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INFRASTRUCTURE ENGINEERING

TRACK WELDING MANUAL

BBB8341 Version 5

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08/07/001	“April 2000” replaced by “latest edition” – Paragraph 1.5.1	1-2	2-Jul-08
08/07/002	“Spoornet” replaced by “Transnet Freight Rail” – Paragraph 4.2.1	4-10	2-Jul-08
08/07/003	Figure 4.18 – angle of coverage of 70o probe on cross section - widened.	4-19	Not complete
	4.3.1 “The main alloying element in rails is carbon” replaced by “The main alloying elements in rail steel are carbon, manganese and silicon”	4-20	26-Jan-11
08/07/004	Add “(powder/blocks)” after “compound” second bullet paragraph 5.1.3	5-1	2-Jul-08
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	5.2.3 – “A double head stainless steel tip tube with two 2H preheating nozzles is sufficient, as it will ensure even heat on both sides of the rail (wheel-spin burns and bettered rail ends” replaced by “For wheel-spin burns and battered rail ends, a double-head stainless steel tip tube with two 2H preheating nozzles must be used. For crossings, a 900mm stainless steel tip tube with a 3H heating nozzle must be used”.	5-1	

	7.12.3 – "The following details shall be stamped with 6mm stencils on the field side of the crown at the welded area: • Company name, e.g. S = Spoornet, M = Metrorail, T = Transnet Projects (previously Protekon), C = Contractor, etc. • The depot will allocate a code letter to the Track Welder, e.g. D • The day, month and last two digits of the year. • Sequence number of the wheel-spin burn (beginning at zero at the beginning of each financial year). • All daily work performed shall be logged on the prescribed field sheet (Annexure 1-8)." Replaced by "The following details shall be written with yellow chalk (sufficient to remain visible for at least 3 months) on the rail web adjacent the welded area: • Sequence number of the wheel-spin burn, beginning at zero at the beginning of each financial year for each Transnet Freight Rail welder, and beginning at zero at the beginning of each day for each contractor welding team. • Welder code (Transnet Freight Rail welders and contractor welders). Transnet projects' welders will be allocated codes starting with PR and sub-contractors' welders will be allocated codes starting with C. • Date welded (Transnet Freight Rail welders and contractor welders). • All daily work performed shall be logged on the prescribed field sheet, Annexure 1-8 for Transnet	7-7	

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	Rail welders and contractor welders). • All daily work performed shall be logged on the prescribed field sheet, Annexure 1-8 for Transnet Freight Rail welders and approved field sheets for Transnet Projects welders and sub-contractors.		
	8.13.4 – “superintendent” replaced by “superintendent/supervisor”	8-10	
	8.2.5 – “Mismatches are caused when rails with different heights of up to 3mm (height difference) are inserted. Battered rail ends can be repaired by welding up the lower rail end 1.5mm and grinding down the higher rail end 1.5mm over a length of 1m.” replaced by “Battered rails ends at fishplated joints with height differences of up to 6mm on yard lines (as classified in the SAP system) with speed restrictions of up to 30km/h may be repaired by welding and grinding as opposed to installing closure rails. For yard lines the repair process shall be as follows. The higher rail shall be grinded down gradually to 1.5mm over a length of 250mm and the lower rail shall be welded up gradually to match the higher rail (max 4.5mm) over a length of 750mm, which will render a gradual incline of maximum 6mm over a length of 1m. The relevant maximum height difference limit for main lines and station lines is 3mm. For main lines and station lines the repair process shall be as follows. The higher rail shall be grinded down gradually to 1.5mm over a length of 250mm and the lower rail shall be welded up gradually to match the higher rail (max 1.5mm) over a length of at 750mm, which will render a gradual incline of maximum 3mm over a length of 1m.”	8-2	
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	9.3.4 – “superintendent” replaced by “superintendent/supervisor”	9-2	
	11.21.1 – “An example of a Track Welders code is SD210906, and has the following meaning: Company name, e.g. S = Spoornet, M = Metrorail, T = Transnet	11-14 to 11-15	

	Projects (previously Protekon), C = Contractor, etc" Replaced by "An example of stencilled detail is shown in Figure11.1, and has the following meaning: Company name (not applicable to Transnet Freight Rail), e.g. M = Metrorail, PR = Transnet Projects (previously Protekon), C = Contractor, etc"		
	11.21.1 – "Joint number e.g. Start with number 1, 2, etc, at the beginning of each financial year." Replaced by "Joint number e.g. Start with number 1, 2, etc, at the beginning of each financial year (1st April)."	11-15	
	11.21.1 – "The Depot will allocate a code letter (except C, I, L, O, M, P and R) to the Track Welder (E.g. D)." replaced "The Depot will allocate a code letter for the Track Welder (E.g. D).	11-15	
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	11.10 – colour coding table replaced with new version received 29-Oct-2007.	11-8 to 11-9	
	Cause and effect examples as annexure to chapter 11.		Not complete
	Figure 11.1 replace SD with PR1		Not complete
	Annexure 12-3 – replace 470 with 5mm crown wear = 470mm.		Not complete
	Annexure 12-4 – add 5mm crown wear.		Not complete
	New chapter 16 for scissors, diamonds, single – and double slips (1:6/7/8/10).		To be drafted before next review.
	New chapter 15 for 1:20 crossings		To be drafted before next review.
	13.5 – Add "When welding is done in track, all welding repair work must be done under total track occupation. Subsequent grinding work can be done under normal occupations. The Maintenance Manager must decide whether it is economical to remove the crossing and perform the repairs in a workshop – taking into account the total occupation requirement."		

10/10/001	7.12.3 – "The following details shall be written with yellow chalk (sufficient to remain visible for at least 3 months) on the rail web adjacent the welded area: • Sequence number of the wheel-spin burn, beginning at zero at the beginning of each financial year for each Transnet Freight Rail welder, and beginning at zero at the beginning of each day for each contractor welding team. • Welder code (Transnet Freight Rail welders and contractor welders). Transnet Capital Projects' welders will be allocated codes starting with PR and sub-contractors' welders will be allocated codes starting with C. • Date welded (Transnet Freight Rail welders and contractor welders). • All daily work performed shall be logged on the prescribed field sheet, Annexure 1-8 for Transnet Freight Rail welders and approved field sheets for Transnet Projects welders and sub-contractors." Replaced by "The following details shall be written with yellow chalk (sufficient to remain visible for at least 3 months) on the rail web adjacent the welded area: • Sequence number of the wheel-spin burn, beginning at zero at the beginning of each financial year for each Transnet Freight Rail welder, and beginning at zero at the beginning of each day for each contractor welding team. • Welder code (Transnet Freight Rail welders and contractor welders). Transnet Capital Projects' welders will be allocated codes starting with PR	7-7	21-Oct-10

	and sub-contractors' welders will be allocated codes starting with C. • Date welded (Transnet Freight Rail welders and contractor welders). • All daily work performed shall be logged on the prescribed field sheet, Annexure 1-8 for Transnet Freight Rail welders and approved field sheets for Transnet Capital Projects welders and sub-contractors."		
10/10/002	8.13.3 – "The following details shall be written with yellow chalk (sufficient to remain visible for at least 3 months) on the rail web adjacent the welded area: • Sequence number of the battered rail ends, beginning at zero at the beginning of each financial year for each Transnet Freight Rail welder, and beginning at zero at the beginning of each day for each contractor welding team. • Welder code (Transnet Freight Rail welders and contractor welders). Transnet projects' welders will be allocated codes starting with PR and sub-contractors' welders will be allocated codes starting with C. • Date welded (Transnet Freight Rail welders and contractor welders). • All daily work performed shall be logged on the prescribed field sheet, Annexure 1-8 for Transnet Freight Rail welders and approved field sheets for Transnet Projects welders and sub-contractors." Replaced by "The following details shall be written with yellow chalk (sufficient to remain visible for at least 3 months) on the rail web adjacent the welded area: • Sequence number of the battered rail ends, beginning at zero at the	8-10	21-Oct-10

	beginning of each financial year for each Transnet Freight Rail welder, and beginning at zero at the beginning of each day for each contractor welding team. • Welder code (Transnet Freight Rail welders and contractor welders). Transnet Capital Projects' welders will be allocated codes starting with PR and sub-contractors' welders will be allocated codes starting with C. • Date welded (Transnet Freight Rail welders and contractor welders). • All daily work performed shall be logged on the prescribed field sheet, Annexure 1-8 for Transnet Freight Rail welders and approved field sheets for Transnet Capital Projects welders and sub-contractors."		
10/10/003	9.3.3 – "The following details shall be written with yellow chalk (sufficient to remain visible for at least 3 months) on the rail web adjacent the welded area: • Sequence number of the flash butt joint, beginning at zero at the beginning of each financial year for each Transnet Freight Rail welder, and beginning at zero at the beginning of each day for each contractor welding team. • Welder code (Transnet Freight Rail welders and contractor welders). Transnet projects' welders will be allocated codes starting with PR and sub-contractors' welders will be allocated codes starting with C. • Date welded (Transnet Freight Rail welders and contractor welders). • All daily work performed shall be	9-2	21-Oct-10

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10/10/004	11.21.1 – "The following details shall be stamped with 8mm stencils on the field side of the rail crown in proximity of the joint: • An example of stencilled detail is shown in Figure11.1, and has the following meaning: o Company name (not applicable to Transnet Freight Rail), e.g. M =	11-14	21-Oct-10

	o Metrorail, PR = Transnet Projects (previously Protekon), C = Contractor, etc, o The Depot will allocate a code letter (except C, I, L, O, M, P and R) to the Track Welder (E.g. D). o The day, month and last two digits of the year. (DDMMYY). o Joint number e.g. Start with number 1, 2, etc, at the beginning of each financial year (1st April)." Replaced by "The following details shall be stamped with 8mm stencils on the field side of the rail crown in proximity of the joint: • An example of stencilled detail is shown in Figure11.1, and has the following meaning: o Company name (not applicable to Transnet Freight Rail), e.g. M = Metrorail, PR = Transnet Capital Projects (previously Protekon), C = Contractor, etc, o The Depot will allocate a code letter (except C, I, L, O, M, P and R) to the Track Welder (E.g. D). o The day, month and last two digits of the year. (DDMMYY). o Joint number e.g. Start with number 1, 2, etc, at the beginning of each work day."		
10/10/005	2.6.2.26 – "Fire Investigation teams shall: • Under no circumstances accept responsibility on behalf of Spoornet, as this may lead to differences between Spoornet and the Insurers. • After the fire has occurred, no work shall be done on the firebreak, until the Claims Examiner has completed his investigation."	2-7	21-Oct-10

	Replaced by "Fire Investigation teams shall: • Under no circumstances accept responsibility on behalf of Transnet Freight Rail, as this may lead to differences between Transnet Freight Rail and the Insurers. • After the fire has occurred, no work shall be done on the firebreak, until the Claims Examiner has completed his investigation."		
10/10/006	13.4.1 – "Only electrodes and flux-cored wire, which have been tested and approved by Spoornet Rail Technology, shall be used (Annexure 4-2)." Replaced by " Only electrodes and flux-cored wire, which have been tested and approved by Transnet Freight Rail (Rail Technology), shall be used (Annexure 4-2)."	13-4	21-Oct-10
10/10/007	14.4.1 – "Only electrodes and flux-cored wire, which have been tested and approved by Spoornet Rail Technology, shall be used (Annexure 4-2)." Replaced by "Only electrodes and flux-cored wire, which have been tested and approved by Transnet Freight Rail (Rail Technology), shall be used (Annexure 4-2)."	14-4	21-Oct-10
10/10/008	14.3.4 – "Condition assessment of rail-bound crossings shall be carried out at least once a year. The following measuring equipment applies: • Feeler/Taper gauge. • Crossing contour gauge (Annexure 3-1). • 1m straightedge. • Depth gauge." Replaced by "Condition assessment of rail-bound crossings shall be carried out at least once a year. The following measuring equipment applies: • Feeler/Taper gauge, and two	14-3	01-Nov-10

	1mm and two 2mm shims. • Crossing contour gauge (Annexure 3-1). • 1m straightedge. • Depth gauge.”		
10/10/009	14.5.7.7 – “Place the convex side of the 1:20 contour gauge, transversely at point P to determine the extent of metal to be removed on the wings. Grind proportionally away on left and right wings until contour gauge touches both wings and nose. This height shall be maintained over a distance of 300mm (between point G and the PI) for 1:12 turnouts, and 230mm (between point G and the PI) for 1:9 turnouts as indicated in blue (Annexures 14-1 and 14.2).” Replaced by “Place the convex side of the 1:20 contour gauge, transversely at point P to determine the extent of metal to be removed on the wings. Grind proportionally away on left and right wings until contour gauge touches both wings and nose. This height shall be maintained over a distance of 300mm (between point G and the PI) for 1:12 turnouts, and 230mm (between point G and the PI) for 1:9 turnouts as indicated in blue (Annexures 14-1 and 14.2). To assist grinding measurements, a 500mm straight edge can be used between point G and the PI.”	14-8	01-Nov-10
10/10/010	Fig 11.1 Remove COMPANY NAME and letter S standing for company name.		01-Nov-10
10/10/011	Annexure 4-2 • Add line to separate battered ends and battered ends 14% manganese crossing • Add ESAB Tubrodur KO 15.42 in type of filling metal for rail manufactured crossing		01-Nov-10
10/10/012	Annexure 14-1 move point D line to cover the 200mm distance		01-Nov-10
10/10/013	Annexure 14-2 • Move point D line to cover the 200mm distance		01-Nov-10

	• Replace 1:9 with 1:12 on heading		

Amendments compiled by: Anna Kgabi

Acknowledgement: I want to thank the following persons who assisted in compiling this manual: Dewald Potgieter, Adam Brand, Gert du Plessis, Theuns Erasmus, Keith Glover, Gerrit Jansen, Anna Kgabi, Ryno Kotze, Theuns Kuhn, MC Liebenberg, Charles Lloyd, Kanak Mistry, Nkgothatse Rakale, Marcel Rautenbach, Gert Strydom, Bart Zaayman and Salomon I. Grobler

CHAPTER 1 – INTRODUCTION.

1.1 TRACK WELDING MANUAL (2007).

1.1.1 This Manual is issued as guidance for track welding, is to be used by Track Welding Personnel and supersedes the "Specifications for Track Welding" and "Spesifikasies vir Spoorbaan Sweiswerk" issued in 1996.

1.1.2 Track Welding Personnel shall know and act according to these guidelines. This Manual shall be updated with amendments issued from time to time.

1.2 RELEVANT RULES, REGULATIONS, GUIDELINES AND INSTRUCTIONS.

1.2.1 All Track Welding Personnel must be in possession of, or have access to the following publications and all instructions and amendments thereto, and must know the contents thereof, and act in accordance therewith:

- Manual for Track Maintenance (2000).
- Spoornet Train Working Rules.
- Spoornet General Appendix No. 6 (Part 1).
- Safety Instructions: Electrical High-tension Equipment (Part 1).
- Safety guidelines for Infrastructure (April 2000).
- Road Rail Vehicle (RRV) Welding Manual.

1.2.2 Employees issued with these instructions are responsible for keeping it up to date by including the latest amendments thereto.

1.3 TRAINING AND ASSESSMENT OF TRACK WELDERS.

1.3.1 The term "Track Welder" used in this manual includes Welder (artisan), Trade Hand (level 4) and Trainee Track Welder.

1.3.2 Only Track Welders who have been assessed and certified competent by an accredited official or his authorized representative may work with welding equipment on rails.

1.3.3 Track Welders receive basic training in metallurgy, which is important for the correct heat treatment of rails.

1.3.4 Track Welders will only be allowed to perform types of track welding in which they have been trained, assessed and certified competent by an accredited official or his representative.

1.3.5 All Track Welders shall be re-evaluated on a regular basis on the following:

- Safe handling of gas equipment (at least once every second year).
- Operating disc cutting machines (at least once every second year).
- Repairing wheel-spin burns.
- Repairing battered rail ends.
- Casting exothermic joints on various rail profiles.
- Repairing Rail-manufactured crossings.
- Repairing Rail-bound crossings.
- Repairing 14% Cast Manganese (monoblock) crossings.
- Repairing Switch blades.
- Preventative grinding.

1.3.6 Corrective, on the job training shall be done when standards and tolerances are not met.

1.4 IN-SERVICE TRAINING.

1.4.1 In-service training is the training and re-training of Track Welders in all phases of track welding and safety issues in order for them to work independently.

1.4.2 All work completed by track welding personnel shall comply with the required quality standards. Should any non-conformance be noted, on-the-job training shall be given immediately.

1.5 CONTRACTORS.

1.5.1 All contractors shall comply with the Construction regulations of the Occupational Health and Safety Act (Act 85 of 1993) and Safety Guidelines for Infrastructure (latest edition).

1.5.2 All contract Track Welders, who have been assessed and certified competent by an appointed accredited official, or his authorized representative may be allowed to weld on track in those aspects of welding he/she was assessed.

1.5.3 All contractors’ tools and equipment shall be inspected before any welding work on a new contract commences and shall conform to all safety requirements.

1.5.4 An authorized person (Track welding) shall inspect all welding work done by contractors. An inspection report shall be issued before payment may be authorized.

1.6 FIELD SHEETS.

1.6.1 Refer to Annexure 1-8.

CHAPTER 2 – SAFETY ASPECTS WITH REGARD TO TRACK WELDING.

2.1 TRAIN OPERATING SAFETY INSTRUCTIONS FOR PERMANENT WAY WELDING.

2.1.1 The Safety Instructions for Permanent Way Welding, as set out in Spoornet General Appendix No 6 (Part 1), shall be adhered to before and during welding operations.

2.2 PROTECTION OF TRAINS AND SAFEGUARDING OF PERSONNEL.

2.2.1 Protection of trains and safeguarding of employees shall be applied in accordance with Spoornet General Appendix No 6 (Part 1) and the Manual for Track Maintenance (2000).

2.2.2 The Track Welder shall ensure that his/her helpers are properly safeguarded before they enter the rail reserve.

2.2.3 Green area talks shall be conducted and recorded daily before work commences.

2.3 TEMPORARY SPEED RESTRICTIONS.

2.3.1 In cases where it becomes necessary owing to the type of work to reduce speed to 30km/h or less, it shall be done in accordance with the Spoornet General Appendix No 6 (Part 1).

2.3.2 A Track Inspector shall make the necessary arrangements when a temporary speed restriction is required. He/she shall ensure that the speed restriction is included in the weekly Temporary Speed Restriction Notice. The length of track, which is indicated in this Notice, shall be limited to minimize the influence on train services.

2.4 PERSONAL PROTECTIVE EQUIPMENT.

2.4.1 Track Welders and their helpers shall be issued with, wear, and keep in good condition, the necessary personal protective equipment when in proximity of the track.

2.4.2 Shields shall be used where possible to protect the public and other workers' eyes against open arc rays.

2.4.3 Personal protective equipment issued to any person shall be recorded.

2.4.4 The following approved personal protective equipment shall be worn when welding, grinding, cutting or pre- or post heating is done:

Table 2.1. Safety Equipment.

SAFETY EQUIPMENT	TRACK WELDER	HELPER
Safety goggles (Light and Dark)	X	X
Welders cap/bush hat	X	X
Leather gloves	X	X
Overall (Complete)	X	X
Safety boots	X	X
Leather apron	X	
Leggings (Spats)	X	X
Face shield	X	
Electronic welding helmet	X	
Ear protection equipment	X	X
High visibility vest	X	X

2.5 SAFE WORKING PROCEDURES.

2.5.1 Only persons, who were trained, assessed and certified competent, may be allowed to work with welding and grinding equipment.

2.5.2 Machines placed on or taken off track shall be switched off and placed in the locked position.

2.5.3 All hand tools shall be kept in a safe condition. A pedestal grinder shall be used to remove metal mushrooming.

2.5.4 All equipment shall be inspected and made safe, daily, before being used.

2.5.5 Grinding wheels and cutting discs shall not be contaminated with oil, grease, and diesel or clogged with steel deposits. Grinding wheels and cutting discs shall not be damaged, cracked or broken and shall be stored and transported in proper containers.

2.5.6 The rotating speed of the grinding and cutting machine spindles may not exceed the maximum permissible speed for grinding wheels or cutting discs. This maximum rotating speed should be indicated on the grinding machine and tested regularly.

2.5.7 All machines shall be operated according to the manufacturers' specifications and safety instructions.

2.5.8 Machines and equipment shall be placed safely away from moving trains in the section, station yards and shunting yards. Machines and equipment shall be safeguarded when transported and shall be stored in a safe place when not in use. Machines, equipment and trolleys not being used shall be removed from track and secured with chains and padlocks.

2.5.9 Jumper cables shall be tested regularly for the correct electrical conductivity and shall be positioned before the track is broken (Annexure 2-1).

2.5.10 Care shall be taken that no steel objects such as straightedges make contact with both rails. This will result in short-circuiting of track circuits. Personnel could also sustain electrical shock and be seriously injured.

2.6 FIRE PREVENTION.

2.6.1 GENERAL.

2.6.1.1 No welding or grinding shall be done within 20m from any truck or road vehicle transporting flammable liquids or gasses.

2.6.1.2 Care shall be taken during grinding and cutting, to ensure that sparks do not cause veld fires. All grinding and cutting machines shall be fitted with spark shields. Development of fire hazards shall be prevented, especially in windy conditions. Any fires shall be extinguished immediately.

2.6.1.3 Machines shall be switched off when refuelling. Equipment and fuel shall not be placed in combustible areas.

2.6.1.4 Gas cylinders and fuel shall be stored and transported separately.

2.6.1.5 Gas equipment shall not be ignited with butane lighters .Flint-lighters shall be used for this purpose.

2.6.1.6 Dye penetrant shall be stored safely and away from all heat sources.

2.6.1.7 Fire extinguishers shall be in close proximity when gas equipment, fuel and machines are stored, transported or used and shall be in good working order. Fire extinguishers shall be checked daily by the welding personnel and annually by fire personnel. A syringe and water container shall be kept at hand to wet grass and other flammable material in the vicinity before welding, cutting or grinding on track.

2.6.2 GUIDELINES REGARDING THE PREVENTION OF VELD FIRES.

2.6.2.1 These paragraphs must be read in conjunction with the relevant paragraphs in the Manual for Track Maintenance (2000).

2.6.2.2 Dry grass is highly flammable and sparks originating from welding and grinding equipment can easily cause veld fires.

2.6.2.3 Strong winds may carry sparks over long distances thus increasing the risk of a veld fire.

2.6.2.4 Veld fires are caused by:

- Damaged or no spark arrestors used with gas welding equipment.
- Sparks from grinding and disc cutting machines.
- Faulty electrical cables.
- Incorrectly fitted crucible covers.
- Careless working procedures, i.e. the incorrect use of grinding machines, gas and electric welding equipment.
- Dumping of hot risers and slag from exothermic casting against grass slopes or on ash banks.
- Making fire paths without considering prevailing weather conditions or taking necessary precautionary measures.
- Gas cutting of rails and not taking necessary precautions and adequate care.
- Negligence in making open fires and cooking activities.
- Cigarette butts thrown aimlessly in grass.
- Glass objects, such as cold drink bottles, carelessly discarded causing veld fires by magnifying the sun's rays.

2.6.2.5 All Transnet workers are responsible for managing risk and preventing losses and claims caused by veld fires.

2.6.2.6 Personnel shall be conversant with the causes of fire and take precautionary measures for prevention thereof. They shall be trained in the correct use of fire extinguishing equipment and shall be able to assist in extinguishing uncontrolled fires. They shall also know the alarm signals for veld fires, and shall report sparks and cinders originating from locomotives.

2.6.2.7 The policy with respect to the removal of flammable material and the provision and maintenance of firebreaks shall be communicated to all relevant personnel.

2.6.2.8 Supervisors and responsible persons at a work site shall ensure that the necessary instructions and guidelines are adhered to. Fire drills shall be practiced regularly to ensure that everybody knows who:

- Takes overall charge
- Is in charge of teams with extinguishers and,
- Is in charge of teams with spades to make fire paths.

2.6.2.9 The following measures are necessary to prevent confusion in the event of a veld fire.

- Arrange for regular safety talks.
- Make use of local fire department for fire prevention training.

2.6.2.10 Cigarette butts shall be put out in a correct manner and not discarded where it can create a fire.

2.6.2.11 Glass utensils such as cold drink bottles that may cause a magnifying effect shall be thrown into a shallow hole and covered with soil.

2.6.2.12 The making of fires shall be prohibited, but if necessary, these fires shall never be left unattended, shall be under full control at all times and extinguished before leaving the work area.

2.6.2.13 Other types of work, or work in station yards or shunting yards shall be performed when severe windy conditions prevail.

2.6.2.14 Machinery and equipment shall be in good working order.

2.6.2.15 Appropriate fire fighting equipment shall be available, e.g.:

- Portable fire extinguishers.
- Syringes and pumps.
- Fire fighters/swatting equipment.
- Enough water to extinguish a veld fire e.g. cleaned used (zoom) cans filled with water, marked to identify water.
- Syringe pumps and water cans, at the work site, to wet the grass around the work area when considered necessary.

2.6.2.16 An alarm system (e.g. a special signal with the alarm hooters) shall be introduced to minimize the reaction time in the event of a veld fire.

2.6.2.17 Inflammable screens shall be available to deflect sparks from machines. Vehicles, machinery and gas cylinders are not to be left in fire hazard areas.

2.6.2.18 Personnel shall, while executing high-risk work, be alerted and ready to extinguish fires that could start during any working process and can cause veld fires.

2.6.2.19 Precautions and care shall be taken when cutting with gas equipment.

2.6.2.20 When working with grinders or disc cutters, additional precautionary measures are necessary to prevent fires. Screens supplied on Road Rail Vehicles shall be used.

2.6.2.21 Necessary precautions shall be in place when performing exothermic casting or Cad welding of bonds.

2.6.2.22 After completion of work:

- Moulds, risers and slag shall be buried away from the track formation.
- Exothermic packing material and other refuse shall be returned to the depot and not burned on site.

2.6.2.23 The following shall be discussed during Act 85 meetings:

- Fire prevention measures.
- Availability and condition of fire fighting equipment.
- Fire fighting training requirements.
- Status of firebreaks.

2.6.2.24 Personnel living on Transnet property shall adhere to the following fire prevention precautions:

- Areas around dwellings (at least 3m) shall be cleared of all grass and combustible material.
- Under no circumstances shall grass and other objects/materials be set alight.
- Where possible, local municipal services shall be used to remove household waste.

2.6.2.25 Actions in the event of a veld fire:

- All other activities shall be ceased and all personnel applied to fire fighting duties.
- Density of vegetation will determine whether only fire swatters or all available equipment shall be used.
- Firebreaks shall be made down wind to limit fire damage.

- Attempts to restrict the fire to Transnet property shall be made.

2.6.2.26 Fire Investigation teams shall:

- Under no circumstances accept responsibility on behalf of Transnet Freight Rail, as this may lead to differences between Transnet Freight Rail and the Insurers.
- After the fire has occurred, no work shall be done on the firebreak, until the Claims Examiner has completed his investigation.

2.7 SAFE HANDLING AND USE OF GAS EQUIPMENT.

2.7.1 GENERAL.

2.7.1.1 Only trained Track Welders who were assessed and found competent will be allowed to use gas equipment.

2.7.1.2 Track Welders shall be evaluated at least every second year and refresher training given when required.

2.7.1.3 Three types of gas are used, namely oxygen, acetylene and liquid petroleum gas (LP-gas), each with its own distinctive cylinder.

2.7.1.4 Knowing the different gasses and their respective cylinders in important in order to ensure safety and avoid damage and loss of equipment.

2.7.1.5 Water, dirt, oil or grease shall under no circumstances come into contact with gas cylinders or cylinder valves. Cylinder valve safety guards shall be firmly in position.

2.7.1.6 Cylinders may not be dragged, rolled or pushed over, but transported on a cylinder trolley or carried by hand. Cylinders may not be dropped when off-loaded from vehicles.

2.7.1.7 Cylinders shall not come into contact with electrical appliances or live wires.

2.7.1.8 Open lights and fires shall be kept away from cylinders.

2.7.1.9 Cylinders may not be used as work surfaces or as a roller.

2.7.1.10 Only standard size spanners shall be used to open and close cylinder valves.

2.7.1.11 Gas cylinders shall be transported only in well ventilated trucks.

2.7.2 OXYGEN.

2.7.2.1 Oxygen is a colourless gas and is supplied in black cylinders.

2.7.2.2 Oxygen is not combustible, but promotes combustion, and shall be stored separate from combustible gasses.

2.7.2.3 Oxygen that comes into contact with grease, oil, clothing, sawdust and other fine organic materials, can easily combust. When oil and grease come into contact with compressed oxygen, an explosion can occur.

2.7.2.4 Oxygen is supplied in high-pressure cylinders with a content pressure of 17.5 – 20MPa. Oxygen cylinders have right-hand thread.

2.7.2.5 Compressed oxygen may not be used to fan fires, operate compressed-air tools or dust off clothing. Fatal consequences can result.

2.7.3 ACETYLENE.

2.7.3.1 Acetylene has a distinctive smell and is supplied in a maroon cylinder with a flat bottom.

2.7.3.2 The cylinder is filled with a porous mass (lime silicon), drenched with acetone, which releases acetylene. Acetylene is kept at a pressure of 1.75MPa and is highly explosive when mixed with air. A mixture consisting of 80% acetylene and 20% air will explode immediately when it comes into contact with a hot object or flame, especially in confined spaces.

2.7.3.3 Acetylene cylinders are equipped with left-handed thread, which indicates a combustible gas. Acetylene cylinders shall always be used in an upright position. Acetone will flow from the cylinder if the cylinder is tilted more than 20° from vertical.

2.7.3.4 Acetylene shall not come into contact with copper. Copper-*acetylite* is caused, which is highly explosive.

2.7.3.5 When acetylene cylinders are transported horizontally, the cylinders shall be allowed to stand upright for a while (± one hour) after off-loading, so that the acetone can restore back to normal before used.

2.7.4 LIQUID PETROLEUM GAS (LP-GAS).

2.7.4.1 LP-gas cylinders may vary in colour, depending on the suppliers (e.g. white, silver, orange or green).

2.7.4.2 LP-gas cylinders with dual outlet valves and with a yellow vertical stripe may not be used. These cylinders are used by industries only. LP-gas cylinders have left-hand thread.

2.7.4.3 Liquid petroleum, if it is kept under moderate pressure, changes to a gas when pressure is released.

2.7.4.4 LP-gas is heavier than air, and for this reason it drops to ground level and can penetrate for example sewer pipes as well as any low cavities on ground level.

2.7.4.5 LP-gas, although not poisonous, has a distinctive smell and may cause suffocation (asphyxia) in places with poor ventilation. LP-gas has a low ignition point and may ignite when in to contact with an open light or flame.

2.7.4.6 LP-gas has a chemical reaction on rubber, which causes the rubber to perish.

2.7.4.7 LP-gas cylinders shall always be used, secured, stored and transported in an upright position.

2.7.5 STORAGE OF CYLINDERS.

2.7.5.1 Gas store rooms shall comply with SABS 087.

2.7.5.2 Gas store rooms shall always be built from refractory materials and be well ventilated at the top and at the bottom. Gas store rooms shall have proper drainage.

2.7.5.3 Full and empty cylinders shall be stored separately and empty cylinders shall be marked "empty". Leaking cylinders may not be stored in storerooms.

2.7.5.4 Acetylene and LP-gas cylinders shall always be stored and secured in an upright position.

2.7.5.5 Oxygen cylinders may be stored upright or horizontally. (Maximum 4 layers stacked). Cylinders shall be wedged to prevent them from rolling.

2.7.5.6 A policy of first-in-first-out shall be applied when issuing cylinders.

2.7.5.7 Cylinders shall be protected against sun, rain, cold, wet ground, acids and rust. (To ensure proper ventilation, no covering, such as protection against the sun, may touch the cylinders).

2.7.5.8 Valves of empty cylinders shall always be closed to prevent breathing. If it is found that a cylinder valve is open, it shall be closed and a label tied to it reading: "WARNING - CYLINDER VALVE LEFT OPEN WHEN EMPTY". This will ensure that moisture and a pureness tests will be done before the cylinder is filled again.

2.7.6 PROCEDURES WITH REGARDS TO LEAKING CYLINDERS.

2.7.6.1 If a cylinder valve does not close completely, the valve shall be opened and closed swiftly to blow out any foreign material from the valve seat, with the regulator disconnected. If the valve still does not close completely, the cylinder shall be taken to a safe place away from walkways and buildings and the gas released into the atmosphere. No open flames, including cigarettes, running machinery and vehicles shall be in the vicinity before the cylinder valve, with the cylinder in the upright position, is opened and the gas released into the atmosphere. The valve shall be closed once the cylinder is empty. A label shall be attached to the cylinder, reading: "WARNING! UNSERVICEABLE CYLINDER, VALVE DID NOT CLOSE OFF", and returned to the supplier.

2.7.6.2 If a gas leak around the valve spindle is evident when the valve is opened, the gland nut shall be tightened. If a gas leak is still evident, the valve shall be closed and the cylinder shall be returned to the supplier. A label: "WARNING! UNSERVICEABLE CYLINDER VALVE LEAKS WHEN OPENED", shall be tied to the cylinder.

2.7.6.3 In cases of any other causes of leaking cylinders, such as safety appliances between the neck of the cylinder and the valve rod, or any other part of the cylinder body, the procedure in 2.7.6.1 shall be followed. In such cases, the label shall indicate where the leak is, e.g.: "WARNING! UNSERVICEABLE CYLINDER LEAKS AT VALVE THREAD".

2.7.7 IDENTIFICATION AND CARE OF GAS WELDING EQUIPMENT.

2.7.7.1 REGULATORS.

2.7.7.1.1 The function of a regulator is to reduce the high gas pressure to the prescribed working pressure.

2.7.7.1.2 The pressure-regulating screw is set to obtain the pressure needed at the burner. The second gauge on the regulator indicates the cylinder pressure.

2.7.7.1.3 Only high-pressure regulators shall be used for track welding purposes. Oxygen regulators are designed to withstand a high cylinder pressure of approximately 20MPa.

2.7.7.1.4 Most regulators have a cylinder-capacity gauge and a release-pressure gauge.

2.7.7.1.5 If a regulator continues to release gas when the regulating-screw is turned out, or pressure builds up on the low-pressure side of the regulator when the burner valve is closed, the regulator shall be replaced immediately. If gauges do not return to zero when pressure is released, the diaphragm is defective and the gauge shall be replaced immediately.

2.7.7.1.6 A regulator shall always be treated as a precision instrument. A regulator shall not be bumped or subjected to sudden pressure, i.e., opening the cylinder valve quickly. The pressure in the regulator shall be released when the work is completed.

2.7.7.1.7 Faulty regulators may not be used. Regulators and supply pipes shall be removed from cylinders before gas equipment is transported.

2.7.7.2 FLASHBACK ARRESTORS.

2.7.7.2.1 Flashback arrestors prevent gasses from flowing back into the regulators and cylinders due to incorrect pressures, blocked nozzles or backfiring.

2.7.7.2.2 Approved flashback arrestors shall be connected to regulators. (Harris type No. 237-086; model 85-10 left-hand thread LP-gas and Harris type No. 237-087; model 85-10 right-hand thread Oxygen).

2.7.7.2.3 Approved flashback arrestors shall be connected to torch-ends. (Harris type No. 237-332; model E460 left-hand thread LP-gas and Harris type No. 237-333; model E460 right-hand thread Oxygen).

2.7.7.3 GAS SUPPLY HOSES.

2.7.7.3.1 Gas supply hoses are used to supply gas from the cylinders to the burner. To ensure safety, it is important to know the difference between various gasses and the respective hoses:

- Black or Blue rubber hoses only for oxygen.
- Red rubber hoses only for acetylene.
- Orange Neoprene hoses only for LP-gas.

2.7.7.3.2 Due to the chemical reaction of LP-gas on rubber, acetylene regulators and hoses may not be used for LP-gas.

2.7.7.3.3 All oxygen couplers have right-hand thread. All flammable gas couplers have left-hand thread.

2.7.7.3.4 Only brass connectors may be used to connect supply hoses. (Copper connectors may not be used).

2.7.7.3.5 Supply hoses longer than 25m are not recommended, as it causes a drop in pressure.

2.7.7.3.6 Hoses may not get into contact with heat, oil, grease or welding slag and sparks. Leaking hoses shall be replaced immediately.

2.7.7.3.7 Hoses may not be placed where trains or road vehicles can move over it.

2.7.7.4 COMPLETE HEATING ATTACHMENT (BURNERS).

2.7.7.4.1 A complete heating attachment consists of:

- A shaft (Universal handle) for cutting and heating.
- Mixing chamber.
  - A F43 mixing chamber for LP-gas.
  - A D2-43 mixing chamber for acetylene.
  - Single or double head stainless steel tip tube-extensions in different lengths for LP-gas.
- Various types of nozzles for heating applications, e.g.
  - H2-nozzles (for wheel-spin burns and battered rail ends) and
  - H3-nozzles (for rail-manufactured crossings), used for pre- or post heating
  - A block nozzle with 32 holes in three rows, used for exothermic casting.

2.7.7.4.2 Different heating attachments (burners) may be used for Oxy-acetylene cutting and welding.

2.7.7.4.3 The instructions of the manufacturer shall always be followed when any burner is lit or extinguished. Only approved nozzle cleaners shall be used to clean nozzles, while oxygen is flowing. The Oxy-LP-gas nozzle shall be removed when cleaning is necessary.

