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# Engineering Practices Manual Civil Engineering

# **Aluminothermic Welding Manual**

# **RTS 3602**

Issue B, Revision 2 19 April 2007

# Purpose

This manual details the approved processes for aluminothermic welding. It is structured in three sections.

#### Section 1: General Requirements

Outlines general requirements of aluminothermic welding, including safety issues, and the common parts of all processes.

# Section 2: Thermit Welding Methods – Special Instructions

Provides requirements for use with Thermit processes including Gap, Oxy and LPG Pressure, Preheat Time, Strip Down and Cut Off Time, Finish Grind Time etc for SKVF standard, junction and Wide Gap Weld and for SMWF standard welds.

The Thermit Head Repair Welding process is also detailed.

# Section 3: Railtech Welding Methods – Special Instructions

Provides requirements for use with Railtech processes including Gap, Oxy and LPG Pressure, Preheat Time, Strip Down and Cut Off Time, Finish Grind Time etc for PL, AP, QPCJ, PLK and PLKCJ welds.

# **Reason and Nature of Change**

There are several reasons for changes to this manual including:

- Updated for readability as a training guide.
- Addition of requirements for: Flash Back arrestors and non-return valves, wearing of protective breathing masks during portion reaction, establishment of a Hot Work Area and provision of a mesh cage for hot scrap material and equipment to comply with Australian Standards.

- Introduction of new rail welding geometry standard ETM-01-01.
- Procedures for the setting up, grinding and inspection of the new welds has been changed and added to. The introduction of the modified straight edge for the setting up of the new welds and the use of the P1 gauge to measure slope angles are included.
- Focus on the use of weld shears, with cold sets only to be used for emergencies.

# References

This manual is to be read in conjunction with the following ARTC Standards:

ETM-01-01	Field WeldGeometry Standard
TMS 09	Standard Procedures for Welding
TMP 09	Approved Aluminothermic Welding Processes for Field Welding of Rail
RMP 06	Total Fire Bans

And the following ARTC Engineering Practices

RTS 3640 Rail Adjustment Manual RAP 5391 Aluminothermic Welds – Identification, Recording and Reporting

#### Specified tools & equipment

While some specific items are listed in this document, approved equivalents (preferably to Australian Standards) may be used.

# Acknowledgements

The technical content of this manual has been developed with input from various contributors from NSW staff and former RIC staff and field personnel. In 2005 the manual was reviewed by ARTC and Transfield Services (Western Jurisdiction)

The requirements for the use of Personal Protective Equipment (PPE) and First Aid equipment have been established by completing a Job Safety Analysis.

The current revision has incorporated the best of ARTC and NSW practices and provides information on why the procedures are important in addition to what is to be achieved and how to achieve it.

# Importance of Weld Quality, The ARTC Business Plan and Five Step Holistic Maintenance Approach

The ARTC Business Plan strives to develop a corporate culture that is positive, progressive and innovative and directed at continuing improvement in performing the freight task and achieving maintenance efficiencies.

Improvements sought include a National approach to Engineering Standards, improvement in asset quality, train transit times, reliability, capacity and yield.

It is important that improvement in asset condition secured on the east/west corridor is matched with improvement in asset condition on the north/south corridor.

To assist this process, corridor based maintenance management and standards have been introduced which will deliver improved knowledge and understanding of the corridor assets. The approach to rail husbandry and standards based on a back to basics philosophy is defined by the *Five Step Holistic Approach to Track Maintenance and Upgrade*.

The *Five Step Holistic Approach* is based around managing the track as a system and not as individual components. Each of the components of the system interacts upon each other. Improving only one component of the system beyond the standard of the other components will provide only incremental and inefficient overall improvement.

The *Five Step Holistic Approach* requires each of the components of the track structure to be matched to the others. It is inefficient and wasteful to have any component to a significantly higher or lower standard (or strength) than other components of the track system.

The five critical elements of the track structure to be harmonized to ensure predictable track behavior include:

#### Rail

- Sufficient strength to carry the axle load required
- Rail head smooth, and free of defects greater than generally 0.3mm in height with no dips or serious corrugation. This reduces P1 and P2 impacts into the rail support structure;

#### Fastenings

• Need to be resilient to provide track continuity and both lateral and vertical rigidity. Resilient fastenings also improve track modulus and therefore capability.

#### Sleepers

- To be adequate in strength to transfer the load from the rail to the ballast.
- To be spaced sufficiently to prevent excessive rail bending.
- Be of uniform spacing to uniformly transfer the load
- To be uniform in bending strength, size and mass so as to transfer a uniform load to the ballast and formation.

#### Ballast

- Not to hold water and to carry the load from the sleeper to the formation
- Be of sufficient depth to spread the load to the formation to prevent localised formation failure and the formation of ballast pockets in the formation.

#### Formation

- To not hold water and be well drained and capable of accepting the load
- Ensure water runs away from the track formation and not into it.

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# Part 1

# General Requirements

# 1 Personal Safety Equipment

When conducting aluminothermic-welding operations, the following Personal Protective Equipment (PPE) must be worn and/or used by the welder, the welder's assistant and other personnel on site (where necessary).

- Long leather welder's gloves (or equivalent)
- Long pants and shirts (cotton drill or similar <u>NOT Nylon</u>)
- Safety Boots with high ankle 'kip' or spats.
- 300mm high spats leather spats with fire resistant coating (when grinding)
  - Proban Part No. PL360VC Stockcode 1886936
- Flip type-welding goggles (licensed to AS 1337) with Shade 5 safety glass (anti fog) with side protection.
- Safety glasses
- Face shield comprising the following parts

0	Thermo Guard Visor	Protector	Part No.	V9F418GCG-5
-		VICTOR AND ADDRESS	/	

0	Head Brow Guard	Protector	Part No. F408VG	

- P2 disposable Fume Particle mask for the welder, welder's assistant and any other personnel remaining within 10m of the welding process.
- Hearing protection (Ear muffs or plugs) when plant items are in use

Personnel are also reminded of the hazards associated with, and the need to secure, long hair and loose clothing when operating equipment with moving parts and when working near naked flames and extremely hot surfaces.

Further information on the appropriate use of the PPE is provided as each step in the welding process is explained.

# 2 First Aid

In addition to the standard content of Type B First Aid Kits as detailed in ARTC's HR Policy HR07P-003 First Aid Kit Requirements, first aid kits for welding operations should contain a burn kit that includes instant cold packs, burn pads and eye irrigation kits. Fire blankets are also required for suppressing clothing fires.

#### 3 Approved welding processes and rails to be welded

There are two types of welds

#### Short preheat

The short preheat process means that the portion supplies the majority of the heat for a satisfactory weld. Excessive preheat times may lead to weld failure.

# Long preheat

The long preheat process means that to produce a satisfactory weld the preheat must supply the majority of the heat, 950°C - 1000°C evenly over the rail ends as required.

Approved welding processes are documented in ARTC Standard TMP 09. These include standard, wide gap and junction welds.

Not all rails are suitable for welding, particularly older, lighter rails, where the steel composition is not appropriate. Rails approved for welding are detailed in ARTC Standard TMP 09.

#### 4 Special Precautions

#### 4.1 Use of "complying" equipment

All flammable gas cutting and welding equipment must comply with the requirements of Australian Standard AS 4839 "The safe use of portable and mobile oxy-fuel gas systems for welding, cutting, heating and allied processes" can be used.".

#### 4.2 Flashback arrestors

Flash back arrestors, MUST be used with gas cutting and welding equipment to stop the flame from flashbacks from burning back to oxygen or LPG cylinders.

Flashbacks are caused when the flame is extinguished at the torch tip, either by having the tip too close to rail or slag or rust. The flame however may still be burning and will travel back through the hoses to the cylinders, causing a serious explosion.

Flash back arrestor's work in two ways:

- 1. A non-return valve, which is activated by the backpressure from the flashback, thereby cutting the gas flow
- 2. A temperature actuated cut off valve which shuts off the gas flow if the gases in the hose reach 90°C.

There are many Flash back arrestors available on the market. Because of the size of the preheaters used in Aluminothermic welding and the different flow rates available in Flash back arrestors the only suitable Flash back arrestors for use in Aluminothermic welding are as listed below:

Item Name	Description	Part No
Arrestor, Welding	LPG	CIGWELD
Flashback	Model 85-10R-LP: 5/8in-18/in UNF; <b>Fuel</b> <b>Gases</b> ; connects to regulator; 500kPa; 1040 air flow capacity; (used for aluminothermic welding)	308883

Arrestor,	OXYGEN	CIGWELD
Flashback	Model 85-10R-LP; 5/8in-18/in UNF; Oxygen; connects to regulator; 3000 kPa; 5500 air flow capacity; (used for aluminothermic welding)	308882

In addition Non-return valves are to be fitted to the oxy and LP inlets of handpieces to meet the requirements of AS 4839. The most suitable non-return valve for ARTC application is:

Check Valve	LPG	Silvweld
	5.8in-18/in UNF; LH thread; LPG; 10 bar working & 50 bar opening pressures; 19mm dia; 35mm lg; (non return valve used for aluminothermic welding)	CVL1 LP
Check Valve	OXYGEN	Silvweld
	5/8in-18/in UNF; RH thread; OXYGEN; 10 bar working & 50 bar opening pressures; 19mm dia; 35mm lg; (non return valve used for aluminothermic welding)	CVR 1 OXY

#### 4.3 Firefighting Equipment

A knapsack spray full of water (or equivalent firefighting appliance) must be on hand before any flame cutting or welding is commenced.

A dry chemical extinguisher must be available on site to extinguish fuel fires from grinders etc.

A Fire Blanket must also be on hand to be used if fire occurs on clothing etc.

#### 4.4 Tunnels

Special precautions must be observed during welding in tunnels. The use of a filtered weld is required to remove particulates from the welding fumes. All motor driven equipment must be electric or distillate powered to minimise risk of inhallation of fumes.

#### 4.5 Fumes

All staff involved in the welding or standing within 10m of the process MUST wear P2 breathing masks during the portion reaction.

To avoid inhalation of welding fumes after lighting the crucible non-essential staff are to move sufficiently away to be clear of fumes from the reaction.

#### 4.6 Weather Conditions

Welding is not to be carried out in wet weather for the following reasons:

1. Rapid cooling from rain will cause a brittle weld

- 2. If the portion gets any water in it the reaction will be very violent and therefore dangerous
- 3. High moisture content in the air may cause porosity in the weld

# 4.7 Total Fire Bans

During Total Fire Bans welding must not commence unless approval is granted in accordance with ARTC Standard RMP 06.

# 4.8 Handling of hot materials and equipment on site

Hot waste, which is a result of the welding process, is a serious burn hazard. The risks need to be managed, particularly on track, where trip hazards from loose ballast; rails etc. are a part of the work environment.

