THERMIT WELDING (GB) LTD

PROCESS MANUALS

SECTION FIVE

SUPPLEMENTARY INFORMATION

SECTION 5 – SUPPLEMENTARY INFORMATION

Section 5 provides additional information and guidelines for welding operators, instructors, and staff deployed on the inspection or assessment of welds manufactured in accordance with this manual.

5.1 WELD IDENTIFICATION

5.1.1 THE SKV-E WELD

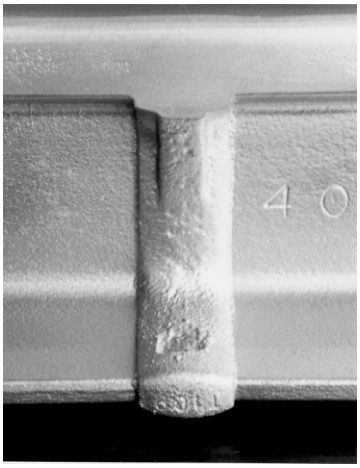
The **SkV-E** (Enhanced) Process, introduced in 2003, has been designed specifically to meet the requirements for weld quality prescribed by Network Rail and has been tested to international standards to demonstrate that when installed according to the specified procedure, is immune to undesirable weld features such as black holes and oxidisation.

The SkV-E weld has a uniform weld collar approximately 40mm wide, and no re-enforcing rib under the head. (Note: If moulds manufactured for welding 54E1 rail profile have been adjusted to fit 56E1 the weld collar may narrow in the middle of the web)

There are two vent risers each side of the rail foot, an inner one approximately 20 mm square, and an outer one approximately 10mm square – similar to those of the SkV-F + process (see section 5.1.2)

The moulds are different in appearance to the conventional SkV-F, having a triangular vent riser, when viewed from the top, and a large connecting vent between the riser and the rail head. The moulds may incorporate a smooth refractory insert in the web and foot area which aids cleaning and enhances the finish of the weld collar.

5.1.2 THE SKV-F WELD



The Thermit® SkV short preheat process, which was introduced into the UK in 1975, was subsequently modified to improve the weld collar shape – called the SkV-F (small collar) weld. This has been in use in the U.K. since 1977.

It can be identified by inspection of the weld collar, which is approximately 40 mm wide with a small re-enforcing rib positioned under the railhead. The remnant of the weld risers will be visible on the upper surfaces of the rail foot, approximately 10mm in board of the foot tip.

A modification of the process was introduced in 1995 which incorporated a second riser on each side of the foot, positioned between the normal riser and the foot tip. This type of weld is referred to as the SkV-F+ weld. Welds of this type will only be found in BS 113A or BS 110A rail, or equivalent profiles.

5.1.3 THE SKV-T WELD

The SkV-T (Triple riser) is a modification of the standard SkV-F weld. Changes have been made to the mould to maximise heat input, both during preheating and pouring by modifying the position the shape of the risers in the rail foot.

Inspection of the weld collar, which remains at 40mm wide – will show the remnants of the three-foot risers on the upper surface of the foot, and a slightly more rounded form under the railhead,

The SkV-T process was only introduced for 60E1/E2 rail profile, and in 2006 was superseded by the SkV-E process. The mould was withdrawn from use in 2007.

5.1.4 THE SKV-L50 and L 80 WIDE GAP WELD

The SkV-L50 weld was introduced for welding a rail gap between 46-50mm. The L50 weld may be identified by measuring the width of the collar which is 65mm. Moulds are available for a wide range of rail profiles and is the recommended wide gap process for 60E1,E2

The SkV-L80 wide gap weld was introduced to enable isolated defects or welds to be replaced without installing a length of rail. The weld features a wide collar (~100mm) with two risers on the upper surface of each foot.

Currently moulds are available for BS 110A & BS 113A (or 54,56 E1) profiles (or equivalent), and for welding 110A or 113A rail to 95R BH rail, and for welding 110A or 113A rail to BR 98lb rail.

5.2 IDENTIFICATION OF RAILS AND CROSSINGS

5.2.1 INTRODUCTION

The procedures that have been developed for the installation and maintenance of rails and track components are related to their composition and profile. Before commencing any welding operation staff must positively identify all the rail components involved.