2.7.7.4.4 The function of the mixing chamber is to mix the flammable gas and oxygen and to supply the mixture at a constant pressure to the nozzle.

2.7.8 FLASHBACK.

2.7.8.1 Flashbacks occur when the flame enters the burner (complete heating attachment) and goes back (retrogresses) into the supply system when working without flashback arrestors.

2.7.8.2 A cylinder can explode and/or the burner and regulators can be damaged beyond repair.

2.7.8.3 Torch-end flashbacks cause carbon layers in the burner, gas valves, supply hoses, flashback arrestors and regulators, reducing their effectiveness and shortening their life span.

2.7.9 REVERSE FLOWING.

2.7.9.1 Reverse flowing occurs when supply hoses contain a quantity of the opposite gas or air, e.g., combustible gas and oxygen are mixed in a single supply hose.

2.7.10 CORRECTIVE ACTIONS.

2.7.10.1 Regulators not set at the correct pressure or nozzles ignited before the flammable gas has begun flowing properly causes backfiring.

2.7.10.2 The correct regulator and nozzle shall be used for the type of work being done. Every regulator shall be set at the correct operating pressure for the equipment being used.

2.7.10.3 The nozzle shall be kept away from any ignition source until the fuel gas flows freely from the nozzle. A triple flint lighter is recommended to ignite burners.

2.7.10.4 When a flame suddenly extinguishes while the burner is being used, it might be as a result of:

- Incorrect regulator pressure and /or gas flow.
- A blocked nozzle.
- The nozzle held too close to the work.
- Overheating of the nozzle.

2.7.10.5 Both universal handle valves shall be closed immediately and the regulator setting and cylinder pressure checked. If the nozzle has overheated, it shall be immersed in cold water with the oxygen valve is left open.

2.7.11 USE OF GAS CYLINDERS AND EQUIPMENT.

2.7.11.1 Cylinder valves may not be changed, loosened or removed from cylinders.

2.7.11.2 A complete heating attachment may not be ignited without the connectors and couplings being tested for leaks first.

2.7.11.3 Testing for leaks may not be done with a flame. Leak detection spray shall be used instead, e.g. HARRIS Safety-spray, type 237-320.

2.7.11.4 A complete heating attachment, which has been ignited, may not be hanged over the cylinder valves or regulator. Nor may the flame be allowed to touch the cylinder.

2.8 REPAIRING PROCEDURE FOR KICK-OUTS.

2.8.1 GENERAL.

2.8.1.1 Kick-outs normally occur where:

- There are extreme compressive stresses in the rails.
- Where there is a lack of ballast in the Perway, especially in curves.
- Wheel-spin burns are repaired and preheating is done incorrectly.
- The Perway was screened and/or tamped outside temperature ranges.

2.8.2 INSPECTION AND DECISION MAKING.

2.8.2.1 The Track Inspector, in conjunction with the welding personnel, shall decide which method shall be followed to repair a kick-out.

2.8.2.2 The following aspects shall be taken into consideration when attending to a kick-out:

- Safety of the employees.
- The temperature of the rails.
- Rail type and profile.

2.8.3 PROTECTION.

2.8.3.1 Protection shall be afforded in accordance with Spoornet General Appendix No 6, (Part 1).

2.8.4 PREPARATION.

2.8.4.1 PREPARATION BY TRACK PERSONNEL.

2.8.4.1.1 Preparation work described in the Manual for Track Maintenance (2000) shall be done before the repairing process commences.

2.8.4.1.2 Jumper cables shall be fitted where the rail will to be cut by Oxy-Propane gas cutting equipment, to ensure electrical continuity within the rail and to prevent electric shock as a result of the potential difference over the rail ends (Annexure 2-1).

2.8.4.1.3 The following shall be checked during preparation:

- Is there enough ballast stone?
- All sleeper fastenings shall be fastened.

2.8.4.2 PREPARATION BY WELDING PERSONNEL.

2.8.4.2.1 The end of the kick-out shall be determined.

2.8.4.2.2 The location where the rail will be cut may not be closer than 4.2m from an exothermic joint or 2m from a flash butt joint.

2.8.4.2.3 Both sides of the rail that will be cut shall be secured to the sleepers.

2.8.5 REMOVING KICK-OUTS.

2.8.5.1 A minimum distance of 12m shall be measured from the end of the kick-out and marked on both rails; this will ensure a safer cutting procedure and simplify the alignment process afterwards.

2.8.5.2 A gap of ±25mm shall be cut (Annexure 2-2) and the procedure in Paragraph 3.8.5 followed.

2.8.5.3 The process shall be repeated until the rail stops creeping.

2.8.5.4 Rail ends shall be cut with a disc cutter to remove oxidized metal caused by the gas cutting process once the track is aligned.

2.8.5.5 Kick-outs shall be repaired in accordance with the Manual for Track Maintenance (2000) and cast exothermic joints as per Chapter 11.

2.8.5.6 It is advisable, for Cr-Mn rails, that a 6m closure rail is inserted on sections of rail where Oxy-Propane gas cutting equipment was used.

CHAPTER 3 – TOOLS AND EQUIPMENT.

3.1 HAND TOOLS.

3.1.1 BALL-PEEN: A ball-peen hammer is used for light work such as dressing and punching work and is available in 200 gram to 900 gram weights.

3.1.2 CHIPPING HAMMER: A chipping hammer is used to remove welding slag and spatter from steel. The flat side of the hammer is used on flat surfaces and the sharp edge for de-scaling in holes and difficult to reach places. Safety goggles shall be worn when a chipping hammer is used.

3.1.3 CHISEL: A chisel is used to clean rough surfaces, remove pop-rivets, split nuts from bolts and cut steel sheets. The cutting edge of the chisel is shaped at an angle of 60°. Mushrooming on the chisel shall be removed.

3.1.4 COLD-SET: A cold-set is a chisel attached to a handle and has a tempered point, which is shaped at an angle of 60°. It is used to cut off copper bonds. Mushrooming on the cold-set shall be removed. It shall be handled with care and the safety of people in the vicinity shall be considered when used.

3.1.5 COMBINATION PLIERS: Combination pliers are a dual-purpose pliers, equipped with side-cutting edges, combination cutters and clamps. The side-cutting section of the pliers is used to cut wire.

3.1.6 FENCING PLIERS: Fencing pliers are used as gripping and wire cutting tools. The front grip and the back part (handle) are used as leverage to fence wire.

3.1.7 FUNNELS: Funnels are used to pour liquid or powder from one container into another, made from plastic or metal, and may be equipped with a sieve.

3.1.8 G-CLAMP: A G-clamp is used to clamp a work piece to a rigid object to prohibit it from moving. G-clamps shall always be placed square on any work piece.

3.1.9 HACKSAW: A hacksaw is used to saw various metals. A saw blade shall be hooked into the mounting pins with the cutting edges of the teeth facing forward.

3.1.10 NOZZLE TIP CLEANERS: Nozzle tip cleaners are used to clean surfaces, holes or grooves of gas cutting and welding nozzles. The correct size shall be used to clean nozzle holes or grooves by in-and-out movements until free from any obstacles.

3.1.11 SCREWDRIVERS - Straight Shank: The following types of screwdrivers are used, flat, Philips and Posy screwdrivers. The correct size shall be chosen and the screwdriver shall be placed square into the groove of the screw.

3.1.12 SHIFTING SPANNER: A shifting spanner is used to fasten and loosen nuts and bolts of various sizes.

3.1.13 SIDE-CUTTERS: Side-cutters are used to remove the outer cables and insulation from electrical wire and to cut soft thin wire.

3.1.14 SLEDGE HAMMER: A sledgehammer is a large, heavy, powerful hammer used to drive or remove various objects e.g. sleeper fastenings and wedges, and is available in sizes from 1.8kg to 7.25kg.

3.1.15 STEEL WEDGES: Steel wedges are thick, flat steel plates of various width and thickness, and are tapered to a smaller thickness. Steel wedges are used to force objects apart, to widen an opening, to lift heavy objects, or to keep a jig firmly in position.

3.1.16 STEEL WIRE BRUSH: A steel wire brush is used to remove dirt, scale, and rust, welding scale or splatter, from steel surfaces.

3.1.17 TOMMY-BAR: A Tommy-bar is a straight round or angular steel bar of various lengths, with one flat and one pointed end, bent in opposite directions. The flat end is used for leverage and the pointed end for aligning holes.

3.2 MARKING TOOLS.

3.2.1 CENTRE PUNCH: A centre punch is used for marking the centre of holes to be drilled or cut, is flat on the one end and has a sharp point at the other end.

3.2.2 CHALK LINE: A chalk line is a line-filled reel in a casing with chalk powder and is used for marking straight lines on surfaces such as concrete floors, and large metal plates.

3.2.3 COMBINATION SQUARE SET: The combination square set is a steel ruler with a central groove on the one side where three different marking-off devices are slotted in, e.g. a square head, centre head and a protractor, which can be mounted to the rule.

3.2.3.1 The square head is used to mark angles of 45° and 90°.

3.2.3.2 The centre head is used to determine the centre of axles or other cylindrical objects.

3.2.3.3 The protractor is used to measure and mark off angles of any degree and direction.

3.2.4 DIVIDERS: A divider is used for drawing arches and circles, determining the centre of a work piece, bisecting lines and transferring measurements. It has two sharp-pointed legs.

3.2.5 LETTER AND FIGURE STAMPS: Letter and figure types are used to stencil on metal objects and shall be used while the steel is still hot. Mushrooming on stamps shall be removed.

3.2.6 PRICK PUNCH: A prick punch is used to permanently mark steel surfaces. It is flat on the one side and has a sharp point (contained angle of 60°) on the other side.

3.2.7 RULER: Rulers are used to make accurate measurements and are made from steel or wood.

3.2.8 SCRIBER: A scriber is used for precision marking on work surfaces. It has a sharp straight edge on one end, and a sharp point at the other end, bent at a 90° angle.

3.3 MEASURING AND TESTING EQUIPMENT.

3.3.1 AMP-METER: An amp-meter is used for measuring electrical current.

3.3.2 CONTOUR GAUGE MEASURING RAIL-BOUND AND MONOBLOCK CROSSINGS: This gauge is used to measure cant, radii, and relative height of nose and wings (Annexure 3-1).

3.3.3 CONTOUR GAUGE MEASURING RAIL-MANUFACTURED CROSSINGS: This gauge is used to measure cant, radii, and height of nose and wings (Annexure 3-2).

3.3.4 DEPTH GAUGE: The depth gauge is used to measure wear and wheel damage on crossings and depth of wheel-spin burns. Measuring wear and wheel damage on crossings is done by placing the notched straightedge of the depth gauge transversely over the wings, then pressing down and releasing the aluminium measuring shaft of the depth gauge, then picking up the depth-gauge and pressing the aluminium measuring shaft in up to the measuring indicator block and taking the reading. Measuring depth of a wheel-spin burn is done by placing the notched straightedge part of the depth gauge in the longitudinal direction over the wheel-spin burn, then pressing down and releasing the aluminium measuring shaft, then lifting up and taking the reading (Annexure 3-3).

3.3.5 DYE PENETRANT: Dye penetrant is used to highlight rail defects and cracks (indicated by red lines or red dots). Dye penetrant is supplied in three different spray cans which are marked with descriptive stickers, namely cleaner, which is used to remove any impurities, a penetration solution, which is used to penetrate cracks and defects; and a developer.

3.3.6 ELECTRONIC HARDNESS METER: This is a hardness meter to determine the metal hardness.

3.3.7 ELECTRONIC TEMPERATURE GAUGE: An electronic temperature gauge is used to measure rail temperature during preheating and welding. The probe of the temperature gauge shall be placed directly on the area to be measured.

3.3.8 GUT: Gut is used as an aid to measure alignment of the track and crossings. It is normally 10m in length.

3.3.9 TAPE MEASURES: Tape measures are used to take short or long measurements, and are available in lengths varying from 1m to 100m.

3.3.10 MIRROR: Mirrors are used to visually examine exothermic joints from underneath the rail.

3.3.11 STOPWATCHES: Stopwatches are used to measure time intervals accurately.

3.3.12 STRAIGHTEDGE: A straightedge is a steel ruler, is available in lengths varying from 0.5m to 1.5m and is subdivided into millimetres. It is used in the setting-up of rails, measuring of battered rail ends, measuring of wheel-spin burns, and quality control of welding and grinding work. A straightedge shall be held at right angles (vertically and horizontally) to the work piece when used.

3.3.13 TAPER GAUGE: A taper gauge is a metal instrument to determine welding tolerances of 0mm to 4mm in graduations of 0.1mm. It is used with a 0.5m or 1m straightedge.

3.3.14 TEMPERATURE CRAYONS: Temperature crayons are used to monitor the temperature during preheating and welding. The temperature crayons are pulled over the heated surface. It melts when the required temperature is reached.

3.4 WELDING EQUIPMENT.

3.4.1 NOTE: All equipment shall be fastened when transported. Only persons that have been trained, assessed and certified by an accredited person (Track Welding) may use this equipment.

3.4.2 ANGLE GRINDER: An angle grinder is used for grinding flat surfaces, as well as cutting of steel. It shall be held firmly with both hands to ensure that sparks are deflected. Safety gear shall be worn and care shall be taken when using an angle grinder.

3.4.3 BENCH GRINDER: A bench grinder is used for sharpening and re-facing tools such as cutters, chisels and drill bits. Only the grinding wheel’s grinding surface shall be used for grinding and not on the side of the grinding wheels. Safety goggles shall always be worn when using a bench grinder.

3.4.4 DISC CUTTER: A disc cutter is used to cut the rail sound, smooth and square. A disc cutter's power source may be electric, petrol or hydraulic, and shall deliver a maximum rotating speed of 5400 revolutions per minute measured at the cutting disc spindle. Only cutting discs of 350mm x 25.4mm x 4mm may be used. The machine shall be mounted to the rail with a mounting clamp. When using a disc cutter one shall always stand firm and comfortable, and start cutting on top of the crown with a sawing action and progress systematically down to the base. Protective gear shall always be worn, and cutting discs removed when work is complete.

3.4.5 MC2 GRINDING MACHINE (Machine crossing): A MC2 grinding machine is used to grind all types of crossings, to do rough grinding on rails, as well as removing metal flow (overlaps) from rails, crossings, points and guard rails. AMC2's power source may be electric, petrol, or hydraulic and shall not exceed 3800 revolutions per minute measured at the grinding disc spindle. Only grinding stones of 250mm x 32mm x 25.4mm may be used. The machine is mounted on four wheels, which move in the longitudinal direction of the track. The grinding wheel is mounted vertically on the machine, and can tilt 30° left or right. The grinding stone is moved transversely when grinding takes place, and the vertical setting is done by hand and locked in position.

3.4.6 MC3 GRINDING MACHINE: This machine is identical to the MC2 grinding machine; apart form the fact that the horizontal and vertical setting is done by means of notches on the height adjustment lever.

3.4.7 MP12 GRINGING MACHINE (Machine profile): A MP12 grinding machine is used to profile the rail crown. Its power source may be electric, petrol or hydraulic, and shall not exceed 6100 revolutions per minute. Only grinding stones of 150mm x 75mm x 15.8mm may be used. The MP12's grinding stone is mounted horizontally between two wheels, can tilt through 90° and moves longitudinally on the rail crown.

3.4.8 NEEDLE DE-SCALER: A needle de-scalar is an air driven tool, which is used to remove rust and foreign objects from steel surfaces. It shall be held in a vertical position above the work piece and moved to and fro. Safety gear shall be worn.

3.4.9 RAIL SHEARING MACHINE: A rail shearing machine is used to shear excess metal from an exothermic joint. Two types of machines may be used; a double blade or a single blade machine. Both machines may be driven by a hydraulic pump or two-stroke petrol motors. The machine shall be placed over the work piece, the lock valve closed, and pumped-up. The lock valve shall be closed after completion, pumped back and the shearing machine removed.

3.4.10 WELDING MACHINES: The welding machine is the power source for all track welding activities and can be petrol, diesel or electrically driven. The electric-driven machine shall be able to deliver a minimum of 270 amps at a duty cycle of 80% when used for track welding. It shall be placed in a safe place and the cables shall always be connected in the correct manner. Cables shall never be laid over open track, but laid underneath the rails. The machine shall be set to the correct amperage based on the electrode being used for welding.

3.4.11 WIRE FEEDER: A wire feeder is used as an additional machine with the welding machine to feed flux-cored wire to the work piece. The positive wire shall be connected to the welding machine and the earth wire to the work piece.

3.5 WIRE FEEDING MACHINE FOR FLUX-CORED WIRE.

3.5.1 OPERATING AND CARE OF THE WIRE FEEDING UNIT.

3.5.1.1 First, the wire feeder is placed clear from the track.

3.5.1.2 The positive cable of the welding machine is then connected to the positive pole (cathode) of the wire feeder.

3.5.1.3 The negative cable (anode) of the welding machine is then connected to the work piece. The negative pole of the wire feeder is clamped to the negative clamp of the welding machine.

3.5.1.4 The supply cable of the welding gun is then to the wire feeder.

3.5.1.5 The welding gun shall be kept straight where possible to ease the feeding of the welding wire. The welding wire reel shall be positioned in the wire feeding machine. Damaged parts of the wire shall be cut off. The wire shall then be fed through the intermediate and outlet nozzle in to the steel liner of the welding gun.

3.5.1.6 The correct wire feed and deposit rates are obtained by setting the feeding tension, amperage and voltage of the machine for 1.6mm flux-cored wire according to the manufacturer’s recommendations.

3.5.1.7 The welding machine is then switched on and the trigger on the welding gun pressed to feed the wire through the gun until it protrudes approximately 35mm through the gun.

3.5.1.8 To protect the nozzle, it shall be ensured that the gas shield is present at all times. The prescribed anti spatter spray shall be used on the gas shield and nozzle to control excessive sticking of spatter.

3.5.1.9 The drop of molten steel formed at the end of the wire shall be cut off immediately after welding.

3.5.1.10 A 3m welding gun for welding wheel-spin burns and battered rail ends and 4.5m welding gun for welding all crossings shall be used.

3.5.1.11 Refer to the RRV Welding manual semi automatic welding equipment.

3.5.1.12 The following steps shall be taken when replacing empty reels:

- Disconnect the welding gun from the wire feeding machine and remove the remaining flux-core wire by pulling it back with a pair of pliers.
- Blow the supply cable clean if compressed air is available. Compressed oxygen may not be used for this purpose.
- Place the new reel in the wire feeder and continue as described in 3.5.1.

3.5.1.13 The following actions shall be taken when welding is completed:

- Switch off the welding machine.
- Cut off the end of the wire (approximately 5mm) if required.
- Release the tension on the rollers.
- Reel the wire back onto the reel and secure.
- Remove the reel with the wire and place it back in the original packaging.
- Disconnect the wire feeding machine form the welding machine.
- Remove the wire feeding machine and supply cable from the work place and place it safely on the vehicle.

3.6 ARC-AIR GOUGING.

3.6.1 ACCESSORIES.

3.6.1.1 The following items are necessary for gouging:

- A welding machine able to deliver 500 amps.
- A compressor, able to deliver compressed air at 12litres/second at 500 kPa. The compressed air and flow rate shall be sufficient to blow away all molten metal.
- A rubber supply hose, approximately 3m in length, with gouging pliers on the one end and a connector on the other. A side lever shall be mounted to the side of the gouging pliers to clamp the electrode. A trigger on the gouging pliers to control the air through the gouging nozzle shall be fitted.

- A water trap shall be fitted in the correct position at the compressor and shall be kept in a good condition.

3.6.2 ASSEMBLING.

3.6.2.1 The air supply hose of the gouging holder shall be connected to the air cylinder of the compressor. The positive pole of the welding machine shall be connected to the gouging holder. The negative pole of the welding machine shall be connected to the work piece.

3.6.2.2 Position the copper-coated carbon electrode (6.5mm thick x 300mm long) in the gouging holder.

3.6.3 OPERATING PROCEDURE.

3.6.3.1 Switch the welding machine and compressor on.

3.6.3.2 Ensure that at least 500kPa air pressure is available.

3.6.3.3 Open the valve of the compressed air cylinder.

3.6.3.4 Obtain an arc, open air flow and commence with gouging.

3.6.3.5 All loose and work-hardened metal shall be gouged away with a smooth stringer action.

3.6.3.6 If the arc-gouging process is used, a further 2mm shall be removed by means of grinding.

3.6.3.7 Use a rail grinding machine (MC2 or MC3) to obtain a smooth surface.

3.7 GAS WELDING EQUIPMENT: ASSEMBLY AND IGNITING METHOD.

3.7.1 GAS WELDING EQUIPMENT.

3.7.1.1 Oxygen and acetylene or LP-gas cylinders.

3.7.1.2 Regulators for oxygen and acetylene or LP-gas cylinders.

3.7.1.3 Universal shaft with cutting attachment with a range of nozzles.

3.7.1.4 Oxygen and acetylene flashback arrestors.

3.7.1.5 Two lengths reinforced rubber hoses fitted with connectors, clamps and parallel clamps.

3.7.1.6 A set of spanners and a spindle key.

3.7.2 ASSEMBLY PROCEDURE (LP-gas, acetylene and oxygen).

3.7.2.1 Only competent Track Welders may use gas equipment.

3.7.2.2 Cylinders shall be safely fixed into position next to the work place.

3.7.2.3 Cylinder valves shall be opened and closed quickly to blow out any dust or dirt in the valves.

3.7.2.4 The adjusting screws of the regulator shall be set to zero working pressure. This is obtained by turning the adjusting setscrews anti-clockwise until the pressure releases completely.

3.7.2.5 The oxygen regulator shall be connected to the oxygen cylinder valve (right-hand thread). The regulator shall be tightened with the correct spanner (not a shifting spanner). No force may be used, but connections must be sound.

3.7.2.6 The oxygen flashback arrestor shall be connected to the oxygen regulator (right-hand thread) and tightened it with the correct spanner.

3.7.2.7 The acetylene/LP-gas regulator shall be screwed into the acetylene/LP-gas-cylinder valve (left-hand thread).

3.7.2.8 The relevant flashback arrestor shall be connected to the relevant regulator (left-hand thread) and tightened using the correct spanner.

3.7.2.9 The gas supply hoses (acetylene - red; oxygen - blue; LP-gas - orange) shall be connected to the correct coupler of the flashback arrestors. The hose-end shall be fitted with the correct control valve inlet and connected to the flashback arrestor. (Only approved O-clips shall be used).

3.7.2.10 Before the burner is connected to the hoses, the oxygen cylinder valve shall be opened very slowly and the pressure adjusting set screw of the oxygen regulator opened slowly for a short while to blow out any foreign matter from the hose. The cylinder valve shall then be closed. The procedure shall be repeated for acetylene or LP-gas.

3.7.2.11 The flashback arrestor shall be connected to the welding torch. The burner valves shall be closed and all connections tightened with the correct spanner.

3.7.2.12 The correct size nozzle shall be fitted to the burner (a 2F nozzle is used with acetylene and a 2NFF nozzle with LP-gas).

3.7.3 TESTING FOR LEAKS.

3.7.3.1 Ensure that both burner valves are closed.

3.7.3.2 Open the acetylene and oxygen cylinder valve slowly, one full turn. Set the regulators to a pressure of 50 to 60kPa for acetylene and 180 to 200kPa for oxygen.

3.7.3.3 Apply approved Harris Safety-Spray Type 237-320 to all the acetylene and oxygen connections. Start with the cylinder-valve spindle, pressure-screw and then all the connections up to the burner inlet. Bubbles will occur at leaks.

3.7.3.4 Leaks shall be fixed immediately by tightening the leaking connections. If the gas still leaks, the connection is faulty and shall be replaced. A leaking cylinder-valve spindle can be fixed by tightening the spindle nut.

3.7.3.5 After the test has been completed, both cylinder valves shall be closed. Ensure that the setscrews of the regulators are set to zero working pressure. This is obtained when turning the adjusting setscrew anti-clockwise until the pressure releases completely.

3.7.3.6 Open both valves on the burner for 4 to 5 seconds to replace the air in the hose with oxygen and LP-gas. Close the burner valves.

3.7.4 IGNITING PROCEDURE.

3.7.4.1 Check that the regulators are set to zero and that the burner valves are closed.

3.7.4.2 Open both cylinder valves very slowly. Do not open the valve spindle more than one full turn.

3.7.4.3 Set the pressure on the regulators in accordance with the instructions from the manufacturer. If the adjusting screw is turned clockwise, the pressure increases.

3.7.4.4 Open the oxygen valve of the burner for approximately 4 to 5 seconds to blow any air/gas mixture out of the system. Close the oxygen valve.

3.7.4.5 Repeat the procedure for the flammable gas.

3.7.4.6 Open the flammable gas valve a ¼ turn on the burner and ignite the gas flowing from the nozzle, using an approved triple flint lighter.

3.7.4.7 Reduce or increase the flammable gas flow by means of the burner valve.

3.7.4.8 Open the oxygen valve of the burner and set the flow until the required flame is obtained.

3.7.4.9 NEUTRAL FLAME: Is obtained by mixing an equal amount of oxygen and flammable gas, which will result in a blunt blue inner cone (Figure 3.1).

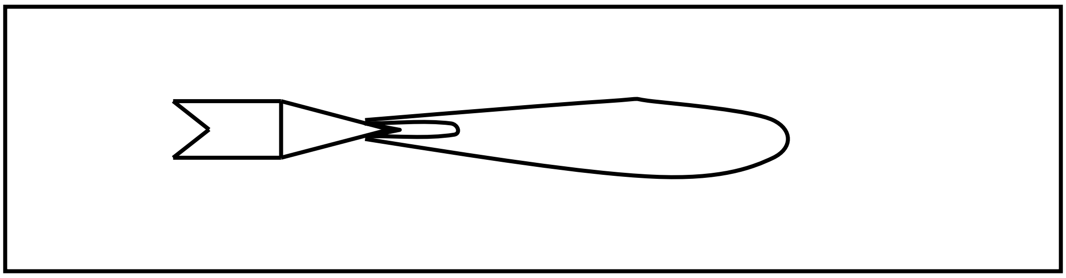

Figure 3.1. Neutral Flame.

3.7.4.10 CARBURISING FLAME: Is obtained by mixing a slight surplus of flammable gas with oxygen, which will result in a featherlike inner cone (Figure 3.2).

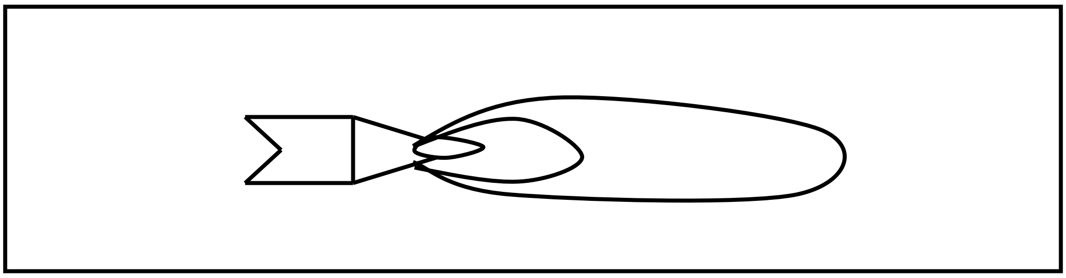

Figure 3.2. Carburising Flame.

3.7.4.11 OXIDISING FLAME: Is obtained by mixing an excessive amount of oxygen with flammable gas, which will result in a sharply defined inner cone (Figure 3.3).

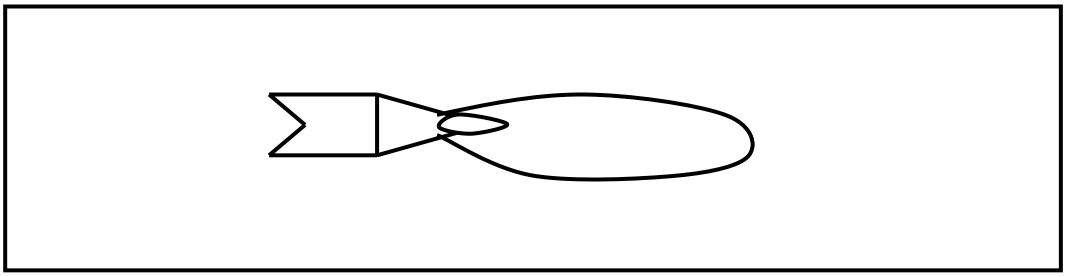

Figure 3.3. Oxidising Flame.

3.7.5 SHUT-OFF PROCEDURE.

3.7.5.1 To extinguish the flame, first close the acetylene/propane valve of the gas equipment, and then the oxygen valve.

3.7.5.2 Close both cylinder valves.

3.7.5.3 Ensure that the setscrews of the regulators are set to zero outlet pressure, in other words, turn the adjusting setscrew anti-clockwise as far as it can turn, but do not force beyond this point.

3.7.5.4 Open the gas equipment valves one by one to release the pressure in the regulators and hoses.

3.7.5.5 Close the gas equipment valves. Ensure that the gas equipment valves are always closed and the regulators are set to zero outlet pressure when the equipment is not in use.

3.8 GAS CUTTING EQUIPMENT: ASSEMBLY AND IGNITING METHOD.

3.8.1 GAS CUTTING EQUIPMENT.

3.8.1.1 Gas cutting equipment is similar to those used in gas preheating, except for the heating attachment being replaced by cutting attachment.

3.8.1.2 Note: The nozzles, regulator and cutting torch attachments for LP-gas differs from those used for acetylene. A PV5 regulator is used on LP-gas equipment.

3.8.2 ASSEMBLY PROCEDURE AND TESTING.

3.8.2.1 The assembly procedure and testing for gas cutting equipment is similar to that of gas welding (Paragraphs 3.7.2 to 3.7.3).

3.8.2.2 LP-gas may not be allowed to flow from gas cylinders for long periods when assembling and testing is done. LP-gas is heavier than air, will accumulate in low-lying sections on the ground/floor, and could be set alight by sparks or hot metal.

3.8.3 IGNITING PROCEDURE.

3.8.3.1 The igniting procedure for a cutting torch is similar to that for a welding torch (Paragraph 3.7.4).

3.8.3.2 Note: The oxygen valve on the universal handle shall be opened completely and left open. Use the oxygen control valve of the cutting attachment to adjust the flame.

3.8.3.3 Use the oxygen control lever to control the oxygen high pressure flow. If the flow of cutting oxygen changes the flame composition, the flame shall be adjusted by means of the oxygen control valve on the cutting attachment.

3.8.4 SHUT-OFF PROCEDURE.

3.8.4.1 The shut-off procedure for gas cutting equipment is the same procedure as for gas welding (Paragraph 3.7.5).

3.8.5 GAS CUTTING PROCESS.

3.8.5.1 Mark the position where the rail needs to be cut with boilermaker's chalk.

3.8.5.2 Ensure that the appropriate fire fighting equipment is available and guidelines regarding the prevention of field fires are followed as discussed in Paragraph 2.6.

3.8.5.3 Rails may be cut with oxy-propane equipment when removing kick-outs.

3.8.5.4 Cutting settings for rails are similar to the settings for cutting 25mm thick plate. The following pressures are used in the gas cutting process: (The figures given are intended as guidance and may vary depending on local conditions).

(a) Oxygen regulator = 270 kPa for oxy-acetylene equipment, and
= 310 kPa for oxy-propane gas equipment.

(b) Acetylene regulator = 60 kPa (Ensure that a 2F cutting nozzle is used).

(c) LP-gas regulator = 60 kPa (Ensure that a 2NFF cutting nozzle is used).

3.8.5.5 Ignite the flame and adjust it to an equal mixture to obtain a neutral flame. A neutral flame is used for cutting rail.

3.8.5.6 Take up a comfortable position when cutting a rail.

3.8.5.7 Keep the tip of the cutting nozzle at a 60° angle, approximately 10mm above the rail flange until the colour of the metal turns cherry-red. Set the cutting lever to maximum to allow the high pressure oxygen to blow away the molten metal.

3.8.5.8 Move the nozzle down at a constant speed along the line mentioned in Annexure 2-2 to the bottom of the rail crown while the cutting nozzle is held approximately 10mm from the rail surface. The cutting nozzle shall be held at 90° to the rail surface to ensure a square cut. As soon as the rail crown is cut through, release the cutting lever to cut off the high oxygen pressure flow.

3.8.5.9 Clean the rail web and flange with a chipping hammer, and follow the above procedure to cut the rail flange and web.

CHAPTER 4 – METALLURGICAL GUIDELINES AND TESTS.

4.1 METALLURGICAL GUIDELINES.

4.1.1 INTRODUCTION.

4.1.1.1 Track welding is important for the following reasons:

- Converting jointed track to continuous welded rail.
- Wheel-spin burns and other surface damage can be repaired.
- The life span of rail and crossing components is extended.
- In order to achieve the above, it is important that we have to know more about metallurgical aspects, as well as the effect which the different welding procedures have on steel, especially regarding heat application and cooling rates.

4.1.2 HISTORY.

4.1.2.1 When iron ore is processed, iron (Fe) is the end product. For rail this product is further processed and elements such as carbon, manganese, silicon, chrome, nickel and molybdenum, sulphur and phosphorus are added. These elements are added to produce the required mechanical characteristics.

4.1.2.2 The earth's crust contains approximately 5% (mass/mass) iron in the form of iron ore. The most important ore in South Africa is hematite (Fe_2O_3), which contains elements such as phosphorus and silicon.

4.1.2.3 Iron ore, coke and limestone are fed into a blast furnace and heated by superheated air. Carbon monoxide and heat are generated by burning blast furnace coke (which is obtained from coal of a high quality) in a blast furnace. The iron ore is reduced to iron by the carbon monoxide. The limestone reacts with the impurities in the iron ore to form a molten slag that floats on the surface of the molten metal.

4.1.2.4 Crude iron contains high percentages of carbon, manganese, silicon, phosphorus and sulphur and these elements shall be controlled within the specified limits to obtain the desired steel.

4.1.2.5 In modern steel works, crude iron is transported in a molten state to the refining plant, where it is refined. Older refining plants include the Bessemer converter and the open-hearth furnace. The Basic Oxygen Process (BOP) is the modern method of steel manufacturing.

4.1.2.6 Steel is also produced in an electrical oven by using steel scrap and a lesser quantity crude or cast iron.

4.1.2.7 In the BOP process, the ladle is loaded with molten metal and scrap metal at a ratio of 70/30. Oxygen is blown at high pressure into the surface of the molten crude iron. The oxygen reacts with the carbon, silicon, manganese and other undesirable elements. Limestone is added as a flux and removes the oxidised impurities as a molten slag, floating on the surface. After the final mixing process and the addition of the alloying elements, the molten steel is degassed to lower the level of hydrogen. The molten steel is then cast into moulds for subsequent manufacturing processes.

4.1.2.8 Two processes are used for the casting of the molten metal, namely the ingot process and the continuous-casting process. Currently only the continuous casting process is used to manufacture rails.

4.1.3 THE IRON/CARBON PHASE DIAGRAM.

4.1.3.1 The iron/carbon phase diagram (Figure 4.1) shows the influence of carbon as an alloying element on the metallurgical structure of the steel.

4.1.3.2 The phases pictured by the diagram are:

- AUSTENITE - A solid solution of Carbon in Iron at a high temperature (723°C for 0.8% Carbon).
- PEARLITE - Is a eutectoid composition of Ferrite and Cementite.
- FERRITE - Almost pure iron with little Carbon (< 0.025%). It is soft with a low tensile strength.
- CEMENTITE (Iron Carbide) - A solid solution of Iron and Carbon (6.67%). It is very hard and brittle.
- MARTENSITE - An over-saturated solid solution of Carbon in Ferrite that has high internal stresses is very hard and brittle.

4.1.3.3 A Pearlitic microstructure provides the best wear resistance and therefore it has the desired micro-structure for a rail.

4.1.3.4 For a rail's microstructure to change to Austenite, it shall be heated to between 750º and 1000ºC. Pearlite, Martensite or Bainite or combinations of these can form, depending on the cooling rate.

4.1.3.5 The chemical composition of Cr-Mn and UIC-C rails is such that Pearlite forms directly from the Austenite phase. (Maximum Carbon content of the rails is 0.8%).

4.1.3.6 If uncontrolled cooling is applied, Martensite will form.

4.1.4 CONTINUOUS COOLING TRANSFORMATION (C.C.T) DIAGRAM.

4.1.4.1 Each rail grade has its own continuous cooling transformation (CCT) diagram (Figure 4.2). The CCT diagram is influenced by the chemical composition.

4.1.4.2 If cooling takes place according to curve 1 or 2, as in Figure 4.2, Pearlite will form. If cooling takes place according to curve 3 or 4, Bainite or Martensite will form respectively.

4.1.4.3 The temperature and cooling rate that is obtained in the HAZ (heat-affected zone) of the joint are determined by the heat input during the welding cycle. In the case of a flash butt welding process, the heat input is local and over a shorter time span. In the case of exothermic casting the heat input is over a longer period. In the case of welding on Cr-Mn and UIC-C rails, the cooling rate is retarded during both welding processes to prevent Martensite formation. The cooling rate of completed exothermic joints can be retarded by insulation by means of an insulating blanket. In the case of flash butt welding, the cooling rate is retarded by means of a flame.

