ALUMINIUM ARMOUR WELDING REPAIR GUIDE

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CVR(T) SUPPLY, SUPPORT, REPAIR, REFURBISH AND UPGRADE

ALUMINIUM ARMOUR WELDING PROCEDURES

1 SUMMARY

The following is a brief overview of CVR(T) Aluminium Armour welding procedures.

Aluminium Armour welding is however a highly specialised process which can, if not done correctly, lead to disastrous results !

Repaircraft PLC therefore offer the following products and services:

1.1 Supply of Welding Equipment and Consumables

1.2 Provision of Aluminium Armour Welding Training Courses

1.3 Supply of specialist Aluminium Armour Welding Personnel to carry out repairs in users own facilities

1.4 Welding Repair of vehicles in the UK

2 INTRODUCTION

Repair by welding has, in certain circumstances, been approved as an acceptable procedure to rectify defects caused by Stress Corrosion Cracking. Repair by welding is, however, to be kept to a minimum, and preference given to the alternative types of repair, where applicable.

3 GENERAL

For the welding of aluminium (particularly the solution heat treated, artificially aged, alloys of the Al, Zn, Mg family) to be carried out satisfactorily and efficiently, there must be a clear understanding of the problems involved.

3.1 Oxide film

The oxide film which forms on the surface of aluminium and its alloys is of particular significance when welding, as it is extremely hard and has a melting point of approximately 2,000ºC, compared with 650ºC - 700ºC for the parent material.

The original oxide film formed at elevated temperatures during plate manufacture will have been removed for vehicle fabrication. The film which forms on the surface at ambient temperatures can be satisfactorily removed by diligent/vigorous wire brushing either rotary machine or by hand. The area scoured should extend at least 49 mm on either side of the weld zone. In order to prevent contamination, only stainless steel wire brushes are to be used. They should not have been used for any other purpose.

New plate for patches, test pieces etc, will first require special chemical or abrasive cleaning.

3.2 Surface condition

When material has been shot peened or metal sprayed in the course of initial production, or heavily corroded in service, some additional difficulty will be experienced in the welding operation due to lack of ‘wetting’ caused primarily by increased surface area affected by oxide films. Finishing using alumina abrasive discs is permissible to restore a clean wieldable surface.

3.3 Cleanliness

It is essential that, after wire brushing or abrasive cleaning and immediately prior to welding, the surface around the area to be welded is cleared of debris and wiped with acetone or paint thinners using a clean rag for each application.

WARNING

BEFORE ANY WELDING IS COMMENCED, THE AREA MUST BE COMPLETELY SOLVENT VAPOUR FREE AND MATERIALS CONTAMINATED WITH SOLVENTS REMOVED TO A SAFE AREA.

CHLORINATED SOLVENTS MUST NOT BE USED

3.4 Thermal Conductivity

The thick sections of aluminium used in AFV fabrication provide a considerable heat sink, consequently high currents with relatively short arcs are essential in order to produce welds with good side wall fusion and root penetration.

4 THE WELDING OPERATION

4.1 Preparation

Before welding, any exfoliation, paint or other contamination must be cleaned from the surrounding area for at least 1550 mm either side of the weld line. The oxide film must then be removed as previously detailed.

4.2 Process

Aluminium material in excess of 5.9 mm thick is to be welded using the MIG process.

The welding wire is fed to the welding gun by a wire drive through a plastic liner in a cable assembly. Within the cable assembly is the shielding gas supply tube and recirculating water cooling facility essential for the efficient operation of the welding torch at the currents needed for welding thick aluminium plate.

The arc is self compensating which maintains the arc length against slight movements of the welder's hand.

4.3 Equipment Description

A water cooled synergic programmable MIG welding unit of 400+ Amps and a "Clean" electricity supply.

4.4 Workshop conditions

The following conditions are to be maintained in the workshop:

4.4.1 Welding areas are to be maintained at a temperature no less than 9°C and not more than 24ºC. The operator is to ensure that the temperature of all metals is not less than 9°C or more than 24ºC at the commencement of welding.

4.4.2 The work shall be protected adequately from draughts during welding.

4.4.3 Cleanliness and prevention of contamination is of paramount importance and precautions must be taken to ensure that the area in which the welding is carried out meets these conditions.

4.5 Techniques

The welding operation must be carried out by an approved welder, experienced in the MIG welding process, with an appreciation of the particular techniques necessary to achieve sound welds in thick aluminium structures and with a demonstrated capability of consistently applying those techniques. The importance of using the correct welding parameters and sound welding techniques cannot be stressed too highly. The MIG welding process can produce severe defects if steps are not taken to produce consistently sound welds.