5.2.2 TYPES OF RAIL STEELS

All rails are manufactured to specifications, which appear as either British or International Standards, or as commercial standards between supplier and customer. The normal standards for rails are given in the following: -

BS9	British Standard 9 - Bullhead Railway Rail: 1935 (superseded by BS11 and withdrawn in 1978),
BS11	British Standard Specification for Railway Rails - BS11: 1985,
AREA	American Railroad Engineers Association - Engineering Specification Pt.2 - “Specification for Steel Rails” - (1979), and
UIC 860/0	International Union of Railways Specification 860-0 “Technical Specification for the supply of Rails” - (January 1989)
EN	Standard for Rails

Rail steel types currently in use are as follows:

BS9:1935 - Bullhead rails (for composition refer to BS11)

BS11:1985 - Normal Grade (NG)

BS11:1985 - Wear Resisting Grade A

BS11:1985 - Wear Resisting Grade B

UIC 860-0 - Wear Resisting Grade A

UIC 860-0 - Wear Resisting Grade B

BSC - AREA 90 kg/mm² grade.

BSC - 90 kg/mm² Chromium grade.

BSC - 110 kg/mm² Chromium grade.

BSC Austenitic Manganese Steel - Low Carbon (LCAMS).

BSC Austenitic Manganese Steel - High Carbon (HCAMS or AMS).

BSC Bainitic Steel

Naturally Hard Rails

Naturally hard rails rely on a varying amount of carbon manganese to produce a range of steels with varying strength and wear resistance. These may be used as either crane rail or fabricated to make built up crossings.

Heat Treated Rails

Heat treated rails are rails rolled from AREA 900 Grade steel which have been heat treated during the production process to produce an increased hardness in the rail head.

Austenitic Manganese Steel (AMS)

Austenitic Manganese steel is only slightly magnetic, hence the use of a magnet as a simple method of determining this type of steel. All other current grades of rail are strongly attracted to a magnet. Rails are supplied in rolled form for use as plain rail or in built-up or part welded crossings.

5.2.3 SWITCHES & CROSSINGS

Switches

Switches are manufactured by machining either full depth Vignole rails , or shallow depth special rail profiles.

Built Up Crossings:

Built up or part welded crossings are normally constructed from one or more of the naturally hard group of rails (normally BS11 or UIC grades) and each component will normally carry the appropriate rolled rail brand markings (see later). When Thermit Welding these components the amount of clearance at the joint shall be taken into consideration when deciding upon which type of mould to use.

Cast Manganese Crossings.

Two types of cast manganese crossings may be in service. The cast (monoblock) crossing is manufactured as a single casting and all should be considered as having been manufactured from **high carbon** AMS steel, and shall not be Thermit welded The cast

centre manganese crossing is manufactured from a small central casting with flash welded leg extensions. These leg extensions will have been manufactured from **low carbon** AMS steel that may only be welded to rails of the same composition.

Cast Bainitic Crossings:

Bainitic crossings comprise of a small central casting manufactured from an alloy steel to which a naturally hard grade of steel has been welded to provide the leg extensions - these will normally be BS11 grade A or equivalent. These may be welded into track using the Thermit welding procedure, which is appropriate to the grade of rail used for the leg extensions.

5.2.4 RAIL IDENTIFICATION MARKS

Location

All rails now incorporate permanent marks for identification purposes. The marking system consists of the following:

Brand Marks

Identification as letters and numbers rolled onto the rail web, on one side only.

Hot Stamp Marks

Hot stamp marks appear at one end of the rail only in the web or side of the head on rails manufactured up to 1982. Rails manufactured since 1982 are hot stamped every 5 metres in the web on the opposite site to the brand marks.

Paint Identification

All rails other than Normal Grade are marked with coloured bands at each end of a rail length. The number and colour of the bands denote the type of rail steel. When identifying rail in track the paint system should not be used as the primary method of identification - reference should be made to the brand marks. The paint bands may have been destroyed during welding.