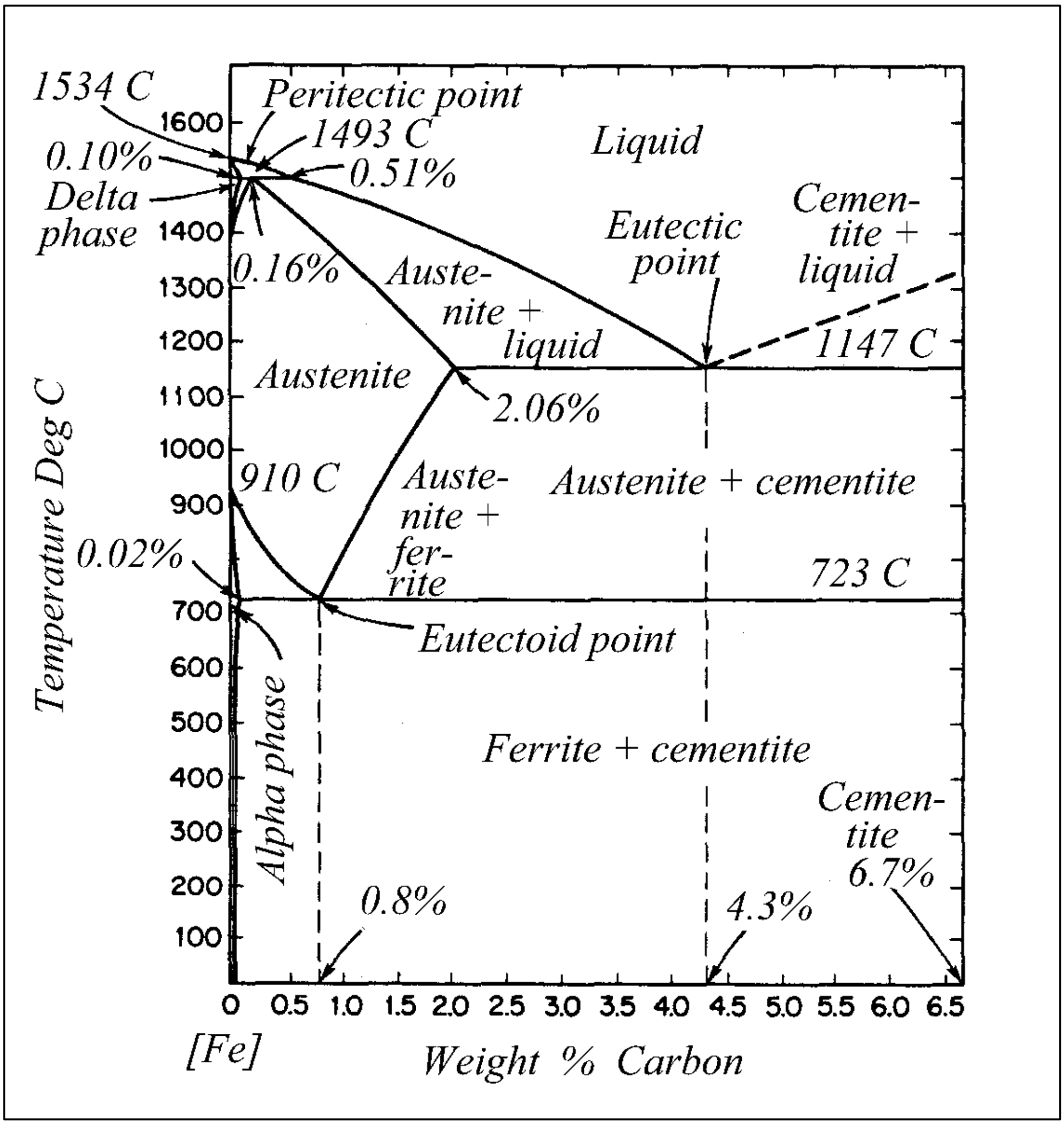

Figure 4.1. Iron/Carbon Phase Diagram.

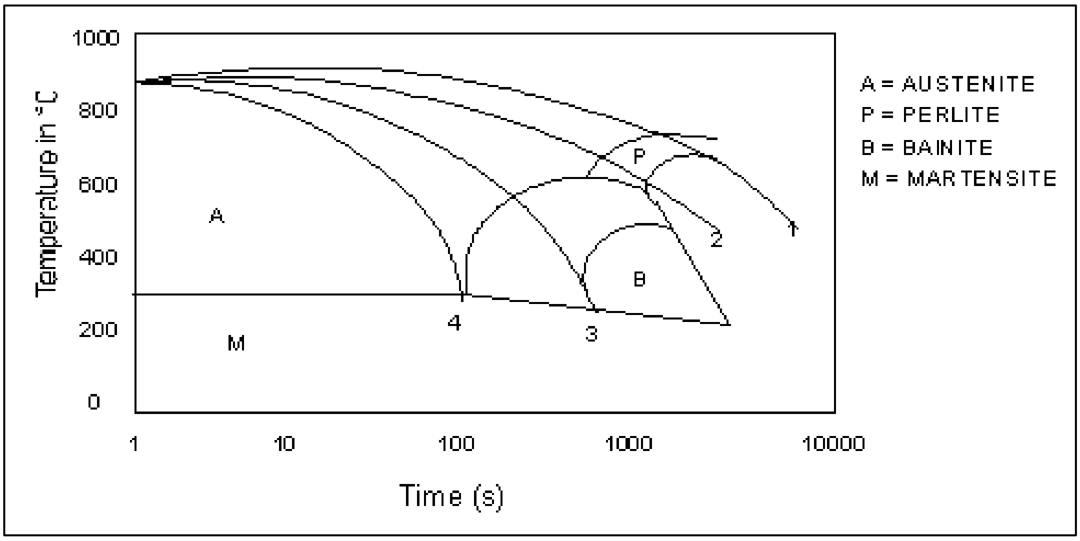

Figure 4.2. Continuous Cooling Transformation (CCT) Diagram for UIC-B Rail.

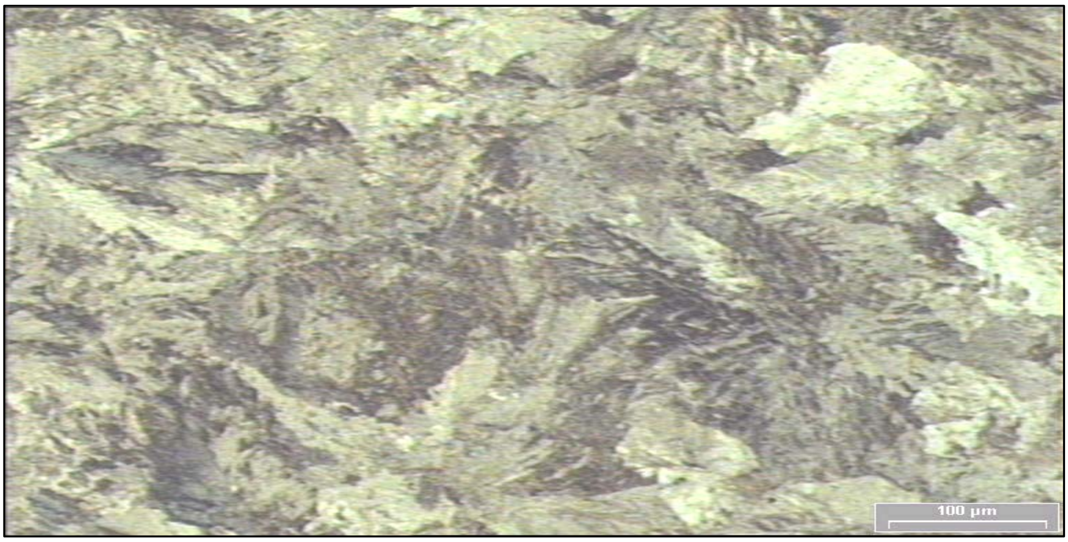

Figure 4.3. Pearlite (Note difference in grain size).

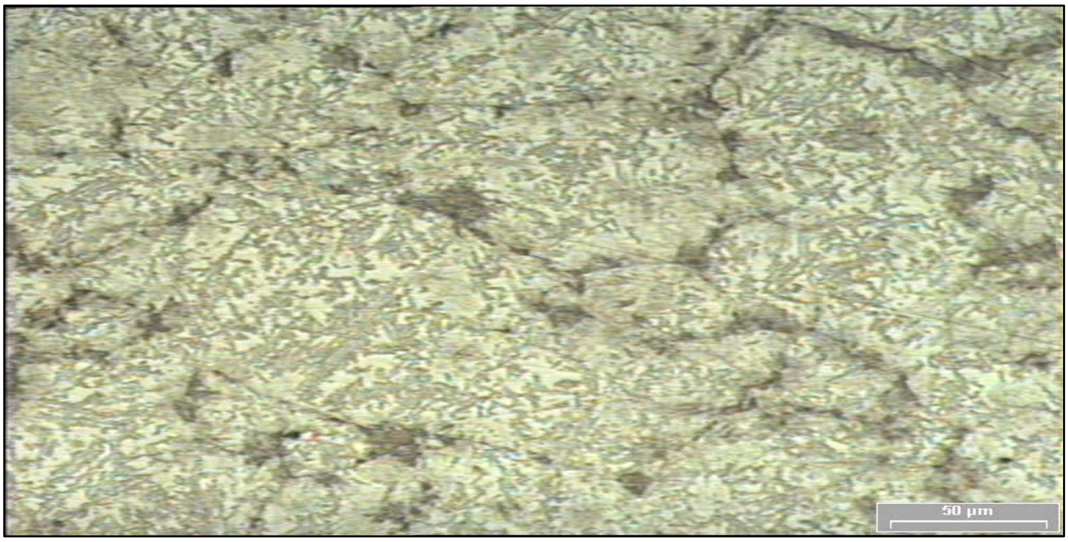

Figure 4.4. Bainite.

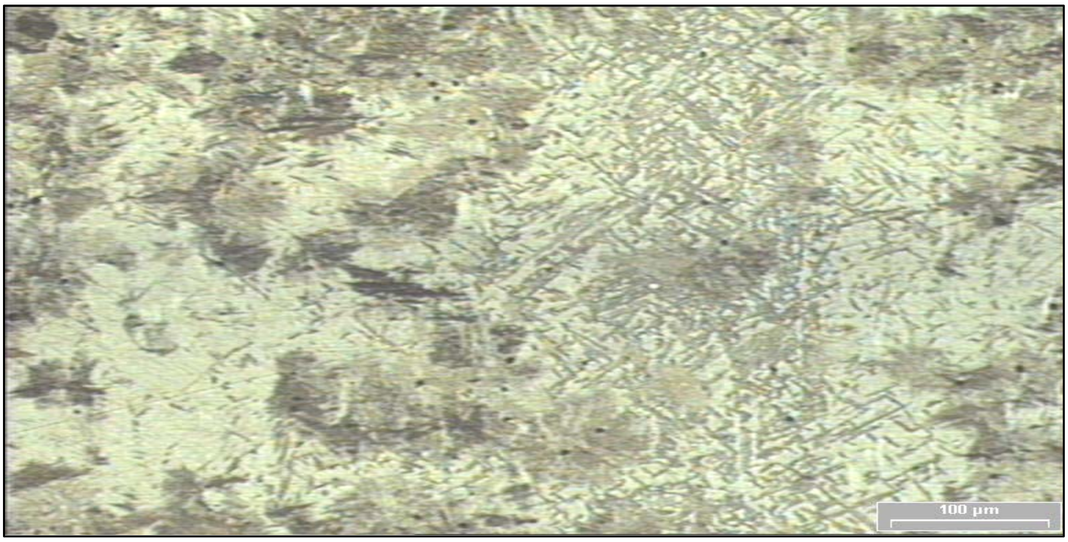

Figure 4.5. Martensite.

4.1.5 TIME/TEMPERATURE TRANSFORMATION (TTT) DIAGRAM.

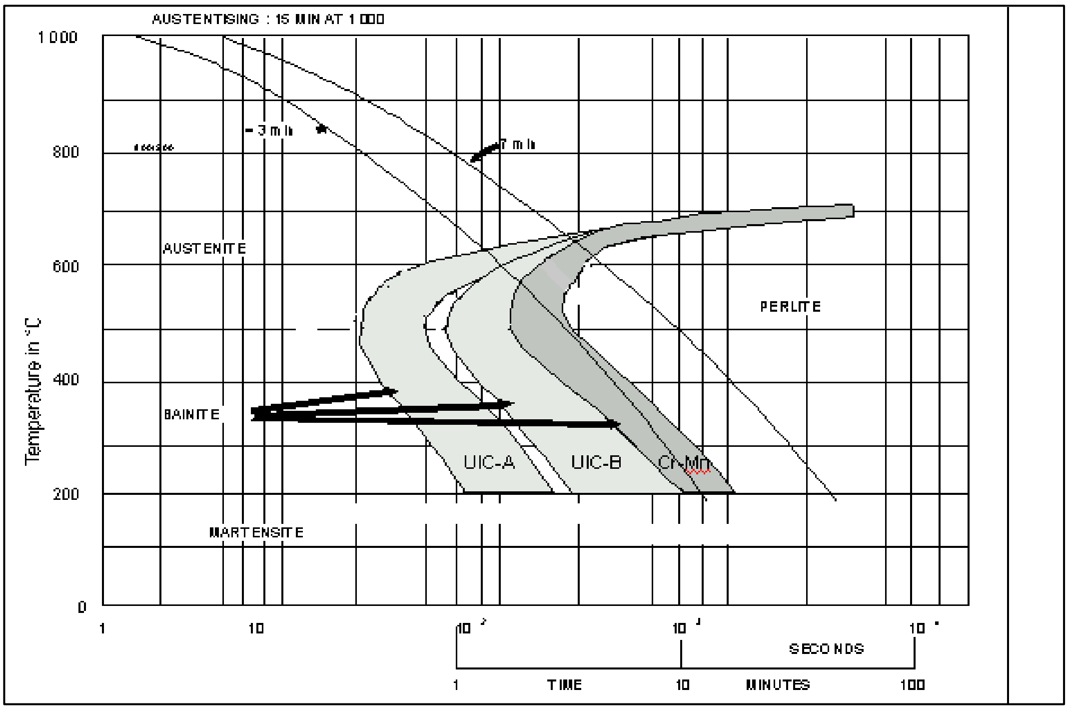

Figure 4.6. Time/Temperature Transformation (TTT) Diagram.

4.1.5.1 The time/temperature transformation (TTT) diagram (Figure 4.6) shows the time needed for a given type of steel to transform from a specific austenising temperature to different crystal structures. In the case of rail steel, the Pearlite transformation time is of special importance, and also the time for transformation to Bainite or Martensite.

4.1.5.2 Manganese as well as Chrome, as in the case of Cr-Mn rails, result in the transformation times being delayed, while the spacing of lamination bands of Pearlite are made narrower (fine Pearlite is formed).

4.1.5.3 The TTT diagram above shows the time/temperature transformation curve for UIC-A, UIC-B and Cr-Mn steel.

4.1.5.4 The two recommended cooling curves for UIC-A, UIC-B and Cr-Mn steel respectively are shown on the diagram. Complete Pearlite is obtained namely 3 minutes for UIC-B steel and 7 minutes for Cr-Mn steel.

4.1.5.5 From the above it can be seen why post heating on Cr-Mn and UIC-C rails must be applied. For UIC-A and UIC-B rail, the preheating and welding temperatures are sufficient to ensure that only Pearlite is formed.

4.1.5.6 In the case of a Cr-Mn rail, retarded cooling (flame heating/insulating blanket) after welding is required to ensure 100% Pearlite transformation. If preheating blocks are used, insulation with a heat resistant blanket is required. Retarded cooling by means of flame heating for 8 minutes or in case of preheating blocks insulation with an insulating blanket is required.

4.1.6 MACRO STRUCTURE.

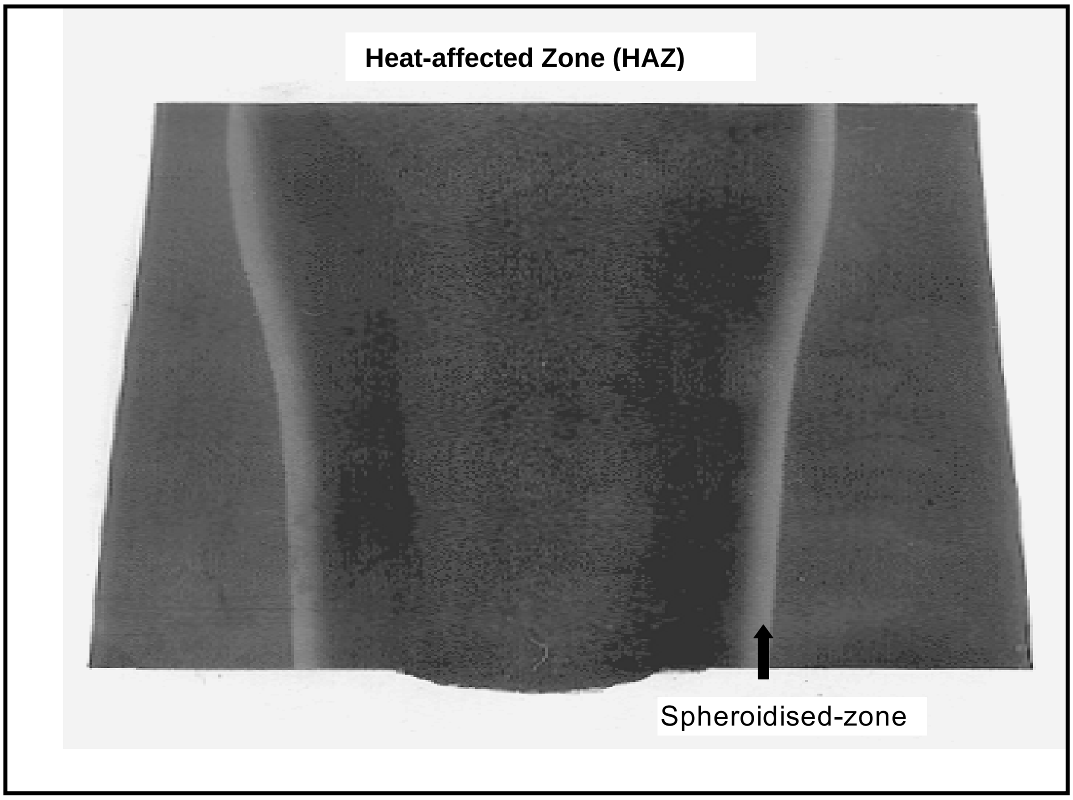

Figure 4.7. Cross Section of Exothermic Joint.

4.1.6.1 Figure 4.7 shows a macroscopic section through an exothermic joint. The Heat-affected Zone (HAZ) is the area in the rail directly next to the fusion zone and varies in width depending on the heat input (temperature and time duration) of the casting process.

4.1.6.2 The spheroidised zones can also be identified. These are the outside edges of the HAZ and are softer than the original rail steel. Spheroidising of the Pearlite takes place in the temperature range 680 to 723°C and results in a decrease in hardness of the rail steel.

4.1.6.3 The area between the spheroidised zone and the fusion line was heated above 723°C. The higher temperature next to the fusion line led to grain growth here and the grains become progressively finer until the spheroidised zone is reached. These cause variations in the hardness values, which differ from those of the parent metal.

4.1.6.4 Defects such as porosity, slag or segregation can also be observed on the macroscopic section.

4.1.7 MICROSTRUCTURE.

4.1.7.1 The majority of rail steel is Ferritic/Pearlitic Carbon steel.

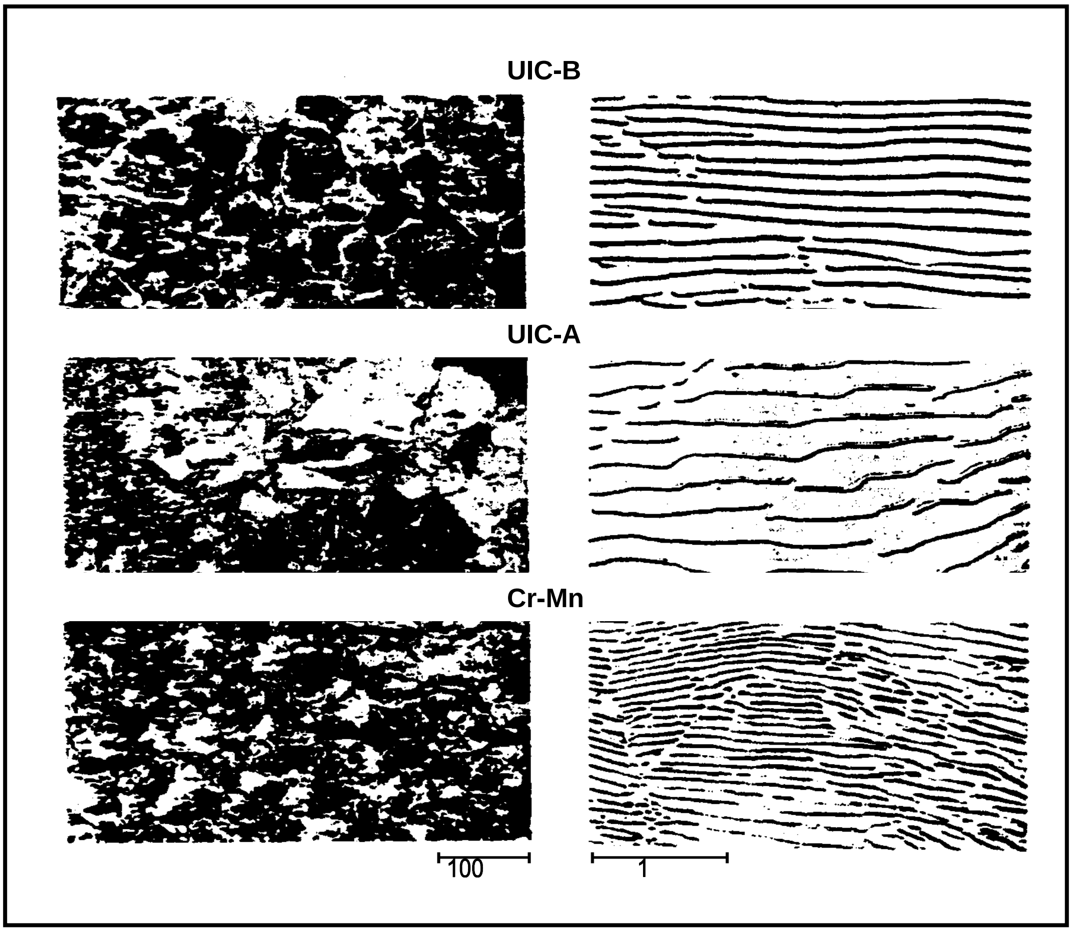

Figure 4.8. Typical Pearlite Microstructure.

4.1.7.2 The Pearlite will be coarse or fine, depending on the chemical analyses and the cooling rate from the austenitic region during manufacture or welding processes. Figure 4.8 shows the coarseness of the Pearlite for three different grades of rails. Note: The finer the Pearlite, the harder the steel.

4.1.7.3 Figure 4.9 shows the change in the microstructure and hardness of a flash butt joint as a result of the heat addition during the welding process.

4.1.8 ROLL MARKS.

4.1.8.1 Before welding is done on any rail, the Track Welder must first check which type of steel it was manufactured from (Annexure 4-1, Identification of Rail Types (Roll Marks for Rails)).

4.1.8.2 Where rails have been painted silver or aluminium, it is an indication that the rail has been manufactured from chrome manganese steel, although positive identification by means of roll marks is very necessary.

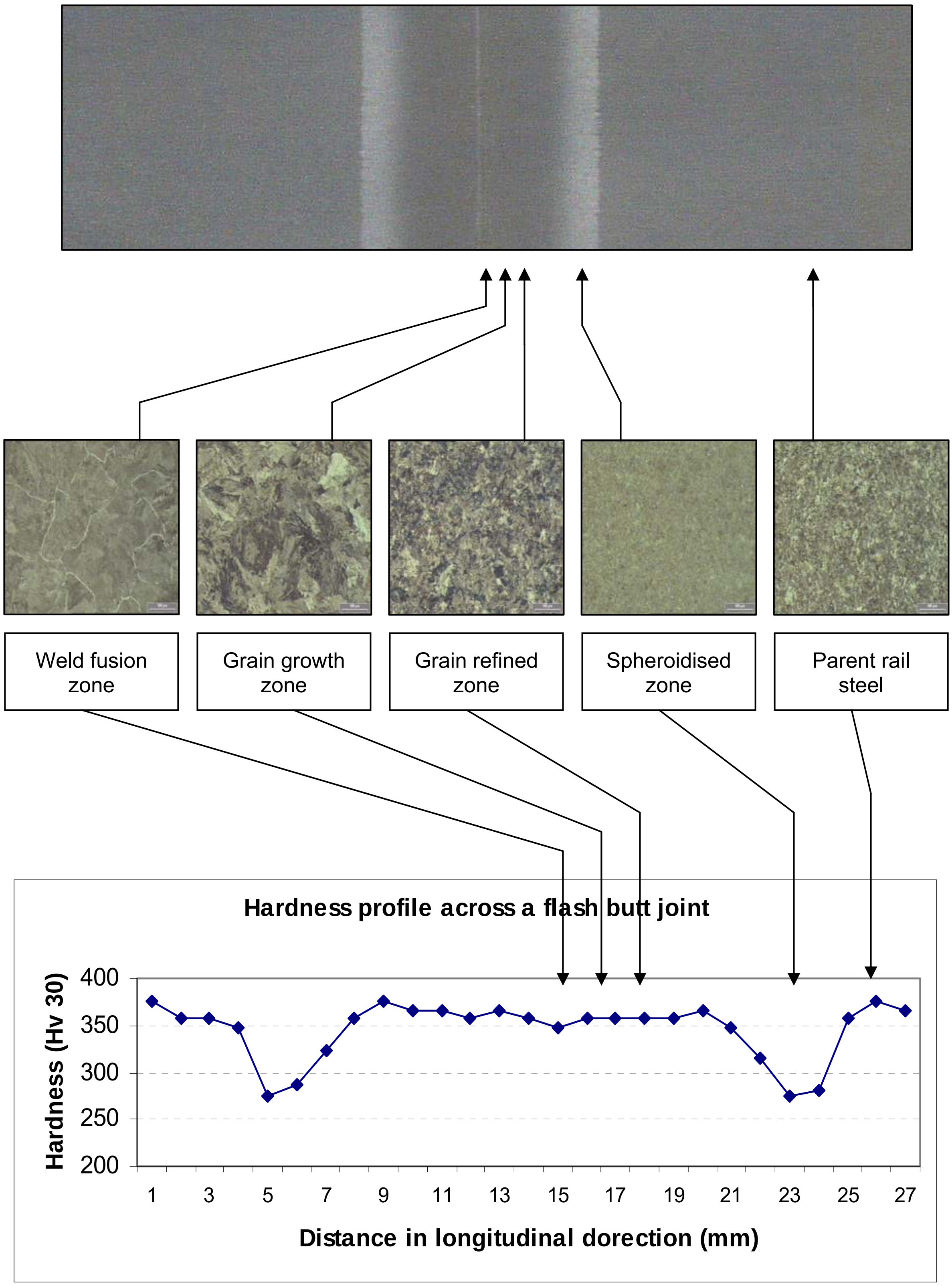

Figure 4.9. HAZ Microstructure and Hardness Values of a Flash Butt Joint.

4.2 METALLURGICAL TESTS.

4.2.1 LABORATORY TESTS: RAILWAY ENGINEERING (RAIL TECHNOLOGY).

Transnet Freight Rail has a fully equipped laboratory at Koedoespoort, which can conduct the following tests:

- Suitability tests of new materials.
- Acceptability tests for electrodes and acceptance of new procedures.
- Research and development of new processes.
- Cause determination of defects and fractures and assistance in preventing future problems.
- Quality assurance of present processes and procedures.

The laboratory can also assist with the following:

- Determining whether the correct welding procedures had been followed.
- Determining whether the prescribed welding procedures had been deviated from.
- Determining if the pre-heat and post-heat procedures for the specific activities and grade of rail had been applied.
- Determining whether defects had its origin in the rail steel or welding material.

4.2.1.1 TEST SPECIMENS.

Test specimens which are forwarded to the laboratory for tests, shall conform to the following:

- Rail of 150mm shall be left on both sides of the outsides of any joint or defect, which shall be tested.
- In the case of a broken rail, both ends of the fracture shall be supplied. The rails shall be cut a minimum distance of 75mm from either side of the rail ends. No flame cutting allowed within 150mm from any fracture surface or defect
- Test specimens shall be protected against rain and other corrosive elements.
- No attempt shall be made to remove rust or other foreign materials
- All test specimens shall be clearly marked. A full report, with information of the derailment, fractures, place, time, temperature, date, welding gap, high or low leg, welding process, roll marks, or any other information, shall be forwarded with the test specimen.
- The test and information required shall be clearly stated.

4.2.1.2 MACROSCOPIC EXAMINATIONS.

Macroscopic investigations determine:

- The effectiveness of pre- and post heating (HAZ).
- The quality of the welded joint, in other words the presence of cracks, porosity, slag inclusions, lack of fusion, foreign matter and materials, as well as the welding technique which was used.

4.2.1.3 MICROSCOPIC EXAMINATIONS.

4.2.1.3.1 From the microscopic examination the same can be determined as with the macroscopic examination, but in much finer detail. The microstructure can be examined under magnifications of 50 to 1000 times.

4.2.1.3.2 It shows the metallurgical grain structure of the rail as well as the welding deposit.

4.2.1.4 HARDNESS EXAMINATIONS.

4.2.1.4.1 The hardness examination is done on any cut through the rail, generally on the same sample used for the macroscopic examination:

4.2.1.4.2 Hardness can be measured in any of the following units: Brinell (HB 10/3000), Vickers (HV) and Rockwell (HRc).

4.2.1.4.3 From hardness examinations the following can be determined:

- Hardness and therefore the type of the rail
- Hardness of the welding metal
- Hardness of the heat-affected zone
- Size of the heat-affected and other zones.

4.2.1.4.4 Different hardness is obtained with the different types of rails, such as:

- HCOB 240
- UIC-A 280
- UIC-B 300
- Cr-Mn 320
- UIC-C (2MCC) 320 to 340
- Head hardened 350 to 400

4.2.1.4.5 Hardness measurements are conducted across the welded area to obtain a hardness profile of the welded area. This profile is valuable in determining the quality of the joint.

4.2.1.5 CHEMICAL ANALYSIS.

4.2.1.5.1 A chemical analysis can be done on the rails and welding metal to ensure that these conform to specifications.

4.2.1.6 SCANNING ELECTRON MICROSCOPE (S.E.M.).

4.2.1.6.1 If problems are experienced to determine the origin and cause of the fracture, the fractured parts can be examined with the S.E.M. This microscope can enlarge fractured faces up to approximately 300,000 times.

4.2.2 NON-DESTRUCTIVE TESTS.

Non-destructive tests are used to determine the quality of welded joints and/or rails without damaging them. Ultrasonic testing, radiography and dye penetrant testing methods are used.

4.2.2.1 RADIOGRAPHS.

4.2.2.1.1 Radiography can be accomplished by using either an isotope or an X-ray tube to bombard the joint with radiation. This will achieve an image on a radiographic film. The difference in densities of the image, which was generated from the joint, will illustrate the soundness of the joint. Imperfections, like shrinkage cavity, lack of fusion, porosities and cracks will appear much darker than the cast material on the radiographic film.

4.2.2.2 X-RAYS.

4.2.2.2.1 The x-ray equipment used is only an industrial version of the one used in a doctor's or a dentist's office. An electron gun inside the tube shoots high-energy electrons at a target made of heavy atoms, such as tungsten. X-rays come out because of atomic processes induced by the energetic electrons shot at the target.

4.2.2.3 GAMMA RADIATION.

4.2.2.3.1 High-energy, short wavelength electromagnetic radiation emitted from the nucleus of an atom. Gamma rays are very penetrating and are shielded by dense materials such as lead. A Collimator, which is a device made from radiation absorbent material such as lead or tungsten is designed to limit and define the direction and angular divergence of the radiation beam.

4.2.2.3.2 Both these above-mentioned forms of radiation are use to inspect the joint in similar ways. The film is placed at the bottom of the rail and a shot is taken in position A and position B (Figure 4.10). The film is then removed and another film is placed against the web of the rail and a shot is taken from Position C (Figure 4.10).

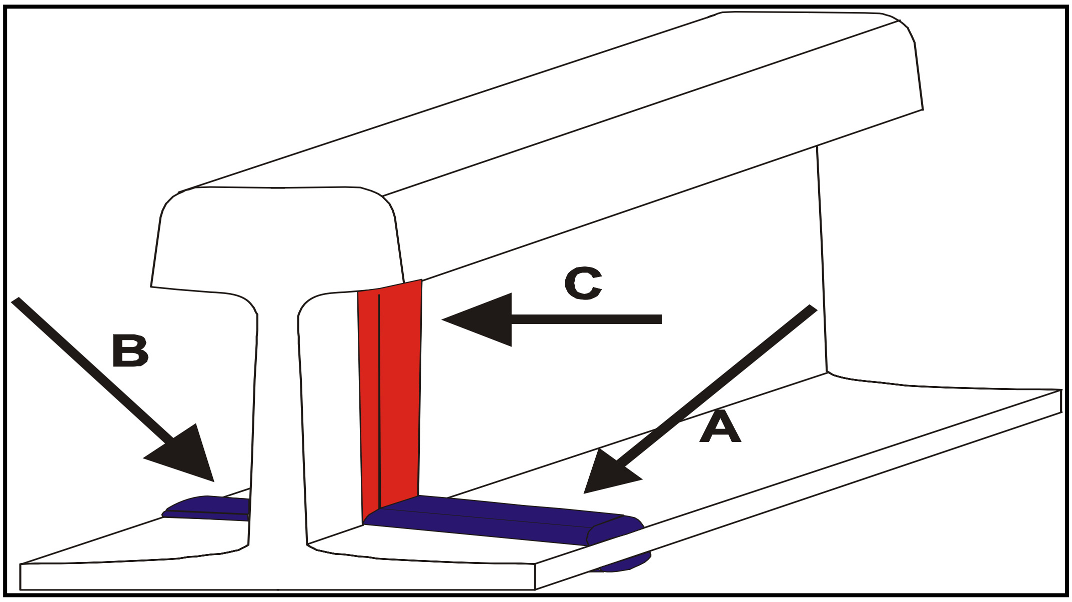

Figure 4.10. Different positions of the source or X-ray tube to radiograph joints.

4.2.2.3.3 This method allows us to inspect mostly the whole joint area, except the crown part. The crown can now be evaluated using ultrasonic equipment. Illustrated in (Figure 4.11) and (Figure 4.12) are the different positions of an X-ray tube where an exothermic joint is being inspected. (Figure 4.13 is a setup of an isotope to radiograph the web area of the rail).

Figure 4.11. Rail Flange X-ray Setup.

Figure 4.12. Rail Web X-Ray Setup.

Figure 4.13. Setup of Isotope to Radiograph the Rail Web.

4.2.2.3.4 Figures 4.14 and 4.15 are illustrations of radiographic images. Figure 4.14 illustrates the one side of the flange of a rail and Figure 4.15 is an image of the web area of the rail. The darker areas represent less material, which indicate the defects in the joint. The particular joint in Figure 4.14 illustrates a lack of fusion between the rail metal and the cast material, and Figure 4.15 is what is called worm holing, which are gas pores that are trapped in the cast metal.

Figure 4.14. Lack of Fusion in the Rail Flange.

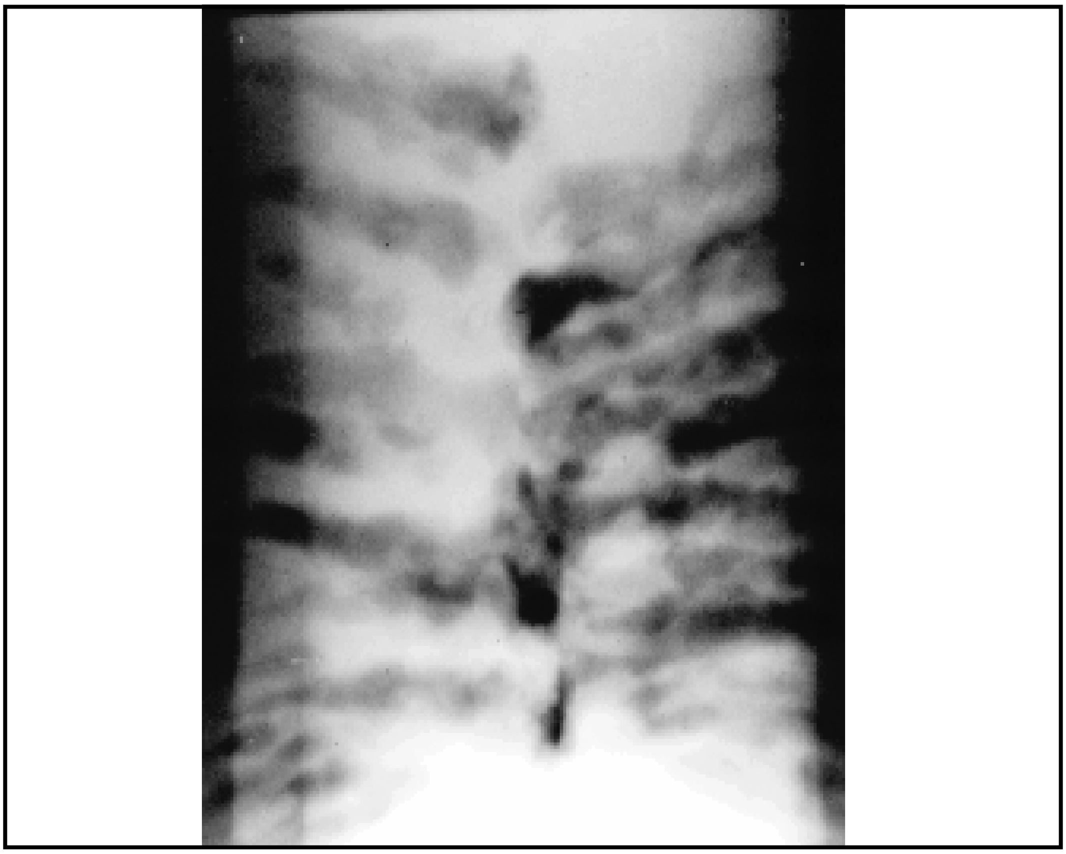

Figure 4.15. Worm holing in the Rail Web.