4.5.1 Cold Start

Once the arc has been struck and before the molten pool has become fully established, welding wire will be fed into the arc at between 100 – 150 mm/s. The high thermal conductivity of the parent material chills the molten pool, consequently the start of the weld within the first 12 mm (1/2 in.) will contain some weld metal not fully fused with the parent material, hence the term ‘Cold Start’. Tack welds used for construction must not therefore be welded over, but removed before the construction weld is made. Cold starts can be prevented by the following:

4.5.1.1 Use of a run-on plate of a compatible material.

4.5.1.2 Remove 26 mm of weld run start if to be joined to a second run.

4.5.1.3 Delay run start by backhopping 14 - 21mm.

4.5.2 Crater / End of run cracks

The most common defect in the MIG welding of aluminium is shrinkage and/or crater cracks at the end of the weld. The defects fall into two categories:

4.5.2.1 Cracks in Starved Craters

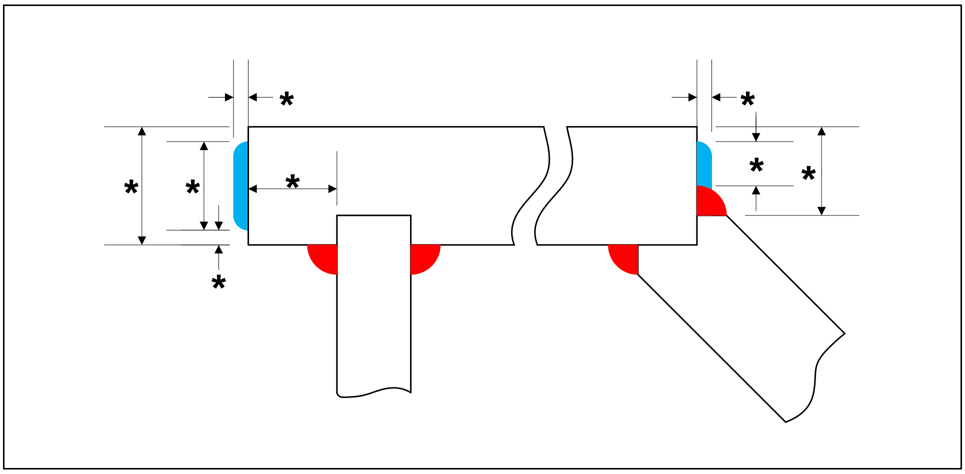
This is due to incorrect welding practice when a weld is stopped at the end of a weld run. The correct technique is to change direction of the welding arc by going back over the molten metal pool filling the crater before breaking the welding arc.

4.5.2.2 Shrinkage Cracks

The only way the deposition of weld metal into the molten pool can be stopped in the semi-automatic MIG welding process is for the arc to be broken sharply. The weld pool is suddenly deprived of the heat source and exposed to the atmosphere. As a consequence, rapid cooling of the molten pool takes place and a shrinkage crack will appear at the end of the weld. Such cracks must be gouged out to leave sound material. They must not be welded over or obscured by peening to help to prevent subsequent crack propagation.

4.5.3 Buttering

Buttering is the coating of an edge with a layer of weld metal. The layer shall be at least 2.9 mm thick in the form of beads deposited by weaving from side to side of the edge or land in transverse direction. Longitudinal beads are not to be used. The buttering may leave an exposed edge or land not more than 5.9 mm wide.



Areas requiring Buttering shown in Blue

4.5.4 Welding Considerations

It is essential that the parent metal adjacent to the weld does not become excessively overheated during welding as this will irreparably weaken it. To ensure that this does not occur over large areas of the parent plate, the interpass temperature shall be kept below 49 ºC, i.e. before additional passes are made the temperature due to the previous pass must fall below 49 ºC. This should ensure that the temperature of the parent metal does not exceed 199 ºC at a distance of 24mm from the weld.

Currents and voltages used will vary depending on the relative thicknesses of the components to be welded, size of weld, joint preparation, welding position etc. Typical parameters for welds likely to be encountered in the repair of CVR(T)'s are given in Table 1.

5 TYPICAL WELDING PARAMETERS

Application	Type	Current	Arc Voltage	Terminal Voltage O, C, V	Gas Flow m^3/Hr	Ahead/Behind Leading Arc
Pad and Boss Attachments	Single Pass	*	*	*	*	*
Exfoliation Gutters	Single Pass	*	*	*	*	*
Crack "V" Preparation	Root Pass Capping Pass	*	*	*	*	*
Crack "Slot"	Root Pass	*	*	*	*	*

with Backing Bar	Capping Pass					
Buttering	Single	*	*	*	*	*

Table 1

5.1 Initial Root Pass to be removed with rotary cutters if heavily contaminated with corrosive debris and the Root Pass repeated.