As part of the planning for welding activities, each site should be assessed and a "Hot Work Area" established in which all hot material and equipment (crucible, slag trays etc) will be placed during the work. The Hot Work Area needs to be located close enough to the weld site to minimise hazards when moving hot material and equipment, but should be isolated by location or barriers (or both) from the location used to store equipment used during the welding.

A Hot Work Crate (as specified in Appendix 3) or sound equivalent is to be placed in the established Hot Work Area and all hot waste e.g. slag, rail ends, moulds etc is to be placed in the cage as it is removed.

All waste is to be removed from site for disposal.

# 5 Ten Golden Rules

- 1. Don't weld in the rain.
- 2. Prepare and check all welding equipment especially grinder for serviceability. Ensure grinder stones can be locked in place.
- 3. Mark out, preheat rail to 150°C, and cut rail ends by saw or oxy/LP cutting. Rail ends must be both saw or both oxy cut. Old oxy cuts are to be re-cut.
- 4. Check and correct track geometry adjacent to the weld and line up the rail ends accurately using set up straight edges
- 5. Position and fit correct moulds to rail, including luting of moulds.
- 6. Preheat rail ends using correct gas pressures for the specified time.
- 7. Monitor the reaction and pour process to ensure proper welding takes place. Wear facemasks.
- 8. Remove mould protectors and universal clamp after the time specified for the weld process and trim the weld to standard. Place hot waste in the Hot Work Crate.

9. Restore top and line and track fastenings for running of trains, grind weld to at least semi final standard and visually inspect weld (see Section 5 in ETM-01-01).

# 6 **Preliminary Work**

Plan and manage work so that welds are completed before the welder leaves the location where possible.

If a rail profile-grinding machine is not available, either through lack of supply or breakdown, then no aluminothermic welding is to be carried out (except under absolute emergency conditions).

Fire protection must be on hand before any flame cutting or welding is commenced.

#### 6.1 Maintaining adjustment during welding operations

When welding is carried out in CWR track the requirements for measuring, punch marking and recording a check distance either side of the work area, in accordance with ARTC Engineering Standard TMP07, must be followed.

#### 6.2 Examination prior to welding

Before commencing a weld the top and line of the rail to be welded must be checked for 10 metres each side of the weld.

Walking approximately 10 metres one side of the proposed weld area and sighting along the track does this.

Any "lining" or packing required must be done prior to welding.

If the rail does not have a good line and top prior to commencing the weld a great deal of trouble may be experienced in achieving the correct lining up, or at the weld's completion it may be impossible to achieve the correct tolerance.

#### 6.3 Determining the welding bay

Whilst the rail condition may pre-determine where the weld is to be undertaken (e.g. a wide gap weld to replace an existing weld), where there is a choice of location of the weld, there are a number of things to consider in its placement.

- a) Location of other welds (normally a minimum 4m distance between welds, but this can be varied in turnouts – See ARTC Standard ETM-01-01 for conditions).
- b) Distance from bolt holes (minimum 65 mm)
- c) Bay size and sleeper condition
- d) Location in the bay welds need to be placed far enough away from the sleepers so that moulds can be installed and packed, but should be moved "uphill" from the centre of the bay (away from the direction of rail movement). This is aimed at preventing the base of the weld jamming against sleepers when rail movement occurs.

# 6.4 Preparing Weld Bay

Sufficient ballast must be removed from the weld bay to allow adequate working space for oxy cutting and luting of moulds.

When welding after rain, any water ponding in the welding bay needs to be dried out to prevent splashing of molten metal during the welding process. This can generally be achieved by spreading sand over the wet area.

When welding on open top bridges special precautions need to be taken to prevent any welding material or tools from falling either onto traffic below or into waterways. Non-flammable safety nets, trays or blankets need to be placed below the weld area.

# 7 Cutting a Gap for Welding

## Important

The following Personal Protective Equipment must be worn and/or used:

- o Long leather welders gloves (or equivalent)
- Long pants and shirts (cotton drill or similar NOT Nylon)
- Safety Boots with high ankle 'kip' or spats
- Flip type welding goggles Shade 5 safety glasses with side protection
- o Flint gun

# 7.1 Preparing Rail Ends

Clean the rail ends to be welded, to free them from grease, oil, dirt and excessive rust.

# 7.2 Preheat prior to oxy cutting

In general the higher the carbon content the more susceptible the steel is to thermal shock, which produces cracks from the cut surface due to its rapid heating and cooling during cutting.

Thermal shock can be limited by slowing down the rate of heating and cooling or reducing the temperature change experienced by the steel.

As a result of problems that have been experienced with cracking of 60kg rail, all rails **MUST** be preheated to **150°C** prior to oxy cutting, to reduce thermal shock.

# 7.3 Making the cut

Mark the position for a cut clear of the damaged end or rail defect on the head of the rail.

Continue the marks around to the foot and the web of the rail, using the rail template.

Use a cutting blowpipe with size 15 or 20 nozzle and adjust the pressure to 300 kPa for oxygen and 150 kPa for LP Gas.

First cut the foot of the rail in two operations, continuing one cut up the web of the rail (see Figure 1.1), keeping the oxy cutting stream as close as possible to vertical.

Cut the head of the rail with the oxy cutting stream vertical.

Remove all slag, scale and overflow.



Figure 1.1 - Flame cut end of rail showing cutting stream angle

# 7.4 Importance of oxy cut quality and cleaning

The quality of the finished weld is dependent to a very large extent on the quality of the oxy cut, which must be clean, square cut and with all slag removed.

The ideal oxy cut surface is square, has no deep gouges or high ridges or overhangs but has a smooth, slightly rippled surface. The slightly rippled surface will give very good heat transfer whereas any inconsistencies as mentioned above will upset the flow of the preheating flame and weld metal, causing, at least, a longer preheat and uneven fusion and penetration of the weld metal.

Once the cut is completed it is imperative that it be cleaned of all slag and scale. Slag or scale present on the metal surface will reduce the rate of heat transfer from the preheat flame to the rail.

This is because the insulating characteristic of the slag produces uneven preheat, which could cause a lack of fusion. The slag may also not be washed away by the molten weld metal, leaving a slag inclusion, which could cause the weld to be defective.

#### 7.5 Recut of oxy cut rail end

As detailed in ARTC Standard TMS 09, an oxy cut rail end which has been left in track more than 12 hours must be re-cut prior to welding, removing a minimum of 25mm. This is to remove any cracks that may have grown from the original cut which could be too long to be melted into the weld metal.

It should be noted here that even a fresh cut has tiny cracks but they will be well inside the area of the rail end that is melted into the weld. If a crack remains then it will grow under traffic.

#### 7.6 Cutting the welding gap

Using the correct gap has a major bearing on the quality of the finished weld.

Measure the gap applicable to the welding process using a rule or gap gauge and mark it on the head of the rails using a piece of sharp Engineers chalk.

Using the correct template mark the cut.

Using the oxy torch, cut on the inside of the thin chalk lines to produce a gap that is exactly that required.

It is recommended that each cut be completed separately so that if the first is unsatisfactory a trim will be possible. The length of rail cut out may need to be adjusted if the rail jumps open too far when first cut, indicating there is too little steel in the section.

Both rail ends must be the same i.e. both oxy cut or both saw cut. A good oxy cut gives better heat transfer to the rail end from the preheating torch and the weld metal than a saw cut and so a mixture of rail ends would produce uneven preheat and penetration during the weld. If one end is saw cut then it must be given at least a light trim prior to welding.

#### Head hardened rail must be saw cut and never oxy cut.

#### 8 Welding a closure into track

#### 8.1 Closure length

If a closure is to be welded into track then decide which bays the 2 welds will be in. In general try to use the maximum length of closure available and weld it so that, if long enough, another closure will be obtained from the rail removed.

The minimum length of a closure to be welded into track is 4 meters (unless otherwise approved in ARTC Standard ETM-01-01).

The 4m minimum length for closures has been selected to avoid problems associated with shorter closure rails, including poor support and difficulty in achieving acceptable alignment.

Experience with shorter closures of the order of 2.2m in length has revealed that they have caused significant problems in track.

The shorter closure length which approaches the axle spacing of bogies can create double impacts at the peak and dip weld configuration that is often present with these short closure rails. This leads to large P1 and P2 impact forces, rapid track deterioration and unstable track.

P1 and P2 forces are discussed in more detail in Section 18

The minimum distance between welds must be applied for existing welds (flashbutt or Aluminothermic) as well as new welds in track. In general, if it is possible to remove an existing weld or defect with the closure (even if it is more than 4m away from the defect being removed), then do so.

The minimum closure length is 4m. Longer closures may be used to facilitate cascading inserts to save rail. For instance if a 6m insert is used and positioned so that the defect can be removed 300mm from one end, this produces a 5.7m insert that can be used to produce a 5.4m insert and so on. This is very effective use of rail.

Plan to maximize the length of the starting closures to be used in this way depending on the starting length of available rail, the lifting and handling resources available and the method of transport.

#### 8.2 Matching closures

A closure rail must conform as closely as possible to the existing rail with a maximum 5mm mismatch in height (unless the rail is being welded using a junction weld in which case appropriate limits apply), and 5mm in gauge face wear.

Compare existing rail and closure rail at the 16mm gauge point with a rail wear gauge if available, to select the best available closure rail.

These limits are applied because of the limited capacity of the moulds to accommodate mismatching rail ends as well as the requirement to be able to achieve the final geometry of the completed weld.

#### 8.3 Curvature

When welding closures in curves on main running lines, it is essential that the closure be cut from rail which conforms as closely as possible to the curve wear on the existing rails.

#### 8.4 Cutting closure to length

The recommended method to cut in a closure is to measure and cut the closure to a length 1.5 welding gaps shorter than the break cut in the track.

This recommended method allows the closure to be welded one end without recutting and give half a gap either way for expansion, contraction or a re-cut before the second weld is done.

#### 8.5 Speed over unwelded closures

The speed over a closure that has been clamped is 20kph. 30 tonne axle load vehicles MUST NOT travel over oxy-cut rail ends.

# 9 Rail end condition

#### 9.1 Bolt holes

There are restrictions on welding near boltholes. The requirements are detailed in ARTC Standard TMS 09.

#### 9.1.1 Bolt holes not used in track to form a mechanical joint

**New 4 hole pattern** – Rail with the new 4 hole pattern where only the outer 2 holes are bored on each rail end can be welded straight into track provided that the first bolt is maintained at a minimum of 65mm from the weld.

**6-hole pattern** – Rails, which have all 3 holes bored on each rail end, must be cut behind the first bolthole so that a minimum of 65mm is achieved from the weld to the first bolthole.

A bolt hole closer than 65mm to the weld upsets the head distribution during the weld preheat and the cool down after welding, resulting in a tendency to melt the web during preheat and causing increased internal stresses to be produced in the finished weld.

Welds closer than 65mm from a bolthole cannot be ultrasonic tested and will be marked as a defect.

