how one determines the strip width appropriate for the specific construction ?

It is the CP Aluminium that is the controlling factor when taking into consideration the ductility and overall strength of the composite.

When considering the width of strip to be used, a rule of thumb is to use strip that is four times as wide as the aluminium plate being used. E.g. 6 mm aluminium plate in the superstructure will call for TRICLAD strip of 24 mm wide.

This will result in a join that is slightly stronger than the plate itself while also providing for an improved heat sink during welding operations. It is suggested that the aluminium plate be placed in the middle of the TRICLAD strip. This will make for sufficient leeway during welding to avoid welding too close to the al/st interface. Additionally it will avoid an uneven spread of stresses during warming up and cooling down during and after welding operations. Having said that; it is however common practice, especially in shipyards with more experience with the use of TRICLAD, to position the aluminium plate at the edge of the strip.



For a steel plate, the “4 times rule” does not apply. In such construction it is considered good practice to divide the tensile strength (in MPa) of the steel plate by 80, to obtain the multiplying factor. E.g. with a 480 MPa tensile strength steel, the strip width should be appr. 6 times the steel plate’s thickness.

TRICLAD can be used to give a continuous join between any aluminium structure and an adjoining steel structure, or to provide local joins. In many cases it allows the straightforward attachment of an aluminium structure to an already existing steel structure. Sketches show some of the ways that the joint strip can be installed between the two structures. There are very few restrictions to it’s use, these are summarized on the next page.

1. Welding

Key points are: (I) The interface between the aluminium and steel shall be kept below 300˚C (570˚F) !
The use of heavy weld deposits is to be avoided; several beads are preferable to one heavy bead. Preferably laid as a series of short runs, rather than one continuous run. Where practical, join the TRICLAD to the aluminium structure first. This gives a better heat sink when welding to the steel. If the aluminium structure is prefabricated, this will give it additional rigidity.

(II) Welding is not permitted closer than 3mm either side of the Al/st interface.

(III) Where a single piece aluminium bulkhead is fastened to a steel hull at both ends, extreme care should be taken to avoid putting too much heat into the aluminium for as it cools it will shrink, generating very high stresses in the join s. This is best designed out by providing freedom to move.

2. TRICLAD can be bent, subject to the following limitations:
Minimum radius of bend 10x strip width in horizontal plane.
300mm in vertical plane
Bending to be carried out cold.
Where tight corners are required, strips may be mitered, or specially cut curves may be specified.

3. Where a structure is being fitted onto a nominally flat steel deck, it is best to use a coaming approx 100mm deep as this can be trimmed to even out any “waviness” of the deck. If the joint is welded directly to the deck, care must be taken not to try to pull the deck straight with the joint; or the aluminium in the joint will be overstressed. In either case, a degree of tailoring is necessary to ensure a good fit.

4. It is good practice not to have joints in the TRICLAD coincident with joins in the steel or aluminium plates to which it is attached.

5. Cutting should be by mechanical means (saw, friction disc or waterjet) NEVER gas or plasma cut

6. Where a ship utilizes a steel hull and both the deck and superstructure are aluminium, TRICLAD strips are fitted around the hull and across the tops of the bulkheads. Those on the bulkheads need not be full length.

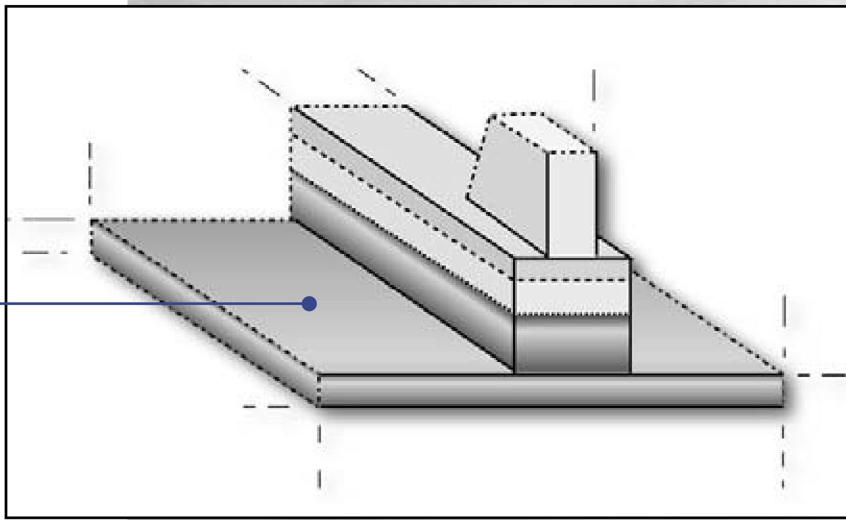
7. Until welders are well experienced with TRICLAD, we recommend the use of “Tempelsticks”or similar indicators to avoid overheating. We also suggest that fabrication drawings include the following warnings:-