Description

All rails manufactured have the basic details of type, origin and steel making method and year of rolling contained in roll marks which are found one side of the rail web at regular intervals. The system of marking was changed at the beginning of 1978 and therefore both systems are described below:

Before 1978

The rails were marked in 18mm high characters at approximately 2.5 metre centres. The information given was:

Rail Section	Manufacturer's Name/Place	Year of Manufacture	Manufacturing Process/Detail

1978 Onwards

The rails are marked in 30mm high characters (initially characters were 20mm high) at approximately 2.5 metre centres. The information given is as follows:-

Rail Section	Steel Grade	Manufacturer Name/Place	Year of Manufacture	Steel Making Process	Purchasing Admin

Rail Grades

Rail Steel	Brand Mark	Paint Marks	Notes
BS11 Normal Grade	**None**	**None**	
BS11 Grade A	**A**	**2 x blue**	
BS11 Grade B	**B**	**3 x blue**	
UIC Grade A	**A**	**2 x blue**	
UIC Grade B	**B**	**3 x blue**	**1**
BSC AREA 90	**AA**	**1 x blue/1 x white**	
HT (340-370)	**HT**	**1 x yellow**	
90 Kg/mm² Cr	**1 CR or 1C**	**1 x red**	**1**
110 Kg/mm² Cr	**1 CR**	**2 x red**	
AMS - LC	**Manganese W**	**1 x green**	**3**
AMS - HC	**Manganese**	**1 x green**	
Bainitic	**BNC**	**None**	

Abbreviations:	CR	Chrome
	AMS	Austenitic Manganese Steel
	LC	Low Carbon
	HC	High Carbon
	HT	Heat Treated

Notes:

1. Some UIC grade B prior to 1979 did not have the brand mark provided but could be identified by the cast number, which is in the 86#B range (where # is a single number).

2. Prior to 1 January 1979 Chromium grade rails were only hot stamped and carried the identification “ICR” adjacent to the hot stamped cast identification number. The 90 and 110 Kg/mm² Chromium grade rails are no longer produced.

3. All AMS rail rolled since 1 January 1979 is of low carbon content (LC/AMS) and is weld able, providing the correct procedure is applied. The brand marking should also include the letter “W”. Low carbon AMS rail is no longer manufactured.

EN Branding System

The EN standard uses the European roll marks for identification of the grade of rail steel. The marks are in the form of horizontal lines located in the rail web

Short Line: ~25mm in length

Long Line ~50mm in length

	Hardness Range	Description	Old Equivalent (see note)	Branding
R200	**200 - 240**	**carbon / manganese**	**BS11 normal**	**none**
R220	**220 - 260**	**carbon / manganese**	**BS 11 normal**	**----------**
R260	**260 - 300**	**carbon / manganese**	**BS 11 Gr A**	**----- ----------**
R260Mn	**260 - 300**	**carbon / manganese**	**BS 11 Gr B**	**---------- ----------**
Grade	**320 - 360**	**1% Chromium**	**BSC 1% Cr**	**---------- ---------- ----------**
R350HT	**350 - 390**	**carbon / manganese - heat treated**	**BSC 350 HT**	**----- ---------- ---------**
R350LHT	**350 - 390**	**Low alloy - heat treated**	**None**	**----- ---------- --------- -----**

NOTE: Old Equivalents are for Thermit Welding Purposes only

5.3 SELECTION OF GAS EQUIPMENT

These notes are provided as reference when selecting the oxy fuel gas equipment for use with the SkV group of processes. They are based upon current knowledge and may be superseded as more information becomes available.

Reference Documents:

BCGA Codes of Practice:	
CP 6 (Rev1,1998):	The safe Distribution of Acetylene in the pressure Range : 0 -1.5 Bar
CP 7 (Rev4,2004):Portable or Mobile Cylinder Supply)	The Safe Use of Oxy-Fuel Gas Equipment (Individual Portable or Mobile Cylinder Supply)
CP 31 (1997)	Safe Storage and Use of Cylinders in Mobile Workshops and service Vehicles
BCGA Guidance Notes	
GN7(2000) Equipment	The Safe Use of Individual Portable or Mobile Cylinder Gas Supplies
UK /EN Standards	

5.3.1 GAS CYLINDERS

The quantity of welds that may be produced using a cylinder of gas, depends upon process, ambient conditions and cylinder size, therefore the following information is for guidance only, and is based around the smallest commercially available cylinders.

OXYGEN

The following information has been recorded during tests with products provided by BOC and Air Products:

	BOC "BR"				Air Products			
Designation	"BR"				30 litre			
Contents	6.5cu mtr.				9.6 cu mtr.			
Pressure	230 B				300B			
Outlet pressure	0-10B				0-8B			
Flow					250l/min			
weight - full					60 kg			
weight -empty	51 kg				49kg			
	S.U.C.		**Re-usable**		**S.U.C.**		**Re-usable**	
	P	**A**	**P**	**A**	**P**	**A**	**P**	**A**
Crucible drying	**n/a**		**1**		**n/a**		**1**	
PREHEAT			**6**		**14**		**10**	
Air temp			**12^0**		**10^0**		**10^0**	

(Information for guidance only)

ACETYLENE

Acetylene gas shall be used when working in enclosed spaces such as tunnels or station areas. The maximum permitted operating pressure is currently 0.62Bar. When used for preheating, the specified operating pressure is measured adjacent to the preheater.