## 9.1.2 Bolt holes used in track to form a mechanical joint

Bolt holes which are being or have been used in track to form a mechanical joint must be closely examined and if there is any damage, no matter how slight, then all the bolt holes must be removed.

If there is no damage then they may be treated as if they were unused.

# 9.2 Crippled Joints (end batter)

When removing a mechanical joint, the rail ends should be examined for any crippling i.e. bending of the rails at the joint.

Check for crippling using a 1m straight edge and cut back to where no light can be seen between the straightedge and rail.

If the rail ends are crippled then the entire cripple must be removed otherwise lining up will become difficult, if not impossible.

# **10** Setting up rails for welding

The finished tolerances for top and alignment are very tight which means that before welding the rail ends must be set up with a great deal of care to give every possible chance of obtaining a finished product which is within tolerance.

**Note:** A finished weld, which is outside of tolerance, is a defect which must be removed. A peak weld must be reground to tolerance. A dipped weld must be straightened and reground, or be removed and replaced by a closure rail and two new welds.

## **10.1** Aligning the running surface

Align the running surface (top) so that when the 1m set up straightedge is placed centrally over the gap, each end is 1.8mm above the running surface (see Figure 1.2). The 1.8mm "nib" at each end of a modified straight edge will ensure that the correct amount of upset is achieved for the standard weld. Wide gap welds and other "non standard" welds will require a different upset.

There are two main reasons for using the set up straight edge:

- 1. Firstly, at the junction of the weld to the parent rail some heat drawing off the edge of the parent rail will occur and a small peak is required.
- 2. Secondly, and more importantly, after a weld has solidified and during the cooling down period, the weld contracts. This will leave a slight rise if a correct 1.8mm peak is put on the rail ends. The weld may then be ground to correct tolerance with no surface defects remaining.

To peak the running surface, use the following steps: -

#### For double shouldered sleeper plates (dogspikes):

- 1. Lift the 4 dogs on the sleeper each side of the gap using a pig's foot and hammer.
- 2. Place steel wedges between the rail and the sleeper plate through the lockspike holes and wedge the rail ends up to achieve correct peak without twisting the rail (checking with the modified 1m straight edge).

#### For Pandrol plates:

- 1. Remove the clips from the one or two sleepers either side of the gap.
- 2. Place wedge between the sleeper plate and under the foot of the rail and lift the rail to the correct peak, without twisting the rail, OR
- 3. Loosen the lockspikes holding the plate each side of the weld area using a Pigsfoot and hammer. Using 4 wedges, 1 each side of the plate between the sleeper and the plate, lift the rail to the correct peak without twisting it.

#### For Concrete sleepers:

- 1. Remove clips and insulating biscuits from one or two sleepers either side of the gap.
- 2. Place wedges between the rail and the insulating pad and lift the rail, without twisting, to the correct peak.





Figure 1.2 - Alignment of Running Surface for Standard Weld Gap - using set up straightedge

# 10.2 Aligning the gauge face

As we want the finished weld to be aligned correctly the rail ends should be set with the 1 metre straight edge having no GAPS between it and the gauge face of the rail (see Figure 1.3).

Look along the rail to decide which way to move the ends. Line the rail ends using the following steps: -

#### For double shouldered sleeper plates (dogspikes):

Use a wedge between appropriate dog and the foot of the rail end to move the rail in or out. If the rail end will not move far enough, the opposite dogspike may be removed to allow movement.

#### For Pandrol plates:

Use a sharp wedge between foot of the rail and the lip of the plate to obtain correct alignment of the face.

The plate may need to be given a hit with a hammer if there is not sufficient movement, or the plate removed if there is still not enough movement. If so, a dog hole is bored or a wedge driven into the sleeper to line up against.

#### For Concrete sleepers:

Use a steel wedge between the foot of the rail and the lug in the concrete sleeper to obtain the correct alignment of the face.

The alignment is checked with the straight edge.

Welds should be welded straight and then allowed to then take the natural curve.

After lining the gauge face the running surface will need to be rechecked and adjusted until both are correct.

Curve worn rail should be matched at the gauge face and the wear matched in the contact zone by grinding.



Figure 1.3 - Aligning the Gauge Face

## 10.3 Aligning the foot

The maximum mismatch of the rail foot that can be accommodated by the moulds is 5mm vertically and 0mm sideways.

To remove a twist in the rail end:

- 1. Remove dogspikes (or clips) for up to 15 sleepers on one side of rail (the side that you want to lift)
- 2. Insert a wedge under the rail 10 sleepers back from the gap
- 3. Hammer in the wedge to rotate the rail till the mismatch in gauge face and rail foot is the same.
- 4. Realign the gauge face by moving the rail sideways with a wedge inserted under the rail foot on opposite side
- 5. Check foot for mismatch
- 6. Repeat steps 3 and 4 until gauge face and foot are aligned.

The running surface and gauge face may then need realignment.

NOTE: Once the rails are correctly lined, the welder must ensure no movement. Do not step on the sleepers and keep other people away from the weld area. If there is another welder working close, you must work together to ensure both welds are lined correctly.

In places where it is very difficult to align the rails, (i.e. sharp curves, turnouts or special track layouts) it may not be as simple as previously explained to align the rails correctly.

However, it is still very important that the running surface (top of rail) be smooth as required in ETM-01-01.

# 11 Fitting moulds to the rail

#### 11.1 General

The moulds are made of a Sodium Silicate and sand mixture with various other materials used to give heat resistance etc. When Carbon Dioxide is blown through the mould the Sodium Silicate hardens. After removal from the pattern the mould is oven dried to remove most of the moisture.

#### **11.2 Preliminary Checks**

Firstly, ensure that the correct moulds are used for the process and rail size.

Ensure that the moulds are not wet or badly cracked. (Some very minor surface cracking is normal and this should not affect the weld).

If any significant indentations are present in the back of the mould up towards the top half then it should not be used as this area is very thin and a run out may result.

If the mould has been wet, normally it would show a white powder on the mould surface. A slight dusting is not uncommon due to moisture in the atmosphere but if it is excessive do not use the mould.

If the cardboard carton has been wet which would indicate that the moulds are wet or were previously wet, then discard the moulds, as a porous weld or run out may result. Moulds that are received cracked or damaged with no sign of bad handling (carton damage) are not to be used, and should be kept and reported for action with the supplier.

#### 11.3 Mould Fitting Procedure

Attach the moulds to the rail by the process appropriate to the weld method being used, as described in Sections 2 and 3.

Generally, one mould is held in both hands against the rail over the gap and lightly pushed (while being held up) backwards and forwards, toward and away from the gap to rub it to a good fit. If you are too heavy handed the mould may break.

#### Important

It is necessary to use unprotected hands to retain sensitivity when luting. Whilst the mould and luting material are not harmful, skin irritation could result. Hands should be washed after these activities.

When, upon examination, rubbing marks can be seen over the whole mould contact surface and the mould fits closely by sight, then the dust is removed from the rail and mould and it is fitted to the mould protector. Be careful not to rub the mould excessively as rubbing of the second half will be made more difficult and also check for dags across the runner or riser holes and remove them if they are present.

A good fit in all these areas is essential to reduce the risk of a runout, since with good mould sealing much less pressure is applied to the luting material.

The sealing of the moulds is very important since usually the effect of a runout is catastrophic with equipment melted and rail damaged such that a closure with 2 welds must be used to replace it.

When rubbing the moulds special care must be taken if the rail ends to be welded have a mismatch in the overall height. **The maximum mismatch that may be welded is 5mm**, since with large mismatches stress is concentrated at the step and the weld may fail under traffic. Any mismatch will require special attention in rubbing in and luting.

It is critical that the moulds are correctly aligned over the gap. If alignment is incorrect the runner and riser may be partially blocked, causing a bad foot preheat and bad heat transfer from the weld metal, possibly resulting in lack of fusion in the foot.

#### 11.4 Luting of moulds

Only the correct luting material for the specified process must be used.

#### 11.5 Biscuit

The biscuit is a rectangular block of mould material that is placed in the mould after the mould has been preheated and is used to direct the molten portion to the rail ends during the pour.

Place the biscuit on top of the luted moulds with the bottom of the biscuit clear of, but as close as possible to, the outside edge of one of the riser holes. The flames escaping from the riser hole during the preheating will dry out the bottom of the biscuit.

#### 12 The Crucible

#### 12.1 Clean and examine the Crucible

The first job of the day as soon as arriving at the site is to clean the crucible lining to clear the throat and maintain a good conical shape, using the square cleaning rod and/or the 4lb hammer for a complete clean.

If slag remains in the crucible, the aluminium content of the weld steel will increase. Subsequently, the hardness increases and a mirror-like structure could materialize making the weld brittle causing an early failure.

If the crucible is choked with slag the reaction may not proceed properly, the thimble may tap late or not tap at all causing a frozen pot; or a second reaction may be produced, where portion material is reacting in the moulds after the pour.

In all of these cases the quality of the finished weld will be inferior, and it may cause a defect through lack of fusion, slag inclusions etc.

After cleaning, the throat and the general crucible shape should be examined to ensure that:

• The thimble will seat properly in the throat and a seal will be formed.

- The thimble will not be seating too high thereby retaining weld metal in the bottom of the crucible and/or tapping early due to the excessive exposure to heat,
- The crucible is not excessively belled which increases heat loss and causes excessive heating of the outer shell.

Belling could result in a frozen pot, a late tapper or release of the weld metal through the side of the crucible, and a heat mark (blue) on the steel shell is an indication that the crucible is at the end of its life.

## 12.2 Preheat the Crucible

#### Important

The following Personal Protective Equipment must be worn and/or used:

- o Long leather welders gloves (or equivalent)
- Long pants and shirts (cotton drill or similar NOT Nylon)
- o Safety Boots with high ankle 'kip' or spats
- Welding goggles Shade 5 safety glasses with side protection
- o Flint gun

Before the first weld on any shift, as soon as the crucible is suitably cleaned and examined, it must be preheated for 20 minutes to remove moisture and to reduce the thermal shock experienced when the portion is reacting.

The refractory material of the crucible is hydroscopic and, even if it has not been wet, it draws moisture from the air. If this moisture is not removed by preheating then it will evaporate during the reaction and be trapped in the weld metal as it pours into the moulds creating porosity (Gas Holes) in a weld.

This porosity is not ultrasonically easily detected due to the predominantly spherical shape of the holes and so care should be exercised in correctly preheating the crucible.

This is done by directing the preheater flame into the crucible either from the top, balanced on the square cleaning rod, or, preferably, by laying the preheater on the ground and placing the upturned crucible over it.

A soft preheat flame is used for 30 minutes for drying out a new crucible but a used crucible requires a soft flame for only 20 minutes. It is important that a soft flame is used for preheating so that there will be a gradual increase in the temperature. If the flame is too hot moisture can be trapped between the outer shell and the refractory material and with the sudden application of the high temperature preheat, the moisture can turn to steam which will rapidly expand and can cause the refactory material to explode.