NEVER
- WELD ACROSS THE INTERFACE, OTHERWISE DISBONDING WILL OCCUR
- MAKE A SHARP BEND IN THE JOINT
- PRE-HEAT JOINT PRIOR TO WELDING OR BENDING
- ALLOW THE INTERFACE TO EXCEED 300˚C
- GAS CUT JOINT STRIP

The main causes of failure in TRICLAD joints (a very small failure rate of below one percent is experienced) are:

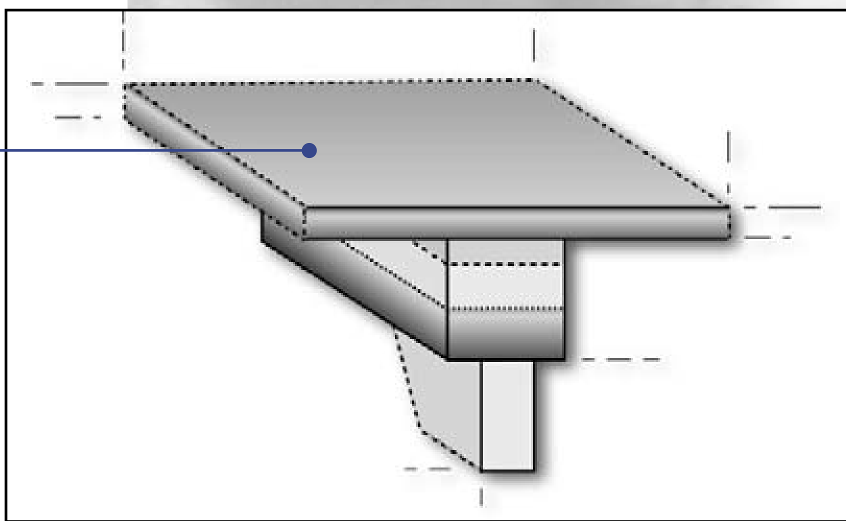
- Overheating of the joint interface due to laying down too heavy a fillet weld (a single, heavy bead)
- Overstressing of the joint due to overrestraining the joint by the ship's structure during fabrication, due to inaccurate fit of panels, or contraction following overheating.
- Bending the strip incorrectly
- Welding too close to, or accross, the interface.

STEEL PLATE



Both the US Navy, and the UK Royal Navy have carried out exhaustive testing of aluminium-steel transition joints in the laboratory, during fabrication, and analysed in service performance. Either are happy that the majority of problems arise from failure to adhere to the simple guidelines given above. Indeed, following the losses of Royal Navy ships in the South Atlantic during the early 1980's, analysis of the damage to ships with aluminium superstructures showed that there were no failures of the transition joints used on these vessels. The myth that aluminium burned was dispelled. In particular, the one ship which was originally cited as an example of the risks of using aluminium in warships, HMS Sheffield, was an all steel ship.

ALUMINIUM PLATE



Tests carried out by the two navies also included fatigue testing and impact (explosively induced water hammer) testing. Almost every failure occurred in the aluminium plate, rather than the transition joint itself. The Royal Navy Engineering College carried out a series of investigations which confirmed all the original testing, and included surveys of recently built ships, plus visits to shipyards.

Welding parameters - general

A detailed WPS as used by a European (defence) yard can be made available upon request.

IT WILL BE CLEAR THAT THE FINAL RESULT OF ANY WELDING OPERATION IS LARGELY DEPENDENT UPON THE WORKMANSHIP AND EXPERIENCE OF THE WELDER HIMSELF. HAVING NO CONTROL OVER THAT, MERREM & LA PORTE THEREFORE ACCEPTS NO LIABILITY IN THIS RESPECT.