5.2 Amp/Volt Meters must be calibrated.

5.3 Argon Shielding gas to be high purity 99.*%.

5.4 Welding wire 1.6 mm BS * shaved, layer wound on spools and protected from contamination by oil, moisture, etc.

5.5 Arc voltage is critical and depends on voltage drop in cable and machine and it is strongly recommended that the volt drop for each set of equipment is measured on calibrated instruments as close to the contactor tip as possible

5.6 Voltages quoted are for cable lengths of approx * metres using a constant voltage type power source.

5.7 Modern programmable machines can be pre-set to give the ideal current operating voltage combination.

5.8 In repair welding operations, the final adjustment of current and voltage depends on joint conditions (adequacy and accuracy of preparation), joint position and operator capability.

In all situations the sound of the arc is indicative of good welding conditions. A good arc emits a very distinctive sharp 'frying' sound.

6 APPROVED LOCATIONS FORWELD REPAIRS

Cracking of modern aluminium armour is very unlikely. The main problems occur with armour plate produced in the 1970's and early 80's.

6.1 Welding is only permitted in the following cases:

6.1.1 Plate cracks extending less than * of the way around bosses or pads mounted on plates not subject to direct ballistic or splinter attack. This is mainly bosses or pads mounted on the floor or sponsons. Severe exfoliation (>T/5 deep) must not be present.

6.1.2 Plate cracks, not around bosses or pads, in areas not subject to direct ballistic or splinter attack. This is mainly bosses or pads mounted on the floor or sponsons. Severe exfoliation (> T/5 deep) must not be present.

6.1.3 Pads or bosses required in association with some armour repair parts.

6.1.4 Where other standard repair schemes call for welding.

6.1.5 Even if it is thought that welding is the appropriate repair technique for other damage, a special repair scheme must be requested.

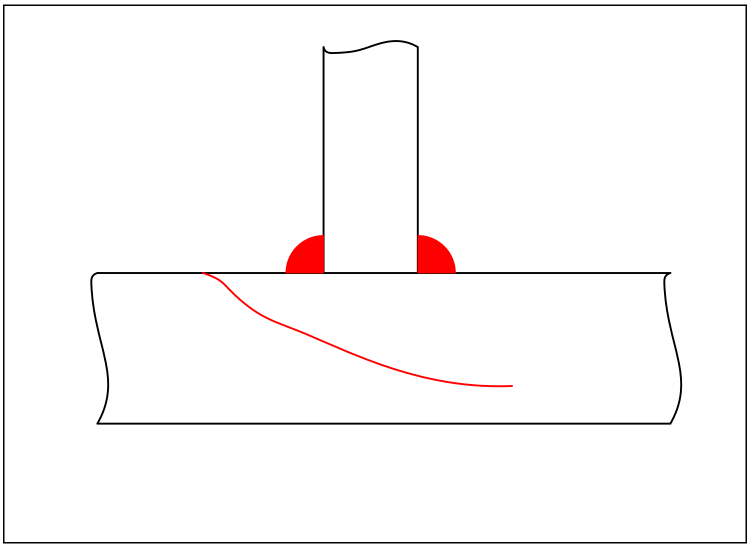
6.2 Pre Welding Inspection

Dye Penetrants must NOT be used.

Determine the extent of the crack using an Eddy Current test.

Determine direction of crack by a “thumb nail” check. The material surface will tend to lift above the direction of crack propagation.