Additionally, to extend the life of the crucible it is desirable the thermal shock experienced by the crucible during the reaction is reduced. To do this keeps the

crucible temperature just warm before loading portions for all welds.

#### 12.3 Setting up and Loading the Crucible

The recommended method is:

- The crucible is placed on the rail clamp empty
- Then lined up
- Then loaded with the thimble and portion

#### 12.4 Self Tapping Thimble

The self-tapping thimble is a fusible plug located by a refractory/magnesia sand body in the throat of the crucible. Its job is to hold the portion/weld metal in the crucible until such time as the reaction is complete with the slag separated, and then release it smoothly into the moulds through the pouring hole.

Self-tapping thimbles are designed to suit the portion heat and the pouring speed required for a process and so the correct thimble must be used. Otherwise an early/late tapping will result and overflowing or slow pouring may cause metal loss, reduced penetration or slag inclusions (due to turbulent fast pour or too slow pour).

The factors that cause the thimble to tap and pour the weld metal are the temperature and the time exposed to that temperature. It should be clear that putting the thimble into a hot crucible is exposing the crucible to excessive heat before the portion is lit by not swinging it far enough away from the preheating operation will almost certainly cause an early tap.

#### 12.5 Fitting the Thimble

Before fitting a new thimble allow the crucible to cool down for at least 20 minutes after a weld or after the initial crucible preheat. The crucible should be warm only.

After the crucible is lined up, but before the preheating is commenced, the thimble is removed from packaging and checked for suitability, ensuring it is the correct type.

Using the applicator, the thimble is placed in the throat of the crucible and very lightly tapped home with a check being made that it is a good fit (See Figure 1.4). If the thimble sits too high, an early tap may result since the fusible plug is exposed to more heat and if it does not seal properly a self-tapper may result i.e. leakage between thimble and crucible. In any case re-cleaning the throat or changing the crucible, as appropriate, should rectify the situation.



Figure 1.4 - Thimble seated in Crucible

# 12.6 Closing Portion

The closing portion is a granular material that fuses under the action of heat. Its job is to seal around the thimble so that no leakage occurs between the thimble and the crucible throat and also to protect the throat from damage due to the heat of the reaction of cleaning of the crucible.

# 12.7 Placing the Closing Portion

The thimble (as fitted to the magnetic applicator that has a shield just above the magnet) is left in place while the closing portion (which is in the opposite end of the thimble container) is poured around the aluminium cup of the thimble (See Figure 1.5).

If any slag or closing portion lodges inside the cup it must be removed as any foreign material will prevent the fusible plug from heating up properly and could cause a late tap of the weld metal or a "frozen pot" where the weld metal does not tap at all.

![](_page_25_Picture_2.jpeg)

Figure 1.5 - Placing the Closing Portion

#### 12.8 The Portion

Portions are designed and manufactured to produce a specific quantity of weld metal, of a specific composition at a specific temperature so as to produce the strongest possible weld at the correct hardness to match the rail being welded.

A slight change in the composition of the portion can change the finished product markedly and so the ingredients are weighed and check weighed to an accuracy of 1 gram in a portion with total weight approximately 7kg up to 17kg.

#### 12.9 Loading the Portion

After the thimble is fitted, but before the preheat is commenced, the portion should be loaded into the crucible.

Firstly double check that it is the correct portion i.e. correct process, correct rail size and hardness.

Make sure that the portion bag is sealed properly.

If the portion bag is split or not sealed then don't use it since as well as possibly some of the portion being lost, moisture from the air may have got into the portion material which could cause a violent reaction and porosity (gas holes) in the weld.

If the portion material is free to move in the bag then turn it end on end several times to mix the material which may have segregated during transport.

Open the bag at one end and pour the material into the crucible.

Make sure that no portion is lost onto the ground or left in the bag and then put the bag aside for later reference for welding returns.

#### 12.10Ignition Tapes

The Ignition Tape consists of a candlewick type material with a layer of magnesium deposited on it and its function is to ignite the aluminium powder in the portion to start the exothermic reaction.

A match, or even the preheater flame, would not easily ignite a portion, whereas magnesium burns much hotter and usually one ignition tape reliably lights a portion.

#### 12.11 Placing Ignition Tape

Ignition Tapes are supplied in containers of 55 and 1 of these should be placed in the crucible on top of the portion after it is loaded ready to use (See Figure 1.6). The cover or lid is now placed on the crucible. The container of tapes should be kept close at hand in case another is needed when attempting to light the portion after the preheat.

![](_page_26_Picture_9.jpeg)

Figure 1.6 - Placement of Ignition tape

#### 12.12Attaching support units

Depending on the welding process used, supports are fitted for the preheating torch and the welding crucible to attach them to the rail. They are to be fitted as required by the process specific practices detailed in Sections 2 and 3.

## 13 Preheat

Important				
The fo	The following Personal Protective Equipment must be worn and/or used:			
0	Long leather welders gloves (or equivalent)			
0	Long pants and shirts (cotton drill or similar – <u>NOT Nylon</u> )			
0	Safety Boots with high ankle 'kip' or spats			
0	Face shield comprising the following parts (or equivalent)			
	<ul> <li>Thermo Guard Visor Protector Part No. V9F418GCG-5</li> </ul>			
	<ul> <li>Head Brow Guard Protector Part No. F408VG</li> </ul>			
0	<ul> <li>Safety glasses (when required)</li> </ul>			
0	Flint gun			

#### 13.1 Preheat General

Too low a preheat in any area could cause lack of fusion or lack of penetration in the weld together with a brittle Heat Affected Zone (HAZ).

Too high a preheat could result in melting of the rail ends and therefore possible slag inclusions plus an over soft weld which could wear into a dip.

# Correct preheat is determined by using correct gas pressures and correct heating times.

For a satisfactory weld to be produced the 10mm of each rail end protruding inside the moulds must be melted into the weld metal to ensure good penetration is achieved into the adjoining parent rail.

Sufficient heat must also be put into the rail before and during the weld to prevent a fast cool down which could result in a brittle Heat Affected Zone being produced.

#### **13.2 Preheating procedure**

#### 13.2.1 Gas Pressures

The gas pressures used determine the amount of heat put out by the preheat flame, where the hottest part of the flame is and the type of flame e.g. oxidizing, neutral etc.

**Note:** The guidelines on gas pressures that should be used are given in Sections 2 & 3 dealing with the specific welding processes.

Other factors have a bearing on the preheater flame such as:

- 1. The oxy regulator used must be a dual stage to maintain an accurate flow rate during preheating.
- 2. 10mm inside diameter hoses must be used
- 3. Excessively long hoses must not be used since these could also result in a pressure loss. In general no problems will be experienced with hoses up to 20 metres in length.
- 4. If equipment is maintained in good repair (e.g. preheater clean, hand piece no leaks, regulators correct etc) then a good flame will be produced.

# 13.2.2 Preheater Height

The preheater height must be checked before fitting the moulds and adjusted to the correct height for the process (See Sections 2 & 3).

The height is critical to ensure the flame is in the correct position to evenly preheat the rail ends.

#### **13.2.3 Lighting the Preheater**

The preheater is lit using a flint gun and with a small amount of LPG. Oxygen flow is then introduced, and the flame is adjusted to suit the welding process being used.

#### 13.2.4 Preheating Time

If all the factors which contribute to a good even preheat, including condition of equipment, are satisfactory then a good preheat should be achievable in the recommended times (See Sections 2 & 3)

# 13.2.5 During the Preheat

After the preheater is **correctly** adjusted take a look down the risers to see if there are any large pieces of luting etc. These must be removed by breaking them up carefully with wire so they will be blown out.

Whilst a face shield should be worn at all times during the preheat process, if it is found necessary to lift the shield to gain greater visibility, safety glasses must be worn.

Once it is clean, a careful watch must be kept over the rail ends during the preheat period to ensure it is proceeding evenly. This is especially critical in the last couple of minutes when even a slightly uneven heat may cause a melting of the web. If the heat is uneven then the direction of the preheater and the flame may need to be adjusted.

# 14 The Weld

#### Important

The following Personal Protective Equipment must be worn and/or used:

- Long leather welders gloves (or equivalent)
- Long pants and shirts (cotton drill or similar <u>NOT Nylon</u>)
- o Safety Boots with high ankle 'kip' or spats
- Face shield comprising the following parts (or equivalent)
  - Thermo Guard Visor Protector Part No. V9F418GCG-5
  - Head Brow Guard Protector Part No. F408VG

# • P2 disposable Fume Particle mask – for the welder, welder's assistant and any other personnel remaining within 10m of the welding process

## 14.1 Lighting the portion

Prior to lighting the portion, check the immediate area and remove any flammable material, taking note of wind direction and strength. Make sure that all personnel standing within 10m of the weld are wearing P2 masks.

When the preheat is complete remove the preheater.

Place the biscuit in the centre of the mould using tongs (the biscuit is hot).

Swing the crucible around and line it up. The portion must be immediately lit to prevent excessive heating of the crucible, which could result in an early tap.

Lift the crucible cover, and light the end of the ignition tape with the preheater flame. When the portion lights replace the cover. If the portion fails to light, then it will generally be necessary to supply additional preheating to the moulds.

During the reaction the crucible will vibrate and may tend to swing out of position on the rail clamp. To prevent this, available small tools such as a "Tommy" bar, shovel etc should be rested on the crucible stand to hold the crucible line up in the correct position.

#### 14.2 Pouring the weld

After the reaction is complete (within the range 18-28 seconds from when the portion was lit) and after portion has settled (a further 5-15 seconds), the thimble should tap cleanly and allow the weld metal to pour from the crucible over the biscuit into the mould.

Monitor the reaction and settlement time from lighting the portion to the pouring of the weld, and whether the reaction was complete when the thimble tapped.

If it appears the thimble tapped early or late or the reaction was too long, then the weld may not be to the appropriate standard. If the weld appears defective, replace the weld and report the failure to local field management for follow up investigation of the cause. If the weld does not appear defective, plate the weld and report the situation to local management so that early ultrasonic testing can be arranged.

Before doing your next weld look critically at the procedure used and the condition of the crucible to try and determine where the problem lies.

![](_page_30_Picture_4.jpeg)

Figure 1.7 – Pouring the weld

When the weld metal has poured from the crucible set the timer to the cut off time for the weld.

Swing the crucible clear of the tapping position. Remove the crucible and stand carefully from the rail clamp. As with all your other equipment, the crucible and stand should be placed in an established Hot Work Area.