Welding conditions

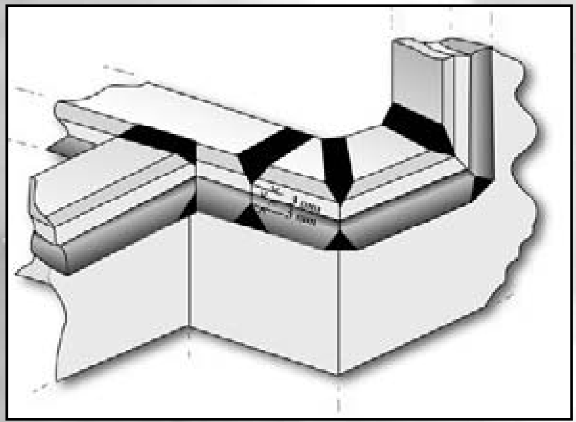
Welding speed is a function of the thermal equilibrium achieved. This in turn is related to the welding conditions, dimensions of the joint, position of the weld, dissipation of heat into the structure etc. All these factors must be taken into consideration, and care taken to ensure that the interface temperature does not exceed 300˚C. Small diameter wires (e.g. 1.2 mm for the aluminium) and small diameter electrodes (e.g. 2.4 mm for steel) are preferred.

Preferred welding process:
GMAW or GTAW for the aluminium side.
Coated electrode or GMAW (with non-inert shielding gas) for the steel.

The recommended welding methods and/or parameters do not differ from those used for the two parent metals, apart from the need to avoid overheating the interface between the two metals. Thus, for welding the aluminium plate to the joint strip, TIG and MIG welding are acceptable. Synergic pulse MIG welding is also now being used.
It is essential that the aluminium oxide film is wire brushed away immediately before the welding operation is carried out and degreased with a solvent. Clean gloves are worn when handling rods or wires. Argon is the preferred shielding gas.
In the event that TIG or MIG welding equipment is not available, then manual arc welding is possible, using covered electrodes consisting of pure aluminium, or aluminium-silicon (5-10% Si) or aluminium 1.2% Manganese, but this is not recommended. The weld will not be as strong as with MIG or TIG due to the risk of gross porosity, and welding by this process is limited to downhand
For the filler metal, assuming the plate to be 5086 or similar, Al-5Mg composition material is recommended (typically 5556A , 5356 or 5183).
In all cases, the use of short tacking runs and avoidance of heavy stringers to ensure that interpass temperatures stay below 200˚C (390 F), is recommended. The weld bead should be flat, or slightly concave.

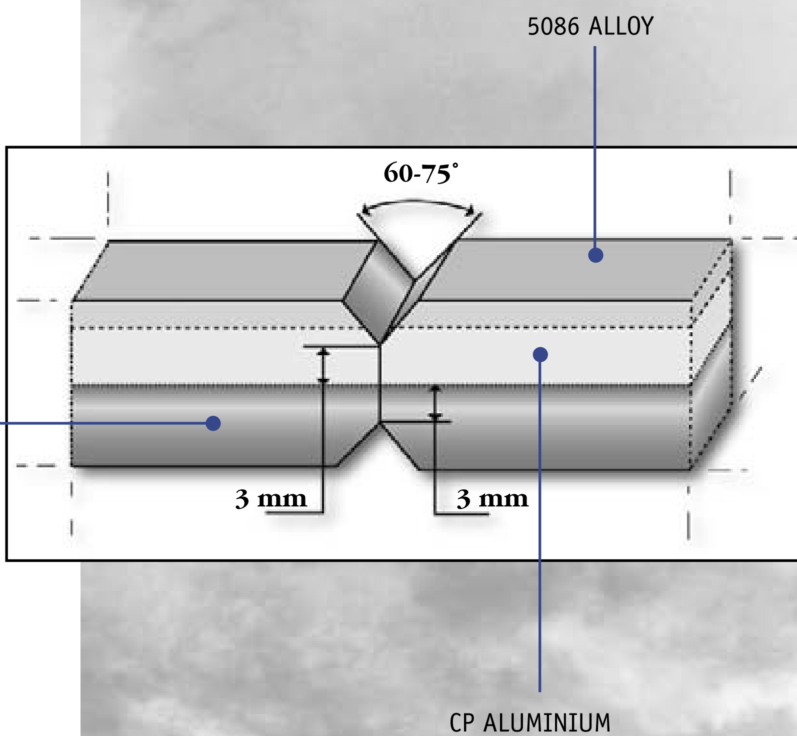
For the steel weld, GMAW (pulsed gas metal arc weld) or FCAW (flux cored arc welding) are the preferred processes, as these result in lower workpiece temperatures than the alternative SMAW (shielded metal arc welding) process. Electrodes should be suitable for low (max 0.12%) carbon steel. Detailed welding procedures are available upon request. However, all procedures should be agreed with the inspection authority who may request weld test pieces. Should weld procedures demand the use of dye-penetrant testing; it should be noted that the semi-porous nature of the aluminium / steel interface will normally show an intermittent indication, and should not be a cause for concern. Pre-heating should be avoided wherever possible, but if conditons require pre-heating, DO NOT PRE-HEAT THE TRICLAD, only heat the aluminium structure being attached to it.