4.2.2.4 ULTRASONIC TESTING.

4.2.2.4.1 Ultrasonic testing is a versatile inspection technique, which can be used to inspect a variety of metallic and non-metallic products such as welds, forgings, castings, sheet, tubing, plastics and ceramics.

4.2.2.4.2 Ultrasonic testing is high frequency sound waves that have the advantage of detecting subsurface defects with access to only one side of the specimen.

4.2.2.4.3 A transducer or probe is used to detect these discontinuities. The transducers produce the sound waves that detect the defects and an instrument or flaw detector is used to interpret the signals from the transducers.

4.2.2.4.4 The defect orientation is very important and could easily be missed if it is not perpendicular to the sound propagation of the probes (Figure 4.16). The 0º probe signal will be deflected because of the crack orientation, but the defect that is detected by the 70º probes will be reported.

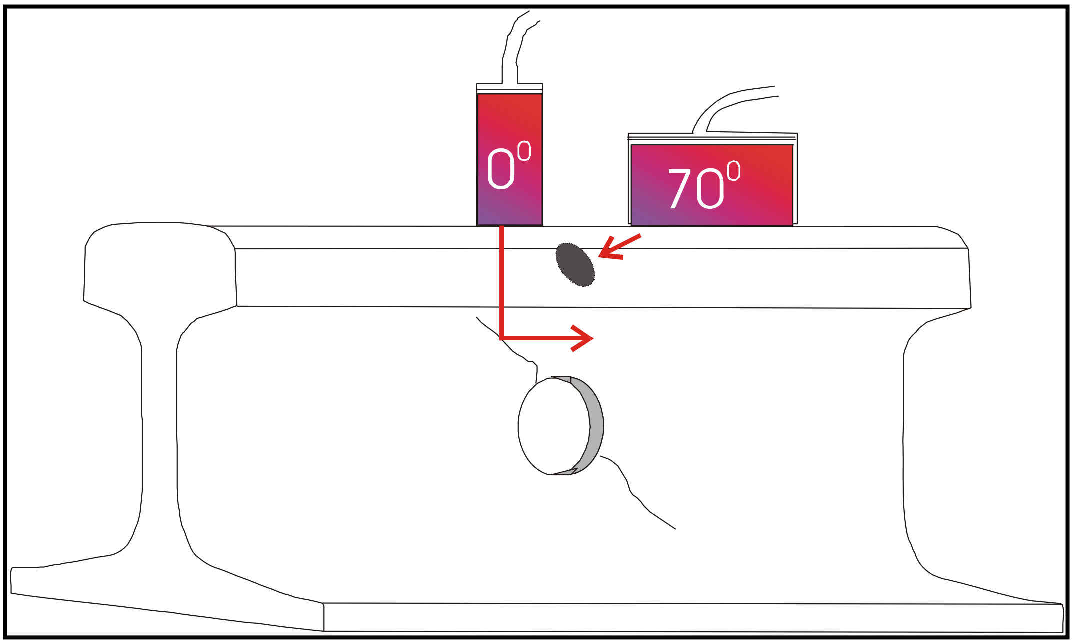

Figure 4.16. Defect Orientation.

4.2.2.4.5 Currently, ultrasonic test cars and ultrasonic trolleys are used to detect defects in the rails. Defects like kidney type (G4), which develop at an incline, are detected with angular probes, and horizontal split head defects are detected with normal or 0º probes.

4.2.2.4.6 It is evident that the more transducers or probes that is used in the testing equipment, the higher the accuracy would be in detecting discontinuities. The ultrasonic trolleys (Figure 4.17) only have two 70º probes (forward and backward) to check for defects in the crown area, and a 0º probe to detect defects up to the bottom part of the rail.

4.2.2.4.7 The wheel probe that is in use in the ultrasonic cars makes it possible to have up to 11 probes inspecting the rail simultaneously. In Figure 4.18 the wheel probe is illustrated with 3 different types of probes, a 37º probe is added to detect bolthole cracks. This makes the ultrasonic cars much more effective than the trolleys by testing rails in track. It shall be considered however that the car can only move on railway lines, and testing individual rails like closures would still be done with the ultrasonic trolleys.

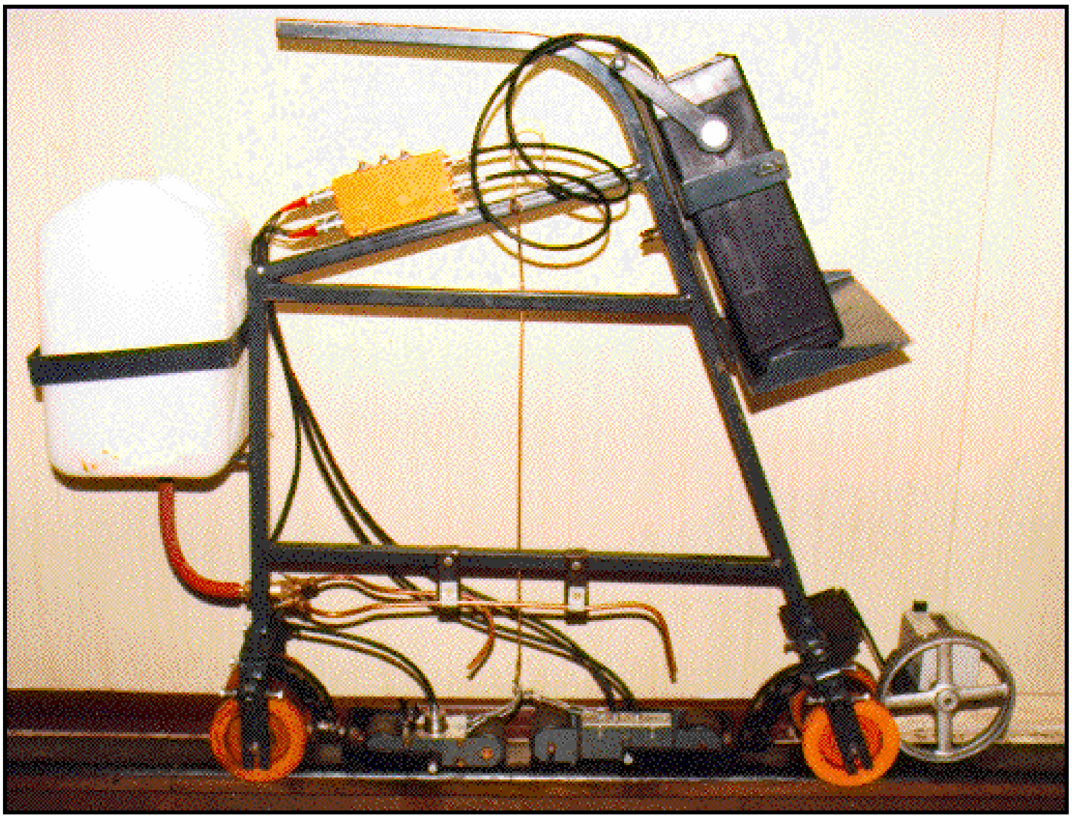

Figure 4.17. Ultrasonic Test Trolley.

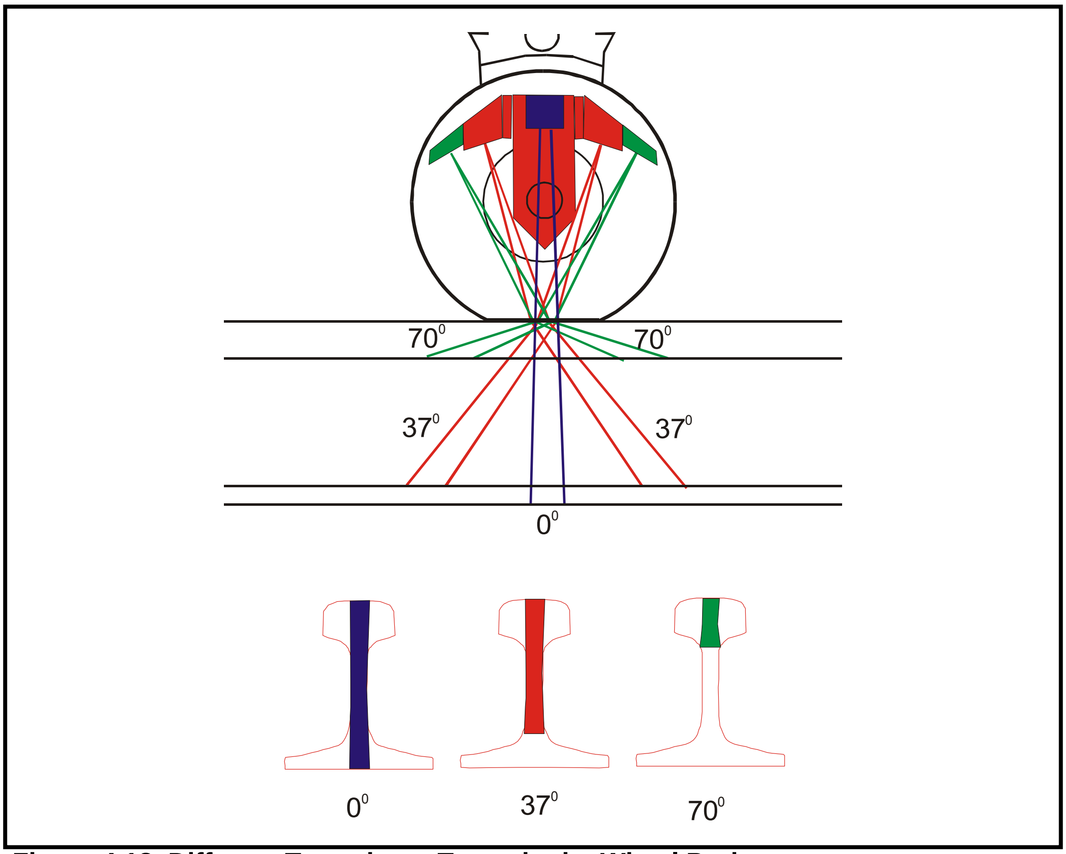

Figure 4.18. Different Transducer Types in the Wheel Probes.

Figure 4.19. Wheel Probes on the Ultrasonic Measurement Car (UMC).

4.3 CHARACTERISTICS OF RAILS.

4.3.1 The main alloying elements in rail steel are carbon, manganese and silicon. The more carbon, the harder the rail and the more difficult it becomes to do welding without adversely affecting the characteristics of the rail. Other alloying elements such as chrome and manganese are also present in rail steel. These elements influence the welding technique.

4.3.2 Different grades of rails are used, namely HCOB, (MMOB, MMOA), UIC-A, UIC-B, 2MCC (or UIC-C), UIC60, Cr-Mn and head hardened rails.

4.3.3 The chemical composition and manufacturing method influence the following properties:

- Impact strength (toughness of steel).
- Hardness (tensile strength determines the wear resistance).

4.4 FLAME CUTTING.

4.4.1 Flame cutting of rails lead to the following defects:

- Oxides are formed on the cut surface and results in insufficient fusion when welding.
- Hardening of the rail end because of quick cooling.
- Small hair-line cracks also appear.
- Embrittling of the rail in the immediate vicinity of the cut if flame cutting takes too long.

4.4.2 To prevent these defects mentioned above, all rails shall be cut with a disc cutting machine.

4.4.3 NOTE: UIC-C (2MCC) and Cr-Mn rails may not be flame-cut.

4.5 GRINDING.

4.5.1 When grinding is done, precautions shall be taken that the correct grinding wheel is used and overheating is avoided by pressing the grinding wheel only very lightly against the work piece during grinding. The material shall under no circumstance be transformed to a blue colour, because it may cause the following:

- Hardening, i.e. hairline cracks will form.
- Poor fusion during welding.

4.6 DISC CUTTING.

4.6.1 When disc cutting is done on rails, the following shall be checked to ensure that the rail characteristics are retained:

- That the revolutions of the disc cutting spindle correspond with the disc cutting specifications.
- That too much pressure is not placed on the machine.

4.7 PRE- AND POST HEATING.

4.7.1 Preheating is necessary to ensure sufficient fusion between the parent metal and welding metal, to counter sagging (distortion) and to prevent formation of Martensite.

4.7.2 Delayed cooling after welding or post heating is done to prevent the formation of untempered Martensite in the parent metal after welding. This is done by delaying the rate of cooling.

4.7.3 Untempered Martensite tends to form cracks under traffic, which leads to metal breakout and possible rail fractures.

4.8 DEFECTS.

4.8.1 The following types of rail fractures may occur if the prescribed welding procedures are not followed:

- Exothermic joint breaks right through.
- Rail breaks next to an exothermic joint.
- Crossing nose breaks.
- Wing rail breaks.
- Switch blade breaks.
- Welded up wheel-spin burn breakout.
- Breakouts, which appear on crossings, battered rail ends, wheel-spin burn repairs and switch blades.

4.9 ELECTRODES.

4.9.1 The chemical composition of electrodes determines whether the microstructure of the welding deposit will be Austenite, Pearlite or Martensite. Ensure the correct electrode is used for each process.

4.9.2 The flux coating covering the electrode contains the alloy elements that will determine the microstructure. Damaging the coating will thus have a detrimental outcome on the welding deposit.

4.9.3 Only electrodes, which have been tested and approved, may be used.

4.9.4 Electrodes approved for use are displayed in Annexure 4-2.

4.9.5 To ensure that the required welding deposit is obtained, the following shall be done:

- Electrodes shall be kept dry.
- The prescribed electrodes shall be used for specific activities (Annexure 4-2).
- The prescribed welding current shall be used; as prescribed by the manufacturer.
- The prescribed welding procedures strictly adhered to.

4.9.6 If the above-mentioned is not applied, it may cause:

- Undercutting.
- Formation of cracks such as under-bead cracking and toe cracking in the rail.
- Formation of cracks in the welding joint.
- Porosity in the welding metal.
- Metal spatter.
- Wasting of electrodes, as they will melt too quickly.

4.9.7 Only the number of electrodes that are necessary for a certain shift shall be issued.

4.9.8 Electrodes shall under no circumstances be subjected to the outlet gasses of welding machines, or come into contact with grease, oil or fuel. Electrodes shall be dried before use in suitable ovens at a temperature of at least 350°C for two hours, or 250°C, for three hours. Afterwards they shall be kept at 100°C until they are used. This process is important, as it will eliminate the hydrogen intake in the parent metal (or HAZ) just underneath the metal deposit. Electrodes shall not be dried more than three times. The flux coating will crumble when dried repeatedly.

4.10 FLUX-CORED WIRE.

4.10.1 The chemical composition of the flux-cored wire determines if the microstructure of the welding deposit will be Austenite, Pearlite or Martensite. Ensure the correct flux-cored wire is used for every process.

4.10.2 As different microstructures could be obtained during the welding process, it is of utmost importance that any previous welding deposit of unknown microstructure be removed; otherwise the required welding deposit will not be obtained. The flux core of the flux-cored wire contains the alloy elements, which will determine the microstructure. Damage to the flux will thus have a detrimental outcome on the welding deposit.

4.10.3 Only approved flux-cored wire may be used (Annexure 4-2).

4.10.4 Flux-cored wire shall always be kept dry and stored in a dry place. Flux-cored wire shall be kept in the original packaging for as long as possible before use. Exposure of flux-cored wire to the atmosphere could lead to rusting. This condition reduces the effectiveness of surface lubricating and lead to clogging of the wire feeder, supply cable or pistol (rust causes oxide inclusions). Flux-cored wire has a seam in the longitudinal direction through which moisture could also be absorbed. For this reason it shall be kept dry. The reel with the flux-cored wire shall be removed from the welding machine before the welding machine is transported.

4.10.5 Flux-cored wire shall not be left in the wire feeder overnight and over weekends, but shall be stored in a dry place and in its original packaging.

4.10.6 To obtain welds of a high quality when welding with flux-cored wire, the following points shall be observed:

- The distance between the rail and the contact tube shall be at least 30 - 35mm at all times. This influences the constant voltage.
- When welding manually, hold the welding gun at an angle of approximately 30° to the welding surface.
- When welding with semi-automatic equipment, the welding gun is held at an angle of 90° to the welding surface.

CHAPTER 5 – PRE- AND POST HEATING.

5.1 GENERAL.

5.1.1 Preheating of rails (Pearlite steel) shall be done before any welding commences. The reason for this is to prevent:

- Adverse metallurgy (Martensite formation).
- Distortion and sagging of the rail.
- Ensure inadequate fusion between molten metal and base material.
- Formation of cracks.
- Hydrogen entrapment (To give hydrogen in rails manufactured prior to 1970 enough time to escape).

5.1.2 Preheating and controlled post heating is necessary when welding is done on Chrome-Manganese rails to prevent the formation of Martensite. (Post heating is retarded controlled cooling)

5.1.3 There are three approved preheating methods.

- Oxy-propane heating.
- Heating compound (powder/block).
- Petrol-air preheating (only for exothermic casting).

5.1.4 The maximum length and depth of a wheel-spin burn to be repaired is described in Chapter 7.

5.1.5 The area to be welded shall be free of moisture and oxides that may deteriorate the quality of the final product.

5.2 PREHEATING WITH OXY-PROPANE.

5.2.1 Preheating with Oxy-LP-gas shall be done with a neutral flame.

5.2.2 The heating tip (nozzle) shall not be held closer than 100mm from the rail. The inner cone of the flame may under no circumstances reach the rail.

5.2.3 For wheel-spin burns and battered rail ends, a double-head stainless steel tip tube with two 2H preheating nozzles must be used. For crossings, a 900mm stainless steel tip tube with a 3H heating nozzle must be used.

5.2.4 The rail area to be welded shall be heated gradually on both sides by alternately moving the flame to and fro over the flange, web and crown.

5.2.5 Rails differ in composition, and for that reason it is very important to correctly identify rails to ensure that the correct heat application is made.

5.2.6 See Table 5.1 for the recommended preheat temperatures for the different rail types. These temperatures shall always be monitored by means of temperature crayons or digital thermometers.

5.2.7 Temperature crayons are available to measure different temperatures, for example 100°, 150°, 200°, 300°, 400° and 550°C.

5.2.8 Rail temperatures shall be measured on the rail surface and not on the welded bead.

5.2.9 To test for the required heat, temperature crayons of the correct temperature range shall be pulled slowly over the heated surface. When the correct temperature is reached, the crayon will melt gradually. If the work piece is overheated, the crayon will melt very quickly. It is necessary to maintain the work piece at the correct preheating temperature.

5.2.10 When extensive welding is to be done, it is necessary to repeat preheating during the welding process to maintain the minimum preheating temperature.

5.2.11 Overheating shall be avoided and under no circumstances shall the prescribed maximum temperature be exceeded. The microstructure of rail steel changes at high temperatures, which will have damaging consequences.

Table 5.1. Recommended preheat temperatures for the different rail types.

RAIL TYPE	TEMPERATURE	
	MINIMUM	MAXIMUM
HCOB	200ºC	350ºC
UIC-A	400ºC	550ºC
UIC-B	400ºC	550ºC
UIC-C	400ºC	550ºC
Cr-Mn	400ºC	550ºC
350 LHT (HH)	400ºC	550ºC
14% Mn	Ambient	200ºC

5.3 PREHEATING WITH PREHEATING COMPOUND.

5.3.1 PREHEATING POWDER.

5.3.1.1 Setting up and loading clinker formers (Figure 5.1).

5.3.1.1.1 Fit the insulating blocks to the clinker formers (the insulating blocks may be rubbed gently to fit into the clinker former).

5.3.1.1.2 Fit the appropriate clinker former to each side of the rail, centrally to the area to be welded. Each clinker former is stamped with the relevant rail mass, e.g. 60kg/m.

5.3.1.1.3 Clamp the clinker formers to the rail, using a G-clamp. The Track Welder shall ensure that the clinker formers are aligned centrally and in line with the opposite former to the area to be welded.

5.3.1.1.4 Seal off the contact area where the clinker former makes contact with the rail by applying a sealing paste.

5.3.1.1.5 The Track Welder shall visually examine the assembly prior to pouring of the preheating powder, to ensure that the insulating blocks are in position and that the clinker formers are aligned correctly.

5.3.1.1.6 Each bag contains sufficient preheating compound to fill one clinker former.

5.3.1.1.7 The Track Welder shall blend each bag of preheating compound to ensure that the bag content is uniform.

5.3.1.1.8 The Track Welder shall slowly pour the contents of the bag into the clinker formers.

5.3.1.1.9 The Track Welder shall during the pouring of the preheating compound visually check the underside and sides of the clinker former to ensure that there are no run-outs.

5.3.1.1.10 The Track Welder shall stop pouring the preheating compound if the preheating compound leaks and seal the area of leakage.

5.3.1.1.11 Each clinker former shall be filled to the top.

5.3.1.1.12 Place two starter blocks in the preheating compound on each side of the rail. The top of each starter block must be exposed.

5.3.1.1.13 The ignition hole of the starter block shall face upwards and may not be covered with preheating compound, as this will affect ignition.

5.3.1.1.14 Any preheating compound shall be removed from the rail surface.

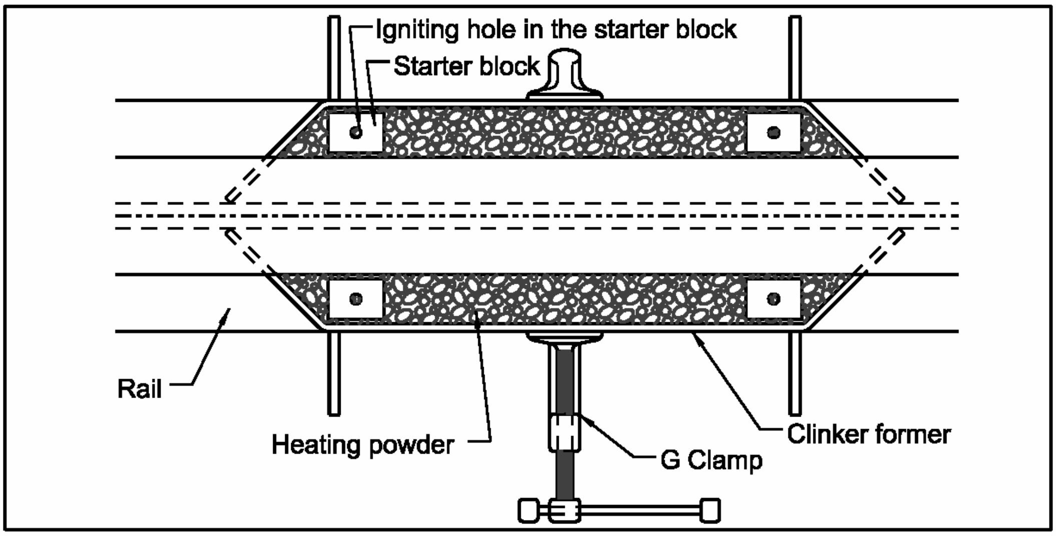

Figure 5.1. Position of Clinker Former

5.3.1.2 Igniting the preheating powder.

5.3.1.2.1 Start the preheating process by lighting the four starter blocks using igniters.

5.3.1.2.2 Cover the rail crown with an insulating material for at least 6 minutes as soon as the preheating powder has burnt out, to ensure that the correct temperature is reached before welding commences.

5.3.1.2.3 The total welding time may not exceed 10 minutes.

5.3.1.2.4 If the welding time on Cr-Mn rails exceeds 10 minutes, welding shall be stopped, the welded area covered with insulating material and the rail allowed to cool down to ambient temperature, after which another preheating powder kit shall be used.

5.3.1.2.5 Preheating using preheating powder kit on Cr-Mn rails are preferred to gas heating method.

5.3.1.2.6 Clinker formers shall be left in position for at least 30 minutes after welding is completed.

5.3.1.2.7 A wheel-spin burn may be heated with a single pair of clinker formers. When a wheel-spin burn is longer than 150mm, it shall be treated as two separate wheel-spin burns. The second half may only be treated when the rail has reached ambient temperature.

5.3.1.3 Cleaning of the rail.

5.3.1.3.1 After the welded area and rail has cooled down for 30 minutes under the insulating blanket, the clinker formers must be removed.

5.3.1.3.2 After the welded area has cooled to ambient temperature, all the burned powder on both sides of the rail shall be removed with a wire brush.

5.3.1.3.3 The clinker formers can be cooled under running water once they have been removed from the rail using a hammer and chisel to clean the clinker former.

5.3.2 PREHEATING BLOCKS.

5.3.2.1 Setting up heating blocks (Figure 5.2).

5.3.2.1.1 Fit the appropriate heating block to each side of the rail, centrally to the area to be welded. Each heating block is stamped with the relevant rail mass, e.g. 60kg/m.

5.3.2.1.2 Fit the steel plates on either side of the heating blocks to prevent damage to the heating blocks by the G-clamp.

5.3.2.1.3 Clamp the steel plates and heating blocks to the rail, using a G-clamp, centrally to the heating blocks, without excessive force.

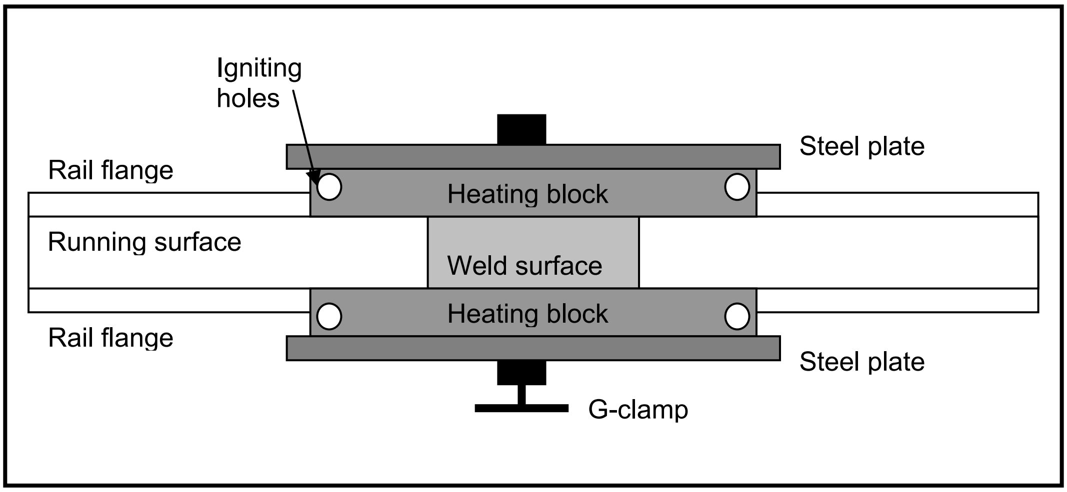

Figure 5.2. Position of Heating Blocks

5.3.2.2 Igniting the preheating blocks.

5.3.2.2.1 Ignite the heating blocks through all four igniting holes (one after the other in quick succession), using igniters, to start the preheating process.

5.3.2.2.2 Cover the rail crown with an insulating material for at least 6 minutes as soon as the preheating blocks have burnt out, to ensure that the correct temperature is reached before welding commences.

5.3.2.2.3 The total welding time may not exceed 10 minutes.

5.3.2.2.4 If the welding time on Cr-Mn rails exceeds 10 minutes, welding shall be stopped, the welded area covered with insulating material and the rail allowed to cool down to ambient temperature, after which the preheating process shall be repeated.

5.3.2.2.5 Preheating using preheating blocks on Cr-Mn rails are preferred to gas heating method.

5.3.2.2.6 Preheating blocks shall be left in position for at least 30 minutes after welding is completed.

5.3.2.2.7 A wheel-spin burn may be heated with a single pair of heating blocks. When a wheel-spin burn is longer than 150mm, it shall be treated as two separate wheel-spin burns. The second half may only be treated when the rail has reached ambient temperature.

5.3.2.3 Cleaning the rail.

5.3.2.3.1 After the welded area and rail has cooled down for 30 minutes under the insulating blanket, the heating blocks must be removed.

5.3.2.3.2 After the welded area has cooled to ambient temperature, both sides of the rail shall be cleaned with a wire brush.

5.3.2.3.3 The steel plates can be cooled under running water once they have been removed from the rail.

5.4 PREHEATING WITH A PETROL-AIR UNIT.

5.4.1 This method will only be used with exothermic casting (See Manufacturer’s Operating Instructions).

5.5 POST-HEAT TREATMENT (RETARDED COOLING) USING OXY-PROPANE.

5.5.1 Retarded cooling is done to delay the cooling rate, and shall be commenced immediately after welding is completed.

5.5.2 Retarded cooling is a prerequisite when welding the following rail grades:

- Cr-Mn.
- UIC-C.
- 2MCC.

5.5.3 If the temperature in the rail drops to below 550ºC after welding work is completed, the welded area and the heating zone shall be heated to 550ºC and kept at that temperature for 8 minutes to prevent the forming of Martensite in the parent metal.

5.6 PREHEATING AND POST HEATING IN EXOTHERMIC CASTING.

5.6.1 Refer to Chapter 11.

CHAPTER 6 – PREVENTATIVE GRINDING.

6.1 GENERAL.

6.1.1 Metal flow is caused by interaction between wheel and rail.

6.1.2 Preventative grinding shall be done to extend the life span of track components.

6.1.3 Overlaps shall under no circumstances be removed by means of gas cutting.

6.1.4 Signalling staff shall be present when overlap grinding is done at switch blades and block joints. This enables safe working arrangements with CTC to switch blades in + or - position.

6.1.5 Protection for safe passage of trains shall be provided in accordance with Spoornet General Appendix No. 6 (Part 1) when preventative grinding is done on track.

6.2 GRINDING AND CUTTING EQUIPMENT.

6.2.1 A MC2 grinding machine with a harder grid grinding stone shall be used to remove the overlap and restore a 13mm radius. A 1:20 contour gauge with 13mm radius shall be used to monitor grinding standard.

6.2.2 An angle grinder with a 3mm cutting disc shall be used to open up splices, dovetails and expansion gaps.

6.2.3 A flap disc shall be used to remove metal flow scales on the rail crown.

6.3 GRINDING OF CROSSINGS.

6.3.1 GENERAL: CROSSINGS.

6.3.1.1 Remove overlaps and obtain a 13mm radius on the gauge corner on the following crossing components:

- Guard stock rail.
- Switch blades full bearing against the crown.
- Rails in a curve on low leg at welding activities.
- Closure rails in sets (turnouts, slips and diamond crossings).
- Insulated rail joints and all fishplate joints.
- Wing rails and nose.

6.3.1.2 Grind all metal flow and sharp edges on undercut profile of stock rail, and a 13mm radius from the trailing end of undercut for a length of 1.5m.

6.3.1.3 Remove any metal flow or sharp edges on the inside of switch blade, which fits to the stock rail, with an angle grinder.

6.3.1.4 After grinding work is completed, dye penetrant shall be used to check for any cracks that may have developed.

6.3.1.5 The planning staff shall indicate whether a Signals Technician is required to assist with switch blade repairs. E.g., where excess metal flow occurs and resetting of the set of points needs to be done.

6.3.1.6 Remove metal flow and flakes occurring on the running surface of the stock rail where train wheels transfer from switch blade to stock rail.

6.3.1.7 It is necessary to mark out dimensions with boilermaker's chalk, prior to grinding to ensure accurate grinding.

6.3.2 RAIL-MANUFACTURED CROSSINGS.

6.3.2.1 Cut a groove at 45° angles, 5mm deep between point and splice rail using an angle grinder with 3mm cutting disc.

6.3.3 RAIL-BOUND CROSSINGS.

6.3.3.1 Cut a groove at 45° angles, 5mm deep between splice rail and the casting insert (dove-tail) using an angle grinder with 3mm cutting disc.

6.3.3.2 Grind the total length between casting and connecting rails at 45° angles.

6.3.3.3 Grind a recess at the trailing side of the crossing (dovetail), no less than 5mm deep and 400mm in length in the direction of the nose, to accommodate false wheel flanges (Annexures 14-1 and 14-2; Indicated in Yellow). Use a MC2 grinding machine to grind these recesses. Grind away metal flow on the casting.

6.3.3.4 Restore the 1:20 cant as well as the gauge corner 13mm radius by means of grinding where sharp edges have formed.

6.3.3.5 The cast-insert-connection-with-splice-rail (dovetail) running surface, on both sides of the nose, shall be measured with a 1m straightedge and maintained in such a manner that it ensures smooth passage of trains.

6.3.3.6 All metal flow/flakes that may form on the cast wing shall be removed to provide a sound metal surface.

6.3.4 MONOBLOCK (14% MN) CROSSINGS.

6.3.4.1 Grind a recess at the trailing side of the crossing (dovetail), no less than 5mm deep and 400mm long in direction of the nose, to accommodate false wheel flanges and prevent metal flow (Annexure 13-1; Indicated in Yellow). Use a MC2 grinding machine to grind these recesses.

6.3.4.2 All sharp edges shall be restored to a 13mm radius.

6.3.4.3 All metal flow/flakes that may form on the cast wing shall be removed to provide a sound metal surface.

6.4 RAIL ENDS AND INSULATED RAIL JOINTS.

6.4.1 Expansion gaps shall be repaired before metal flow exceeds 2mm.

6.4.2 A cutting disc shall be positioned in such a manner, that both sides of the expansion gap are square after cutting and 10mm deep.

6.4.3 Metal flow at insulating joints shall be repaired in the presence of a Signals Technician, due to following procedural factors:

- The insulating T-piece consisting of two parts, to be removed and replaced.
- Metal flakes and grinding sparks may cause short circuits.

6.5 STANDARDS AND TOLERANCES.

6.5.1 Standards and tolerances as prescribed Chapters 7 to 14 of this manual shall be complied with once preventative grinding is completed.

CHAPTER 7 – REPAIRING WHEEL-SPIN BURNS.

7.1 GENERAL.

7.1.1 Wheel-spin burns (skid marks) are caused by stationary or near stationary locomotive traction wheels, which rotate faster than the actual movement of the locomotive.

7.1.2 Metal breakouts from the rail crown at wheel-spin burn locations and surface defects are aggravated as result of the dynamic impact caused by traversing wheels.

7.1.3 Wheel-spinning induces heat to the rail at a very high rate. A small area is affected during wheel-spinning, resulting in rapid cooling and the microstructure of the rail transforming to Martensite.

7.1.4 Martensite is a very hard and brittle microstructure. Hairline cracks develop resulting in breakouts and surface defects.

7.1.5 The importance of the removal of wheel-spin burns is dependent on various factors:

- type of rail
- axle mass
- type of traffic
- speed
- tonnage
- depth of the wheel-spin burns.

7.2 INSPECTION AND DECISION-MAKING.

7.2.1 The Depot Engineer shall lay down a policy for his Depot regarding the repair of wheel-spin burns.

7.2.2 The workload of wheel-spin burns shall be determined either by foot or trolley inspections.

7.2.3 Prioritising and planning shall be done in conjunction with track maintenance staff.

7.2.4 Wheel-spin burns up to 1mm deep may be repaired by grinding alone. Wheel-spin burns deeper than 1mm shall be repaired by grinding and welding.

7.2.5 Wheel-spin burns deeper than 6mm shall preferably be replaced by inserting a closure rail.

7.2.6 Where more than two wheel-spin burns appear within 1m on the same rail, the welding process shall be performed using a staggered method irrespective of the preheating method used.

7.3 PROTECTION.

7.3.1 The Track Welder shall ensure that protection is applied in accordance with Spoornet General Appendix No 6 (Part 1) before repair work is commenced.

7.3.2 Wheel-spin burns may be repaired between trains or under total occupation.

7.4 FIRE PREVENTION.

7.4.1 Safety aspects regarding fire prevention shall be adhered to at all times (Chapter 2).

7.5 PREPARATION.

7.5.1 PREPARATION BY TRACK PERSONNEL.

7.5.1.1 The following preparation work, as described in the Manual for Track Maintenance (2000), shall be done by Track Personnel before welding work commences:

- Slacks, which were caused by wheel-spin burns, shall be lifted out and tamped.
- Fasteners shall be loosened and the rail pads shall be removed from the sleepers over a distance of 1.2m on both sides of the wheel-spin burns to be repaired. (Rail pads to be removed to avoid damage during preheating).
- The minimum distance of loosened sleepers is important to allow counter sagging of the rail when preheated.
- Damaged sleepers, worn and round ballast shall be replaced.

7.5.2 PREPARATION BY WELDING PERSONNEL.

7.5.2.1 All foreign materials, such as grease, oil, rust, etc. in the direct vicinity of wheel-spin burns shall be removed by using a chipping hammer and a steel brush.