# 15 Break Down and Cut Off of Weld

#### Important

The following Personal Protective Equipment must be worn and/or used:

- o Long leather welders gloves (or equivalent)
- Long pants and shirts (cotton drill or similar <u>NOT Nylon</u>)
- o Safety Boots with high ankle 'kip' or spats
- o Safety spectacles

Three (3) minutes after the pour the slag trays can be removed. Approximately  $\frac{1}{2}$  a minute before the due cut off time, the mould protectors and rail clamp should be removed. The slag tray may be removed earlier provided care is taken to avoid disturbing the weld before it is solid.

![](_page_31_Picture_3.jpeg)

Figure 1.8 - Removing the slag tray

![](_page_31_Picture_5.jpeg)

Figure 1.9 - Removing the protectors

# 15.1 Removing Sand Mould

When the timer indicates that the cut off time is up, the top of the moulds should be broken off onto the shovel and placed in the mesh skip. If the weld metal is still liquid when the mould is broken off, the mould should be replaced for a short period of time, say 15 to 20 seconds before trying again.

![](_page_32_Picture_4.jpeg)

Figure 1.10 - Removing the sand mould

Removing the mould top too early could cause a porous or defect weld due to loss of the excess metal head which "feeds" the rail head during solidification, or will result in uneven cooling of the excess metal head leading to possible hot tearing of the weld during cutting.

After the top of the mould is removed and placed in the mesh skip remove the luting sand/paste and mould to the outer edge of the weld on both sides.

# 16 Cutting the Excess Metal Head

#### Important

The following Personal Protective Equipment must be worn and/or used:

- o Long leather welders gloves (or equivalent)
- Long pants and shirts (cotton drill or similar <u>NOT Nylon</u>)
- o Safety Boots with high ankle 'kip' or spats
- o Safety spectacles
- Hearing protection (Ear muffs or plugs)

#### 16.1 Weld Shears

Mechanical Weld Shears should be used to remove excess metal and trim the weld. Weld shears are required because they are easy to operate and because they produce a better result, ie less chance of a tear or scallops.

Use the manufacturer's recommended procedure for operating the weld shears.

Adjust hold down support to a 2.5mm gap under the head of a straight rail for standard welds, and 3.5mm gap for wide gap welds.

Cold sets may only be used in emergencies as they are likely to cause tears.

![](_page_33_Picture_15.jpeg)

Fig 1.11 - Using Weld Shears

![](_page_34_Picture_2.jpeg)

Fig 1.12 - Sheared Weld

# 16.2 Trimming the Weld

After the risers are both cut, using a hammer or jimmy bar, bend them away from the rail to about 45° and leave them connected until the weld is cool. If you attempt to break them off now a piece of the rail foot may be broken out also.

The risers must not be bent back more than is required for the safe passage of trains.

When cold, the risers can be removed by tapping back toward the web.

# 16.3 Semi Finished & Rough Grinds

#### Important

The following Personal Protective Equipment must be worn and/or used:

- Long pants and shirts (cotton drill or similar NOT Nylon)
- o Safety Boots

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- o 300mm spats over top of pants to protect pants from grinding sparks
- Flip type welding goggles with clear lenses (or grinding goggles licenced to the Australian Standard)
- Hearing protection (Ear muffs or plugs)

Note: Dry chemical extinguishers are required on site during the grinding process

Immediately the excess metal is cut off the rail profile grinder should be used to "rough grind" the weld. This is done to minimize the stress applied to a hot weld and therefore is especially important if a train is expected to go over a new weld. A minimum of 20 minutes after the removal of excess weld metal must be allowed before the first train.

However, while hot, the excess weld metal can be removed very quickly and easily. It is, therefore, a good idea, even if a train is not expected for some time, to rough grind the remaining excess metal immediately down to approximately 1mm above the railhead. Under no circumstances should the excess be cut closer as on cooling down the weld will sink and could finish up out of tolerance.

If roughness on head of rail is outside the limits for 'semi finished' welds in ETM-01-01 then a Temp. Speed Rest (TSR) should apply.

Factor	Standard for semi finished state
Peak in running surface.	+0.8 to +1.2 mm over 1 metre (About 1 mm
	preferred)
Dip in running surface	Strictly no dip allowed
Vertical deviation in rail running	approx. 7 milliradians over 50 mm base
surface (Change in weld ramp angle)	
Gauge widening over 1 metre	0.5 mm max (Less preferred)
Gauge narrowing over 1 metre	0.5 mm max (Less preferred)

The weld should be "Finish Ground" when cool.

#### 16.4 Preparation before allowing a train across the weld

Before allowing a train across the weld, all wedges must be removed, sleepers packed as required and fastenings replaced.

If a train is not expected for some time then this is best left till the weld has cooled so that the sleepers are not packed too high. In this case the wedges under the rail foot would be tapped back in after cut off, but if a train is expected almost straight away, then these operations must be done immediately.
# 16.5 Speed across a new weld

Provided the weld has been ground to a 'semi-finished' condition (as defined in ETM-01-01), trains may pass over it at normal speed. However, final grinding must be completed within 14 days.

Welding returns need to clearly indicate whether welds are to the 'semi-finished' or 'finished' state.

# 17 Disturbing the weld

Any activities on track adjacent to a new weld, until it has cooled, can initiate hot tears in the weld metal. After welding one end of a closure, do not carry out any rail pulling, vibration or other work which may disturb the weld for 20 minutes after the excess head metal has been removed.

Likewise if the rail gap is being held by rail tensors during the weld, do not remove the tensors until 20 minutes after the excess head metal has been removed. If there is any indication that the rail may have moved during this time, the weld MUST be replaced. If it cannot be replaced immediately, it MUST be plated and reported immediately to the local field management for follow up.

# 18 Finishing off the weld

Welds must not be final ground until they have completely cooled. The "Finished Grind" tolerances are detailed in ARTC Standard ETM-01-01.

The specially designed rail profile grinder is to be used. It <u>must</u> be in a condition whereby stones can be fully locked i.e. they don't 'float' over the rail.



#### Figure 1.15 – Grinding

It should be clearly understood that each weld must be ground off to at least temporary 'semi final' standard using the correct rail profile grinder before any traffic at normal speed is allowed to pass over it.

To achieve the "best" result it is necessary to set the weld high enough so that after the weld has cooled it will be peaked. After the weld has cooled and is ready to be ground, the rough part of the weld is ground off. The grinder is then moved away from the weld to a flat section of the rail and the grinding stone is lowered to just touch the rail, raised a fraction and **locked in this position**.

The grinder is then run across the weld and adjacent rail in long continuous sweeps. This operation is difficult during the initial grinding until the section being ground becomes more uniform. The grinding continues until the grinding zone has become smooth and uniform.

While the weld is being ground three things are happening. **The railhead is heating up** and therefore it is rising. Secondly, the **grinding stone is wearing** and thirdly, **metal is being removed** from the weld and adjacent rail.

At this time there is no point in measuring the height of the weld, as it will be high. The final result can only be assessed after the process is finished and the rail has cooled to the ambient temperature. If the setting up has been correct, in other words the weld was set just high enough, and the grinding was carried out correctly, then the weld should be between 0.1mm and 0.5mm high over a meter length and the P1 weld gauge should not show a significant reading when run over the full grinding zone.

The vertical weld alignment must be checked across the head of the rail from gauge face to the outside edge of the wheel contact band, and the maximum peak and weld ramp angle along the entire grinding zone must be within the tolerance outlined in ARTC Standard ETM-01-01.

Note the following points. While grinding, the "sweep" must continue until the grinding stone no longer **contacts the rail**. In the area being ground there are three different levels of hardness and if the "sweeps" are not long and uniform the grinding stone will find and remove more metal from the soft sections. For Aluminothermic welding, the weld metal is generally harder than the rail, and the edge of the heat affected zone (HAZ) will be softer than the weld metal and the rail. On new rail, that is not yet work hardened, the HAZ may not be as noticeable.

If a step or misalignment is left at the new weld, when a wheel on a rail vehicle hits the misalignment, an impact force P1 occurs. This is an initiating factor that causes settlement in the nearby sleepers and pushes ballast down into the formation causing ballast pockets. When a wheel on a rail vehicle rolls into the small depression at the settled sleepers the impact produced is called the P2 force.

P1 forces also initiate rail corrugation resulting in propagation of P1 forces along the rails. An example of the propagation of rail corrugation is shown in Figure 18.1.



Figure 18.1 Corrugations Gerringhap to Pura Pura before rectification

The P1 force system is associated with lack of smoothness of the weld or rail, while the P2 force system is associated with lack of smoothness of the track.

It is easy to recognize that tamping alone will not correct these problems as the poor track top will keep coming back. This is why it is so important to get the weld geometry right by proper grinding.

A variety of poor weld alignments result in P1 forces due to excessive weld ramp angle. These include the step weld, dipped weld, excessive peaked weld, severe hardness profile, and a combination of the above. They can mostly be avoided by use of good set up and grinding procedure.

To assist correct grinding of the rail two tools are suggested; the ARTC Finishing Straightedge that has 0.5mm nibs on each end of one of its straight edges, and the P1 gauge shown below.

The straightedge indicates the straightness of the weld over a 1 metre base showing whether the weld is high, low or level.

The P1 gauge indicates whether the ramp angle (or smoothness) in the vicinity of the weld is within tolerance. The P1 gauge indication is determined over a 50mm base. The P1 gauge provides a better indication of smoothness tolerance than a straightedge.



P1 GAUGE

A P1 gauge is not a substitute for a straight edge nor is the straight edge a substitute for the P1 gauge. Their function is different but they are complementary to each other.

Careful setting up of the weld and the use of the correct grinding technique will produce welds that are at the correct height with almost no angular displacement. Remember that grinding in order to correct "setting up" mistakes is expensive in terms of time and equipment consumed.

Lastly, grind the transition from running surface to gauge face to match the profile of the adjacent rails.

# **19** Introduction to the P1 Gauge

The "P1 GAUGE" was developed as an **additional guide**, which may be used in conjunction with a straight edge to assess the quality of the grinding at a weld.

The principle of operation is based on a 50mm base line with a hardened steel probe measuring the rise or fall over 50mm. The resulting indication is read in terms of angular displacement and can be expressed in milliradians, although the gauge provides a "GO", "NO GO" indication at the 7 milliradian permissible limit. This represents a displacement of about 0.35mm over a 50mm base.

# **INSTRUCTIONS FOR USE.**

The gauge is held with the forefinger and thumb between the two wheels and placed on the rail next to the weld to be checked. The three wheels must be in firm contact with the rail surface before it is run across the zone to be measured.

On a "flat" surface the pointer will move to the zero position and not move while the gauge is traversed across the section being checked. If there is a rise or fall in the section under test, the pointer will move to one side of the zero point or the other. The maximum amount of deflection is noted and compared against the permitted tolerance (See fig. 1)



If a weld to be assessed with the P1 gauge is say, 0.3mm high when measured over a metre length, **and is correctly ground**, then the weld and the adjacent rail will be convex in shape. The pointer will then move slightly to one side as the gauge is run across the area that has been ground. (See fig. 2)

For visual confirmation using a straightedge, any high or low point indicated by the P1 Gauge will be located at the dual wheels at the centre of the instrument.