guidelines



Butt joints
Strip ends should be chamfered. The strips should be butted and firmly clamped. If possible, the aluminium weld should be made first, using several straight passes in order to minimise temperature rise of the joint strip interface.

Until sufficiently experienced, it is recommended to monitor the interface's temperature by using heat sensitive paint or other suitable means.
The welding parameters should be adjusted to achieve full penetration of the weld bead allowing cool down time between the subsequent passes.
The 3 mm unwelded area at either side of the interface should be hammer peened if a water tight joint is required. Alternatively; drill and inject sealant or epoxy.



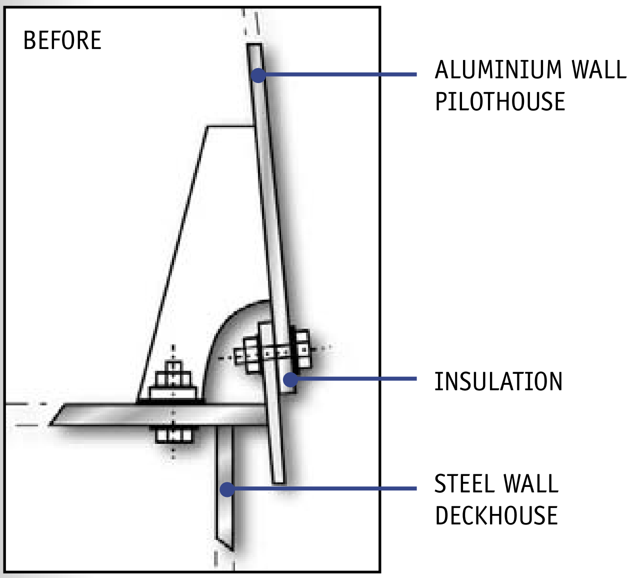
Where the end of a TRICLAD strip butts against a single metal (aluminium or steel); jointing or sealant should be inserted to prevent corrosion. On no account should an attempt be made to weld across the interface between the steel and the aluminium in the joint!

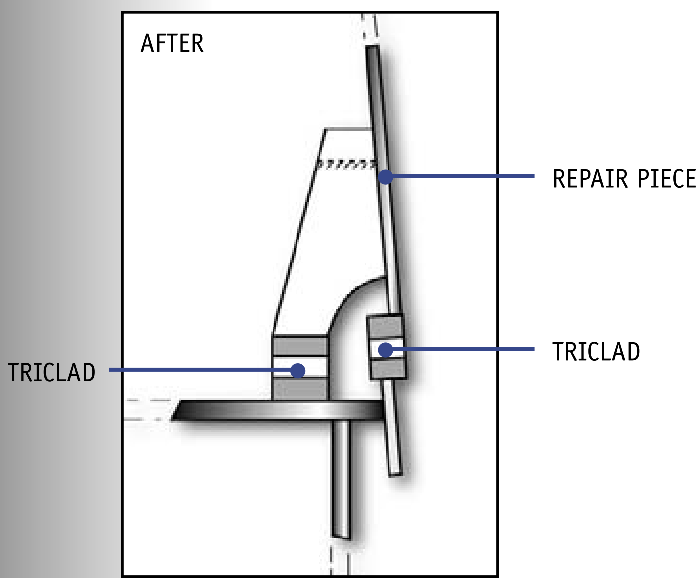
Corners may be mitred as shown or, where space permits, bend.
Bends are stronger and permit the positioning of joints in more accessible positions. Bends should have a minimum radius of not less than 10 times the joint's width in the plane of the bend.