The recommended minimum cylinder size, based upon work carried out by BOC gases when operating at low ambient temperatures, is:

	BOC				Air Products			
Designation	**D**		**J**		**30 litre**			
Contents	**3.3m3**		**2.35m3**		**4.0**			
Pressure					**15.5B**			
Outlet pressure	**0-1.5B**		**0.1.5B**		**0-1.5B**			
Flow					**17L/min**			
Weight - full	**51 kg**		**31 kg**		**50kg**			
Weight - empty					**45 kg**			
	SUC	**LLC**	**SUC**	**LLC**	**SUC**	**LLC**	**SUC**	**LLC**
Air temp^{0}C				**>3**		**10**		
Crucible drying				**1**		**3**		
No of welds				**>7**		**12**		

Each Cylinder is full at commencement of the work - crucible drying for 15 mins minimum

* The period between drying and the first preheat is not less than 25 mins

* The period between successive preheating stages is approx. 60 minutes

Still air conditions with no additional wind chill.

While the most common cylinder size for Thermit welding is the “F” size (33.73 kg), no measurements have to date been carried out on cylinders larger than the “J” size.

Wherever possible, the gas cylinders should be placed in a position where there is maximum protection against wind chill.

No rail cutting is included in the above data

PROPANE

Propane Cylinders are available in a range of sizes. The 47kg “E” size should cover most working conditions; but the introduction of the low pressure preheating methods has enabled smaller cylinders to be used.

Tests have been completed which indicate that the 23.5 kg propane cylinders will operate correctly under the following conditions:

Boundary Conditions:

Cylinder Size: 23.5 kg (content weight)

Operating pressures: 3.0 B Oxygen, 0.7 bar Propane – set at the preheater.

Crucible drying: 12.0 Mins

Rail Cutting: Assume flame cutting – 4 Mins at standard preheat pressures

Preheating: 3.0 Mins

Frequency: 1st weld 30 Mins after crucible dried, then 45 Mins between welds.

Air temp: ^{0} C.		>0		0		0 - -5		-5 - -10	
Windchill:^{0} C.		>0		0		0 - -5		-5 - -10	
% contents*		100	50	100	50	100	50	100	50
	Time (Mins)								
Crucible drying	**0**	√	√	√	√	√	**n/a**	√	**n/a**
Weld no 1	**30**	√	√	√	√	√	**n/a**	√	**n/a**
Weld no 2	**75**	√	√	√	√	√	**n/a**	√	**n/a**
Weld no 3	**120**	√	√	√	√	√	**n/a**	√	**n/a**
Weld no 4	**165**	√	√	√	√	√	**n/a**	√	**n/a**
Weld no 5	**210**	√	√	√	√	√	**n/a**	**n/a**	**n/a**
Weld no 6	**255**	√	√	√	√	√	**n/a**	**n/a**	**n/a**

Notes: Tests have demonstrated that that the 23.5 kg cylinder will operate at cylinder temperatures as low as -9^{o}C. (Measured at the bottom of the cylinder)

N/A indicates that the data is not currently available

5.3.2 GAS FITTINGS

All oxy fuel gas equipment is subject to mandatory inspection and safety checks which must be carried out at prescribed intervals. All hose connections must conform to BS EN 559

The current BCGA Code of practice CP7 recommends the following safety devices be fitted to mobile gas supply systems, where the hose diameter is greater than 6.3mm bore, and/or greater than 3m in length:

GAS		mixer inlet	regulator outlet
Acetylene	option 1	NRV + FA	FA + P.COV or T.COV
	option 2	NRV	FA + P.COV + T.COV
Propane	option 1	NRV + FA	FA + P.COV or T.COV
	option 2	NRV	FA + P.COV + T.COV
Oxygen	option 1	NRV + FA	FA + P.COV or T.COV
	option 2	NRV	FA + P.COV + T.COV

(Refer to CP 7 clause 8.2)

NRV:	Non return Valve
FA;	Flame Arrestor
P.COV, T.COV:	Pressure activated cut off valve, temperature activated cut off valve

For Thermit Welding, it is recommended, that in order to avoid restrictions to gas flow if two flame arrestors are fitted, option 2 should be considered as best practice..