6.3 Crack Path Oblique to Plate Surfaces

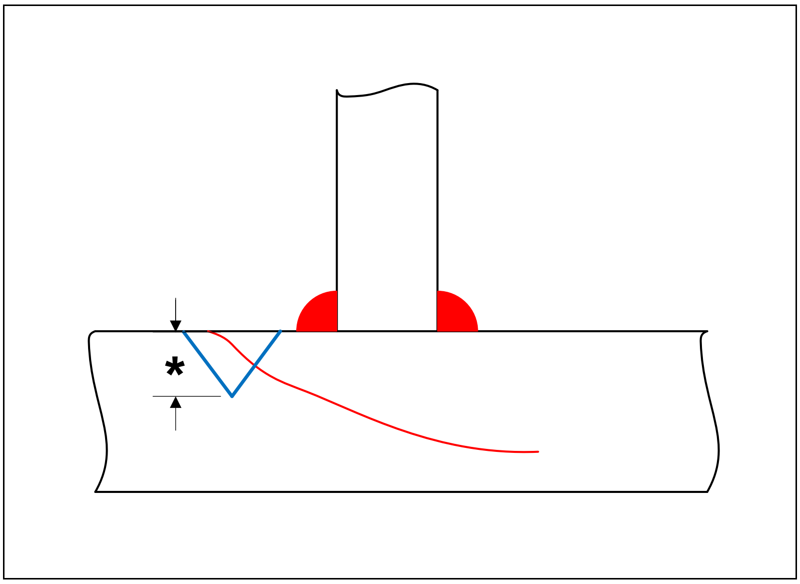


Typical Oblique Crack Path

6.3.1 Preparation

Prepare for welding as follows, (where T = Plate Thickness):

Cut back from the inside surface to provide a welding “V” 80º to 90º included angle to a depth of * to * T minimum, using rotary cutters, hand tools or Alumina (A*) grinding discs.



"V" Preparation

6.3.2 Welding

Carry out welding procedure as follows:

Make root pass using recommended parameters, adjusted to suit conditions.

Remove this weld pass using rotary cutters, since this weld can be very porous and may contain corrosive debris. The original preparation should be substantially achieved.

Make second pass in order to fill * to * of depth of "V" preparation.

Again, remove weld if weld metal still unsound.

Make capping to recommended welding parameters to provide sight reinforcement to weld run.

6.4 Crack Perpendicular to Plate Surface

Through Crack Path

6.4.1 Slot Preparation

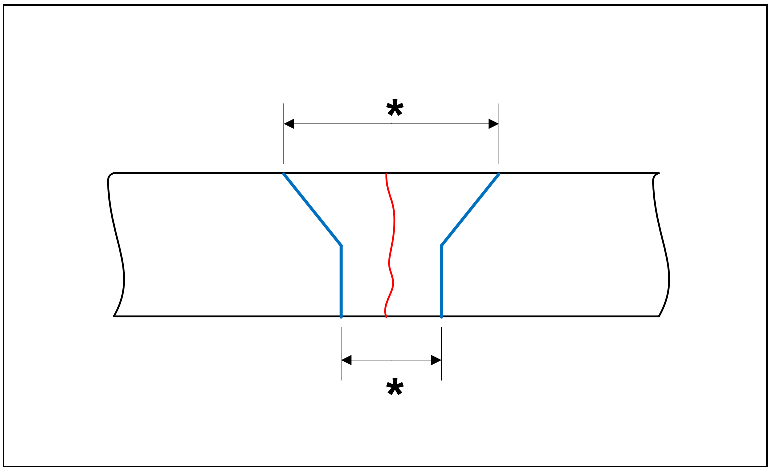
Prepare for welding as follows, (where T = Plate Thickness):

Two methods of producing the slot are given, method used will depend on equipment available.

Drill 5.9 mm dia holes through plate along line of crack ensuring the holes overlap one another and that the line of holes extends at least 5.9 mm beyond the visible ends of the crack. Link up holes with each other to provide a slot 5.9 mm minimum width.

OR

Machine out a slot 5.9 mm minimum width along the path of the crack, through the plate extending at least 5.9 mm beyond the visible ends of the crack.

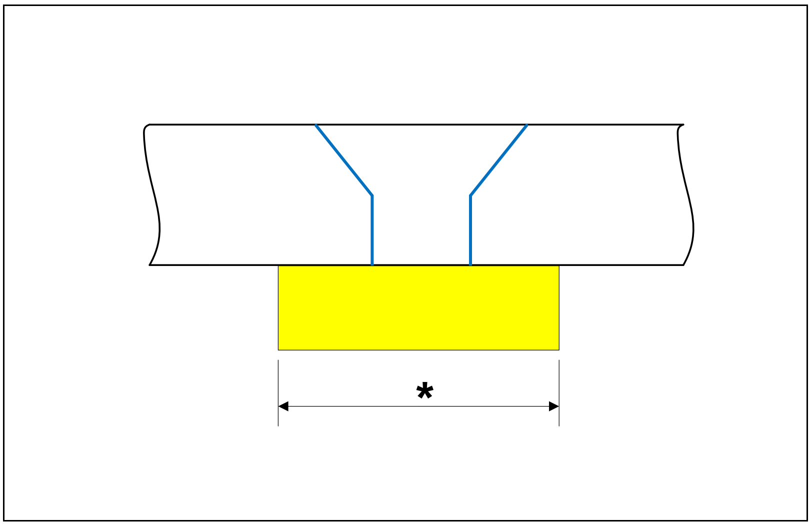


“V” Preparation

Cut out a welding “V” at 90º to a width equal to the plate thickness (T).
Wire brush and clean plate surface for 49 mm either side of weld preparation

6.4.2 Steel Backing Bar

Copper bar must NOT be used.