Repair of corroded mechanical joints

The left hand sketches show a common solution to this problem.

Alternatively; a corroded bolted connection (A) might be field repaired using TRICLAD transition joint by design B or completely replaced on new structures by design C.





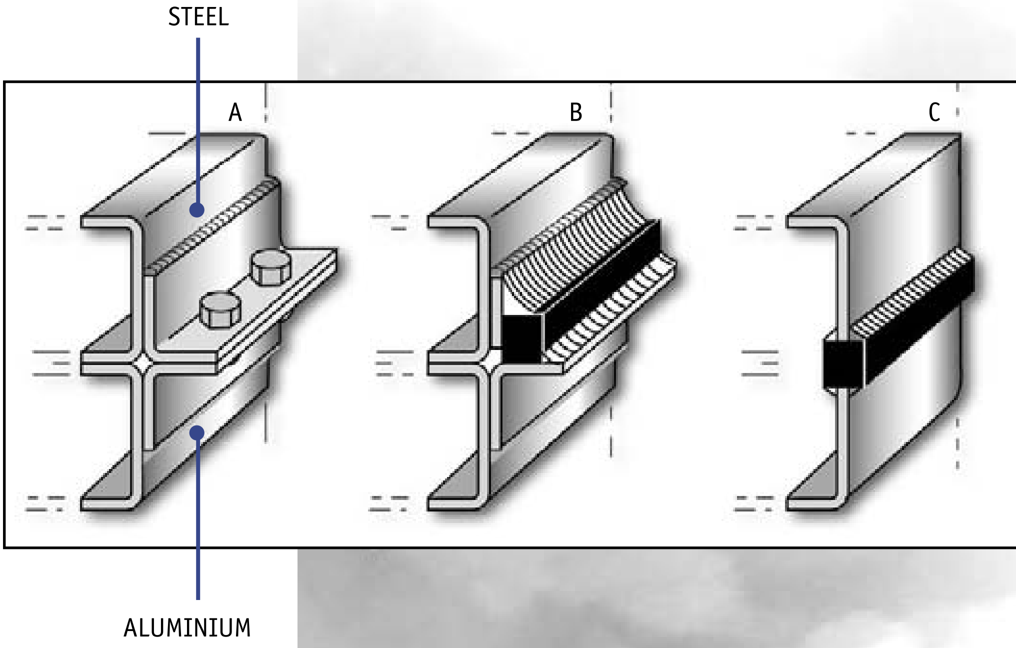
Painting

In general terms, painting should be as recommended for aluminium hulls. However; antifouling paints containing copper, mercury or lead salts are not recommended as they may encourage galvanic corrosion.

The area either side of the joint should be thoroughly cleaned by wire brushing.
An initial coat of approx 5/6 microns of etching primer should be applied.
A second coat of chrome or zinc chrome prime, 40 microns thick, should then be applied.
A two coats of marine undercoat each approx 40 microns thick, should then be applied.
A final 40 micron thick coat of marine topcoat paint completes the painting.

Typical paint specs are

Etch primer	DEF Stan 80-15
Primer	DEF Stan 80-77
Undercoat	DGS 168A
Topcoat	DGS 168A



Some commonly asked questions

How can the different coefficients of expansion between aluminium and steel be accommodated ?
Whilst the coefficient of expansion of aluminium is almost 50% higher than that of steel, the phenomenon exists regardless of how the metal structures are joined; and the forces required to restrain the aluminium are the same. However, with a transition joint the force is applied uniformly, rather than at a series of points with mechanical joints, and is well within the shear load capabilities of the bond.