There is a wide range of fittings available commercially, a number of which have been provided for testing with the Thermit Welding processes. Where specific products have been identified, the list is not exhaustive, and is provided is for information purposes only and other items may be used provided they comply with the technical specifications.

All hose fittings must comply with the appropriate BS EN standard (BS EN 560) and either threaded, or quick release couplings may be used. All couplings must be rated to 10Bar

5.3.3 REGULATORS

Regulators may be either gauged or gauge-less, with a contents indicator.

All regulators shall be manufactured to BS EN 2503.The recommended types are:

- For Oxygen : Multistage 0 - 10 bar
- For Propane: Single or Multistage 0 - 3.5 bar
- For Acetylene: Single or Multistage 0 - 1.5 bar

(The use of multi stage regulators may be prescribed by the Track Authority). The choice of specific products remain with the end user.

5.3.4 FLASH BACK ARRESTORS

Flash back arrestors, manufactured to BS EN 730, shall be fitted to all gas hoses on the exit of the regulator. The minimum requirements for use on Network Rail Infrastructure are:

- Resettable
- Incorporate Flame arrestor, pressure and temperature activated cut off valve

(In accordance with CP7)

5.3.5 PRESSURE GAUGES

Pressure Check gauges manufactured to BS EN 562 shall be fitted to both the oxygen and the fuel gas hoses. The gauges are positioned between the regulator hose and the appliance as described for specific processes. The gauges must be clearly calibrated in such a way that the correct operating pressure may be easily read off the dial. All pressure gauges shall be regularly calibrated at no more than 6 monthly intervals.

- For Oxygen : range 0-6 bar min
- For Propane: range 0-2.5 bar min
- For Acetylene: range 0-2 bar min

5.3.6 HOSES

Gas hose should be manufactured to BS EN 559, and shall be fitted with hose check valves (non-return valves), manufactured to BS EN 730. All connecting fittings must comply with BS EN 560. All hose shall be 3 ply (min) construction

Hose with a 10mm hose diameter is recommended, however tests have shown that the correct preheating conditions can be achieved with hose of the following dimensions:-

	Colour	**Int bore (mm)**	**Length (m)**
Oxygen:	(Blue)	8 or 10	5 – 20 (max).
Propane:	(Orange)	8 or 10.	5 – 20 (max)
Acetylene:	(Red)	10	5 – 20 (max)

5.3.7 LOW PRESSURE PREHEATING

The low pressure preheating method adopted for use with the SkV-F and E welding methods prescribes operating pressures measured at the appliance. To achieve this, pressure check gauges have been attached to the preheating mixer stem either directly or via a metal tee piece

5.4 WELDING "LINESIDE" OR "OUT OF TRACK"

5.4.1 INTRODUCTION

The Aluminothermic welding of rails at lineside is not an ideal method of producing sound quality welds. The best practice is welding with the rails in their final position, correctly supported on baseplates, or similar fittings.

These guidelines provide information to enable competent welders to adapt the standard welding processes, as described in **Section 1**, to manufacture welds in lengths of rail positioned out of track.

Rails must not be welded unless they have been correctly positioned, prepared, and restrained such that they are unable to be moved during the welding operation.

5.4.2 SCOPE

These guidelines are to be used when welding rails that are not in their final position, and include:

- Rails positioned on the sleeper ends
- Rail positioned in the "4 foot"
- Rail positioned in the Cess, 6', 10' or further distant from the running rails
- Rails on Steel Sleepered Track.

When welding on rails that are positioned "Out of Track", reference must be taken to any specific instructions issued by the Track Authority.

5.4.3 RESPONSIBILITIES

All staff required to undertake Lineside Welding must be trained and assessed as competent in the use of approved equipment designed for the alignment and restraint of rails positioned out of track. Appropriate training procedures must be provided by the supplier of this equipment.

The Welder remains responsible for the safe operation of the welding process, and that the procedure complies with the requirements of the welding manual and Network rail Technical Standard.

If welds are to be manufactured "out of track" prior instruction must be given by the representative of the appropriate Track Authority.