7.5.2.2 All loose metal and cracks of the wheel-spin burn shall be removed by using a MC2 grinding machine.

7.5.2.3 Dye penetrant shall be used to ensure all defects have been removed. The surface to be tested shall be cleaned thoroughly with a steel brush.

7.6 GRINDING PROCESSES.

7.6.1 All loose metal and hairline cracks shall be removed with a MC2 grinding machine, before any welding work is done.

7.6.2 Removing undesired metal from the crown using a grinding machine shall commence at the longitudinal centre of the wheel-spin burn, progressing transversely across the rail crown until all cracks and loose metal are removed. The same process shall then be repeated on the other side/half of the wheel-spin burn.

7.6.3 All overlaps as well as previous welding material shall be removed by grinding,

7.6.4 If a wheel-spin burn is present on a previously repaired wheel-spin burn location, grinding shall be done to a depth of at least 3mm or until all defects have been removed. This will ensure that all defects have been removed including:

- Slag inclusion.
- Undercutting.
- Porosity.

7.6.5 Slight pressure shall be applied during grinding work. It shall be ensured that grinding stones are not damaged or clogged with fine steel. The use of damaged grinding stones could be fatal.

7.6.6 If grinding is required to a depth of greater that 12mm, track personnel shall be approached to decide whether the passage of trains is safe.

7.7 PREHEATING.

7.7.1 Preheating of different types of rail, either by means of gas flame or heating powder shall be done strictly in accordance with Chapter 5.

7.7.2 Preheating shall be done in an inverted V shape on both sides of the rail, beginning 50mm either side of the welding surface on the crown, progressing downwards to the flange and ending 150mm either side of the welding surface (Figure 7.1). This method will counteract sagging caused by heat induced by:

- Wheel-spinning.

- Grinding out loose metal.
- Preheating on running surface.
- Rough and final grinding.

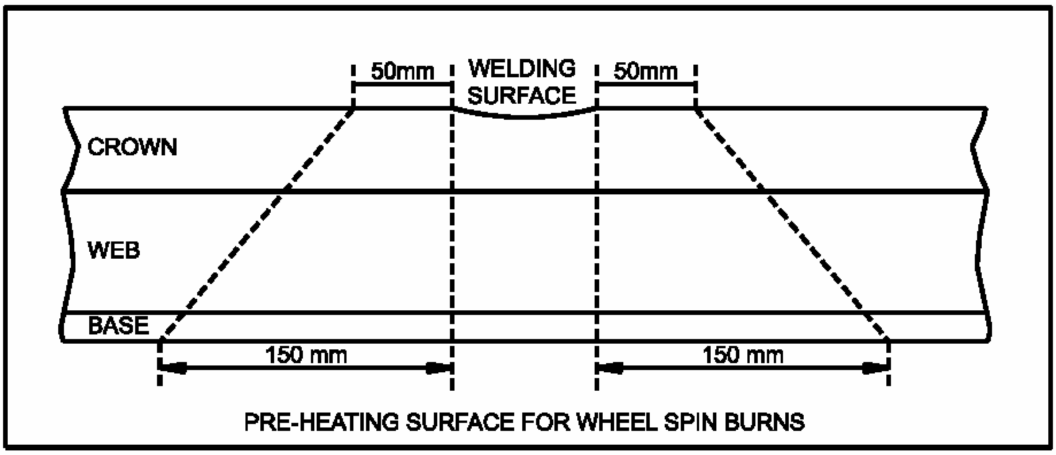

Figure 7.1. Oxy-Propane Preheating Area.

7.8 HEATING POWDER PROCESS.

7.8.1 Wheel-spin burns shall be repaired under total track occupation conditions when heating powder is used.

7.8.2 A wooden block shall be placed underneath the rail at the wheel-spin burn. (Wooden block may be a portion of timber sleeper approximately 500mm in length). A steel plate, 150mm x 150mm x 20mm with insulation material shall then be placed on the wooden block to lift the rail. Steel wedges shall be used between the wooden block and the steel plate to strain the rail (Figure 7.2). This method will counteract sagging.

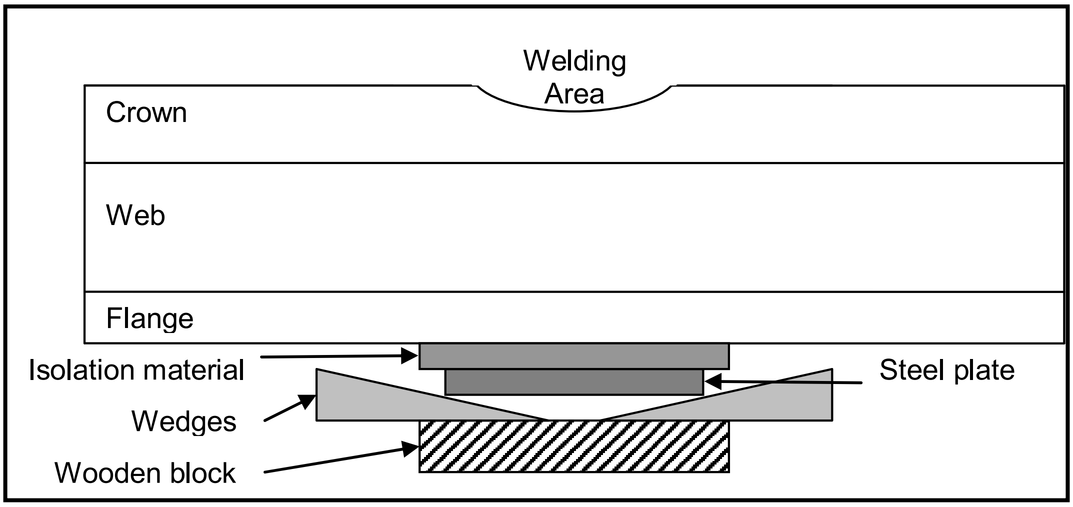

Figure 7.2. Rail Lifting Setup.

7.9 WELDING PROCESSES.

7.9.1 GENERAL.

7.9.1.1 Employees and the public shall be protected against the danger of arc flashes, which may cause arc-eyes.

7.9.1.2 No welding shall be done in rain or fog.

7.9.1.3 Welding cables shall be unwound completely before welding work commences, to avoid inconsistent polarity changes and damage to electronic components.

7.9.1.4 The earth-cable of the welding machine shall be fitted with a suitable clamp and shall be clamped next to the welding area, to prevent short circuits as well as loss of current.

7.9.1.5 The welding-arc length shall be kept as short as possible - approximately the core thickness of the electrode that is used for welding.

7.9.1.6 Welding beads on all types of rails may not be longer than 150mm to control the heat. Welding beads shall be deposited in such a manner that one bead overlaps the other. Welding deposits shall be cleaned directly after being deposited.

7.9.1.7 Every welding bead shall be peened softly with the ball of a 1kg hammer to relieve internal stresses, which could lead to future defects.

7.9.1.8 If cracks, porosity, undercutting, grooves, cavities or slag inclusions appear in the welding work, the entire defect shall be removed by means of grinding.

7.9.1.9 Welding repair of wheel-spin burns can be done by means of manual metal arc welding (MMAW, a constant current (CC) process), or flux-cored arc wire (FCAW, a constant voltage (CV) process).

7.9.1.10 Weaving welding method by means of manual metal arc welding or flux-cored arc welding is not permitted, except in the case of semi-automatic processes. The staggered method shall be used with manual metal arc welding or flux-cored arc welding processes. The staggered method for wheel-spin burn repair is described below:

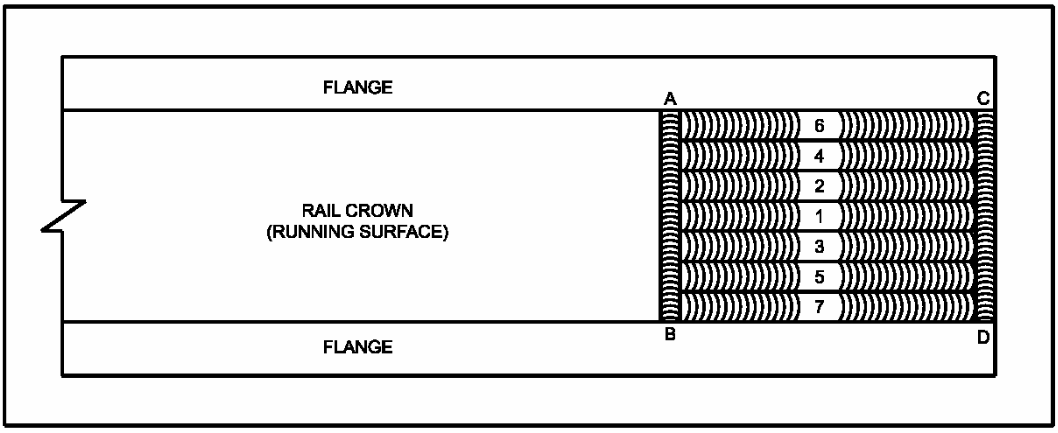

Figure 7.3. Staggered welding method for wheel-spin burns (except for semi-automatic welding processes).

(a) Weld beads AB and CD transversely at the ends of the grinding area.

(b) Weld beads 1 at the centre of the rail crown from AB to CD.

(c) Weld bead 2 next to bead 1, on the left side of bead 1, from AB to CD.

(d) Weld bead 3 next to bead 1, on the right side of bead 1, from AB to CD.

(e) Weld bead 4 next to bead 2, and bead 5 next to bead 3, and so forth.

(f) Follow this pattern until the full width of the crown has been welded.

7.9.2 SEMI-AUTOMATIC WELDING.

7.9.2.1 See Road Rail Welding Vehicle Manual as well as manufacturer’s guidelines for the semi automatic procedures.

7.10 RETARDED COOLING (POST HEATING).

7.10.1 Retarded cooling shall be done as set out in Chapter 5.

7.11 ROUGH GRINDING AND FINAL GRINDING.

7.11.1 An MC2 grinding machine shall be used to rough grind wheel-spin burns. An MP12 grinding machine shall be used to final grind wheel-spin burns to obtain a sound profile. Excess welding deposits on the gauge corner, running side and field side of the crown, shall be removed by grinding.

7.11.2 Rough grinding on chrome-manganese rails shall be done after retarded cooling is completed.

7.11.3 Final grinding shall be done after the sleepers on either side of the work place have been tamped and the rail has cooled down to ambient temperature.

7.11.4 Before final grinding is done, the rail pads shall be in position and the fasteners shall be secured.

7.11.5 A train may pass over the work place when:

- The rail has cooled to 300ºC or lower.
- The wooden blocks and steel wedges have been removed.
- The track has been made safe for the passage of trains.

7.12 STANDARDS AND TOLERANCES.

7.12.1 Welding deposits shall be removed by grinding until it matches the rail profile adjacent to the repaired wheel-spin burn. Grooves, ripples, or undercuts may not be present in the rail profile after grinding.

7.12.2 Grinding shall be done in such a manner that a 0.2mm feeler gauge may not enter underneath a 1m straightedge placed on the running surface of the rail. Only a gradual curvature is permissible.

7.12.3 The following details shall be written with yellow chalk (sufficient to remain visible for at least 3 months) on the rail web adjacent the welded area:

- Sequence number of the wheel-spin burn, beginning at zero at the beginning of each financial year for each Transnet Freight Rail welder, and beginning at zero at the beginning of each day for each contractor welding team.
- Welder code (Transnet Freight Rail welders and contractor welders). Transnet Capital Projects' welders will be allocated codes starting with PR and sub-contractors' welders will be allocated codes starting with C.
- Date welded (Transnet Freight Rail welders and contractor welders).
- All daily work performed shall be logged on the prescribed field sheet, Annexure 1-8 for Transnet Freight Rail welders and approved field sheets for Transnet Capital Projects welders and sub-contractors.

7.12.4 The Technical Superintendent/Supervisor or his representative shall examine all welding work, and a report shall be submitted to the Depot Engineer.

CHAPTER 8 – REPAIRING BATTERED RAIL ENDS.

8.1 GENERAL.

8.1.1 Rails are joined by means of fishplates and bolts. When trains traverse a joint, continuous hammering of train wheels damages the two adjoining rail ends. These damaged rail ends are called battered rail ends and can be repaired by means of welding and grinding (Figure 8.1).

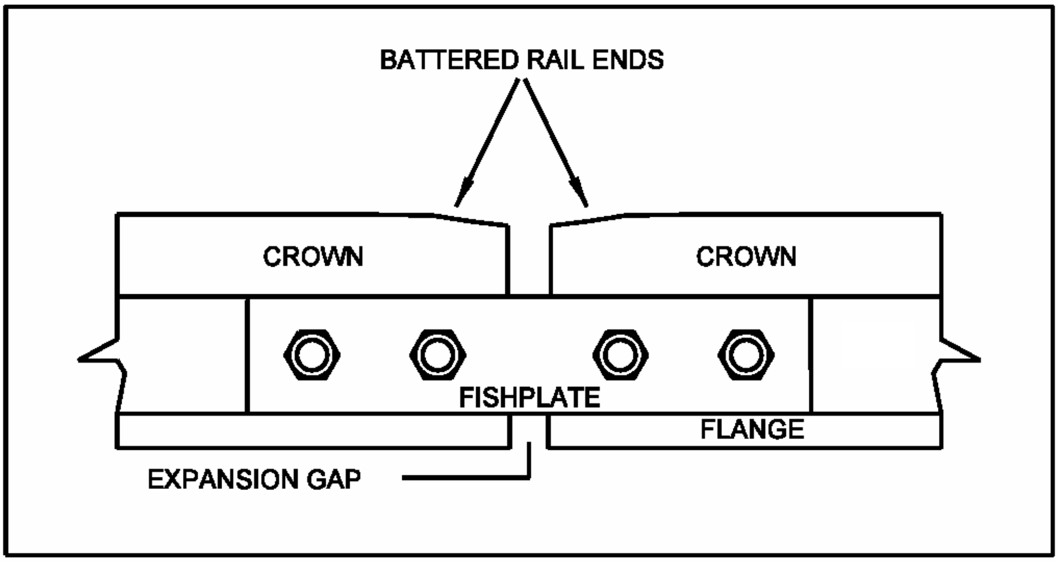

Figure 8.1. Typical battered rail ends.

8.2 INSPECTION AND DECISIONS MAKING.

8.2.1 The workload of battered rail ends shall be determined either by foot or trolley inspections.

8.2.2 The repair of battered rail ends by means of welding work shall be considered when the battering reaches 1mm in depth.

8.2.3 Dips on battered rail ends appear when train wheels have hammered fishplate joints to such an extent that the rail ends are bent downwards. Dipped rail ends shall be cropped (or bent upwards with a vertical Jim-crow) before preparation and welding work commences (Figure 8.3).

8.2.4 Rail ends shall be measured separately on the running surface with a 1m straightedge to determine where the dipped or bent ends start. Bent ends of 2mm or more shall be cropped.

8.2.5 Battered rails ends at fishplated joints with height differences of up to 6mm on yard lines (as classified in the SAP system) with speed restrictions of up to 30km/h may be repaired by welding and grinding as opposed to installing closure rails.

8.2.6 For yard lines the repair process shall be as follows. The higher rail shall be grinded down gradually to 1.5mm over a length of 250mm and the lower rail shall be welded up gradually to match the higher rail (max 4.5mm) over a length of 750mm, which will render a gradual incline of maximum 6mm over a length of 1m.

8.2.7 The relevant maximum height difference limit for main lines and station lines is 3mm. For main lines and station lines the repair process shall be as follows. The higher rail shall be grinded down gradually to 1.5mm over a length of 250mm and the lower rail shall be welded up gradually to match the higher rail (max 1.5mm) over a length of at 750mm, which will render a gradual incline of maximum 3mm over a length of 1m.

8.2.8 MARKING-OFF PROCEDURE WHERE MISMATCHES OCCURE.

8.2.8.1 Rails shall be measured for mismatches by placing a 1m straightedge evenly over the expansion gap of the rails.

8.2.8.2 If rails differ in height, the straightedge shall be placed on the higher rail and pressed down firmly by hand onto the running surface. The gap between the straightedge and the lower rail running surface shall be measured 450mm from the lower rail end (Figure 8.2).

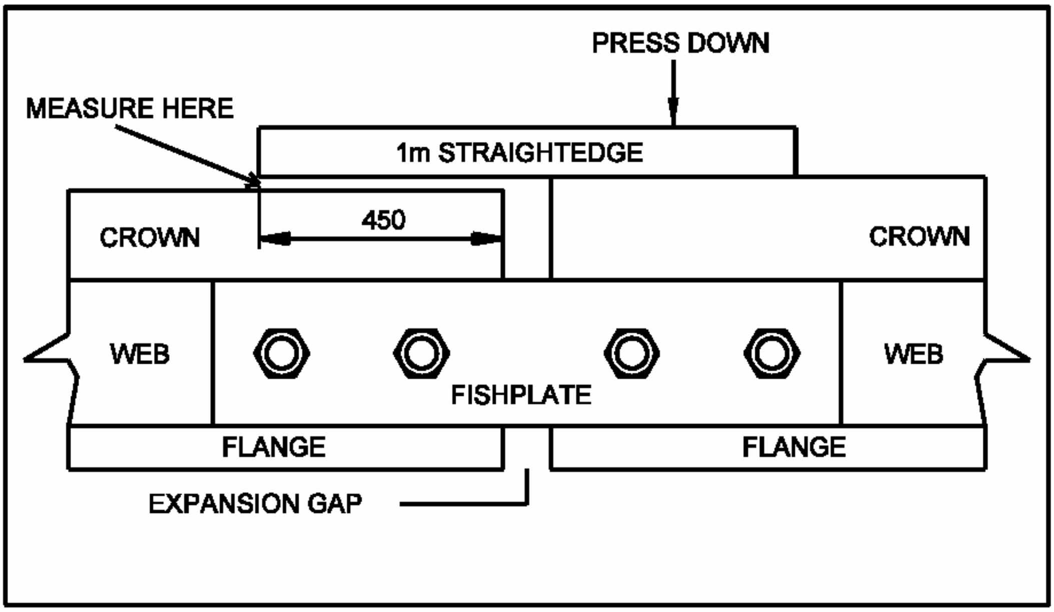

Figure 8.2. Measuring for mismatches.

8.2.8.3 IMPORTANT: If a mismatch exceeds 3mm, one of the rails shall be replaced with a suitable closure rail.

8.2.9 It is prohibited to cast an exothermic joint where battered rail ends were repaired previously by open-arc welding.

8.2.10 Boltholes in the rail web shall be examined for cracks using dye penetrant after the fishplates have been removed.

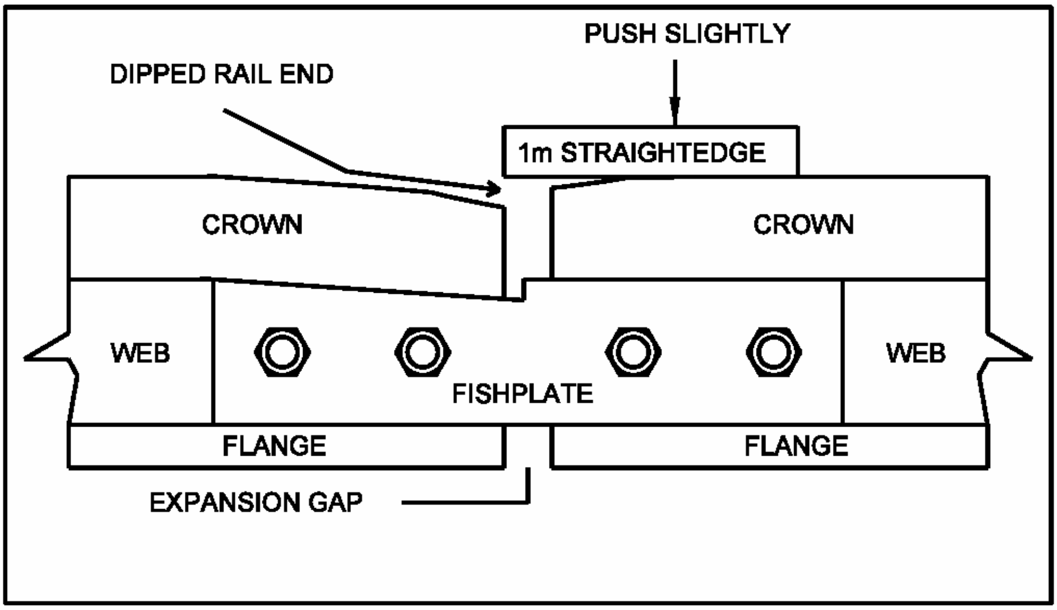

Figure 8.3. Identification of dips on battered rail ends.

8.3 PROTECTION.

8.3.1 Protection shall be afforded in accordance with Spoornet General Appendix No 6 (Part 1) when battered rail ends are repaired.

8.3.2 Repairs to battered rail ends can be done between trains or under total occupation.

8.4 SAFE WORKING PROCEDURES.

Refer to Chapter 2.

8.5 PREPARATION.

8.5.1 PREPARATION BY TRACK PERSONNEL.

8.5.1.1 Preparation work described in the Manual for Track Maintenance (2000) shall be done before welding work commences.

8.5.1.2 Jumper cables shall be fitted to ensure electrical continuity in the rails.

8.5.1.3 Fishplates, rail pads and soleplates shall be removed before welding of rail ends commences. Grease and foreign matter shall be removed from the fishplate mating surfaces at the rail ends and the surfaces brushed clean.

8.5.1.4 The following shall be checked during preparation:

- Dipped ends removed.
- Wear on fishplates.
- Wear on rail crown.
- Condition of bolts, nuts and spring washers.
- Presence of oval or cracked bolt holes.
- Correct expansion gaps.
- Sleeper condition and spacing.
- Enough ballast stone.
- Sleeper fasteners are tight.

8.5.1.5 The following shall be done after welding:

- Fishplates cleaned.
- Fishplates greased.
- Fishplates transposed.
- Fishplates replaced (if required).
- All bolts tightened (torque).

8.5.2 PREPARATION BY WELDING PERSONNEL.

8.5.2.1 The Track Welder shall identify the rail correctly to apply the correct repair procedure.

8.5.2.2 After rail ends are cleaned, visual inspection shall be done and dye penetrant shall be used to test for cracks and other defects.

8.5.2.3 All bumps and humps shall be removed by grinding before marking-off the area to be welded.

8.5.2.4 Battered rail ends shall first be marked-off before welding. The surface shall then be evaluated to decide whether welding or grinding is required.

8.5.2.5 The process for measuring the welding area is as follows: Place a 0.5m straightedge on the running surface of the rails, with the one end of the straightedge lapping 6mm over the opposite end. Mark with yellow chalk where light stops shining through underneath the straightedge to determine the length to be welded. Repeat the same process on the opposite rail end (Figure 8.4).

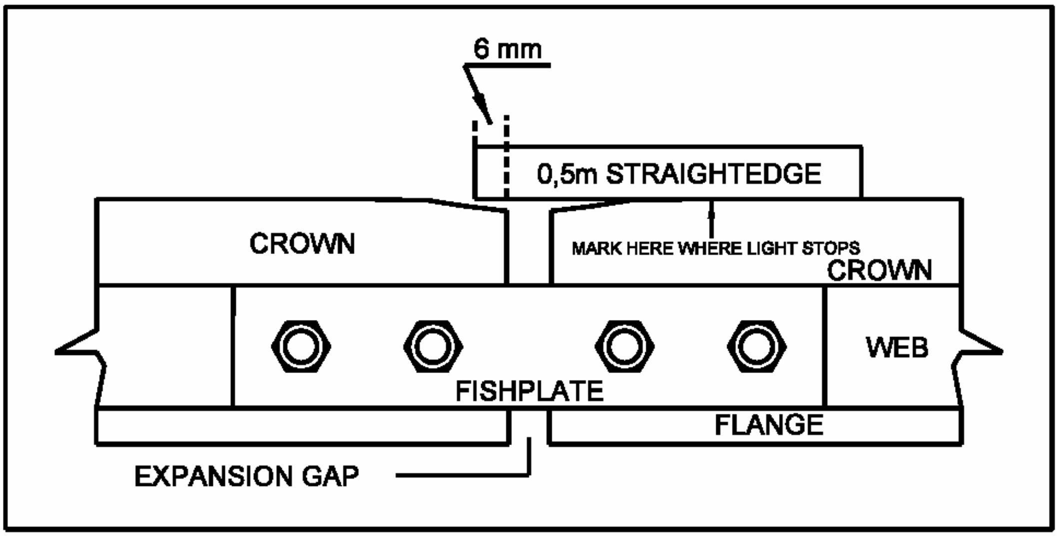

Figure 8.4. Measuring welding area on battered rail ends.

8.6 GRINDING PROCESS.

8.6.1 Before any welding work can take place the following shall be removed using a MC2 grinding machine:

- Loose and work-hardened metal.
- Hairline cracks.
- Overlaps.
- Old welding material.

8.6.2 This will ensure that all defects have been removed including:

- Slag inclusions.
- Undercutting.
- Porosity.

8.6.3 Dye penetrant shall be used to ensure that all defects have been removed. The surface to be tested shall be thoroughly cleaned with a steel brush.

8.6.4 Slight pressure shall be applied during grinding. It shall be ensured that grinding stones are not damaged or clogged with fine steel. Using damaged grinding stones could be fatal.

8.6.5 If grinding is required to a depth of greater that 12mm, track personnel shall be approached to decide whether the passage of trains is safe.

8.7 PREHEATING.

8.7.1 Heating of the different types of rails, either by means of gas or heating powder, shall be done strictly according to Chapter 5.

8.7.2 Preheating shall be done up to 50mm either side of the welding area on the crown, web and flange (Figure 8.5). This will induce an even spread of heat in the rail.

8.7.3 The rail shall be preheated to the prescribed temperature before welding commences.

8.7.4 Each rail end shall be preheated and welded separately (Figure 8.5).

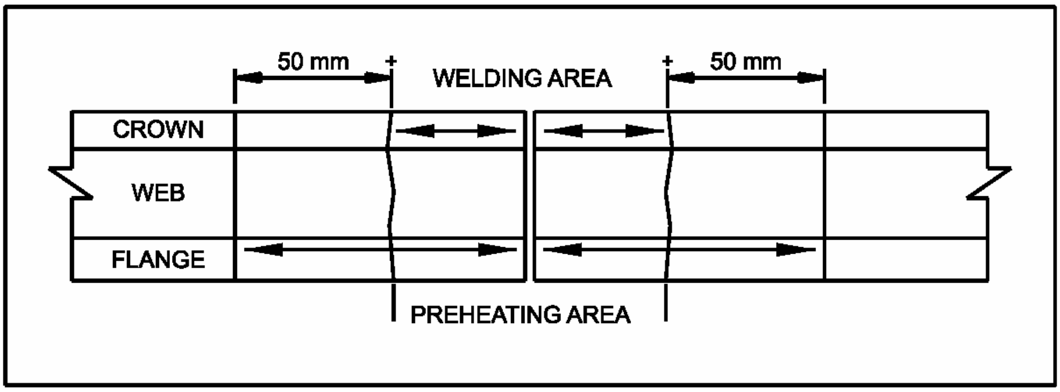

Figure 8.5. Preheating area.

8.8 WELDING PROCESSES.

8.8.1 GENERAL.

8.8.1.1 Employees and the public shall be protected against the danger of arc flashes, which may cause arc-eyes.

8.8.1.2 No welding shall be done in rain or fog.

8.8.1.3 Welding cables shall be unwound completely before welding work commences, to avoid inconsistent polarity changes and damage to electronic components.

8.8.1.4 The earth-cable of the welding machine shall be fitted with a suitable clamp and shall be clamped next to the welding area, to prevent short circuits as well as loss of current.

8.8.1.5 The welding-arc length shall be kept as short as possible - approximately the core thickness of the electrode that is used for welding.

8.8.1.6 Welding beads on all types of rails may not be longer than 150mm to control the heat. Welding beads shall be deposited in such a manner that one bead overlaps the other. Welding deposits shall be cleaned directly after being deposited.

8.8.1.7 Every welding bead shall be peened softly with the ball of a 1kg hammer to relieve internal stresses, which could lead to future defects.

8.8.1.8 If cracks, porosity, undercutting, grooves, cavities or slag inclusions appear in the welding work, the entire defect shall be removed by means of grinding.

8.8.1.9 Welding repair of battered rail ends can be done by means of manual metal arc welding (MMAW, a constant current (CC) process), or flux-cored arc wire (FCAW, a constant voltage (CV) process).

8.8.1.10 Weaving welding method by means of manual metal arc welding or flux-cored arc welding is not permitted, except in the case of semi-automatic processes. The staggered method shall be used with manual metal arc welding or flux-cored arc welding processes. The staggered method is described below:

8.8.1.11 NB: Different repair scenarios on battered rail ends shall be treated as follows:

- Both rail ends measured with 0.5m straightedge will indicate welding length required. Where the light stops shining through underneath the straightedge.
- One rail end measured with 0.5m straightedge will indicate welding length where light stop shining through underneath the straightedge, the other end will indicate no welding required, treat as prescribed in Figure 8.6.

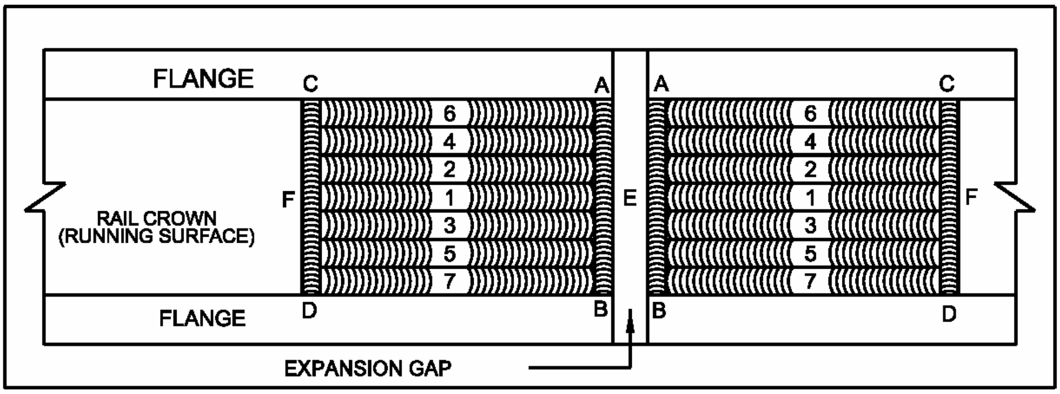

Figure 8.6. Staggered welding method for battered rail ends (except for semi-automatic welding processes).

The staggered method for battered rail end repair is described below:

(a) Weld beads AB and CD transversely at the ends of the grinding area.

(b) Weld bead 1 (i.e. EF) at the middle of the rail crown from AB to CD.

(c) Weld bead 2 next to bead 1, on the left side of bead 1, from AB to CD.

(d) Weld bead 3 next to bead 1, on the right side of bead 1, from AB to CD.

(e) Weld bead 4 next to bead 2, and bead 5 next to bead 3, and so forth.

(f) Follow this pattern till the full width of the crown has been welded.

8.8.2 Where battered rail ends are repaired, both rail ends shall have a hard-facing surface of at least 70mm long x 3mm deep.

8.9 RETARDED COOLING (POST HEATING).

8.9.1 Retarded cooling shall be done as set out in Chapter 5.

8.10 ROUGH GRINDING.

8.10.1 Rough grinding shall commence on the running surface and rail end as soon as possible after welding. The welding area shall then be allowed to cool down to ambient temperature and track personnel shall do final fettling as indicated in the Manual for Track Maintenance (2000).

8.11 CUTTING EXPANSION GAPS.

8.11.1 Metal protruding from expansion gaps shall be removed as soon as possible after welding work, as expansion gaps can close and cause fractures. A wedge shall be placed in the expansion gap on the base to prevent the joint from closing when cutting takes place.

8.11.2 The width of the expansion gap is measured at the bottom of the rail crown. The correct cutting disc (3mm) shall be used (Annexure 27 of the Manual for Track Maintenance (2000)).

8.11.3 The cutting disc shall be positioned in such a way, that both sides of the expansion gap are cut square. The expansion gap shall be cut 10mm deep, or through the deposited metal, whichever is the deepest (Figure 8.7).

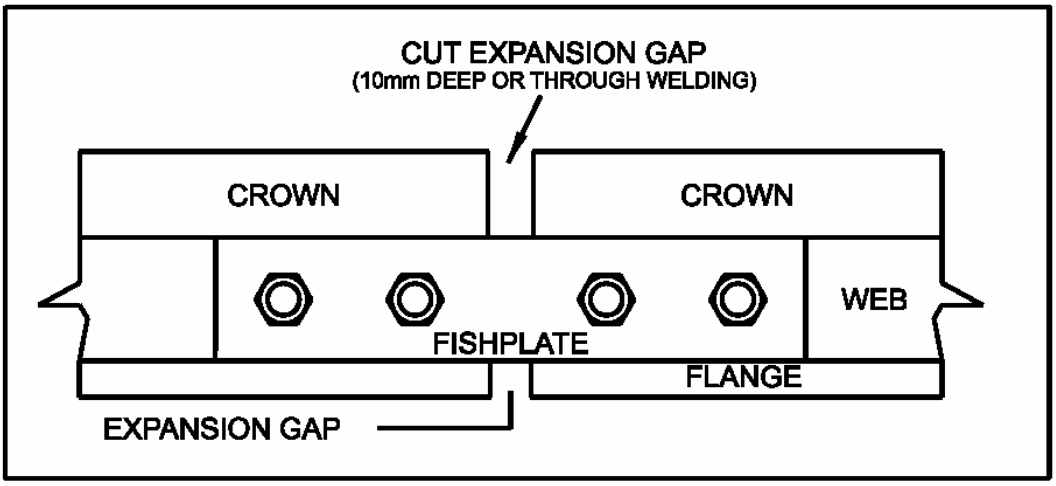

Figure 8.7. Cutting of expansion gaps.

8.12 FINAL GRINDING.

8.12.1 Final grinding shall be done after the sleepers on both sides of the working place have been tamped and the joint has cooled to ambient temperature.

8.13 STANDARDS AND TOLERANCES.

8.13.1 Welding deposits shall be removed by grinding until it matches the rail profile adjacent to the repaired battered rail ends. Grooves, ripples, or undercuts may not be present in the rail profile after grinding.

8.13.2 Grinding shall be done in such a manner that a 0.2mm feeler gauge may not enter underneath a 0.5m straightedge placed on the running surface of the rail (Figure 8.8).

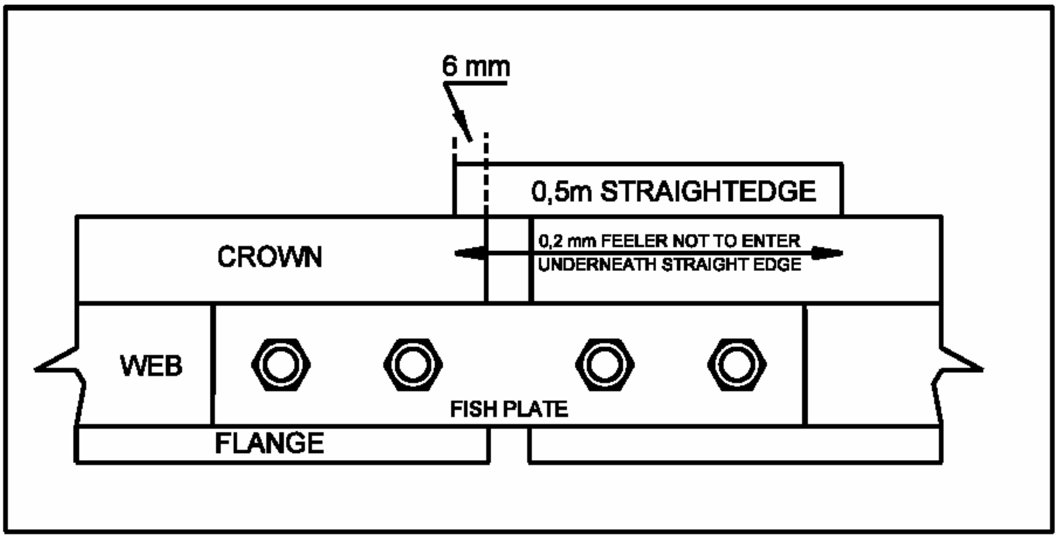

Figure 8.8. Tolerances for battered rail end repairs.

8.13.3 The following details shall be written with yellow chalk (sufficient to remain visible for at least 3 months) on the rail web adjacent the welded area:

- Sequence number of the battered rail ends, beginning at zero at the beginning of each financial year for each Transnet Freight Rail welder, and beginning at zero at the beginning of each day for each contractor welding team.
- Welder code (Transnet Freight Rail welders and contractor welders). Transnet projects' welders will be allocated codes starting with PR and sub-contractors' welders will be allocated codes starting with C.
- Date welded (Transnet Freight Rail welders and contractor welders).
- All daily work performed shall be logged on the prescribed field sheet, Annexure 1-8 for Transnet Freight Rail welders and approved field sheets for Transnet Projects welders and sub-contractors.

8.13.4 The Technical Superintendent/Supervisor or his representative shall examine all welding work, and a report shall be submitted to the Depot Engineer.

CHAPTER 9 – REPAIRING DIPPED HEAT-AFFECTED ZONES ON FLASH BUTT JOINTS.

9.1 GENERAL.

9.1.1 Dipped heat-affected zones on flash butt joints are commonly found on chrome-manganese rails. A typical dipped joint is shown in Figure 9.1.