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# If the pointer moves beyond the first marks either side of the zero then the grinding is of a poor standard and further grinding should be carried out.

It is possible, with the correct grinding technique, to get very little or, almost no deflection on the P1 gauge dial when checking the grinding standard.

# **INSTRUMENT MAINTENANCE.**

# When not in use, the instrument should always be kept in its box.

Due to the nature of the surface to be tested there will be some wear on the probe in contact with the rail. To resist this wear the probe is tipped with tungsten carbide. However when it does wear, the pointer can be returned to a zero reading on a flat surface by the following simple adjustment:

Using a 2mm Allen key, loosen the socket set screw at the rear of the gauge and rotate the eccentric axle with a screw driver until the pointer is centered, then re-lock the set screw.

No lubrication is required and, if used, will attract dust and grit and may make the instrument unserviceable.







Figure 1.16 – Finished Weld (Note Weld Identification label)

# 20 Marking, Recording and Reporting Welds

# 20.1 Welding Return RAP 5391

All information required to fill out the Welding Return detailed in ARTC Engineering Practice Manual RAP 5391 must be taken down and every welder must fill out and send a Welding Return to his/her supervisor every week with every weld done in track noted on that return.

Even if no welds are done a Nil return must be sent in to assure that the return has not been lost in transit.

## 20.2 Marking of Welds

Every weld is ultrasonically tested and to enable these welds to be located it is required that they be marked on the inside foot of the rail with the Weld Number, Licence Number then Date (month and year only) using a Ballmarker with white DOP ink or welder identification stickers in accordance with the requirements of RAP 5391.

This information must also be shown on the welding return to confirm that the Ultrasonic operator has indeed found the correct weld.

## 20.3 Visual Inspection of Welds

The worker who supervised the production of the weld shall carry out visual Inspection (for suspected defects) of all new welds:

- Porosity
- Slag Inclusions
- Uneven Heat Affected Zones
- Other Visual Indications of Defective Weld.

#### Non Destructive Testing (Visual)

While all new aluminothermic welds should be inspected by the NDT Inspector (using ultrasonic techniques that look at the internals), time may elapse before the inspection is undertaken so it is considered necessary to visually inspect aluminothermic welds to gain an indication of their condition.

Some experience is required to visually inspect aluminothermic type welds, so welds thought to be defective should not be removed from track merely by using the practices below. It is however a guide to weld quality and is a useful indicator to assess welder performance.

If a weld is thought to be defective the Supervisor should be informed and arrangements made to ultrasonically examine the suspect weld.

#### **Running Surface**

# After the completion of a aluminothermic weld and the passage of several trains it is possible to see the extent of the weld metal and associated heat marks (on used rail).

The weld should be about 50 to 60mm wide and the two sides of the weld parallel. On work-hardened rail (used rail) some heat marks will appear 20 to 25mm from the edge of the weld. (See fig.1)



Defective welds may be narrow, 20 to 30mm wide, V or Y shaped, the bottom of the V or Y facing away from the pour side of the weld. (See fig.2)



The foot or flange area is another important area for visual inspection. Examination of this area will usually show a difference between the pour side (field side) and the side away from the pour. The increased heat input caused by the hot metal on the pour side causes more sand from the mould to adhere to the rail foot adjacent to the weld. It is reasoned that sufficient heat is available to fuse sand to the rail foot adjacent to the weld, and then the heat is sufficient to complete the fusion between the rail flange or foot and the weld metal.

# Any welds that show holes, slag inclusions, hot tears or other defects must be removed immediately.

## 20.4 Before leaving the Site

- Box up the sleepers, check all fastenings are replaced,
- Make a careful check for any fires or smoldering sleepers, bridge timbers or vegetation and extinguish any fires found.
- Replace any burnt insulating pads on concrete sleepers
- Clean up and remove from site any rubbish including the steel scrap.

# Appendix 1 – Care and Maintenance of Welding Equipment

# 1 General

#### 1.1 Moisture

Portions, crucible linings, crucible thimbles, moulds, and pouring pots should be kept dry at all times. Portions cannot be dried and used once they become damp. If they are used, the reaction will be violent and the weld weak and porous.

## 1.2 Maintenance

On a regular basis checks should be made of all equipment and the following work should be done: -

Inserting handles into hammers; cleaning, lubricating and filling the grinding machine; cleaning screw threads on equipment, checking crucibles and replacing if necessary and cleaning the preheating torch should be carried out.

#### 2 The Crucible

As far as possible, the crucible must always be kept dry. To ensure that the crucible is dry, it should be heated before use. Care must be taken when handling crucibles because a crack in a crucible lining will require its replacement.

If the crucible shell is broken or inadequate in any way, it must be removed and replaced with a new lining. Before use, the crucible must be dried thoroughly by preheating for at least twenty (20) minutes.

## 3 The Crucible Thimble

To extract the used thimble, remove the slag from above the thimble, turn the crucible upside down, then carefully knock the thimble downward and out from the bottom.

If the new thimble is not a tight fit with the crucible lining, the thimble should be covered with one or two layers of paper to form a close fit.

## 4 Preheating Torch

#### 4.1 Care

The preheating torch should be placed carefully in the toolbox after use, before transportation. Torches must not be thrown on the ballast. After preheating and before tapping, take off the torch and lay it down with the burner head upwards. Care must be taken to make sure that the torch head does not come in contact with the mould; otherwise the torch head will become too hot and melt.

## 4.2 Maintenance

Clogged or damaged torches not in good working order must not be used and must be repaired only by experienced workers.

After 100 welds have been made, the holes in the burner head should be cleaned out with the tools provided.

If this maintenance is not carried out, the performance of the torch will deteriorate resulting in longer preheating times or insufficient preheating of the rail ends.

# Appendix 2 – Welding Process – Troubleshooting Guide

Possible Cause		Remedies			
Shor	Short Head				
1	Preparing the crucible	Loss of metal due to incorrect preparation of crucible. Carefully pour the portion into the crucible to avoid loss of welding material.			
2	Gap Width	Too large a gap requires additional metal. Adjust gap as recommended.			
3	Mould Adjustment	Incorrect loose attachment of moulds will cause loss of metal. Fit mould as per instructions.			
4	Incorrect Aligning of Pouring Pot	Sloping of Pouring Pot towards the centre of the moulds can cause a fast flow of metal, with loss into the slag pot. Adjust Pouring Pot. Sloping of Pouring Pot backwards will cause metal to stay in the Pouring Pot.			
5	Pouring of Crucible Metal downhill	Fit the crucible to preheat support to ensure that the welding is poured from the low side of the rail.			
6	Careless Luting	Always commence luting under the foot of the rail. Pack firmly into place as advised.			
7	Incorrect high gas	Will cause overheating of the rail head and web with melting and running of the metal, causing a larger gap size and a short head. Set pressures as stipulated.			
8	Incorrect Tip Height	As above (7). Adjust the torch height as per instructions.			
9	Excessive Preheating	Will cause running of metal on the head and web of rail, causing a larger gap and a short head. Preheat for recommended length of time.			
10	Badly Flame Cut rail ends	Difficult to set correct gap or maintain even preheat, both resulting in too large a gap with a short head. Ensure good flame cut rail ends at all times.			
11	Incorrect Portion Size	Always check that the welding portion is the correct size for the weight of the rail being welded.			
Poro	us Welds				
1	Luting Mixture	"Over wet" luting mixture can allow excessive moisture to be released during pouring into the weld metal. Mix the luting sand as per instructions (Applicable to Thermit process only).			
2	Careless Luting	Globules of sand dropped into the mould can cause sand inclusion, gas entrapment and porosity. Take care when luting.			
3	Use of beach sand and other alternative luting mixtures	Beach sand contains shell grit, which releases CO2 during the welding process causing porosity. Always use the correct luting mixture.			

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	Possible Cause	Remedies
4	Small Gap	A smaller gap than stipulated will cause lack of preheat with porosity in the head of rail. Always check gap with gauge provided.
5	Excessive Preheating	Will cause the metal to run on the head and web of rail, causing porosity in the weld. Preheat for recommended length of time.
6	Lack of Preheat	Will cause cold spots with the metal forming into shot or pellets causing a porous weld.
7	Badly Flame Cut rail ends	Difficult to preheat correctly causing head and web to heat inconsistently and overheat, causing porous weld. Ensure good flame cut rail ends at all times.
8	Damp Welding Portion	Will react violently, and will result in a porous weld. Always store portions in a dry place.
9	Crucible Preheat	The crucible must be preheated for twenty (20) minutes before use every day so as to remove moisture which will cause a violent reaction and a porous weld.
10	Wet Conditions	Welding carried out in rail or very damp conditions can result in a violent reaction and a porous weld. Never weld in doubtful weather.
Lack	of Fusion	
1	Small Gap	A small gap will cause lack of preheat with of fusion to the foot and web of rail. Always check gap with gauge provided.
2	Low Pressures	Incorrect low pressure reduces the preheat to the foot of the rail, resulting in lack of fusion. Set pressures as stipulated.
3	Lack of Preheating	Will cause cold spots on the web and foot of the rail, resulting in lack of fusion. Preheat as per Instructions.
4	Badly Flame Cut rail ends	Causes difficulty in preheating with lack of fusion. Cut rails as recommended.
5	Machine Cut Face to a Flame Cut Face	Difficult to preheat, causing lack of fusion to flame cut face. Always match machine cut ends together or flame cut ends together. Never match a machine end to a flame cut end.
Inclu	sions	
1	Careless Luting	Careless luting could cause globules of sand to fall into the mould, resulting in sand inclusions. Take care when luting.
2	Wet Luting Mixture	An "over wet" luting mixture could cause moisture to be released into the weld metal during pouring, causing gas inclusions. Mix luting mixture as per Instructions.
3	Excessive Preheating	Will cause the mould to break down with globules of sand flowing into the weld metal, causing sand inclusions. Preheat for recommended length of time.

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	Possible Cause	Remedies
4	Careless Positioning of the Preheating Torch	Care must be taken in positioning the Preheating torch as the sand mould can be damaged, causing sand material to fall into welding gap. Position preheater as per Instructions.
Misc	ellaneous	
1	Tearing of Metal	Caused by trimming too early with the metal still in a plastic stage. Trimming should always be carried out along the rail, not across.
2	Sand Mould Breakdown	Moulds that have been wet and allowed to dry, should be replaced, as the material in the mould has changed and can break down during the preheat and allow molten metal to flow out.
3	Excessive Preheating Time	Small diameter tubing under 10mm (3/8") I.D. will cause pressure drops, especially over long lengths. Always use the correct 10mm (3/8") I.D. tubing.
4	Incorrect Portion Size	Under no circumstances should part of another portion be added as this will cause a change in the chemical analysis of the mixture and will result in a weak, faulty weld. Always use the correct portion.
5	Hot Tears	Caused by rail movement before the weld has set. Do not disturb the weld until at least 10 minutes after removing the excess weld metal from the head.