5.4.4 PROCEDURE

The additional requirements when manufacturing welds “Out of Track” are:

Site Arrangements

All lineside welding shall be carried out in the Green Zone or absolute possession of the Track. The lead Infrastructure Contractor shall provide appropriate protection under Section T of the Rulebook.

Lineside welding may not take place in the 6-foot or 10-foot of the Permanent Way without cover of an absolute possession of both adjacent lines.

Consideration must be given to the condition of the ground upon which the rail is to be positioned and the location of the supports. Adequate room must be provided to enable the welding process to be undertaken in accordance with the procedure described in **Section 1**.

If the rails are to be welded positioned on the ends of the sleepers, all ballast must be cleared from the shoulders in the welding area.

Consideration shall be given to the final length of the rail which is to be welded, and the methods selected for supporting it. Details of the final length of the rail should be recorded on the weld report. The maximum length of rail to be welded at lineside is normally 1200ft (366m).

Positioning of the Rail

The rail shall be supported on sleepers, bearers or blocks of at least 600mm length, fitted with fastening to restrain the rail. If the rails are not placed on sleepered track, (i.e. on the sleeper ends or in the 4’), the supports should be positioned approximately 2,4,6,10,10 and 30 sleeper spacing each side of the joint.

When working on the sleeper ends, a minimum of 300 mm distance between the existing rail and the joint to be welded will be required to enable all the welding equipment to be fitted, and the weld trimmed and ground.

When working in the 4’, the rails must be positioned such that they remain central between the running rails to within +/- 50 mm. Before the line is opened to traffic, all the blocks and fittings shall be removed.

When in position, the rails must be securely fastened to the blocks

Preparation of the Gap

If the rails have been laid overlapping, a tight gap is to be cut in the centre of the supports and the rails brought into alignment. If both cess and 6’ rails are to be welded, the weld positions must be opposite each other.

The final welding gap shall be prepared by adjustment or mechanical cutting. The final gap shall be within the tolerances specified for the appropriate welding process -refer to **Sections 1 and 2.**

Rail Alignment

The rails must be aligned and positioned with the aid of an approved alignment beam, or device, which must be located securely about the joint, and not removed until the time specified in **Section 2**..

Datum Marks

Datum marks shall be applied by a scriber on a semi-permanent background 150mm from the fixing clamps of the beam either side of the joint. Additional datum marks shall be applied at the second block each side of the joint.

These datum marks shall be checked at the intervals prescribed in **Section 1** of the manual

Welding Process

Setting up and execution of the aluminothermic weld shall be in accordance with normal practice, as described in sections 1 and 2 of this manual.

The weld must be trimmed at the specified time using a hydraulic trimming machine fitted with a longitudinal pump action – to avoid unnecessary lateral disturbance of the welded joint. The joint must then be left undisturbed for the period of time specified in **Section 2** to allow the joint to stabilise.

Removal of Equipment

Alignment aids are removed at the time prescribed in Section 1.

Prior to grinding the joint must be fastened down onto the supports.

Grinding
The weld is ground to leave a minimum of 0.75 mm around the running surface and edge. Final profile grinding is completed when the welded rail has been fastened down and the track aligned.

On completion of the grinding, the weld identification marks shall be stamped adjacent to the weld and shall include the letter “L” on the back edge of the rail head within the weld area.
Weld Inspection

Welds manufactured out of track for Network Rail will be subject to ultrasonic inspection within 4 weeks of installation in accordance with Line Standard RT/CE/S/055. The inspection process is the responsibility of Network Rail, or the client.

If the rail has had to be moved from the welding site to its final position in track, the weld must be inspected to check that it has not been damaged. Damage caused during movement of the rail is not the responsibility of the Welder.

Weld Records
All welds manufactured out of track must be reported on the welding contractors weld record, which should include final weld location, and place of welding (i.e. sleeper ends, cess etc.)

5.4.5 WELDING ON STEEL SLEEPERS

Rails may be supported on steel sleepers which have not been fully ballasted and consolidated by tamping. In these circumstances, the weld must be manufactured with the aid of alignment devices.

A minimum of two sleepers each side of the joint must be of the same depth and material and positioned square to the rails.

The procedure for welding will be that prescribed for welding “out of track”.

5.5 TECHNICAL BULLETINS

Technical Bulletins are provided as an update to the operating manual or as additional information. Holders of the manual are advised to make appropriate references in the manual where these Bulletins apply.