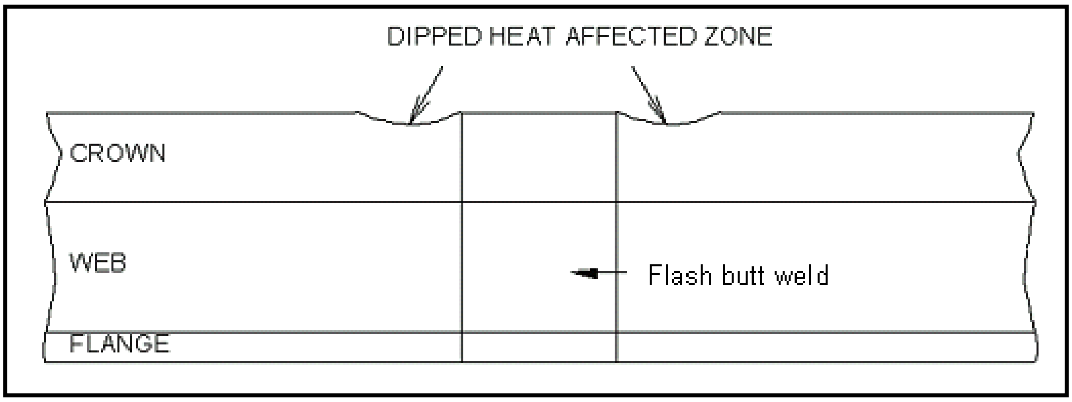

Figure 9.1. Schematic representation of a dipped flash butt joint.

9.2 INSPECTIONS AND DECISION MAKING.

9.2.1 The dips are measured with a 1m straightedge and feeler gauge, with the straightedge placed centrally over the joint.

9.2.2 If the dip is measured to be:

- Less than 0.4mm deep, it shall be repaired by grinding only, to a tolerance of 0.2mm.
- More than 0.4mm deep, it shall be repaired by means of manual metal arc welding (MMA, a constant current (CC) process), or flux-cored arc wire (FCAW, a constant voltage (CV) process).
- Repair work shall be done in accordance with Chapter 7.
- On Heavy Haul lines, joints with dips deeper than 0.3mm shall be replaced with a closure rail.

9.3 STANDARDS AND TOLERANCES.

9.3.1 Welding deposits shall be removed by grinding until it matches the rail profile adjacent to the repaired joint. Grooves, ripples, or undercuts may not be present in the rail profile after grinding.

9.3.2 Grinding shall be done in such a manner that a 0.2mm feeler gauge may not enter underneath a 1m straightedge placed on the running surface of the rail. Only a gradual curvature is permissible.

9.3.3 The following details shall be written with yellow chalk (sufficient to remain visible for at least 3 months) on the rail web adjacent the welded area:

- Sequence number of the flash butt joint, beginning at zero at the beginning of each financial year for each Transnet Freight Rail welder, and beginning at zero at the beginning of each day for each contractor welding team.
- Welder code (Transnet Freight Rail welders and contractor welders). Transnet projects' welders will be allocated codes starting with PR and sub-contractors' welders will be allocated codes starting with C.
- Date welded (Transnet Freight Rail welders and contractor welders).
- All daily work performed shall be logged on the prescribed field sheet, Annexure 1-8 for Transnet Freight Rail welders and approved field sheets for Transnet Projects welders and sub-contractors.

9.3.4 The Technical Superintendent/Supervisor or his representative shall examine all welding work, and a report shall be submitted to the Depot Engineer.

CHAPTER 10 – REPAIRING SWITCH BLADES.

10.1 GENERAL.

10.1.1 Preventive maintenance shall be done regularly on switch blades, to increase life span.

10.1.2 The smaller cross sectional area of a switch blade in comparison to that of a full crown area shall be taken into consideration when welding work is done on switch blades.

10.1.3 If switch blades are not repaired according to the following guidelines, fractures may occur which could lead to derailments.

10.1.4 Only competent Track Welders who have been certified by an accredited official may conduct welding repairs on switch blades.

10.1.5 Track Welders that were not exposed to welding of switch blades for longer than one year shall undergo a competency test before being allowed to do this type of work.

10.1.6 No welding may be done on undercut switch blades.

10.1.7 Minor metal flow and shelling shall be removed from the switch blades by means of light grinding.

10.1.8 Always test for cracks on the switch blades after grinding with dye penetrant.

10.2 INSPECTION AND DECISION MAKING ON HINGED SWITCH BLADES.

10.2.1 Track personnel are responsible for the visual inspection of switch blades and if necessary, for notifying the Maintenance Manager (Planning) of any defects. The Technical Supervisor, in conjunction with the Track Inspector, will then decide if the switch blade can be repaired by means of welding, grinding or if it has to be replaced.

10.2.2 Switch blades and stock rails shall be checked regularly for defects.

10.2.3 Switch blades and stock rails shall lock for a minimum distance of 1.5m measured from the tip (point) of the blades (Figure 10.1).

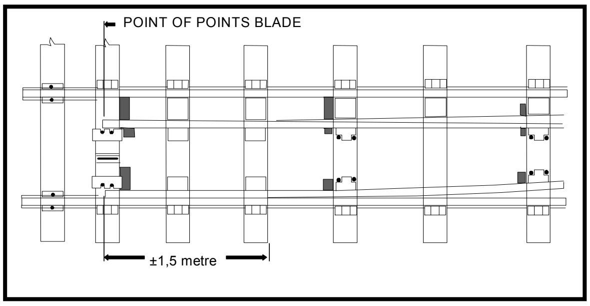

Figure 10.1. General layout of a set of points.

10.2.4 Metal flow (overlap) on stock rails and switch blades shall be removed before it has exceeded 2mm or developed to such an extent that the switch blade is prevented from moving in the positive lock position.

10.2.5 Causes of switch blade breakouts include:

- Overlaps on the stock rail.
- A switch blade, which does not fit the stock rail.
- Side wear on the stock rail.

10.2.6 Single breakouts up to 150mm in length and 10mm deep within the first 1m from the tip of the switch blade, may be repaired by welding and grinding in track.

10.2.7 Breakouts longer than 150mm within the first 1m from the tip of the switch blade may be repaired by welding in a workshop only.

10.2.8 Where defects occur further than 1m from the tip, the blade shall be replaced. Heat application further than 1m from the tip of the switch blade will lead to distortion.

10.2.9 Wheel-spin burns and battered rail ends in the portion of the switch blade where full crown profile is present shall be treated according to the prescribed directives (Chapters 7 and 8).

10.2.10 NB: The above mentioned only applies to horizontal cracks and beak-outs and/or defects, which can be repaired. More than one breakout within 1m from the switch blade's tip may be welded, provided that every breakout is treated separately.

10.3 PROTECTION.

10.3.1 Protection shall be afforded according to Spoornet General Appendix No 6 (Part 1).

10.3.2 Repairs to switch blades shall be done under total occupation conditions.

10.4 FIRE-PREVENTION.

10.4.1 Safety aspects regarding fire prevention shall be followed at all times (Chapter 2).

10.5 PREPARATION.

10.5.1 PREPARATION BY TRACK PERSONNEL.

10.5.1.1 Repair work shall always be carried out in conjunction with track personnel, train operations personnel, and a Signals Technician. It is required that this is done under full occupation conditions and that enough time is allowed to complete the preparation.

10.5.1.2 It is important that the set of points is well tamped before any work is carried out on the switch blade.

10.5.2 PREPARATION BY WELDING PERSONNEL.

10.5.2.1 All grease and foreign materials shall be removed before any examination work or grinding work commences.

10.5.2.2 The switch blade shall be visually examined for horizontal and vertical defects. Affected areas shall be inspected by non-destructive methods. If defects are present, a decision shall be made in conjunction with track personnel whether the switch blade shall be replaced.

10.5.2.3 Employees and the public must be protected against the danger of arc flashes.

10.5.2.4 No welding shall take place in rain or fog conditions.

10.5.2.5 The following shall be done during workshop repairs:

- Care shall be taken during handling and storing.
- Switch blades shall be placed on blocks before repairs to enable easily cleaning and examination.
- Switch blades shall be bolted to a jig to counteract distortion.

10.6 GRINDING PROCESS.

10.6.1 Grinding shall be done with a MC2 grinding machine until all defective material has been removed. An additional 3mm shall be removed by grinding to ensure parent metal has been reached.

10.6.2 The switch blade shall be replaced if defects are deeper than 13mm after grinding.

10.6.3 Switch blades shall be checked with dye penetrant to ensure that no further defects are present.

10.7 PREHEATING.

10.7.1 Heat application regarding different grades of rail shall be strictly adhered to as set out in Chapter 5.

10.7.2 The grinding area plus 100mm on both sides thereof shall gradually be pre-heated by moving the flame to and fro over the flange, web and crown (Figure 10.2). This method will induce even heat in the switch blade.

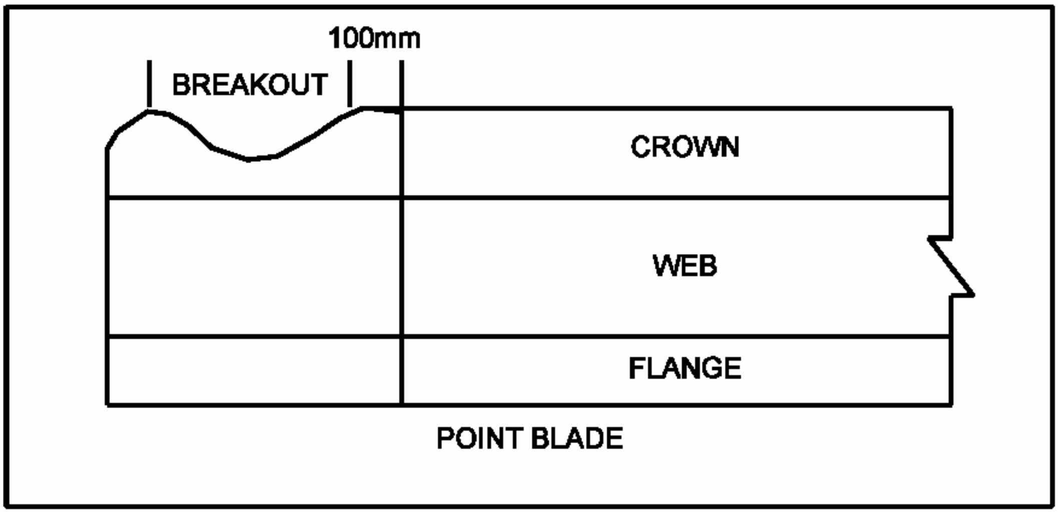

Figure 10.2. Preheating of defective area.

10.8 WELDING PROCESS.

10.8.1 Switch blades can be repaired by means of manual metal arc welding (MMA, a constant current (CC) process), or flux-cored arc wire (FCAW, a constant voltage (CV) process).

10.8.2 To counteract distortion and overheating, the step back welding method shall be applied.

10.8.3 Continue with this process until the welding metal is built up high enough to ensure an even and smooth finish.

10.8.4 Overheating shall be avoided to minimize distortion.

10.9 FINAL GRINDING.

10.9.1 Grinding on the welded area shall be done to the required height and profile as soon as possible after the switch blade has cooled down to ambient temperature.

10.9.2 Grinding on the welded running surface of the switch blade shall be done until it matches the adjacent running surface in the horizontal as well vertical planes (Figure10.3).

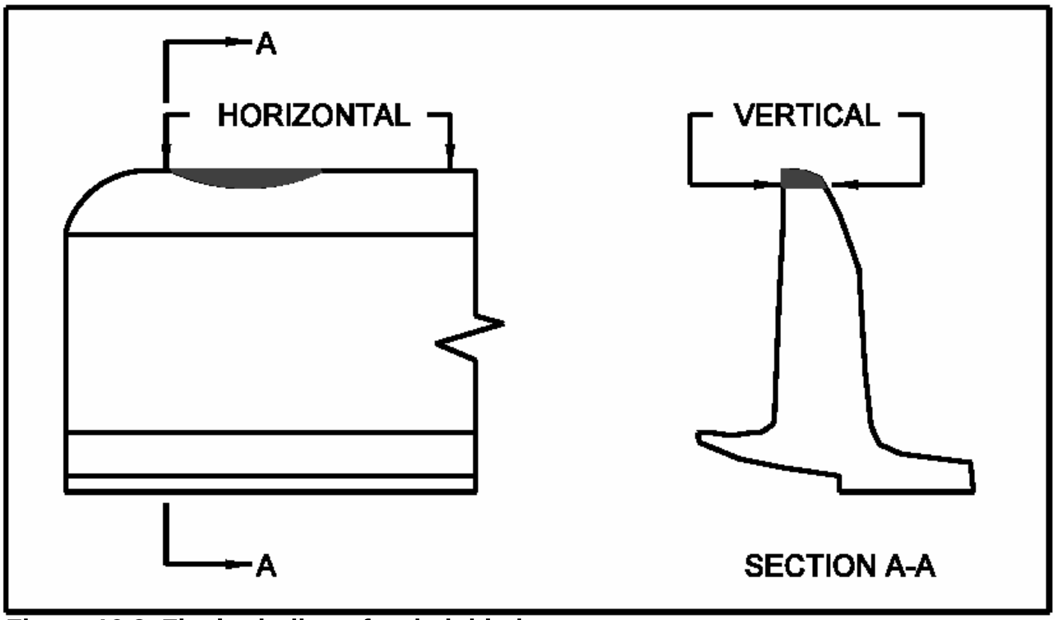

Figure 10.3. Final grinding of switch blade.

10.9.3 Grinding of the matching surfaces of the switch blade shall be done according to the contour to fit neatly against the stock rail.

10.9.4 Signals Technicians and track personnel shall set up and test the switch blades.

10.9.5 The running side shall be checked for defects. The blade shall be finally tested with dye penetrant. If any cracks do occur, these shall be completely removed (as set out above) and built up again by means of welding. Under no circumstances may a crack be left in a switch blade. The blade will break which may cause a derailment.

10.9.6 If the switch blade does not fit, a Track Welder, in conjunction with track personnel, shall make the necessary adjustments.

10.10 STANDARDS AND TOLERANCES.

10.10.1 A 0.2mm feeler gauge may not enter underneath a 1m straightedge, placed centrally over the running surface (longitudinally) of the switch blade.

10.10.2 The horizontal gradient of the switch blade running surface shall be maintained at all times. A gradual radius shall be affected by grinding in the vertical surface on the running side of the switch blade.

CHAPTER 11 – EXOTHERMIC CASTING OF RAILS (SKV-PROCESS).

11.1 GENERAL.

11.1.1 Track Welders, who were trained and have passed the assessment for exothermic casting on the Transnet Railway Network, may undertake exothermic casting work. Esselen Park or an approved body will issue a certificate to Track Welders who passed their theoretical and practical training.

11.1.2 Only authorized officials from Central Office may conduct practical testing of Track Welders, which will be moderated by Esselen Park or an approved body.

11.1.3 Track Welders shall also be re-evaluated regularly by means of radiography and physical methods.

11.1.4 The equipment used for exothermic casting shall be kept in a good condition and shall be checked by Supervisors on a monthly basis. The Track Welding Equipment Checklist may be used for this purpose.

11.1.5 All exothermic casting kits shall be stored in a dry place and protected against moisture. Storing of exothermic casting consumables shall comply with the manufacturer's specifications and used according to manufacturing dates. A policy of first-in-first-out shall be applied when issuing exothermic kits.

11.1.6 NB. Shelf life of all exothermic casting consumables is 3 years.

11.1.7 Castings of exothermic joints are not permissible in rainy conditions.

11.1.8 A disc cutter shall be used to cut the prescribed gap. The minimum distance from rail ends to the edge of nearest bolthole is 25mm.

11.1.9 If for any reason, an exothermic joint was rejected, the joint shall be removed completely, and replaced with a suitable closure rail of 4.2m or wide gap joint.

11.1.10 Two rail temperature readings shall be taken during the welding process:

- Place thermometer 2m from the rail end, after the rail end has been cut.
- First temperature reading: Before the rail ends are aligned.
- Second temperature reading: After excess metal has been sheared.

- These readings shall be recorded together with the joint data on the prescribed field sheet (Annexure 1-8).
- Use two thermometers to verify the rail temperature, one each by welding and track staff.

11.1.11 All joints inside turnouts, except for hinge joints, may be joined exothermically at rail temperatures higher than 5° Celsius.

11.1.12 When a turnout is to be joined exothermically to the running line, it shall be done within the specified temperature ranges (Annexure 1-3).

11.1.13 Rail joints, which are more than 20m inside a tunnel, may be joined exothermically if the rail temperature is above 5° Celsius.

11.1.14 Fishplate joints on Monoblock crossings may not be exothermically joined. The crossing and rail ends shall fit tightly to prevent any battering.

11.1.15 Time required to complete an exothermic joint:

- A minimum time period of 45 minutes shall be allocated to the Track Welder to complete an exothermic joint. This makes provision for:
  - Alignment of rail ends.
  - Mounting of exothermic casting equipment and consumables.
  - Casting of exothermic joint.
  - Shearing and rough grinding of joint.

11.1.16 NB: Above mentioned time does not include the preparation of the track, final grinding and cleaning of the joint.

11.1.17 All new exothermic joints that are subjected to axle loads in excess of 26 ton shall be fitted with joggle plates, until the joints are radiographically and ultrasonically tested and found to be defect free. Joggle plates may then be removed.

11.2 INSPECTION AND DECISION MAKING.

11.2.1 The Maintenance Manager will determine workload and priorities. This will be provided to the Production manager who will arrange for work to be done.

11.2.2 The rail type shall be identified by the roll marks (Annexure 4-1).

11.2.3 All dipped joints shall be cropped and rails moved up before any exothermic joint can be cast.

11.2.4 NB: Casting of exothermic joints is not allowed where battered rail ends were repaired by means of arc welding.

11.2.5 A minimum distance of 2m shall be maintained between a flash butt joint and an exothermic joint (Annexure 1-5).

11.2.6 Permanent closure rails with a minimum length of 4.2m, without boltholes, matching the existing rail profile shall be used.

11.2.7 The rail height shall be measured at the rail ends by means of an outside calliper and steel ruler to establish the correct rail height difference. The maximum and minimum height will determine which type of mould to be used.

11.2.8 Composite exothermic kits shall be used to join two rails of different profiles, and the rail height difference on these rails shall not exceed 3mm.

11.3 PROTECTION OF TRAINS AND SAFEGUARDING OF PERSONNEL.

11.3.1 Protection of trains and the safeguarding of personnel shall be afforded in accordance with Spoornet General Appendix No 6 (Part 1).

11.4 SAFE WORKING PROCEDURES.

11.4.1 Refer to Chapter 2.

11.5 PREPARATION.

11.5.1 PREPARATION BY TRACK PERSONNEL.

11.5.1.1 Preparation work as described in the Manual for Track Maintenance (2000) shall be done before the welding process starts. This includes replacing ballast, sleepers, applying and fitting jumper cables and removing fishplates.

11.5.1.2 Installing closure rails and insulating joints:

- Cast the joint on one end of the closure rail or insulating joint before beginning preparation on the other end. This will assist in controlling gap sizes influenced by the effects of rail expansion and/or contraction due to temperature changes.

- Cut lines shall be made by using sharp Boilermaker's chalk.
- Length of closure shall be 10mm shorter than the length required in track minus the prescribed gap size (Table 11.1).
- Preparation for the second joint shall only begin after the first exothermic joint is cast.

Table 11.1. Prescribed rail gaps.

PROCESS	MINIMUM/ MAXIMUM RAIL GAP
SKV-F	24 – 26mm
SKV-M	35 – 40mm
SKV-L	40 – 50mm

- Temperature ranges as stipulated in Manual for Track Maintenance (2000) shall be strictly adhered to.
- Temperature readings shall be logged on the prescribed field sheets for audit and inspection purposes.

11.5.1.3 Rails with surface defects, and oval or cracked bolt holes shall be cropped and replaced with closure rails no shorter than 4.2m.

11.5.1.4 Rail ends that have been cut with gas equipment in the past shall be cropped at least 150mm using a disc cutter.

11.5.1.5 In cases where existing CWR is joined by exothermic casting, 80 sleepers on both sides of the joint shall be loosened for de-stressing purposes as specified in the Manual for Track Maintenance (2000).

11.5.1.6 Exothermic joints in track shall be centred between two sleepers in order to allow for clamping with G-Clamps and joggle plates.

11.5.1.7 The track alignment shall be brought to prescribed standard for a minimum distance of 5m on both sides of joint. Three sleepers on both sides of the joint shall be loosened. This will assist in aligning the two rail ends.

11.5.2 PREPARATION BY WELDING PERSONNEL.

11.5.2.1 The Track Welder shall identify the rail type correctly before an occupation is taken, so that the correct casting process can be decided upon.

11.5.2.2 Rail surfaces shall be cleaned using a steel brush, chipping hammer and waste before jumper cables are fitted to ensure that rail ends are free from grease, oil, rust and foreign matter.

11.5.2.3 Bolt holes shall be eliminated.

11.5.2.4 Grinding shall be done on the rail ends to render a shiny metal surface after the rail gap is obtained for a distance of 50mm on both sides. (The purpose is to remove oxides from the rail surface).

11.5.2.5 Exothermic casting is not allowed where arc welding was done on the rail surface, e.g. welding repair of battered rail ends and wheel-spin burns.

11.5.2.6 Overlaps shall be removed by grinding over a distance of at least 0.5m on either side. Copper bond residues shall be removed to obtain a shiny surface.

11.5.2.7 All rails shall be cut with a disc cutting machine. Gas cutting is only permitted where kick-outs are removed.

11.6 EXOTHERMIC CASTING EQUIPMENT.

11.6.1 GENERAL.

11.6.1.1 Tools and equipment used in the exothermic casting process shall comply with Act 85 requirements.

11.6.2 USE OF THE LONG-LIFE CRUCIBLE.

11.6.2.1 Assembling the long life crucible:

- Sealing paste shall be applied uniformly around the top of crucible rim.
- The extension sleeve and crucible are clamped by means of a clamp ring.
- After tightening the screw, lightly tap around the circumference of the ring with a hammer, and then re-tighten.
- Remove any excess paste inside the crucible.

11.6.2.2 Preheating the crucible:

- The crucible shall be dried out at 150°C:
    - Daily, before being used.
    - Each time a new crucible is used.

- o If more than an hour has lapsed since previous casting.
- o Applying uniform heat distribution, by rotating the flame inside the crucible.

11.6.2.3 Cleaning the crucible after casting:

- Excessive slag in crucibles shall be removed by using the thimble drift.
- Easy removal of slag is obtained when it is chopped vertically towards the thimble hole. Turn the crucible upside down, remove the residual thimble with thimble drift, and tap it lightly with a small hammer. Take care not to damage the thimble seat.
- Accumulation of slag in the upper part of the crucible may be carefully removed with a thimble drift.
- Renew a crucible when hot spots are visible on the crucible shell, and when the thickness of the refractory material after the removal of slag is inadequate/cracked. This may help avoid run-outs.
- It is recommended that the crucible be placed inside a drum filled with sand to absorb shocks when transported.
- Care shall be taken that the liner is not exposed to water.
- NB: The inside of the crucible lining may not be patched.

11.7 COMPOSITION OF AN EXOTHERMIC CASTING PORTION.

Table 11.2. Composition of an exothermic casting portion.

Element	**Z80**	**Z110**	**Z120**
Carbon	0,45 - 0,65	0,65 - 0,75	0,70 - 0,85
Manganese	0,80 - 1,30	0,80 - 1,30	0,80 - 1,30
Aluminium	0,2 max	0,2 max	0,2 max
Vanadium	Min	0,20	0,2
Chromium	Min	0,2 (After welded)	0,40 - 0,60
Hardness (BN)	228 - 269	311 - 375	350 - 380
Deflection at destruction			
48kg/m	18mm	11mm	11mm
57kg/m	18mm	11mm	11mm
60kg/m		11mm	11mm

11.8 TYPES OF EXOTHERMIC CASTING PROCESSES.

- SKV-F PROCESS (0 - 3mm crown wear).Obtainable in 22, 30, 40, 48, 57 and 48 to 51kg/m (other sizes are available on request).

- SKV-F PROCESS (0 - 3mm crown wear; 3-piece mould).Obtainable in 40, 48, and 57kg/m.

- SKV-M PROCESS (0 - 3mm crown wear, 3-piece mould slab track in tunnels).Obtainable in 48, 57kg/m, S60, UIC60/60E1.

- SKV-L PROCESS (0 - 3mm crown wear).Obtainable in 48, 57kg/m, S60, UIC60/60E1.

- SKS PROCESS (CRANE RAIL).Obtainable in 64 and 88 kg/m (other sizes are on request).

- SKV-F PROCESS (COMPOSITE MOULDS).Obtainable in 40 to 48, 48 to 51, 48 to 57, 57 to S60 and 57kg/m to UIC60/60E1.

- SKV-F PROCESS (3 - 6mm crown wear, step-mould).Obtainable in 48 and 57kg/m.

- SKV-M PROCESS (3 - 6mm crown wear, step-mould).Obtainable in S60 and UIC60/60E1.

11.9 HEAD HARDENED RAILS.

11.9.1 Exothermic casting procedures for HH rails are the same as for UIC-A type rails with the following additional processes.

Table 11.3. Portion types and cooling treatment for HH rails.

RAILS	PORTION	COOLING TREATMENT
48kg/m UIC-A - 48kg/m HH	Z80	No retarded cooling
48kg/m Cr-Mn - 48kg/m HH	Z110	Retarded cooling***
57kg/m UIC-A - 57kg/m HH	Z80	No retarded cooling
57kg/m UIC-A - 60kg/m Cr-Mn	Z80	Retarded cooling***
57kg/m Cr-Mn - 57kg/m HH	Z110	Retarded cooling***
60kg/m Cr-Mn - 60 kg/m HH	Z110	Retarded cooling***
UIC60 M HH - HH	Z120	No retarded cooling
UIC60 L HH - HH	Z120	No retarded cooling
48 SKV-F HH - HH	Z120	No retarded cooling
48/51 SKV-F HH - HH	Z120	No retarded cooling
48 SKV-M HH - HH	Z120	No retarded cooling
48 SKV-L HH - HH	Z120	No retarded cooling
57 SKV-F HH - HH	Z120	No retarded cooling
57 SKV-M HH - HH	Z120	No retarded cooling
57 SKV-L HH - HH	Z120	No retarded cooling

Note: *** Retarded cooling to be applied on the Cr-Mn rail side only.

11.10 COLOUR CODING TO PRODUCTS FOR EASY IDENTIFICATION.

Exothermic Description, marking on box and sticker colour		profile	profile	grade
22 Skv - F	Turquoise - Orange	Turquoise		700 - 900
30 Skv - F	Brown - Orange	Brown		700 - 900
40 Skv - F	Violet - Orange	Violet		700 - 900
40 Skv - L	Violet - Orange	Violet		700 - 900
40/48 Skv - F	Violet - Blue - Orange	Violet	Blue	700 - 900
48 Skv - F	Blue - Orange	Blue		700 - 900
48 Skv - M	Blue - dark blue - Orange	Blue	Dark blue	700 - 900
48 Skv - L	Blue - Blue - Orange	Blue		700 - 900
48 Skv - F Cr-Mn	Blue - Yellow	Blue		1100
48 Skv - L Cr-Mn	Blue - Blue - Yellow	Blue	Blue	1100
48 Skv - F 3-6mm Stepped	Blue - Orange	Blue		700 - 900
48/51 Skv - F	Blue - Orange	Blue		700 - 900
48 Skv - F HH 350 LHT	Blue - White	Blue		1200
48 Skv - L HH 350 LHT	Blue - Blue -White	Blue	Blue	1200
48/57 Skv - F HH 350 LHT	Blue - White	Blue		1200
48/51 Skv - F HH 350 LHT	Blue - White	Blue		1200
48/57 Skv - F	Blue - Red - Orange	Blue	Red	700 - 900
48 Slabtrack	Red - Orange	Blue		700 - 900
57 Skv - F	Red - Orange	Red		700 - 900
57 Skv - M	Red - Dark Red - Orange	Red	Dark red	700 - 900
57 Skv - F 3-6mm Stepped	Red - Orange	Red		700 - 900
57 Slabtrack	Red - Orange	Red		700 - 900
57 Skv - L	Red - Red - Orange	Red	Red	700 - 900
57 Skv - F Cr-Mn	Red - Yellow	Red		1100
57 Skv - L Cr-Mn	Red - Red - Yellow	Red	Red	1100
57/60 Skv - F	Red - Green - Orange	Red	Green	700 - 900
57 Skv - L HH 350 LHT	Red - Red -White	Red	Red	1200
57 Skv - F 3-6mm Stepped HH 350 LHT	Red - White	Red		1200
57/UIC60 - F HH 350 LHT	Red - Green -White	Red	Green	1200
57 Skv - F HH 350 LHT	Red - White	Red		1200
57/UIC60 - F Cr-Mn	Red - Green - Yellow	Red	Green	1100
57/S60 - F Cr-Mn	Red - Green - Yellow	Red	Green	1100
UIC60 Skv - M HH 350 LHT	Green - White	Green		1200
S60 Skv - M HH 350 LHT	Green - White	Green		1200
UIC60 Skv - L HH 350 LHT	Green - Green - White	Green	Green	1200
UIC60 Skv - M HH 350LHT 3-6mm Step	Green - White	Green		1200
S60 Skv - M Cr-Mn	Green - Yellow	Green		1100
S60 Skv - L Cr-Mn	Green - Green - Yellow	Green	Green	1100
S60 Skv - M Cr-Mn 3-6mm Stepped	Green - Yellow	Green		1100
UIC60 Skv - M Cr-Mn	Green - Yellow	Green		1100
UIC60 Skv - L Cr-Mn	Green - Green - Yellow	Green	Green	1100
UIC60 Skv - M Cr-Mn 3-6mm Stepped	Green - Yellow	Green		1100
S60/UIC60 Skv - M Cr-Mn	Green - Yellow	Green		1100
64 Kg Skv - SKS	Profile clearly marked			700 - 900
88 Kg Skv - SKS	Profile clearly marked			700 - 900
A 75 - SKS	Profile clearly marked			700 - 900
A 100 - SKS	Profile clearly marked			700 - 900
A 120 - SKS	Profile clearly marked			700 - 900
A 151 - SKS	Profile clearly marked			1100
A186 - SKS	Profile clearly marked			700 - 900
MRS 87	Profile clearly marked			700 - 900

11.11 THE EXOTHERMIC CASTING PROCESS.

11.11.1 PREPARATION OF THE JOINT.

11.11.1.1 Refer to Paragraph 11.5.

11.11.2 ALIGNING OF RAIL ENDS TO CAST EXOTHERMIC JOINT.

11.11.2.1 Use rail aligner or steel wedges to lift the rail ends after the rail pads have been removed.

11.11.2.2 Special care shall be taken when aligning rails to turnouts.

11.11.2.3 A 1m straightedge, two 1mm shims for the SKV-F process and two 2mm shims for the SKV-M/L processes, shall be used to set up the rail ends to the required height. The straightedge shall be placed over the gap, with the shims exactly the same distance from the ends of straightedge. Lift the rails by means of wedges or rail aligner until the rail ends at the gap is flush with the edge of straightedge.

11.11.2.4 Check the rail crown and flange alignment using the straightedge.

11.11.2.5 The Track Welder shall check the first joint cast everyday to ensure that the correct alignment was obtained. If the vertical alignment is incorrect, the shims shall be adjusted.

11.12 MOUNTING AND SEALING THE MOULDS.

11.12.1 Place the universal mounting clamp on the rail crown and use the universal gap gauge to ensure that the mounting clamp arms are positioned centrally over the gap.

11.12.2 The burner holder shall be placed in the universal mounting clamp, centrally over the gap and set to the correct height of 35mm above the rail crown. The burner holder and burner are then removed as a unit.

11.12.3 The exothermic moulds shall be cleaned and examined for defects. Each half-mould shall then be fitted against the side of rail. Moulds may be rubbed gently against the side of the rail, if it does not fit correctly.

11.12.4 Place the half-mould and shoe centrally and vertically over the gap. The securing screw shall be in the centre of the mould shoe and the second half-mould and shoe shall be positioned exactly in line with the first half-mould. Insert cardboard, supplied by the portion manufacturer, between the rail crown and the moulds, to prevent sealing sand from entering the gap. The securing screws shall be finger-tight, to prevent damage to the mould. Ensure that the pouring plug fits tightly into the moulds, especially where worn and new rails are joined.

11.12.5 Use the mould vertical alignment gauge to ensure that moulds are fitted vertically over the joint.

11.12.6 Premixed luting-sand is already mixed and ready for use, no water may be added.

11.12.7 Moulds shall be properly sealed and compacted with a rammer. Prevent any tapping against the mould shoes. This may lead to misalignment of the joint.

11.12.8 Sealing shall be flush with the mould shoes. Luting-sand shall be placed on the thread of the clamp to protect it from splatter.

11.12.9 The slag tray holders shall be fitted to the mould shoes, and the slag tray placed on top of the slag tray holder.

11.12.10 Cover plates shall be placed over the rails on both sides of the joint to prevent splatter damaging rails.

11.13 SETTING UP AND LOADING THE CRUCIBLE.

11.13.1 The tripod and crucible shall be placed on the universal mounting clamp away from the mould assembly. The crucible shall then be swung over the centre of the pouring plug and adjusted to 35mm above the mould.

11.13.2 The crucible shall, after the correct casting position has been obtained by adjustments, be swung away from the mould assembly to be filled.

11.13.3 An automatic thimble is included with the exothermic kit. The thimble shall be placed firmly into the crucible outlet with the thimble applicator. Spread sealing slag evenly around the thimble and remove the thimble applicator carefully. No slag may remain inside the aluminium tube, as this will delay tapping time or cause solidification.

11.13.4 The exothermic portion during the loading of the crucible shall be mixed thoroughly by shaking the bag up and down to ensure the composition of the portion is mixed thoroughly. The exothermic portion composition shall then be poured into the crucible through one’s fingers and care shall be taken that no portion particles fall into the moulds. The portion shall form a pyramid shape inside the crucible, which will aid the combustion process.

11.14 GAS PREHEATING.

11.14.1 Preheating the joint is necessary to remove moisture in the moulds and sealing sand as well as to heat the rail ends to ± 950ºC which will ensure proper fusion of the rail ends and molten metal.

11.14.2 The following gas pressures and preheating times are applicable to all 60kg/m SKV-M and 60kg/m SKV-L processes:

- Oxygen gas pressure - 300kPa
- Propane gas pressure - 100kPa
- Preheating time - 7 to 8 minutes
  - Use an exothermic casting flow gauge meter to obtain the correct gas pressure. This meter shall be mounted on the universal welding handle (Order No. 321-514, Harris).

11.14.3 Gas pressures and preheating times applicable to all welding processes used on General Freight lines:

- Oxygen gas pressure - 200kPa
- Propane gas pressure - 60kPa
- Preheating time:
  - SKV-F - 7 minutes
  - SKV-M & SKV-L - 8-minutes
    - Use an exothermic casting flow gauge meter to obtain the correct gas pressure. This meter shall be mounted on the universal welding handle (Order No. 321-514, Harris).

11.14.4 Preheating times shall always be controlled using a stopwatch.

11.14.5 A carburising flame shall be used with the preheating process. (This can be obtained by opening the LP-gas valve completely and adjusting the oxygen valve to get the correct flame).

11.14.6 The flame rising out approximately 500mm above the riser apertures is an indication that the gas flow and flame type (carburising) are correct. Under no circumstances may an oxidising flame be used, as this will oxidise the rail ends and glaze the moulds, resulting in gas vapours being trapped in the moulds, and leading to gas voids in the weld.

11.14.7 Hold the flame underneath the two slag trays to ensure that the slag trays are completely dry.

11.14.8 Place the preheating burner (block nozzle) and burner holder as a unit into the universal clamp. Ensure the burner is vertical and centred above the gap.

11.14.9 When one of the oxygen/LP-gas cylinders turns out to be empty while preheating, the preheating process shall be stopped and the empty cylinder replaced. If cracking of the moulds has occurred, the moulds shall be replaced.

11.14.10 The burner shall be removed and pouring plug positioned into the mould as soon as the required preheating time has been reached. The crucible shall then be swung into the correct position centrally over the pouring plug.

11.14.11 Gas flow, type of flame and preheating times are very important to ensure a joint that conforms to the specifications.

11.15 PETROL/AIR PREHEATING OPERATING INSTRUCTIONS.

11.15.1 Operate as specified and instructed in the manufactures manual regarding safe working procedure.

- Centralise burner in moulds.
- Start the motor.
- Set following pressure valves simultaneously.
  - Air valve.
  - Petrol Valve.
  - Combined pressure shall be 30kPa.
- Ignite burner and set flame.
- Preheating time:
  - SKV-F = 7 minutes and
  - SKV-M/L = 8 minutes, time controlled using a stopwatch.

11.16 CASTING PROCESS.

11.16.1 After the preheating time has been reached, the moulds and sealing sand will be dried out and rail ends heated to ± 950°C.

11.16.2 The igniter shall be lit, placed 20mm deep at an angle of 45° in the exothermic portion, and the crucible cover placed on top of the crucible. 20 to 25 seconds after ignition, the molten metal will automatically flow onto the pouring plug and into the mould. After casting remove slag trays, crucible tripod, swing arms, mould shoes and universal clamp.