What are the small holes visible at the interface between the aluminium and steel and do they affect the performance of the joint ?
The holes are small pockets of intermetallic material, and are a characteristic of the bond between the two metals. Indeed, they may pass from one side of the joint to the other, but the testing of the joints takes this into account. In service, these pores will be sealed either by harmless corrosion products, or by paint, or, in most cases, a combination of the two.

My operating conditions are particularly severe. Are there any other joints that suit my application ?
We also produce joints with a titanium layer. These are particularly suited to use on LNG tanks , or where elevated welding temperatures are likely to occur.

I see that the manufacturers of joints recommend sophisticated welding techniques; we do not have access to such equipment. What can we do ?
These techniques have been developed to meet the very stringent requirements of the military and enable costs to be pared to the minimum by giving optimum structural strength and maximum building rates. Provided that you have equipment capable of producing (to the inspection authority) acceptable aluminium to aluminium welds and similarly acceptable steel to steel welds, then you can use TRICLAD. We would suggest that you monitor the welding operations to ensure that no overheating occurs and err on the conservative side when specifying the size of TRICLAD joint.

Special thanks are due to D. Nowell of Nobelclad UK for his extensive assistance in drafting this brochure.

Pictures shown are courtesy of:
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Schelde Scheepsnieuwbouw,
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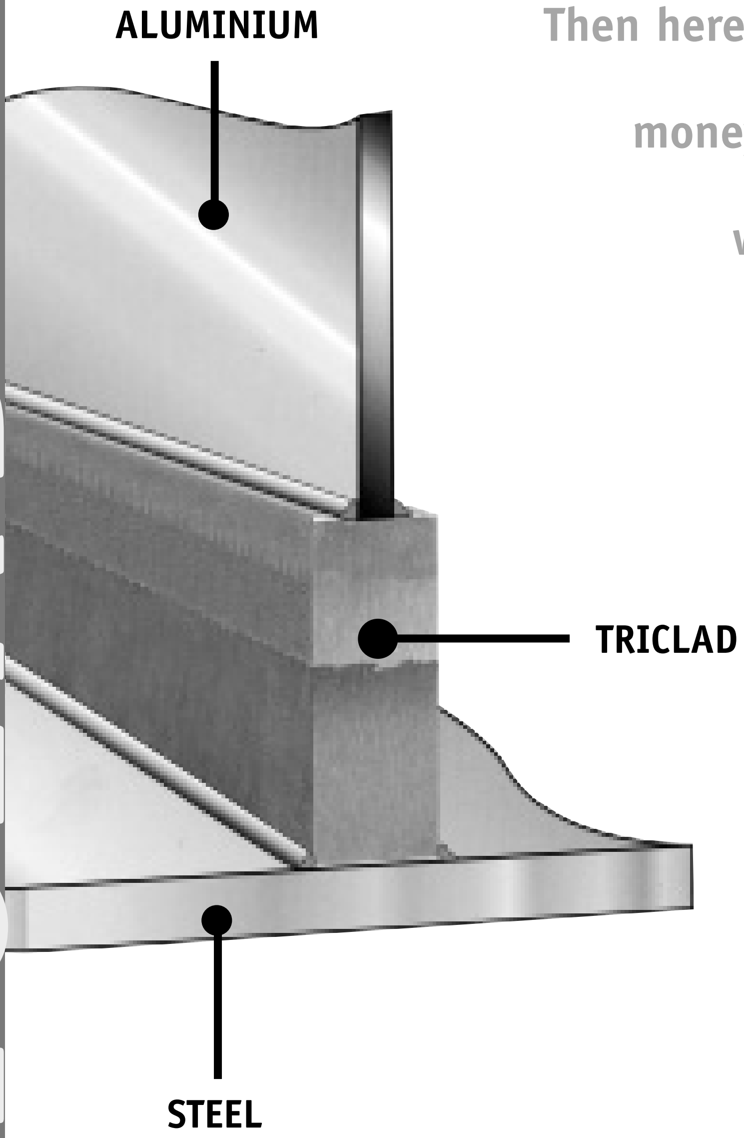
TRICLAD®

Joining Aluminium to Steel?

Then here is the product to save money on both construction work and maintenance!



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