Suggested design only, sound alternatives are acceptable.

# Part 2

# Thermit Welding Methods

# **Special Instructions**

These Special Instructions apply to Thermit's SKVF, SMWF and HEAD REPAIR welds. They are additional to Part 1 General Instructions

# 1 Thermit SKVF Method

These instructions are in addition to the General Instructions.

# 1.1 Gap

The weld gap for all SKVF welds except wide gap is  $25mm \pm 2$ .

The weld gap for wide gap welding is  $65 \text{mm} \pm 2$ .

## 1.2 Attaching universal clamp

Position the universal clamp on the rail by using the gap gauge and check that the locating arm is in line with the centre of the gap (See Figure 2.2)



Figure 2.1 – Universal Support

Check that the universal clamp is vertical after tightening to the rail.



Figure 2.2 - Positioning of the Universal clamp with the aid of the Gap Gauge

Assemble the preheating torch and fit it into the supporting cradle.

# **1.3 Setting preheater height**

Place the preheater in the preheater support on the universal clamp.

Adjust the height so that the short leg of the gap gauge is a neat fit between the top of the rail and the bottom of the preheater tip (See Figure 2.3).

Preheater height for 60kg, 53kg, (107lb), 47kg, (94lb) and 41kg, (80lb) should be 35mm.



Figure 2.3 - Adjusting Preheater Torch Height

Provided the cradle height is not altered, this adjustment need only be carried out once or twice each day as a check.

Remove the preheating torch from its cradle.

# 1.4 Check moulds and rubbing in (See Section 1)

Check the moulds for cracks in the foot/web area in additional to the usual checks.

Care is to be taken when rubbing in the moulds, ensuring that the foot/web is not cracked.



Figure 2.4 - Rubbing in Moulds

# 1.5 Mixing Luting Sand

Mix the dry luting material with water. This is packed in a bag in the mould unit box. The moisture content of the luting material is correct when it can be compressed in the hand and dropped onto a rail from a height of 500mm and does not break.

## **1.6** Attaching moulds to rail and luting

Place each side in mould covers.

Place the mould centrally over the rail gap and use the locating arms of the universal clamp to hold the moulds in place by tightening the "T" screw to apply a firm but not excessive pressure to the mould.



Figure 2.5 - Positioning the Moulds

When luting the head of a rail, the piece of cardboard or luting cards (See Figure 2.6) supplied with portion bags, must be placed in position across the gap on top of the rail. The luting material is then packed firmly around head of rail with the aid of a 50mm paint scraper. This prevents luting material from falling into moulds. Also, the cardboard turns to carbon when moulds are preheated, eliminating a slight groove, which forms at the edge of luting sand and hot metal.



Fig 2.6 - Placing Cardboard on Head of Rail



Fig 2.7 - Luting of the Moulds

Firmly pack luting sand around the moulds and the join under the rail (see Figure 2.7).

Fill the luting grooves surrounding the rail and under the rail foot with luting material and pack it firmly into place to prevent leakage of the molten metal when the mould is filled. Take care when luting under the rail foot, to make sure that the luting material is placed on the correct side of the luting groove.

Attach slag trays to sides of mould covers and place dry luting sand in trays.



Figure 2.8 - Luting complete

# 1.7 Lining up crucible

The crucible is to be lined up with the thimble hole over the centre of the moulds.



Figure 2.9 - Lining up the Crucible

Check crucible is the correct height – 25mm between top of moulds and bottom of crucible.

# **1.8 Preheating Pressures**

Any Oxy check gauge is to be used at all time on the hand piece.

LPG 150KPA

Oxygen 500KPA

# 1.9 Preheat

Preheat the rail ends to dull red web and foot with some colour change in the head.

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This should be achieved after:

Rail size	Standard and junction (mins)	Wide gap (mins)
47kg	2	2.5
53kg	2	2.5
60kg	2.5	2.5



Figure 2.10 - Lining up Preheater

# 1.10 Strip down and Cut off

	SKVF Standard and junction (mins)	Wide gap (mins)
Strip down	4.5	8
Cut off	5	9

# 1.11 Quick Reference Table

	STANDARD Weld		JUNCTION Weld			Wide Gap Weld			
Rail Size Kg.	47	53	60	41-47	47-53	53-60	47	53	60
Prealignment for W	elding (	Gap with	n 1 m S	traight Ec	dge				
Top (Running surface)	1.8 mm Each End		1.8 ı	1.8 mm Each End		2.5 mm Each End			
Side (Gauge Face)	No Gap			No Gap		No Gap			
Gap (mm)	25±2		25±2		65±2				
Oxy Pressure	500		500		500				
LPG Pressures	150		150		150				
Preheat Time	2	2	2.5	2	2	2.5	2.5	2.5	2.5
Colour Required	red foot & web some change in head		red foot & web some change in head		some ead	red foot & web some change in head			
Strip Down Time	4.5		4.5		8				
Cut Off Time	5		5		9				
Finish Grind Time	When Cool		When Cool		When Cool				

# 2 Thermit SMWF Method

These instructions are in addition to the General Instructions

## 2.1 Gap

The weld gap for all SMWF welds except wide gap is 20 mm  $\pm 2$ .

#### 2.2 Attaching universal clamp

Position the universal clamp on the rail by using the long arm of the gap gauge so the arms of the universal clamp are in the centre of the gap.

Check that the universal clamp is vertical.

#### 2.3 Setting preheater height

Place preheater in preheater support on the universal clamp.

Adjust the height so that the short leg of the gap gauge is a neat fit between the top of the rail and the bottom of the preheater tip.

The height is 55mm.

#### 2.4 Check moulds and rubbing in

Check the moulds for cracks in the foot/web area in addition to the usual checks.

Care is to be taken when rubbing in the moulds, ensuring that the foot/web is not cracked.

## 2.5 Attaching moulds to rail and luting

Place each side in mould covers.

Place mould centrally over weld gap and use the arms of the universal clamp to hold the mould in place by tightening the "T" screw to apply a firm but not excessive pressure.

Place 1mm card between mould and rail over the weld gap.

Firmly pack luting sand around the moulds and the join under the rail.

Attach the slag tray to the side of the mould cover and place dry luting sand in the tray.

Attach the pouring cup and mould to the side of the mould and ensure it is level.

Fit the precast pouring pot into the steel pouring potholder and hook the holder onto the lugs of the mould protector.

Level the pouring pot if necessary by packing with a little luting sand or on the new type pots by using the adjustable support bar.

It is important to keep the pouring pot level because if it tilts backwards, the molten metal can overflow at the back and damage the equipment. If the pouring pot tilts forward the flow rate will increase and could become too fast for the pouring hole in the mould, with the result that metal and perhaps slag pours over into the rail gap prematurely. All metal must flow down the receiving riser and if welding on a curve, the pour should always be from the low side of the rail.

# 2.6 Lining up crucible

Check crucible is the correct height, with a gap of 25mm between the top of the pouring cup and the bottom of the crucible.

The crucible is to be lined up with the thimble hole over the centre of the pouring cup mould.

## 2.7 Preheating Pressures

LPG 150KPA

Oxygen 250KPA

## 2.8 Preheat

Preheat the rail ends till the rail appears bright red web, foot and head.

This should be achieved after

Rail size (Kg)	Preheat time (Mins)
41	4
47	5
53	6

# 2.9 Strip down and Cut off

	SMWF (Mins)
Strip down	4.5
Cut off	5

# 2.10 Quick Reference Table

	Standard Weld			
Rail Size (Kg).	41	47	53	
Prealignment for Weldir	ng Gap Under	1m Straight E	Edge	
Top (Running Surface)	1.8 mm each end			
Side (Gauge Face)	No Gap			
Gap (mm)	20 ± 2			
Oxy Pressure (Kpa)	250			
LPG Pressures (Kpa)	150			
Preheat Time (Min)	4	5	6	
Colour Required	Even Bright Red All Over Rail Ends			
Strip Down Time (Min)	4.5			
Cut Off Time (Min)	5			
Finish Grind Time	When Cool			

# 3 Thermit Head Repair Weld

# (Welding Procedure for all rail sizes)

#### 3.1 Preliminary

Examine the head defects, their size, number and proximity to each other and determine if repair of the defects or replacement by a closure, is the most economical solution.

The head defect is to be ultrasonically tested within 14 days of the planned removal, to ensure that any defect does not extend more than 8mm below the running surface.

Squat defects can generally be detected visually/ultrasonically during track/rail inspections.

The actual size of the squats, and in particular the length and depth of the horizontal sub-surface cracking associated with them, can be quantified reasonably accurately by using the ultrasonic thickness gauge.

Any transverse cracking associated with squats or wheelburns, may be difficult to detect with the conventional 70° probe because of the horizontal sub-surface cracking, or surface damage, so care should be taken when doing this inspection.

#### Note:

- 1. If the sub-surface cracking extends beyond 8mm, the defect should be removed by a closure.
- 2. Should any transverse defects be found then the standards laid down in TES 02 will apply.

## 3.2 Repair Procedure

- 1. Ensure a good top over the repair area by packing as required.
- 2. Locate the head defect to be repaired and measure it (see Figure 1) to determine if one weld will be required or more than one, end on end. Repair area of one weld is 100mm. When using multiple repairs the head repair welds must overlap by at least 15mm, with no more than two welds overlapping.
- 3. Mark with chalk the 100mm-repair area or the mould location to evenly cover the repair area.
- 4. If the repair area falls over a sleeper, lift the dogs or remove the clips on that sleeper alone, otherwise lift the dogs or remove the clips on the sleeper each side of the repair area.
- 5. The moulds may now be rubbed to a neat fit on the rail and to each other (the reservoir half on the high side), fitted to the mould protector then set aside.
- 6. A bead of luting should be applied from the tube to the luting grooves in the moulds just prior to fitting.



## Figure 1

- 7. Set peaking of the rail at the repair area to approx. 1.5mm each side of the 1 metre straight edge using wedges on the sleeper/s under the repair area.
- 8. Fit the universal rail clamp to the rail, locating the arms at the centre of the repair area.
- 9. Check and adjust the preheater height to 70mm.
- 10. Fit the moulds centrally over the repair area and clamp firmly.
- 11. Tear the 0.5mm cardboard and place half under each end of the mould-luting wedge.
- 12. Pack the wedge firmly with luting sand or premixed paste.
- 13. Fit the biscuit to the moulds ensuring it locates properly.
- 14. Place the crucible on the clamp and adjust the height to 20mm above the moulds with the pouring throat directly above the wire loop on the biscuit.
- 15. Swing the crucible away, fit the ATS-ER thimble, load the correct hardness portion and place an ignition tape.
- 16. Remove the biscuit and hold it with tongs, or on your round cleaning wire, at the side of the preheater flame, when lit, to completely dry it both sides.
- 17. Light the preheater (SKV modified E36A i.e. with heat shields) with pressures set at 500kPa Oxygen, 150kPa LPG adjusted to full flow Oxygen.
- 18. Preheat the repair area evenly inside the moulds for 2 mins for all rail sizes, sliding the preheater backwards and forwards in the preheater support cradle. The railhead should show a dull red at the end of the preheat.