Steel Backing Bar

6.4.3 Welding

Make root pass using recommended parameters (see Table 1), adjusted to suit local conditions.

If found to be heavily contaminated with corrosive debris, remove weld using rotary cutters.

Make intermediate and capping passes using the recommended parameters, (adjusted to suit local conditions), to provide slight reinforcement.

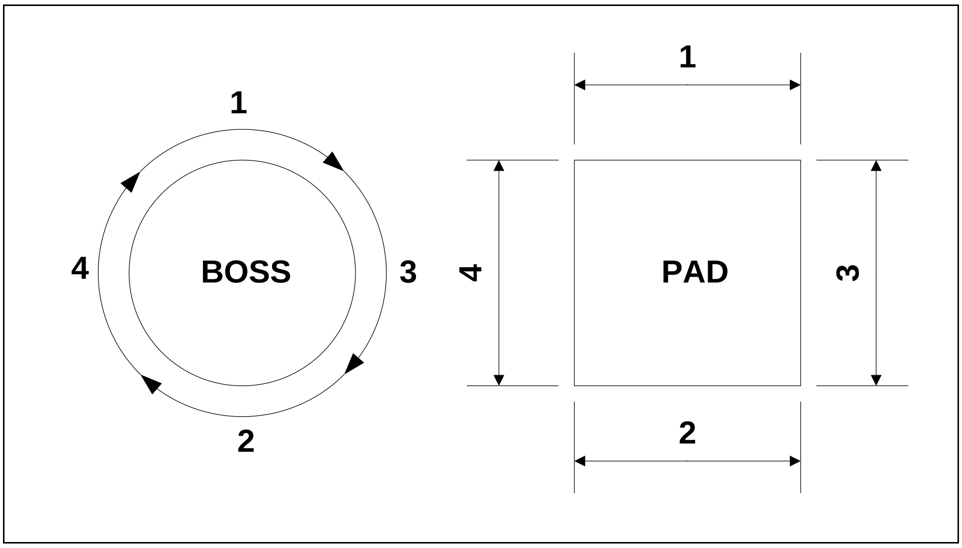
Remove backing bar and dress plate surface previously covered by bar.

6.5 Pad or Boss Attachments

The welding parameters for this operation are given in Table 1.

Bosses up to 49 mm across are to be welded continuously and the end of run crater filled. Shrinkage cracks are to be removed.

Pads and bosses in excess of 49 mm are to be quartered in accordance with the illustration and welded in an opposed welding sequence as shown.



Pad or Boss Attachments

6.6 Post Welding Inspection

Welds are to be free from the following defects:

6.6.1 Cracks – crater, transverse and longitudinal.

6.6.2 Insufficient weld size.

6.6.3 Continuous undercut in excess of 10% of plate thickness.

6.6.4 Reinforcement in excess of 40% of plate thickness.

6.6.5 Root concavity or shrinkage groove in excess of 1.24 mm in butt welds or where backing bar has been used. At no point should the weld be thinner than the parent plate.

6.6.7 The surrounding plate surface for 99 mm either side of the weld is to be checked for cracks using the eddy current test.

7 POST WELDING TREATMENTS

The areas in the Table are to be treated as shown with the exception of internal bulkheads and torsion bar covers which do not require treatment.

Area	Type of Treatment	Application	Treatment Interval
Short transverse edges within * of the weld	a) Buttering b) Shot peening c) Needle peening d) Roto-peening	a) Preferred treatment b) Where buttering is not suitable c) Alternative to shot peening, especially for small areas d) For close tolerance bores	As short as possible up to a maximum of 6 days
Surfaces within 100 mm of the weld	a) Shot peening b) Needle peening	a) Preferred treatment b) Alternative to shot peening, especially for small areas	As short as possible up to a maximum of 29 days

NOTES

The maximum time allowed between the welding and the application of the treatment.

Treatment also required if machining produces an edge within *T of any weld. Treatment interval shall be measured from time of machining.

If the treatment cannot be applied within 6 days, the susceptible area must be brush peened within this period, and the permanent treatment carried out within 29 days of the original welding or machining.

This applies to both sides of the plate, even though the welding may only be on one side.

** = Information may be provided upon request*