11.16.3 The molten metal in the rail flange and web areas solidifies first. The bigger volume of molten metal in the crown area, takes longer to solidify. Solidification progresses from the outside to the inside of the weld. Any impurities will be trapped on top of the excess metal and riser-gate stubs as these solidify last.

11.17 SHEARING OF THE EXOTHERMIC JOINT.

11.17.1 Remove all loose sand from the rail crown before placing the shearing machine into position over the joint.

11.17.2 Care shall be taken not to disturb the moulds. Damaged moulds can lead to quick cooling or run-outs, which may result in defective exothermic joints, e.g. shrinkage cavities.

11.17.3 Excess metal shall be sheared away using an approved double bladed hydraulic shearing machine.

11.17.4 Care shall be taken not to tear the cast metal when shearing the joint before metal has solidified completely. Sufficient time shall be allowed before shearing is done, as this will enable hot metal to solidify.

11.17.5 Bend risers downwards by means of two Tommy bars. Do not use a hammer.

11.18 FINISHING.

11.18.1 ROUGH GRINDING.

11.18.1.1 A layer (no less than 1mm) of cast metal shall remain on the crown after rough grinding the joint, to allow further contraction during cooling. This will ensure that the joint is not hollow after cooling.

11.18.1.2 Only after rough grinding is done and the joint has cooled down to 300°C, a train may be allowed to pass at a maximum speed of 30km/h, provided that steel support plates (150mm x 150mm) of suitable thickness have been placed between rail and sleepers.

11.18.1.3 If, after the train has passed, the rail temperature still exceeds 200°C, the sleepers shall be loosened.

11.18.1.4 After the joint has cooled down to ambient temperature, the steel support plates and wedges may be removed. The rail pads shall be replaced and all the sleepers fastened and tamped.

11.18.1.5 The beginning temperature, end temperature, and portion batch number shall be written on the prescribed field sheet and on the field side of the web, with chalk, at each joint.

11.19 RECTIFICATION.

11.19.1 The joint shall be rejected when it has cooled down to ambient temperature and the vertical alignment fault is more than 1mm, based on a straightedge measurement. A maximum of 1mm may be removed off the rail crown by grinding.

11.20 FINAL GRINDING.

11.20.1 Final grinding shall be done in such a manner that the top and gauge side of the crown are within the specified tolerances and that the profile of the rail is maintained.

11.21 MARKING OF EXOTHERMIC JOINTS.

11.21.1 The following details shall be stamped with 8mm stencils on the field side of the rail crown in proximity of the joint:

- An example of stencilled detail is shown in Figure11.1, and has the following meaning:
  - Company name (not applicable to Transnet Freight Rail), e.g. M = Metrorail, PR = Transnet Capital Projects (previously Protekon), C = Contractor, etc,
  - The Depot will allocate a code letter (except C, I, L, O, M, P and R) to the Track Welder (E.g. D).
  - The day, month and last two digits of the year. (DDMMYY).
  - Joint number e.g. Start with number 1, 2, etc, at the beginning of each work day.

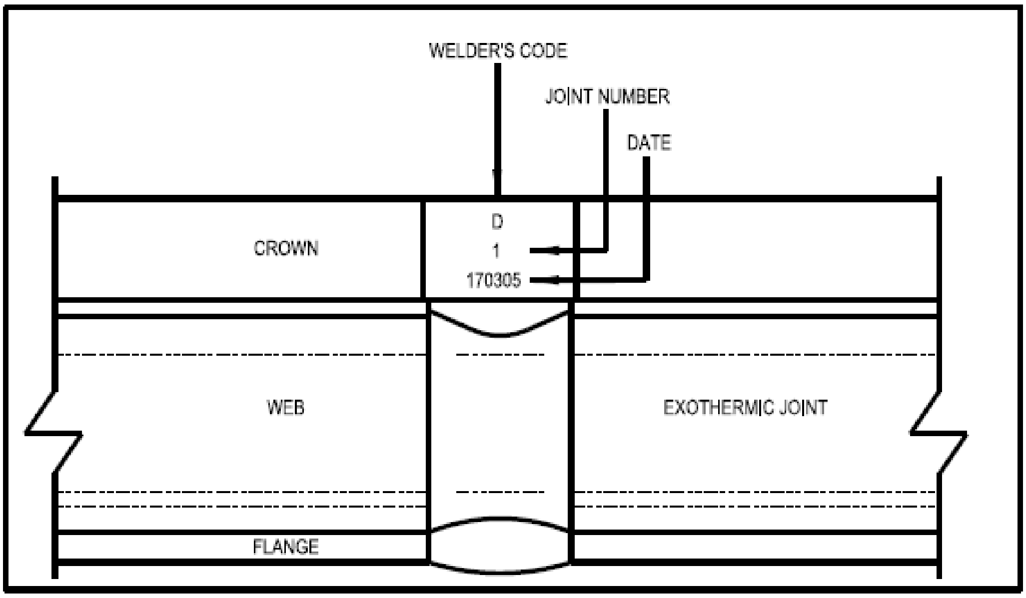

Figure 11.1. Example of joint marking.

11.21.2 Joints shall be numbered for control purposes. These numbers shall start at one at the beginning of every financial year. The Track Welder shall allocate a number to every joint and this number shall then be written on the rail web and stamped on the joint for record purposes. Use Track Welding Field sheet (Annexure 1-8) for inspections and record purposes.

11.22 INSPECTION OF EXOTHERMIC JOINTS.

11.22.1 A Technical Supervisor shall inspect the exothermic joint visually after completion of the joint.

11.22.2 Annual X-ray tests of exothermic joints shall be conducted.

11.22.3 All exothermic joints cast by contractors shall be tested by means of X-ray and ultrasonic method, and defective joints shall be replaced.

11.23 STANDARDS AND TOLERANCES.

11.23.1 Final grinding and cleaning of all exothermic joints shall be done within 24 hours after casting the joint.

11.23.2 All mould material shall be removed, with a suitable blunt tool, from the joint, as soon as possible after the joint has cooled down to ambient temperature.

11.23.3 The joint shall be sound, without cracks, slag, sand inclusions, undercuts, porosity, or any foreign matter. A mirror shall be used for inspection purposes.

11.23.4 Joint alignment shall be as follows: (Annexure 11-1).

- **VERTICAL ALIGNMENT.**

  The flange of rail and crown shall be vertically aligned to a tolerance of 3mm.

- **SQUARE ALIGNMENT.**

  The edge of the collar on one side of the flange shall be horizontally aligned to the edge of the collar on the opposite side of the flange to a tolerance of 3mm.

- **HALVE-MOULD ALIGNMENT.**

  The two mould halves shall be aligned under the flange to a tolerance of 3mm.

11.23.5 A 0.2mm feeler gauge may not fit anywhere between the rail crown and a 1m straightedge, which shall be placed longitudinally and centrally over the joint.

11.23.6 A 0.2mm feeler gauge may not fit anywhere between the rail crown and a 1m straightedge, which shall be placed longitudinally on the gauge side of the crown and centrally over the joint. (The same applies on the field side in case of future transposing).

11.24 EXOTHERMIC PROCESSES WITH UNIQUE STANDARDS AND PARAMETERS.

11.24.1 Preheating parameters for exothermic casting with Oxy/LP-gas shall be applied as per Table 11.4, and Petrol/air as per Table 11.5.

11.25 EXOTHERMIC CASTING OF RAILS: 24 TO 26MM GAP (SKV-F).

11.25.1 GENERAL.

11.25.1.1 The procedures described in Paragraphs 11.1 to 11.24 shall be strictly followed in conjunction with Paragraph 11.25.

11.25.1.2 Chrome-manganese rails shall be treated as indicated in Table 11.3.

11.25.2 PREPARATION OF THE JOINT.

11.25.2.1 A gap of 24-26mm for SKV-F is required to ensure adequate fusion between the exothermic metal and rails.

11.25.2.2 Rail ends shall be tested for cracks by using dye penetrant.

11.25.2.3 Rail ends shall be lifted 1mm to compensate for sagging caused by applied heat.

11.25.3 POST-CASTING PROCEDURES.

11.25.3.1 See Tables 11.4 and 11.5 for relevant parameters.

11.25.3.2 Loose sand on the rail crown shall be removed.

11.25.3.3 Excess cast metal shall be removed by means of a hydraulic shearing machine. Risers shall be bent vertically, away from joint.

11.25.3.4 Chrome-manganese rail joints shall immediately after shearing, but no later than 8 minutes after casting, be covered completely with an approved insulating material for at least 30 minutes.

Table 11.4. Parameters for Exothermic casting using Oxy/LP gas preheating method.

Description	SKV-F Weld	SKV-F Cr-Mn 48kg/m- and 57kg/m	SKV-M Weld	SKV-L Weld	SKV-M 60kg/m	SKV-L 60kg/m
Gap	24 – 26 mm		35 – 40mm	40 – 50mm	35 – 40mm	40 – 50mm
Burner Type(Block Nozzle)	32 holes					
Burner Height	35mm					
Pre-heat time: 48kg/m 57kg/m	7minutes				8minutes	
Gas Pressures: (Flow Pressure) At exothermic test gauge assembly	200 kPa oxygen 60 kPa propane				300 kPa oxygen 100 kPa propane	
Flame Length	500mm					
Remove Tri-Pod, Crucible and Slag trays	2minutes		3minutes		3minutes	
Remove universal clamp and mould shoes	3minutes		4minutes		4minutes	
Shearing after "X" minutes from pour	5-6minutes SKV-F		SKV-M or L 6-7minutes			
Treatment of weld	No retarded cooling	Cover Cr-Mn joints with Insulating Blanket within 8min after casting for 30min		No retarded cooling	Cover Cr-Mn joints with Insulating Blanket within 11min after casting for 30min	

11.25.3.5 NOTE: For HH rail parameters remain the same – except for no retarded cooling. For composite joints the rail parameters remain the same for SKV-F.

Table 11.5. Parameters for Exothermic casting using Petrol/air preheating method.

Description	SKV-F Weld	SKV-F Cr-Mn 48kg/m-and 57kg/m	SKV-M Weld	SKV-L Weld	SKV-M 60kg/m	SKV-L 60kg/m
Gap	24 – 26 mm		35 – 40mm	40 – 50mm	35 – 40mm	40 – 50mm
Burner Type (Special Type)	Petrol Air Burner					
Burner Height	65mm					
Pre-heat time: 48kg/m 57kg/m	7minutes				8minutes	
Pressure on Gauge	Pump Sutobilt: 30kPa Green Pump: 25kPa				Pump Sutobilt: 30kPa Green Pump: 25kPa	
Flame Length	500mm					
Remove Tri-Pod, Crucible and Slag Trays	2munits		3munites		3munites	
Remove Universal Clamp and mould shoes	3minutes		4minutes		4minutes	
Strip after X minutes from pour	5-6minutes		SKV-M or L 6-7minutes			
Treatment of weld	No retarded cooling	Insulating Blanket to be on 8minutes after pour only for Cr-Mn rails		No retarded cooling	Insulating Blanket to be on 11minutes after pour only for Cr-Mn rails	

11.25.3.6 Note: Cr-Mn rails in Tables 11.4 and 11.5 also include 2MCC and UIC-C rails.

11.25.3.7 Apply retarded cooling in accordance with Table 11.3.

11.25.3.8 After joint has reached ambient temperature, the risers shall be bent upwards.

11.25.3.9 All mould material shall be removed from joint collar. Joint surroundings shall be cleaned with a chisel, ball peen hammer and wire brush.

11.26 EXOTHERMIC CASTING: 35-40MM GAP (SKV-M) AND 40-50MM GAP (SKV-L).

11.26.1 GENERAL.

11.26.1.1 The procedures described in Paragraphs 11.1 to 11.24 shall be strictly followed in conjunction with Paragraph 11.26.

11.26.1.2 Chrome-manganese rails shall be treated as indicated in Table 11.3.

11.26.1.3 The 40-50mm Gap (SKV-L) exothermic portion shall be used where an existing exothermic (SKV-F) joint has to be removed, or where rail gaps are larger than those prescribed for SKV-F joints. (The old joint shall be removed completely).

11.26.2 PREPARATION OF THE JOINT.

11.26.2.1 A 35-40mm gap for SKV-M or 40-50mm gap for SKV-L is required to ensure adequate fusion between the exothermic metal and rails.

11.26.2.2 Rail ends shall be tested for cracks by using dye penetrant.

11.26.2.3 Rail ends shall be lifted 2mm to compensate for sagging caused by applied heat.

11.26.3 POST-CASTING PROCEDURES.

11.26.3.1 See Tables 11.4 and 11.5 for parameters.

11.26.3.2 Loose sand on the rail crown shall be removed.

11.26.3.3 Excess cast metal shall be removed by means of a hydraulic shearing machine. Risers shall be bent vertically, away from joint.

11.26.3.4 Chrome-manganese rail joints shall immediately after shearing, but no later than 8 minutes after casting, be covered completely with an approved insulating material for at least 30 minutes.

11.26.3.5 Apply retarded cooling in accordance with Table 11.3.

11.26.3.6 After joint has reached ambient temperature, the risers shall be bent sideways.

11.26.3.7 All mould material shall be removed from joint collar. Joint surroundings shall be cleaned with a chisel, ball peen hammer and wire brush.

11.27 EXOTHERMIC CASTING OF COMPOSITE JOINTS 24-26MM GAP (SKV-F).

11.27.1 GENERAL.

11.27.1.1 The procedures described in Paragraphs 11.1 to 11.24 shall be strictly followed in conjunction with Paragraph 11.27.

11.27.1.2 Chrome-manganese rails shall be treated as indicated in Table 11.3.

11.27.1.3 A Junction joint is the joining of different rail profiles e.g. 40kg/m to 48kg/m rails, 48kg/m to 57kg/m rails, or 57kg/m to 60kg/m rails. Junction joints require the use of exothermic composite mould kits and mould shoes.

11.27.1.4 When a 40kg/m and 57kg/m rail are joined, a 48kg/m closure rail and appropriate composite kits shall be used to join the adjacent rails to the 48kg/m closure rail.

11.27.1.5 Left-hand and right-hand sets shall be manufactured when junction rails are manufactured off-track.

11.27.2 PREPARATION OF THE JOINT.

11.27.2.1 A gap of at least 24-26mm for SKV-F is required to ensure adequate fusion between the exothermic metal and rails.

11.27.2.2 Rail ends shall be tested for cracks by using dye penetrant.

11.27.2.3 Rail ends shall be lifted 1mm to compensate for sagging caused by applied heat.

11.27.2.4 The top and running side of the crown shall be aligned with the aid of a 1m straightedge. A deviation in the alignment will however occur at the flange.

11.27.2.5 Maximum allowable rail height differences are displayed in Table 11.6. When the limits in Table 11.6 are exceeded, suitable closure rails shall be used.

Table 11.6. Rail height difference limits.

Joint profiles	Max height difference (mm)	Min height difference (mm)
40/48	26	20
48/57	18	12
57/60	3	3
57/UIC60 or S60	10	4

11.27.3 POST-CASTING PROCEDURES.

11.27.3.1 See Tables 11.4 and 11.5 for parameters.

11.27.3.2 Loose sand on the rail crown shall be removed.

11.27.3.3 Excess cast metal shall be removed by means of a hydraulic shearing machine. Risers shall be bent vertically, away from joint.

11.27.3.4 Chrome-manganese rail joints shall immediately after shearing, but no later than 8 minutes after casting, be covered completely with an approved insulating material for at least 30 minutes.

11.27.3.5 Apply retarded cooling in accordance with Table 11.3.

11.27.3.6 All mould material shall be removed from joint collar. Joint surroundings shall be cleaned with a chisel, ball peen hammer and wire brush.

11.27.3.7 After joint has reached ambient temperature, the risers shall be bent upwards.

11.28 EXOTHERMIC CASTING OF TURNOUT SETS 24-26MM GAP (SKV-F).

11.28.1 GENERAL.

11.28.1.1 The procedures described in Paragraphs 11.1 to 11.24 shall be strictly followed in conjunction with Paragraph 11.28.

11.28.1.2 Chrome-manganese rails shall be treated as indicated in Table 11.3.

11.28.1.3 Exothermic composite mould kits 48kg/m to 51kg/m rails shall be used when joining stock rails and switch blades.

11.28.2 PREPARATION OF THE JOINT.

11.28.2.1 A 24-26mm gap for SKV-F is required to ensure adequate fusion between the exothermic metal and rails.

11.28.2.2 Rail ends shall be tested for cracks by using dye penetrant.

11.28.2.3 Rail ends shall be lifted 1mm to compensate for sagging caused by applied heat.

11.28.2.4 When inclined (1:20) and vertical rails at turnout sets are joined, the crown and flange shall be aligned. For this purpose a rail alignment device shall be used (Manual for Track Maintenance (2000)).

11.28.3 POST-CASTING PROCEDURES.

11.28.3.1 See Tables 11.4 and 11.5 for parameters.

11.28.3.2 Loose sand on the rail crown shall be removed.

11.28.3.3 Excess cast metal shall be removed by means of a hydraulic shearing machine. Risers shall be bent vertically, away from joint.

11.28.3.4 Chrome-manganese rail joints shall immediately after shearing, but no later than 8 minutes after casting, be covered completely with an approved insulating material for at least 30 minutes.

11.28.3.5 Apply retarded cooling in accordance with Table 11.3.

11.28.3.6 All mould material shall be removed from joint collar. Joint surroundings shall be cleaned with a chisel, ball peen hammer and wire brush.

11.28.3.7 After joint has reached ambient temperature, the risers shall be bent upwards.

11.28.4 GRINDING.

11.28.4.1 A MC2 grinding machine and angle grinder shall be used where a MP12 grinding machine cannot be used.

11.29 EXOTHERMIC CASTING ON CONCRETE SLABS.

11.29.1 GENERAL.

11.29.1.1 The procedures described in Paragraphs 11.1 to 11.24 shall be strictly followed in conjunction with Paragraph 11.29.

11.29.1.2 Chrome-manganese rails shall be treated as indicated in Table 11.3.

11.29.1.3 Exothermic casting of rails on concrete slabs mainly occurs in tunnels. Spacers are necessary to lift the rail ± 80mm from the concrete slab, to fit exothermic mould kits.

11.29.2 EQUIPMENT AND CONSUMABLES.

11.29.2.1 The following shall be used:

- 3-piece mould kit.
- One pair special mould shoes and one bottom tray.
- One pair special refractory moulds and one bottom slab.
- Fifteen special spacers, (75mm x 75mm x 8mm angle iron), two round bars (16mm diameter) which are welded to each angle iron to fit into the holes of the Pandrol chairs/shoulders.

11.29.3 PREPARATION OF THE JOINT.

11.29.3.1 The 15 special spacers shall be evenly spaced over a distance of 20m on both sides of the joint to lift the track ± 80mm.

11.29.3.2 Bottom tray shall be fitted underneath the flange.

11.29.3.3 Two half-moulds shall be fitted over the gap and the refractory tile shall be fixed to the bottom of the moulds. The tile and the moulds shall fit sound before sealing begins.

11.29.3.4 The gap between the tile and the bottom tray shall be sealed with sealing sand. The flat side of the refractory tile shall under no circumstances be placed against the rail, as it may cause contracting cracks and insufficient fusion underneath the flange. The collar formation of the bottom shall face upwards.

11.29.3.5 Mould shoes shall be positioned over the moulds and tightened slightly. The gaps between the mould shoes and the rail shall be sealed.

11.29.3.6 All openings between the mould shoes, refractory tile and rail shall be properly sealed.

11.29.4 POST-CASTING PROCEDURES.

11.29.4.1 See Tables 11.4 and 11.5 for parameters.

11.29.4.2 Loose sand on the rail crown shall be removed.

11.29.4.3 Excess cast metal shall be removed by means of a hydraulic shearing machine. Risers shall be bent vertically, away from joint.

11.29.4.4 Chrome-manganese rail joints shall immediately after shearing, but no later than 8 minutes after casting, be covered completely with an approved insulating material for at least 30 minutes.

11.29.4.5 Apply retarded cooling in accordance with Table 11.3.

11.29.4.6 All mould material shall be removed from joint collar. Joint surroundings shall be cleaned with a chisel, ball peen hammer and wire brush.

11.29.4.7 After joint has reached ambient temperature, the risers shall be bent upwards.

11.30 EXOTHERMIC CASTING OF CRANE RAILS WITH 24-26MM GAPS (SKS).

11.30.1 Exothermic casting kits and procedures for crane rails are available on special request from the supplier.

CHAPTER 12 – REPAIRING RAIL-MANUFACTURED CROSSINGS.

12.1 GENERAL.

12.1.1 The turnout is the single most expensive item in track and incorrect welding procedures can be detrimental. For this reason, quality work is of utmost importance.

12.1.2 Good co-operation and planning between Maintenance and Production personnel is therefore necessary to ensure the best results.

12.1.3 Repairs to rail-manufactured crossings may be done by Track Welders, who have been declared competent by an accredited person from Central office in conjunction with Esselen Park or an approved body.

12.2 DEFINITIONS AND METHODS OF MEASUREMENT.

12.2.1 POINT X.

12.2.1.1 Point X is a reference point measured 1m from the tip of the crossing nose in the trailing direction.

12.2.2 POINTS H_1 AND H_2.

12.2.2.1 Points H_1 and H_2 are 25mm from the running side of the crown on both sides of the crossing nose in line with point X. These are the points where crown wear is measured using a depth gauge, or feeler gauge with a 1m straightedge (Annexures 12-1 to 12-4).

12.2.3 CROWN WEAR H.

12.2.3.1 Crown wear H is the larger of the two measurements at points H_1 and H_2 (Figure 12.1).

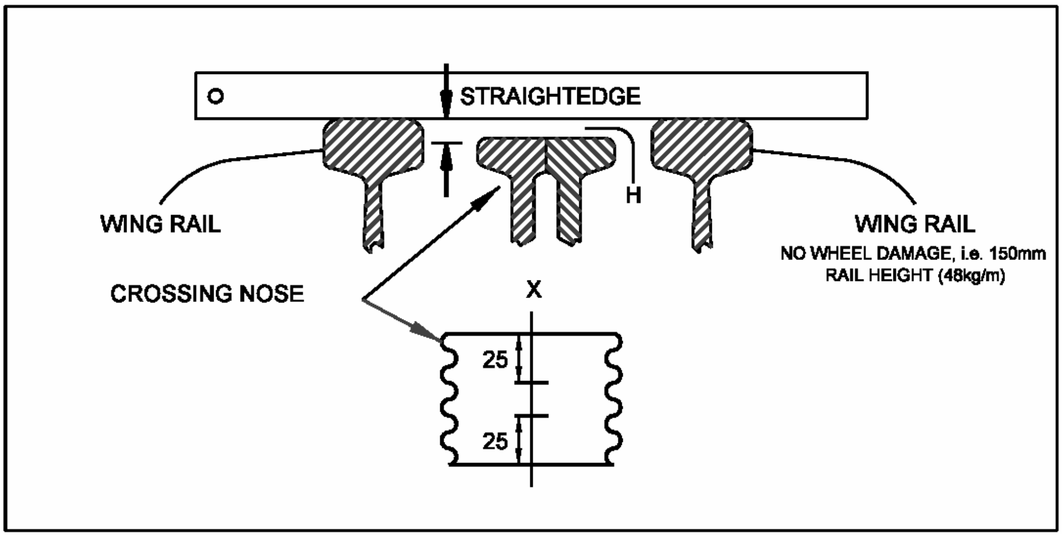

Figure 12.1. Crown Wear H.

12.2.3.2 Crown wear H will be used to determine the position of point P (Annexures 12-1 and 12-2 for 1:9 crossings, and Annexures 12-3 and 12-4 for 1:12 crossings).

12.2.3.3 No crown wear H exists at X on a new crossing.

12.2.4 POINT P.

12.2.4.1 Point P is 25mm from the tip of the splice, measured in the facing direction on all new rail-manufactured crossings.

12.2.4.2 Determining the position of point P on a crossing depends on the degree of crown wear. Distance from the tip of the nose to the tip of the splice rail is:

- 1:9 crossings - ±555mm.
- 1:12 crossings - ±720mm.

12.2.4.3 Length of decline at the tip of the nose is 70mm for 1:9 and 1:12 crossings.

12.2.4.4 Point P may not be closer than 250mm from the tip of the nose.

12.2.4.5 70mm from the tip of the nose in the trailing direction, the height difference between the nose and wings shall be 6.4mm, which makes provision for the profile of a new train wheel (Annexures 3-2 and 12-5).

12.2.4.6 The effective nose surface length for a new crossing is:

- 555mm – 70mm – 25mm = 460mm for a 1:9 crossing.
- 720mm – 70mm – 25mm = 625mm for a 1:12 crossing.

12.2.4.7 The position of point P for a worn crossing shall be determined as follows. Divide the effective nose surface length by 6.4, to divide the nose length into intervals of:

- 460/6.4 = 72mm for a 1:9 crossing.
- 625/6.4 = 98mm for a 1:12 crossing.

12.2.4.8 For every 1mm of crown wear H, point P moves one interval closer to the point of the nose. Example:

- Point P on a new 1:9 crossing is 25mm from the tip of the splice rail.
- Point P on a 1:9 crossing with 1mm crown wear H is 25mm + 72mm = 97mm from the tip of the splice rail.
- Point P on a 1:9 crossing with 2mm crown wear H is 25mm + 72mm + 72mm = 169mm from the tip of the splice rail.
- Etc. (Annexure 12-1).

12.2.4.9 Table to determine position of point P.

Table 12.1. Position of point P depending on crown wear H.

Crown wear H	**Point P's distance from the tip of the splice rail in the facing direction**	
	1:9 Crossings	**1:12 Crossings**
0mm	25mm	25mm
1mm to 1,49mm	97mm	123mm
1.5mm to 2.49mm	169mm	221mm
2.5mm to 3.49mm	241mm	319mm
3.5mm to 4.49mm	305mm	417mm
greater than 4.5mm	305mm	470mm

12.2.5 AREA Q.

12.2.5.1 Area on the wings damaged by train wheels at the transfer area is defined as Q (mm^2).

12.2.6 AREA R.

12.2.6.1 Area on the nose damaged by train wheels at the transfer area is defined as R (mm^2).

12.2.7 POINT E.

12.2.7.1 Point E is the point where wheel contact becomes visible on the wings (trailing side).

12.2.8 POINT F.

12.2.8.1 Point F is 100mm from point E on the wings in the trailing direction (Figure 12.2).

12.2.9 POINT D.

12.2.9.1 Point D indicates where welding on the wings will stop on the facing side (Figure 12.2).

12.2.9.2 Determining the location of point D will be further discussed in Paragraph 12.6.2.4 (Figure 12.2).

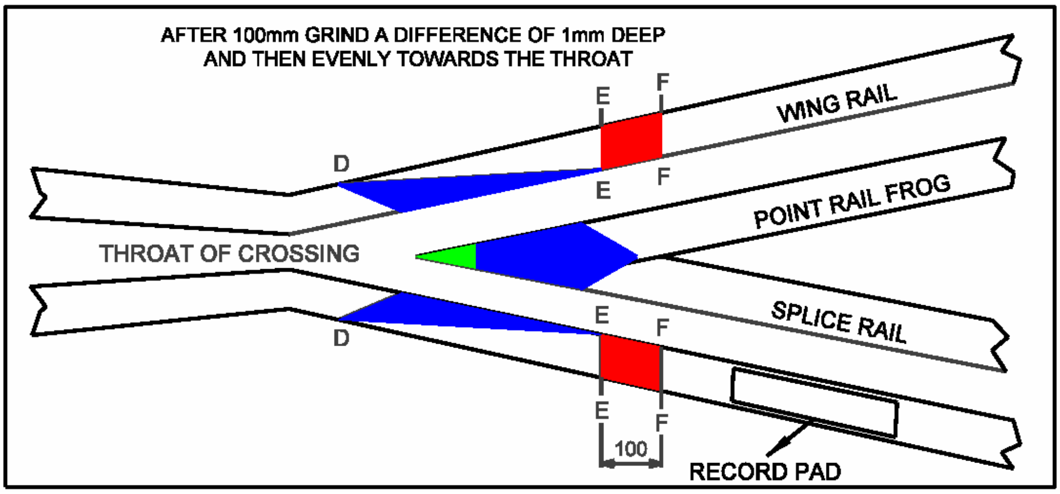

Figure 12.2. Location of Points E, D and F.

12.2.10 DISTANCE L.

12.2.10.1 L is the distance between point P and point X on the nose. After welding, the section between point P and point X shall have constant height.

12.2.11 POINT S.

12.2.11.1 Point S is 70mm from the tip of the nose in the trailing direction. The distance between point S and the tip of the nose shall at all times remain 70mm.

12.2.12 DISTANCE M.

12.2.12.1 M is the distance between point P and point S (Figure 12.4).

12.2.13 POINT C.

12.2.13.1 Point C indicates the end of the welding area on the nose (trailing side).

12.2.14 RECORD PAD.

12.2.14.1 The record pad is brazed on the end of the right (when facing the trailing side) wing rail (Figure 12.2).

12.2.14.2 Information that shall be recorded on the record pad includes the welder code, date maintained, turnout number and G or W indicating whether grinding or welding was done.

12.2.14.3 The dimensions of the record pad are 150mm x 50mm.

12.3 INSPECTION, DECISION MAKING AND PLANNING.

12.3.1 Maintenance (track) Personnel are responsible for the inspection of turnout sets, slips and crossings, and where any abnormal wear or defects occur, necessary arrangements shall be made to do repair work. This inspection includes determining crown wear H and, based on that (amongst other factors), prioritizing the particular turnout for maintenance.

12.4 PROTECTION OF TRAINS AND THE SAFEGUARDING OF PERSONNEL.

12.4.1 Protection of trains and the safeguarding of personnel shall be done in accordance with Spoornet General Appendix No 6 (Part 1).

12.4.2 Repairs to rail-manufactured crossings may be undertaken between trains or under total occupation.

12.5 SAFE WORKING PROCEDURE.

12.5.1 Refer to Chapter 2.

12.6 PREPARATION.

12.6.1 PREPARATION BY TRACK PERSONNEL.

12.6.1.1 Track personnel shall ensure that the track formation is well drained and that there is sufficient clean ballast.

12.6.1.2 The crossing and adjacent track shall be de-stressed before welding, as broken or bent crossing bolts indicate stress.

12.6.1.3 Excessive side wear and/or cracks may not be present on the crossing.

12.6.1.4 Sleepers shall be in a good condition and properly tamped, and all crossing bolts and coach screws shall be inserted and tightened.

12.6.1.5 Excessively worn rail fasteners shall be replaced.

12.6.1.6 Track geometry shall conform to the relevant standard (depending on line type) before welding/preventative grinding commences.

12.6.1.7 All Nylock nuts shall be removed and replaced with standard nuts before preheating commences.

12.6.1.8 All crossing and sleeper fastenings shall be loosened to allow for contraction and expansion caused by applied heat.

12.6.2 PREPARATION BY WELDING PERSONNEL.

12.6.2.1 Ensure that all undesirable matter, such as grease, oil and rust are removed from the immediate working area.

12.6.2.2 Precautions shall be taken during the preheating and welding process to prevent wooden sleepers from being damaged by heat.

12.6.2.3 Determining of the area to be welded on the nose:

- Place the one end of the straightedge on the feeler gauge with crown wear measurement H obtained at point X, and the other end towards the trailing direction.
- The point where light stops shining underneath the 1m straightedge is point C, which identifies where welding shall stop.

12.6.2.4 Determining of the areas to be welded on the wings:

- Mark out points E and F.
- Grind between points E and F until the rail height (measured with an outside calliper) between points E and F is equal to the original rail height minus crown wear H (indicated red in Figure 12.2).
- Lower the wings gradually from point E in the direction of the throat by grinding so that the rail height is constant between point F and the throat area.
- Place the one end of the straightedge on point E and the other end towards the throat of the crossing.
- The point where light stops shining underneath the 1m straightedge is point D, which identifies where welding shall stop.

12.6.3 GRINDING PRIOR TO WELDING.

12.6.3.1 Before any welding work can commence, all loose and work-hardened metal as well as hairline cracks shall be removed with a MC2 grinding machine.

12.6.3.2 All overlaps and previous welding deposits shall be removed by grinding.

12.6.3.3 In cases where a rail-manufactured crossing had undergone repair welding in the past, grinding shall be done 3mm deep or until other defects have been removed. This will ensure the removal of all defects such as:

- Slag inclusion.
- Undercutting.
- Porosity.

12.6.3.4 Dye penetrant shall be used to ensure that all defects have been removed. The surface shall be cleaned thoroughly with a steel brush before testing with dye penetrant.

12.6.3.5 During grinding work slight pressure shall be applied. Care shall be taken that grinding stones are not damaged or clogged with fine steel. Using damaged grinding stones could be fatal.

12.6.3.6 In cases where grinding the running surface deeper than 12mm is required, the track personnel shall be notified in order for them to decide whether the passage of trains is safe.

12.7 PREHEATING.

12.7.1 Preheating of different types of rails shall be done strictly as set out in Chapter 5.

12.7.2 The spacing blocks and rails shall be pre-heated simultaneously to delay cooling.

12.7.3 The area to be welded, shall be pre-heated gradually on both sides of the rail (up to 100mm past the area to be welded), evenly to and fro over the flange, web and crown by means of a 900mm stainless steel tip tube with a 3H heating nozzle.

12.7.4 Rail-manufactured crossings are manufactured from different grades of steel. If the roll marks are not visible, the rail type shall be assumed to be UIC-A.

12.8 WELDING PROCESSES.

12.8.1 PRECAUTIONS.

12.8.1.1 Employees and the public shall be protected against the danger of open-arc flashes.

12.8.1.2 No welding is allowed in rain or fog.

12.8.1.3 The earth cable shall be fitted with an approved clamp and clamped next to the welding area to prevent short circuits and the loss of current.

12.8.1.4 The welding arc length shall be kept as short as possible – approximately the core thickness of the electrode that is used for welding. Welding beads on all types of rails may not be longer than 150mm to control the heat. Welding beads shall be deposited in such a manner that the one bead overlaps the other. Welding deposits shall be cleaned directly after welding.

12.8.1.5 Peen every welding bead softly with the ball of a 1kg hammer to relieve the internal stress, which could lead to future defects. If cracks, porosity, undercutting, grooves, cavities or slag inclusions appear in the welding work, the whole defect shall be removed by means of grinding.

12.8.1.6 Pre-heat the rail to the prescribed temperature before welding commences.

12.8.1.7 Welding repairs of rail-manufactured crossings can be done by means of manual metal arc welding (MMA, a constant current (CC) process), or flux-cored arc wire (FCAW, a constant voltage (CV) process).

12.8.2 WELDING METHOD ON THE CROSSING.

12.8.2.1 The method that is used to weld rail-manufactured crossings is called the stringer bead method. This method is shown in Figure 12.3 and discussed below:

12.8.2.2 Welding method on the nose (from point C to tip of nose; Figure 12.3). This method eliminates slag inclusion and ensures that heat is evenly distributed.

- Weld bead 1 in the middle of the nose.
- Weld bead 2 on the right side of bead 1.
- Weld bead 3 on the left side of bead 1.
- Weld bead 4 next to bead 2.
- Weld bead 5 next to bead 3.

- Follow this sequence until the full width of the crown has been welded.

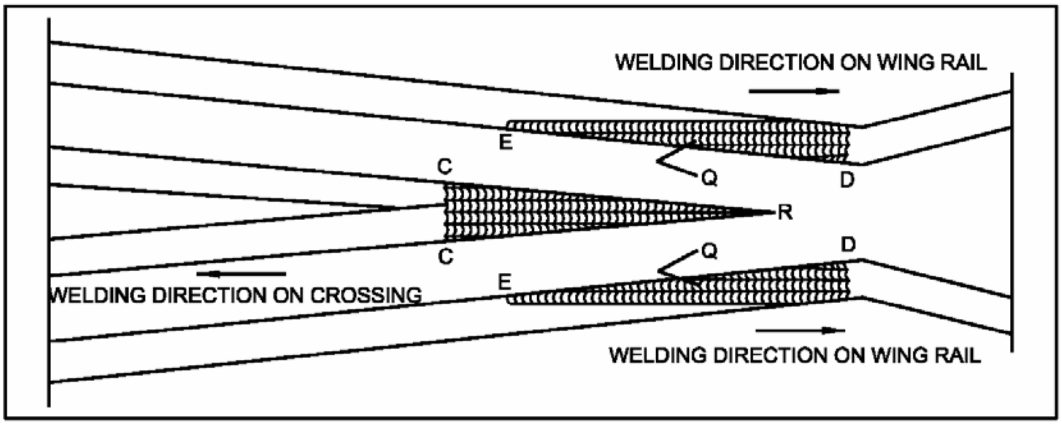

Figure 12.3. Welding method.

12.8.2.3 Welding method for the wing rails (area between points D-E shown in Figure 12.3).

- Weld bead 1 at the edge of running side.
- Weld bead 2 next to bead 1.
- Weld bead 3 next to bead 2.

12.8.2.3.1 This sequence shall be repeated until the full width of the crown has been welded.

12.8.2.3.2 This process shall be followed until the welded area is 3mm higher than the required height. This will ensure a smooth and even surface after grinding.

12.8.2.3.3 Welding beads shall be deposited next to each other on both sides of the splice joint, in such a manner that the point and splice rails are not welded together, as this will cause metal breakouts. After welding, the splice shall be cut open using an angle grinder with a 3mm cutting disc, to minimize metal flow and breakouts.