- 19. Place the biscuit in position when the preheat is complete using tongs or pliers ensuring it seats correctly.
- 20. Swing the crucible over the biscuit and light the portion.
- 21. After the weld metal has poured remove the crucible and place it "off track" or at the next weld site.
- 22. Remove the mould protectors and rail clamp 5.5 minutes after the pour.
- 23. Break away the mould from the ends of the weld by sliding a hotset along the railhead.
- 24. Break away the sides of the moulds and slag by hitting on the top corners with a hammer and then lifting the slag with a hotset.
- 25. Remove excess metal head at 6-7 minutes after the pour using 150mm stroke hydraulic shears. Extreme care must be taken not to cut when the weld metal is too hot thereby causing a hot tear.
- 26. Remove wedges, lift and pack, rough grind and replace fastenings before allowing a train across weld. If geometry complies with 'semi finished' condition in ETM-01-01 no TSR is required, if not, a TSR must be applied.
- 27. "Finish grind" the weld to ARTC Standard ETM-01-01 when the weld has cooled completely.
- 28. Mark the weld position and welder identification in accordance with the requirements of ARTC Engineering Practice Manual RAP 5391.

# Part 3

# Railtech Welding Methods

# **Special Instructions**

These Special Instructions apply to Railtech's AP, PL, QPCJ, PLK and PLKCJ welds. They are additional to Part 1 General Instructions

# 1 Railtech PL and AP

These instructions are in addition to the General Instructions.

# 1.1 Gap

Weld type	Gap	Rail size
PL std and junction	25mm +-2	47, 53, 60
PL wide gap	65 mm +-2	53, 60
AP	19mm +-2	47, 53

# 1.2 Attaching moulds to rail and luting

Place each side of the mould in the mould covers and place base plate mould in the base plate cover.

Place luting paste from the tube supplied on each side of base plate.

Place base plate under the foot of the rail centrally covering the weld gap and tighten clamp screws while tapping base plate.

Place side mould on rail and ensure that the mould is aligned to the base plate.

Fit mould clamps and tighten.

Pack luting paste around moulds and base plate.

Place slag tray on mould clamp and place dry luting sand in tray.

## 1.3 Crucible

The crucible stand is attached to the rail and the crucible is fitted to the stand.

Crucible is lined up over the centre of the moulds and then moved back out of the way.

## **1.4 Preheater support**

The preheater support is attached to the rail on the opposite side of the weld gap and the preheater is fitted over the support.

## 1.5 Preheater tip

AP weld preheater tip part number 78205400

PL weld preheater tip part number 78200600

## 1.6 Preheater height

Check the preheater height.

The preheater height for PL and AP weld is:

- Standard and junction is the low setting on the support
- PL Wide gap weld is the high setting on the support

# **1.7 Preheating Pressures**

LP check gauge to be used at all times

Weld Type	LPG (Kpa)	Oxygen (Kpa)
PL	40	150
AP	30	150

## 1.8 Preheat

Preheat the rail ends to dull red web and foot and some colour change in the head.

This should be achieved after

Rail size	PL Standard and junction	PL Wide gap	AP Standard
47kg	3		5
53kg	3	3	6
60kg	3.5	3.5	N/A

Note: that all of the values shown in the Tables are in minutes

# 1.9 Strip Down and Cut off

	PL Standard and junction	PL Wide gap	AP Standard
Strip	3	10	4
Cut off	4	11	5

Note: that all of the values shown in the Tables are in minutes

# 1.10 Quick Reference Table

# 1.10.1 PL

	Standard Weld		Wide Gap Weld			
Rail Size (Kg).	47	53	53			
Prealignment for Welding Gap Under 1m Straight Edge						
Top (Running Surface)	1.8 mm each end		2.5 mm each end			
Side (Gauge Face)	No Gap					
Gap (mm)	25 ± 2		65 ± 2			
Oxy Pressure (Kpa)	180					
LPG Pressures (Kpa)	40					
Preheat Time (Min)	2.5		3			
Colour Required	red foot & web some change in head					
Strip Down Time (Min)	3.5		10			
Cut Off Time (Min)	Z		11			
Finish Grind Time	When Cool					

# 1.10.2 AP

	Standard Weld	Wide Gap Weld			
Rail Size (Kg).	47	53			
Prealignment for Welding Gap Under 1m Straight Edge					
Top (Running Surface)	1.8 mm each end				
Side (Gauge Face)	No Gap				
Gap (mm)	19				
Oxy Pressure (Kpa)	150				
LPG Pressures (Kpa)	30				
Preheat Time (Min)	5	6			
Colour Required	even right red all over rail ends				
Strip Down Time (Min)	4				
Cut Off Time (Min)	5				
Finish Grind Time	When Cool				

 $\Delta S$
# 2 Railtech QPCJ

These instructions are in addition to the General Instructions.

### 2.1 Gap

The welding gap for all rail sizes is 25mm ± 2mm

### 2.2 Attaching moulds to rail and luting

Place each side of the mould in the mould covers and place base plate mould in the base plate cover.

Place luting paste from the tube supplied on each side of base plate.

Place base plate under the foot of the rail centrally covering the weld gap and tighten clamp screws while tapping base plate.

Place side mould on rail and ensure that the moulds are aligned to the base plate.

Fit mould clamps and tighten.

Pack luting paste around moulds and base plate.

Place slag tray on mould clamp and place dry luting sand in tray.

### 2.3 Crucible

The crucible is the one shot, single use, crucible.

No crucible preheat is required.

Load portion.

### 2.4 Preheater support

Gap and the preheater is fitted over the support

### 2.5 Preheater tip

QPCJ weld preheater tip part number 78205600

### 2.6 Preheater height

Check the preheater height

The preheater height is the low setting on the support.

### 2.7 Preheating Pressures

Oxygen 180kPa

LPG 40kPa

## 2.8 Preheat

Preheat the rail ends to dull red web and foot and some colour change in the head.

This should be achieved after:

Rail Size	QPCJ (Mins)
53kg	4
60kg	4.5

# 2.9 Strip Down and Cut off



# 2.10 Quick Reference Table

	QPCJ		
Rail Size (Kg).	60HH		
Prealignment for Welding Gap Under 1m Straight Edge			
Top (Running Surface)	1.8 mm each end		
Side (Gauge Face)	No Gap		
Gap (mm)	25		
Oxy Pressure (Kpa)	180		
LPG Pressures (Kpa)	40		
Preheat Time (Min)	4		
Colour Required	red foot & web some change in head		
Strip Down Time (Min)	7		
Cut Off Time (Min)	8		
Finish Grind Time	When Cool		

# 3 Railtech PLK and PLKCJ

These instructions are in addition to the General Instructions.

Additional instructions on the PLKCJ welding process are contained in Section 4.

### 3.1 Gap

Weld type	Gap	Rail size
PLK std	25mm +-2	53 & 60
PLKCJ	25mm +-2	53 & 60

### 3.2 Setting the Regulator pressures

Assemble the oxy/LPG equipment with a LP test gauge at the hand piece.

Turn on cylinders (ensure that the control knob is fully out).

Open the handle oxygen valve, turn control knob in until the regulator is reading 300kPa then close handle valve.

Open the handle LPG valve, turn control knob in until the test gauge is reading 40kPa then close handle valve.

### Final adjustment

Light the torch, turn LPG handle valve fully on.

Adjust oxy handle valve to required flame.

Check and adjust LPG so that the test gauge reads 40kPa.

### 3.3 Attaching moulds to rail and luting

Place each side of the mould in the mould covers and place base plate mould in the base plate cover.

Place luting paste from the tube supplied on each side of base plate.



Fig 3.1 - Base plate mould and luting in Base Plate-

Place base plate under the foot of the rail centrally covering the weld gap and tighten clamp screws while tapping base plate.



Fig 3.2 –Base plate clamped to rail

Place side mould on rail and ensure that the moulds are aligned to the base plate.

Fit mould clamps and tighten.



Fig 3.3 - Side moulds with mould clamp attached

Place luting paste around moulds and base plate.

Place slag tray on mould clamp and place dry luting sand in tray.

### 3.4 Crucible

The crucible stand is attached to the rail and the crucible is fitted to the stand.

Crucible is lined up over the centre of the moulds and then moved back out of the way.

### 3.5 Preheater support

The preheater support is attached to the opposite rail and the preheater is fitter over support.

### 3.6 Preheater tip

PLK weld preheater tip part number 78214000

### 3.7 Preheater height

The preheater height for PLK is the low setting on the support.

### 3.8 Preheating Pressures

Weld Type	LPG (Kpa)	Oxygen (Kpa)
PLK	40	300
PLKCJ	40	300

## 3.9 Preheat

Preheat the rail ends to dull red web and foot and some colour change in the head.

This should be achieved at:

Rail Size	PLK Standard	PLKCJ
53kg	3	3
60kg	4	4

Note: that all of the values shown in the Tables are in minutes

### 3.10 Strip Down and Cut off

	PLK Standard	PLKCJ
Strip	5	5
Cut off	6	6

Note: that all of the values shown in the Tables are in minutes

### 3.11 Quick Reference Table

	PLK and PLKCJ		
	Standard Weld		
Rail Size (Kg).	53 60		
Prealignment for Welding Gap Under 1 m Straight Edge			
Top (Running Surface)	1.8mm each end		
Side (Gauge Face)	No gap		
Gap (mm)	25 ± 2		
Oxy Pressure (Kpa)	300		
LPG Pressures (Kpa)	40		
Preheat Time (Min)	3	4	
Colour Required	red foot & web some change in head		
Strip Down Time (Min)	5		
Cut Off Time (Min)	6		
Finish Grind Time	When cool		

# 4 Railtech PLKCJ

These instructions are in addition to the special PLK & PLKCJ Instruction in Section 3.

### 4.1 Crucible

The crucible is the one shot e.g. single use

### • No crucible preheat is required

- Load portion
- Insert ignition tape



Fig 3.4 - Unused One Shot Crucible

### 4.2 Placement and lighting of Crucible

After preheating the rail ends and placement of the biscuit in the moulds, the crucible is placed in the centre on top of the moulds.

Remove the crucible lid, light the portion and replace the lid.



Fig 3.4 -One shot crucible after pouring weld

### 4.3 Crucible removal

When pour is complete, wait a minimum of 1 minute then remove the crucible using a Crucible fork – part number 82631410.



Fig 3.5 - Removing used crucible