12.9 FINAL GRINDING.

12.9.1 A MC2 grinding machine shall be used for grinding crossings.

12.9.2 Grinding the wing rails shall be done in accordance with the standards and tolerances in Paragraph 12.10.

12.9.3 Grinding on the nose shall be done from point S in the direction of point P. A contour gauge (Annexure 3-2) shall be used to ensure the 6.4mm height difference between point S and the wings. The area where grinding is done shall be marked with yellow chalk. Grinding shall be done with an even incline in the direction of point P until the 1m straightedge reaches the yellow chalk mark.

12.9.4 Grinding on the point rail and splice rail shall be done in a manner that ensures the following:

- A constant rail height from point P to point X.
- A height difference of no less than 3mm between point P and point S.

12.9.5 This shall be measured by placing a straightedge longitudinally on the point rail. Care shall be taken that the yellow chalk marks at point P and point S are not disturbed during grinding.

12.9.6 Final grinding on the wing shall be done from point F towards the facing side until specified standards and tolerances are reached (Figure 12.2).

12.9.7 After rough grinding and before final grinding:

- Divide the nose into two equal parts using a chalk line.
- Using the 1:20 contour gauge, grinding the nose shall be done on both sides of the chalk line, ensuring the 1:20 inclination.
- After this, restore the 13mm radius to the nose and wings, by grinding.

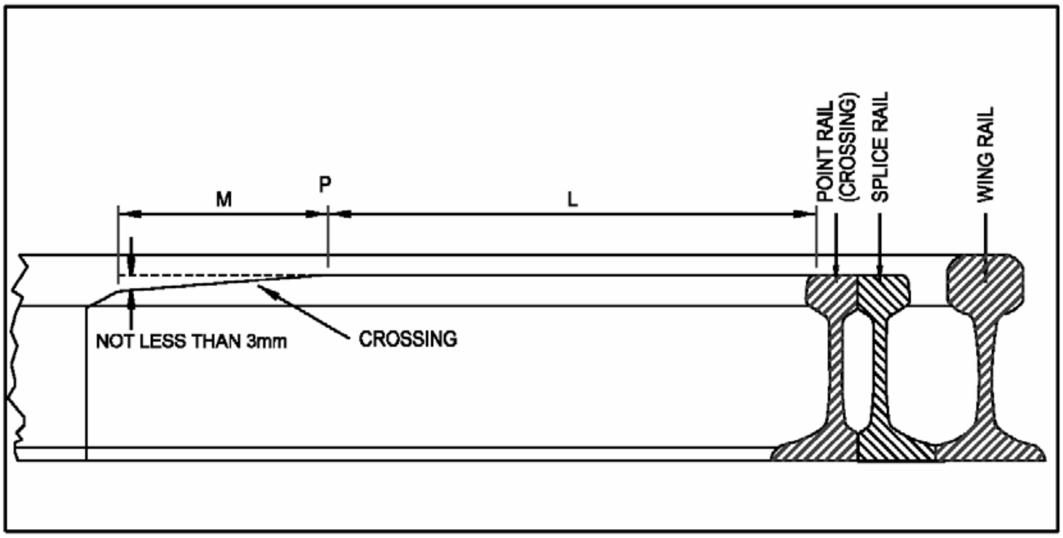

Figure 12.4. Indication of Distances M and L.

12.9.8 By grinding the 1:20 inclination and 13mm radius correctly, metal flow and breakouts on the crossing will be minimized. The original profile of the splice and point rail shall be maintained.

12.9.9 Always remember when grinding the crossing, the crossing nose should fit the wings and not the wings the crossing nose.

12.9.10 Ensure that the point rail and splice rail are cut open with an angle grinder, 5mm deep with a 3mm cutting disc, at an angle of 45^o. This will minimize metal flow and breakouts which could lead to defects.

12.9.11 Any remaining grooving as well as sound grinding shall be done with an angle grinder.

12.9.12 The crossing shall be tested with a dye penetrant for defects.

12.10 STANDARDS AND TOLERANCES.

12.10.1 A feeler gauge of 0.2mm may not enter anywhere underneath a 1m straightedge placed on the crossing nose and wing rails in the longitudinal direction.

12.10.2 Once the crossing has been repaired, all defects shall have been removed, including:

- Broken chairs.
- Wheel-spin burns.
- Battered rail ends and dipped joints.
- Incorrect inclination and radius.
- Loose and missing fastenings.
- Out of standard track geometry (by means of tamping and/or component replacement).

12.10.3 All daily work performed shall be logged on the prescribed field sheet (Annexure 1-8).

12.10.4 A Technical Superintendent or his representative shall inspect all welding work. Thereafter a report shall be submitted to the Depot Engineer.

12.10.5 The Brinell hardness of the parent metal shall be approximately 280.

CHAPTER 13 – REPAIRING 14% CAST MANGANESE (MONOBLOCK) CROSSINGS.

13.1 GENERAL

13.1.1 Monoblock crossings offer greater stability than rail-manufactured crossings and have better design characteristics such as built-in cant in the wings, which ensures smoother transition of the wheels.

13.1.2 Monoblock crossings are manufactured from 14% manganese steel, which has work-hardening ability and a life span that exceeds that of rail-manufactured crossings by up to three times.

13.1.3 The unique chemical composition of 14% manganese steel comprises of 1 to 1.2% carbon, and 12 to 14% manganese (HATFIELD STEEL), which is very brittle.

13.1.4 Austenitic structures are not stable, resulting in precipitation of the carbide structure when material is exposed to temperatures of more than 200ºC. This is attributable to very high carbon content in the steel, which forms carbides on grain boundaries and causes the cast piece to break easily.

13.1.5 Only qualified artisan welders, who have successfully passed the relevant modules from the Advanced Track Welding course, may be used for this process.

13.2 DEFINITIONS AND METHODS OF MEASUREMENT.

13.2.1 POINT P.

13.2.1.1 Point P is located 167mm from the PI for 1:9 turnouts (48kg/m), 215mm for 1:12 turnouts (48kg/m) and 230mm for 1:12 turnouts (57kg/m), measured in the trailing direction on all cast monoblock crossings (Annexure 13-1).

13.2.2 AREA Q.

13.2.2.1 Area on the wings damaged by train wheels at the transfer area (approximately between points D and E) is defined as Q (mm^2) (Annexure 13-1).

13.2.3 AREA R.

13.2.3.1 Area on the nose and insert damaged by train wheels at the transfer area (approximately the area between the PI and point C) is defined as R (mm^2) (Annexure 13-1).

13.2.4 POINT E.

13.2.4.1 Point E is ±600mm from the PI in the trailing direction for 1:12 crossings and ±500mm for 1:9 crossings on both wings (Annexure 13-1).

13.2.5 POINT D.

13.2.5.1 Point D indicates where welding on the wings will stop on the facing side.

13.2.5.2 Determining the location of point D will be further discussed in Paragraph 13.5.4.2.3.

13.2.6 DISTANCE L.

13.2.6.1 L is the distance between point P and point C on the nose. After welding, the section between point P and point C shall have constant height.

13.2.7 DISTANCE M.

13.2.7.1 M is the distance between point P and the tip of the nose.

13.2.8 POINT C.

13.2.8.1 Point C indicates the end of the welding area on the nose (trailing side).

13.2.9 RECORD PAD.

13.2.9.1 The record pad is welded onto the crossing as indicated in Annexure 13-1.

13.2.9.2 Information that shall be recorded on the record pad include the welder code, date maintained, turnout number and G or W indicating whether grinding or welding was done.

13.3 INSPECTION AND DECISIONMAKING.

13.3.1 The purpose of condition assessment and safety inspections is to determine in advance when, which and where repairs have to be done to a crossing.

13.3.2 Preventative grinding shall be done within the first month after new turnouts were installed in track, to prevent metal flow caused by the work hardening process. Preventative grinding shall be done in accordance with Chapter 6.

13.3.3 Maintenance personnel are responsible for visual inspection of monoblock crossings, and the necessary corrective work shall be arranged if any abnormal wear or defects are present.

13.3.4 Condition assessment of monoblock crossings shall be carried out at least once a year. The following measuring equipment applies:

- Feeler/Taper gauge.
- Crossing contour gauge (Annexure 3-1).
- 1m straightedge.

13.3.5 Condition assessment (wear measurement, description of cracks or any other defects, remarks and recommendations) shall be recorded on the appropriate track welding field sheet. The relevant work shall be prioritised as prescribed in Paragraph 13.3.7. The completed forms shall be forwarded to the Maintenance Manager for notification and decision-making.

13.3.6 All foreign matter shall be removed from a crossing for inspection purposes.

13.3.7 Crossing wear and repair actions.

Table 13.1. Crossing wear and repair actions.

Track Standard	**Wheel damage at Point P**	**Work to be perform on Turnout**
A	0 – 1mm	Preventative Grinding
B	1.1 – 2mm	Preventative Grinding
B1	2.1 – 3mm	Preventative Grinding
B2	3.1 – 4mm	Preventative Grinding (GFB Lines) Weld Crossings (Heavy Haul Lines)
	4.1 – 5mm	Weld Crossings (GFB Lines)
B3	5.1 – 7mm	Weld Crossing (Bad)
C	7.1 – 8mm	Weld Crossing (Very Bad)
C1	Cracks and breakouts	Weld Crossing (Urgent)

13.3.8 The following types of defects may be encountered at monoblock crossings:

- Small vertical and horizontal cracks.
- Wheel damage to the nose and wings of the crossing.
- Visible casting defects.

- Metal breakouts at the nose and wings of crossings.
- Excessive overlaps.
- Sharp edges.
- Wheel-spin burns.

13.3.9 The following defects may result in a crossing being classified as being beyond repair:

- Excessive wheel damage and corrosion.
- Un-repairable and excessive casting defects.
- Horizontal and vertical cracks in boltholes.
- Horizontal and vertical cracks on the cast piece.
- Wear on the cast piece caused by train wheels.

13.3.10 Unevenness to running surfaces of the monoblock crossing may develop as result of work hardening, and shall be rectified by means of preventative grinding.

13.4 ELECTRODES AND FLUX-CORED WIRE.

13.4.1 Only electrodes and flux-cored wire, which have been tested and approved by Transnet Freight Rail (Rail Technology), shall be used (Annexure 4-2).

13.4.2 Central Office shall inform the Depots of the correct electrodes and flux-cored wire to be used, changes and new products that will be implemented.

13.5 WELDING REPAIRS DONE IN TRACK.

When welding is done in track, all welding repair work must be done under total track occupation. Subsequent grinding work can be done under normal occupations. The Maintenance Manager must decide whether it is economical to remove the crossing and perform the repairs in a workshop – taking into account the total occupation requirement.

13.5.1 PROTECTION OF TRAINS AND SAFEGUARDING OF PERSONNEL.

13.5.2 PROTECTION OF TRAINS.

13.5.2.1 Protection shall be afforded in accordance with Spoornet General Appendix No 6 (Part 1) when preventative grinding or welding repairs to rail-bound crossings are done in track.

13.5.3 FIRE PREVENTION.

13.5.3.1 Safety aspects regarding fire prevention shall be taken into account at all times (Chapter 2).

13.5.4 PREPARATION.

13.5.4.1 PREPARATION BY TRACK PERSONNEL.

13.5.4.1.1 Track Maintenance Personnel shall ensure that:

- The track is well drained.
- Sufficient clean ballast stone is available.
- Sufficient sleepers fastenings are loosened on both sides of the defect on the crossing.
- Horizontal and vertical alignment and track gauge of the turnout are corrected.
- All missing nuts and bolts are replaced.

13.5.4.1.2 At least five sleepers from the throat to trailing end of crossing shall be loosened by the track personnel for the purpose of lifting the crossing for the placement of spacers/wedges. This allows for sagging caused by heat induced by welding.

13.5.4.2 PREPARATION BY WELDING PERSONNEL.

13.5.4.2.1 Attend to Paragraph 13.3 before marking-off the crossing for welding.

13.5.4.2.2 Determining the area to be welded on the nose:

- Point P for the different types of monoblock crossings shall be determined as indicated in Annexure 13-1.
- Place a 1m straightedge on crown of crossing, with the one end at point P and the other towards the trailing end of crossing.
- Apply slight pressure on straightedge on the trailing side of the crossing. The point where light stops shining underneath the 1m straightedge indicates point C. This indicates where welding shall stop on the trailing side. The height difference between point P and the other end of the straightedge indicates the wheel damage and can be approximated by using a taper gauge at point P.

13.5.4.2.3 Determining the areas to be welded on the wings:

- Place the feeler gauge transversely on wings of the casting at point P.

- Place the one end of the straightedge on the feeler gauge with measurements obtained as per Paragraph 13.5.4.2.2, and the other end towards the throat of the casting.
- The point where light stops shining underneath the 1m straightedge, is point D, which indicates where welding shall stop on the facing side.

13.5.4.2.4 The crossing shall be lifted 25mm with a jack and a steel plate (150mm x 200mm x 25mm) shall be placed between the sleepers and the crossing base. This will prevent sagging.

13.5.5 GRINDING PRIOR TO WELDING.

13.5.5.1 All loose and work-hardened metal, as well as hairline cracks shall be removed using a MC2 grinding machine before welding work on a crossing commences.

13.5.5.2 Apply slight pressure during the grinding process to avoid over heating (metal turning blue) of the steel. Ensure that the grinding stones are not damaged or clogged with fine steel. Using damaged grinding stones could be fatal.

13.5.5.3 Remove overlaps.

13.5.5.4 Use dye penetrant to ensure all loose metal and hairline cracks are removed. Any sign of cracks, loose metal or porosity will be highlighted as red lines or dots through the white developer.

13.5.5.5 If the running surface is lowered more than 10mm to remove a defect, grinding shall be stopped to not impede on the safe passage of trains. The track personnel shall decide whether the track is safe for the passage of trains.

13.5.6 PREHEATING.

13.5.3.1 Preheating of the monoblock crossing is not permitted.

13.5.7 WELDING PROCEDURE.

13.5.7.1 Staggered method for welding of crossings.

13.5.7.1.1 Crossing may be welded by means of manual metal arc welding (MMAW) or flux-cored arc welding (FCAW).

13.5.7.1.2 The Staggered method is used whereby welding beads are welded at different places on the casting (Figure 13.1).

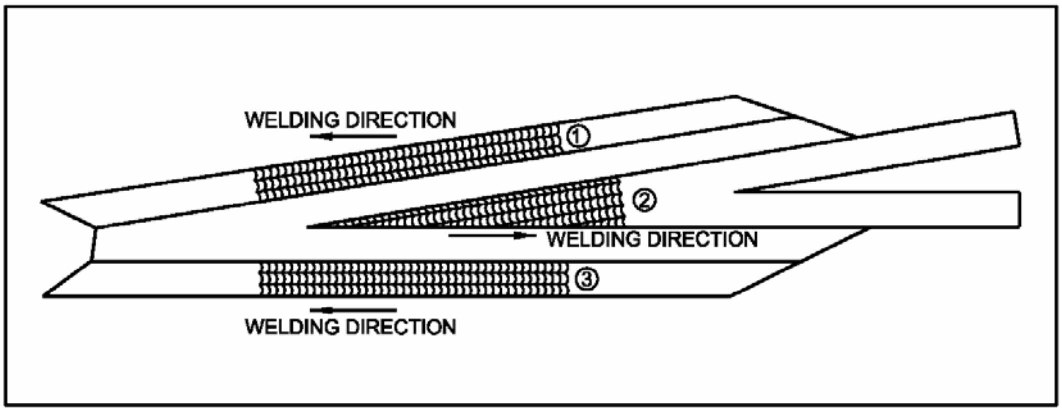

Figure 13.1. Staggered method.

13.5.7.1.3 The staggered method shall be applied until the damaged area is welded (built-up) more than 3mm above the required level. This will ensure a smooth and even running surface after final grinding (Annexure 13-2).

13.5.7.1.4 All slag and spatter shall be removed from the welding beads and crown after the welding process.

13.5.7.1.5 The welded area shall be peened with the ball end of a 1kg hammer to release any internal stresses.

13.5.7.1.6 The temperature of the casting may never rise above 200°C, as this will render carbide, which may cause hairline cracks and brake-outs in the casting.

13.5.7.1.7 Apply the record pad to the crossing.

13.5.8 ROUGH GRINDING.

13.5.8.1 The casting shall cool to ambient temperature before the steel spacer plate may be removed underneath the crossing and all the sleepers fastened and tamped, where after grinding may commence.

13.5.8.2 **NB: When grinding is done on crossing, wings should fit to nose and not nose to wings**.

13.5.8.3 Grinding shall commence with the nose of the casting. Place a 1m straightedge longitudinally in the centre of the nose with one end at point P, and the other towards the trailing end of the crossing. Ensure constant height between point P and point C by grinding. Grind a decline of 3mm from point P to the tip of the nose. It is recommended that point P is left 1mm higher than normal crown wear for distance L towards the trailing end of nose, to allow for work-hardening of the welded metal.

13.5.8.4 Draw a line (with boilermaker's chalk or chalk-line) longitudinally on centre of the nose to sub-divide the nose into two equal halves.

13.5.8.5 Place the concave side of the 1:20 contour gauge on the nose and grind a 1:20 contour to both sides of the nose to match the running surface of the train wheels.

13.5.8.6 A sharp edge will be present on the centre of the nose once 1:20 cant has been achieved on both running surfaces.

13.5.8.7 Place the convex side of the 1:20 contour gauge, transversely at point P to determine the extent of metal to be removed on the wings. Grind proportionally away on left and right wings until contour gauge touches both wings and nose. This height shall be maintained over a distance of 600mm (between point E and the PI) for 1:12 turnouts, and 500mm (between point E and the PI) for 1:9 turnouts as indicated in blue (Annexure 13-1).

13.5.8.8 Grind an even decline on the wings from the PI towards point D as per Annexure 13-1.

13.5.9 FINAL GRINDING.

13.5.9.1 Grind a 13mm radius to gauge corners on wings and both sides of the nose.

13.5.9.2 The sharp edge on the centre of nose shall be removed to leave a sound surface.

13.5.9.3 Grinding shall match running surface of the rest of the casting.

13.5.9.4 Spray running surface of area repaired to observe rail wheel interaction.

13.5.9.5 No grooves, porosity, slag inclusion or undercuts may be present in the welded areas. If such defects do occur, the section in question shall be re-welded and re-grinded.

13.5.10 STANDARDS AND TOLERANCES.

13.5.10.1 Use dye penetrant to test for the presence of cracks after final grinding.

13.5.10.2 A 0.2mm feeler gauge may not enter underneath a 1m straightedge when placed longitudinally on the nose and wings of casting.

13.5.10.3 A decline of 3mm shall be present from point P to the tip of the nose.

13.5.10.4 A 1:20 inclination shall be present on the crown and the gauge corner shall have a radius of 13mm on the nose and wing surfaces of the monoblock crossing.

13.6 WELDING REPAIRS DONE IN A WORKSHOP.

13.6.1 INSPECTION.

13.6.1.1 The crossing shall be cleaned thoroughly by using a wire brush, needle scalar etc. Shot-blasting may be applied if available.

13.6.1.2 When a crossing is found suitable to be repaired in a workshop, it shall be placed on a workbench (jig) specifically made for the repair of monoblock crossings.

13.6.2 PREPARATION BY WELDING PERSONNEL.

13.6.2.1 The same procedure as described in Paragraph 13.5.4.2 shall be followed to prepare the crossing for welding in a workshop.

13.6.2.2 The crossing (placed on the workbench) shall be lifted and a spacer plate (thickness 50mm to 75mm depending on the depth and area to be welded) inserted underneath the nose, and the crossing shall be bent backwards to prevent it from sagging at the nose during the welding process.

13.6.3 GRINDING PRIOR TO WELDING.

13.6.3.1 The same process a described in Paragraph 13.5.5 shall be followed to grind the crossing prior to welding in a workshop.

13.6.4 PREHEATING.

13.6.4.1 Preheating of the monoblock crossing is not permitted.

13.6.5 WELDING PROCEDURE.

13.6.5.1 The same procedure as for welding of the crossing in track (Paragraph 13.5.7) shall be followed to repair the crossings in a workshop.

13.6.5.2 The crossing shall be left in the tensioned position until it has reached ambient temperature, where after the casting may be de-stressed.

13.6.6 ROUGH GRINDING.

13.6.6.1 Grinding after welding is the same procedure as in the case for repair of monoblock crossings in track, refer to Paragraph 13.5.8.

13.6.7 FINAL GRINDING.

13.6.7.1 Final grinding procedure is the same as in the case for repair of monoblock crossings in track, refer to Paragraph 13.5.9.

13.6.8 STANDARDS AND TOLERANCES.

13.6.8.1 See Paragraph 13.5.10.

CHAPTER 14 – REPAIRING RAIL-BOUND CROSSINGS.

14.1 GENERAL.

14.1.1 The metallurgical composition of the 14% manganese insert (Hatfield-steel), as well as the connecting rails, can adversely be changed by incorrect heat application. Special precautionary measures are therefore necessary when these components are welded.

14.1.2 Running surfaces of new casting inserts have already been machined and profiled correctly, and no grinding is permitted on the running surface of the machined casting wing and nose. Only preventative grinding is allowed (Chapter 6).

14.1.3 Only qualified artisan welders, who have successfully passed the relevant modules from the Advanced Track Welding course, may be used for this process.

14.2 DEFINITIONS AND METHODS OF MEASUREMENT.

14.2.1 POINT X.

14.2.1.1 Point X is a reference point measured 1309mm from point of intersection (PI) for 1:12 turnouts, and 980mm from PI for 1:9 turnouts, in the trailing direction.

14.2.2 POINTS H_1 AND H_2.

14.2.2.1 Points H_1 and H_2 are 25mm from the running side of the crown on both sides of the crossing nose in line with point X. These are the points where crown wear is measured using a depth gauge, or feeler gauge with a 1m straightedge.

14.2.3 CROWN WEAR H.

14.2.3.1 Crown wear H is the larger of the two measurements at points H_1 and H_2.

14.2.3.2 Negative crown wear H exists at point X on a new crossing (Nose is higher than rail-bound rails).

14.2.4 POINT P.

14.2.4.1 Point P is 180mm from the PI for 1:9 turnouts and 240mm from the PI for 1:12 turnouts, measured in the trailing direction on all rail-bound crossings (Annexures 14.1 and 14.2).

14.2.5 WHEEL DAMAGE.

14.2.6 The difference between crown wear H and crown wear at point P is the wheel damage.

14.2.7 AREA Q.

14.2.7.1 Area on the wings damaged by train wheels at the transfer area is defined as Q (mm^2).

14.2.8 AREA R.

14.2.8.1 Area on the nose and insert damaged by train wheels at the transfer area is defined as R (mm^2).

14.2.9 POINT E.

14.2.9.1 Point E is 450mm from the PI for 1:9 turnouts, and 580mm from the PI for 1:12 turnouts, in the trailing direction.

14.2.10 POINT D.

14.2.10.1 Point D indicates where welding on the wings will stop on the facing side.

14.2.10.2 Determining the location of point D will be further discussed in Paragraph 14.5.3.2.5.

14.2.11 POINT G.

14.2.11.1 Point G is 230mm from the PI for 1:9 turnouts, and 300mm from the PI for 1:12 turnouts, in the trailing direction.

14.2.12 DISTANCE L.

14.2.12.1 L is the distance between point P and point X on the nose. After welding, the section between point P and point X shall have constant height.

14.2.13 DISTANCE M.

14.2.13.1 M is the distance between point P and the tip of the nose.

14.2.14 POINT C.

14.2.14.1 Point C indicates the end of the welding area on the nose (trailing side).

14.2.15 RECORD PAD.

14.2.15.1 The record pad is brazed on the end of the right (when facing the trailing side) rail-bound rail.

14.2.15.2 Information that shall be recorded on the record pad include the welder code, date maintained, turnout number and G or W indicating whether grinding or welding was done.

14.3 INSPECTION, DECISION MAKING AND PLANNING.

14.3.1 The purpose of condition assessment and safety inspections is to determine in advance when, which and where repairs have to be done to a crossing.

14.3.2 Preventative grinding shall be done within the first month after new turnouts were installed in track, to prevent metal flow caused by the work hardening process. Preventative grinding shall be done in accordance with Chapter 6.

14.3.3 Maintenance personnel are responsible for visual inspection of rail-bound crossings, and the necessary corrective work shall be arranged if any abnormal wear or defects are present.

14.3.4 Condition assessment of rail-bound crossings shall be carried out at least once a year. The following measuring equipment applies:

- Feeler/Taper gauge, and two 1mm and two 2mm shims.
- Crossing contour gauge (Annexure 3-1).
- 1m straightedge.
- Depth gauge.

14.3.5 Condition assessment (wear measurement, description of cracks or any other defects, remarks and recommendations) shall be recorded on the appropriate track welding field sheet. The relevant work shall be prioritised as prescribed in Paragraph 13.3.7. The completed forms shall be forwarded to the Maintenance Manager for notification and decision-making.

14.3.6 All foreign matter shall be removed from a crossing for inspection purposes.

14.3.7 The following types of defects may be encountered at rail-bound crossings:

- Small vertical and horizontal cracks.
- Wheel damage to the nose and wings of the crossing.

- Visible casting defects.
- Metal breakouts at the nose and wings of crossings.
- Excessive overlaps.
- Sharp edges.
- Wheel-spin burns.

14.3.8 The following defects may result in a crossing being classified as been beyond repair:

- Excessive wheel damage and corrosion.
- Un-repairable and excessive casting defects.
- Horizontal and vertical cracks in boltholes.
- Horizontal and vertical cracks on the cast piece.
- Wear on the cast piece caused by train wheels.

14.4 ELECTRODES AND FLUX-CORED WIRE.

14.4.1 Only electrodes and flux-cored wire, which have been tested and approved by Spoornet Rail Technology, shall be used (Annexure 4-2).

14.4.2 Central Office shall inform the Depots of the correct electrodes and flux-cored wire to be used, changes and new products that will be implemented.

14.5 WELDING REPAIRS DONE IN TRACK.

14.5.1 PROTECTION OF TRAINS.

14.5.1.1 Protection shall be afforded in accordance with Spoornet General Appendix No 6 (Part 1) when preventative grinding or welding repairs to rail-bound crossings are done in track.

14.5.2 FIRE PREVENTION.

14.5.2.1 Safety aspects regarding fire prevention shall be taken into account at all times (Chapter 2).

14.5.3 PREPARATION.

14.5.3.1 PREPARATION BY TRACK PERSONNEL.

14.5.3.1.1 Track Maintenance Personnel shall ensure that:

- The track is well drained.

- Sufficient clean ballast stone is available.
- Sufficient sleepers fastenings are loosened on both sides of the defect on the crossing.
- Horizontal and vertical alignment and track gauge of the turnout are corrected.
- And that all missing nuts and bolts are replaced.

14.5.3.1.2 At least five sleepers from the throat to trailing end of crossing shall be loosened by the track personnel for the purpose of lifting the crossing for the placement of spacers/wedges. This allows for sagging caused by heat induced by welding.

14.5.3.2 PREPARATION BY WELDING PERSONNEL.

14.5.3.2.1 Remove all foreign matter, such as grease, oil, and rust.

14.5.3.2.2 Attend to Paragraph 14.3 before marking-off for welding.

14.5.3.2.3 Measure out the areas on the nose to be welded in accordance with Paragraph 14.2.

14.5.3.2.4 Determining the area to be welded on the nose:

- Point P for the different types of rail-bound crossings shall be determined as indicated in Annexures 14-1 and 14-2.
- Adjacent to point P, place the one end of the straightedge on the feeler gauge with measurements obtained as per Paragraph 14.2, and the other end towards the trailing end of the casting.
- The point where light stops shining underneath the 1m straightedge, is point C, which indicates where welding shall stop (indicated green and blue in Annexures 14-1 and 14-2).

14.5.3.2.5 Determining the areas to be welded on the wings:

- Place the feeler gauge transversely on wings of the casting at point P.
- Place the one end of the straightedge on the feeler gauge with measurements obtained as per Paragraph 14.2, and the other end towards the throat of the casting.
- The point where light stops shining underneath the 1m straightedge, is point D, which indicates where welding shall stop (Indicated green and blue in Annexures 14-1 and 14-2).

14.5.3.2.6 The crossing shall be lifted 25mm with a jack and a steel plate (150mm x 200mm x 25mm) shall be placed between the sleepers and the crossing base. This will prevent sagging.

14.5.4 GRINDING PRIOR TO WELDING.

14.5.4.1 All loose and work-hardened metal, as well as hairline cracks shall be removed using a MC2 grinding machine before welding work on a crossing commences.

14.5.4.2 Apply slight pressure during the grinding process to avoid over heating (metal turning blue) of the steel. Ensure that the grinding stones are not damaged or clogged with fine steel. Using damaged grinding stones could be fatal.

14.5.4.3 Remove overlaps.

14.5.4.4 Use dye penetrant to ensure all loose metal and hairline cracks are removed. Any sign of cracks, loose metal or porosity will be highlighted as red lines or dots through the white developer.

14.5.4.5 If the running surface is lowered more than 10mm to remove a defect, grinding shall be stopped to not impede on the safe passage of trains. The track personnel shall decide whether the track is safe for the passage of trains.

14.5.5 PREHEATING.

14.5.5.1 Preheating of the 14% MN area of the rail-bound crossing is not permitted.

14.5.6 WELDING PROCEDURE.

14.5.6.1 Staggered method for welding of crossings.

14.5.6.1.1 Crossing may be welded by means of manual metal arc welding (MMAW) or flux-cored arc welding (FCAW).

14.5.6.1.2 The Staggered method is used whereby welding beads are welded at different places on the casting.

14.5.6.1.3 The staggered method shall be applied until the damaged area is welded (built-up) more than 3mm above the required level. This will ensure a smooth and even running surface after final grinding (Annexure 13-2).

14.5.6.1.4 All slag and spatter shall be removed from the welding beads and crown after the welding process.

14.5.6.1.5 The welded area shall be peened with the ball end of a 1kg hammer to release any internal stresses.

14.5.6.1.6 The temperature of the casting may never rise above 200°C, as this will render carbide, which may cause hairline cracks and brake-outs in the casting.

14.5.6.1.7 Apply the record pad to the crossing.

14.5.7 ROUGH GRINDING.

14.5.7.1 The casting shall be allowed to cool down to ambient temperature before the steel spacer plate may be removed underneath the crossing and all the sleepers fastened and tamped, where after grinding may commence.

14.5.7.2 **NB: When grinding is done on crossing, wings should fit to nose and not nose to wings**.

14.5.7.3 Grinding shall commence with the nose of the casting. Place a 1m straightedge longitudinally in the centre of the nose with one end at point P, and the other towards the trailing end of the crossing. Ensure constant height between point P and point X by grinding. Grind a decline of 3mm from point P to the tip of the nose. It is recommended that point P is left 1mm higher than normal crown wear H for distance L towards the trailing end of nose, to allow for work-hardening of the welded metal.

14.5.7.4 Draw a line (with boilermaker's chalk or chalk-line) longitudinally on the centre of the nose to sub-divide the nose into two equal halves.

14.5.7.5 Place the concave side of the 1:20 contour gauge on the nose and grind a 1:20 contour to both sides of the nose to match the running surface of the train wheels.

14.5.7.6 A sharp edge will be present on the centre of the nose once 1:20 cant has been achieved on both running surfaces.

14.5.7.7 Place the convex side of the 1:20 contour gauge, transversely at point P to determine the extent of metal to be removed on the wings. Grind proportionally away on left and right wings until contour gauge touches both wings and nose. This height shall be maintained over a distance of 300mm (between point G and the PI) for 1:12 turnouts, and 230mm (between point G and the PI) for 1:9 turnouts as indicated in blue (Annexures 14-1 and

14.2). To assist grinding measurements, a 500mm straight edge can be used between point G and the PI.

14.5.7.8 Grind an even decline on the wings from the PI towards point D as per Annexures 14-1 and 14.2.

14.5.7.9 Note that the casting is 1mm lower than the connecting rails at Section A-A in Annexures 14-1 and 14-2.

14.5.7.10 Grind an even decline on the wings from point G towards point E.

14.5.8 FINAL GRINDING.

14.5.8.1 Grind a 13mm radius to gauge corners on wings and both sides of the nose.

14.5.8.2 Sharp edge on the centre of nose shall be removed to leave a sound surface.

14.5.8.3 Grinding shall match running surface of the rest of the casting.

14.5.8.4 Spray running surface of area repaired to observe rail wheel interaction.

14.5.8.5 No grooves, porosity, slag inclusion or undercuts may be present in the welded areas. If such defects do occur, the section in question shall be re-welded and re-grinded.

14.5.9 STANDARDS AND TOLERANCES.

14.5.9.1 Use dye penetrant to test for the presence of cracks after final grinding.

14.5.9.2 A 0.2mm feeler gauge may not enter underneath a 1m straightedge when placed longitudinally on the nose and wings of the casting.

14.5.9.3 A decline of 3mm shall be present from point P to the tip of the nose.

14.5.9.4 A 1:20 inclination shall be present on the crown and the gauge corner shall have a radius of 13mm on the nose and wing surfaces of the rail-bound crossing.

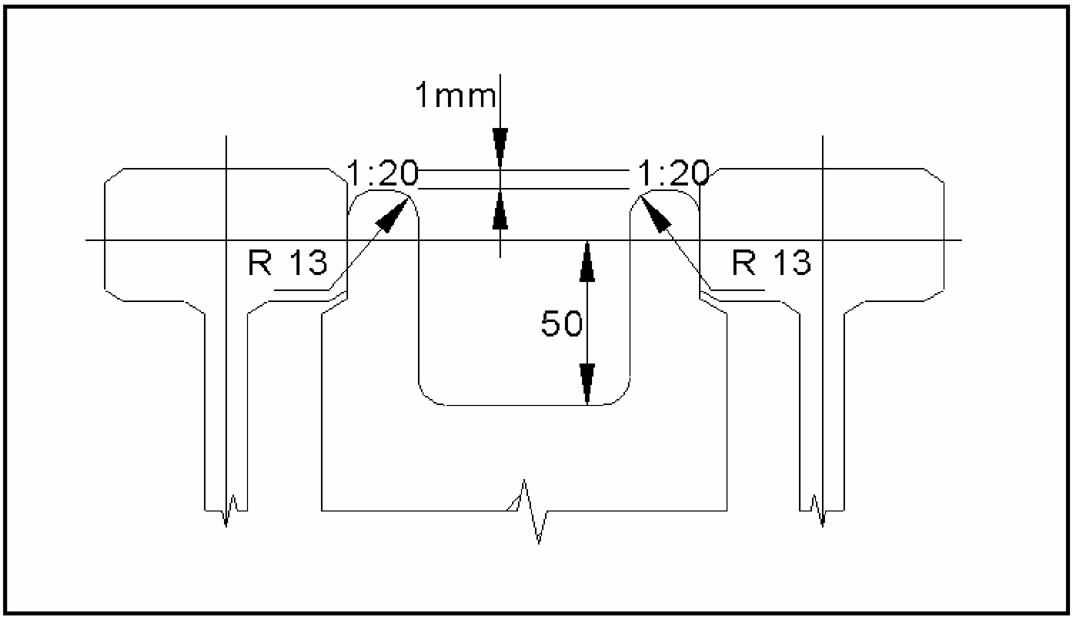

Figure 14.1. Facing Direction.

14.6 WELDING REPAIRS DONE IN A WORKSHOP.

14.6.1 INSPECTION.

14.6.1.1 The crossing shall be cleaned thoroughly by using a wire brush, needle scalar etc. Shot-blasting may be applied if available.

14.6.1.2 When a crossing is found suitable to be repaired in a workshop, it shall be placed on a workbench (jig) specifically made for the repair of rail-bound crossings.

14.6.2 PREPARATION BY WELDING PERSONNEL.

14.6.2.1 The same procedure as described in Paragraph 14.5.3 shall be followed to prepare the crossing for welding in a workshop.

14.6.2.2 The crossing (placed on the workbench) shall be lifted and a spacer plate (thickness 50mm to 75mm depending on the depth and area to be welded) inserted underneath the nose, and the crossing shall be bent backwards to prevent it from sagging at the nose during the welding process.

14.6.3 GRINDING PRIOR TO WELDING.

14.6.3.1 The same process as described in Paragraph 14.5.4 shall be followed to grind the crossing prior to welding in a workshop.

14.6.3.2 Welding repairs done on connecting rails:

- Casting insert shall be dismantled from connecting rails.
- The connecting rail is placed in a jig to eliminate any distortion (Annexure 14-3).
- Repair defects in accordance with Chapter 7 (Wheel-spin burns).

14.6.4 PREHEATING.

14.6.4.1 Preheating on turnout inserts is not permitted.

14.6.4.2 Follow pre- and post heating processes as prescribed in Chapter 5.

14.6.5 WELDING PROCEDURE.

14.6.5.1 The same procedure as for welding of the crossing in track (Paragraph 14.5.6) shall be followed to repair the crossings in a workshop.

14.6.5.2 The crossing shall be left in the tensioned position until it has reached ambient temperature, where after the casting may be de-stressed.

14.6.6 ROUGH GRINDING.

14.6.6.1 Grinding after welding is the same procedure as in the case for repair of rail-bound crossings in track, refer to Paragraph 14.5.7.

14.6.7 FINAL GRINDING.

14.6.7.1 Final grinding procedure is the same as in the case for repair of rail-bound crossings in track, refer to Paragraph 14.5.8.

14.6.8 STANDARDS AND TOLERANCES.

14.6.8.1 See Paragraph 14.5.9.